PROCEEDINGS OF THE

# SCIENCE ASSOCIATION OF NIGERIA

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EDITOR

Dr. B. HOPKINS

*University College, Ibadan*

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## SCOPE OF THE PROCEEDINGS

*The Proceedings of the Science Association of Nigeria* are intended to record the activities of the Association.

With other national societies of scientists in West African territories, the Science Association of Nigeria is affiliated to the West African Science Association which publishes a journal. This *Journal of the West African Science Association* caters for original articles of a scientific nature.

Thus, for scientists in Nigeria, the *Proceedings of S.A.N.* are complementary to the *Journal of W.A.S.A.*

The first number covers the first three years of the Association. It is hoped that in future a number shall appear annually.

## ORIGINS OF THE ASSOCIATION

THE West African Science Association was founded in 1953. Although its members were distributed throughout West Africa they were predominantly resident in Ghana where all its activities took place. It had been felt for some time that similar activities should take place in Nigeria and in May 1957 a circular was dispatched to as many scientists as possible resident in or near Ibadan. The replies received were mainly in favour of the formation of an Ibadan Branch of the W.A.S.A. though many persons preferred the formation of an independent association in Nigeria. A meeting was held on 25th October at which it was agreed that an organization to bring scientists together should be formed in Nigeria and should, if possible, be associated with the W.A.S.A. A committee to draft the aims and constitution of an association and to approach the W.A.S.A. was elected as follows:

| | | |
|---|---|---|
| *Chairman* | : | Professor J. Grayson |
| *Secretary/Treasurer* | : | Dr. B. Hopkins |
| *Members* | : | Mr. R. W. J. Keay |
| | | Dr. E. Njoku |
| | | Dr. J. M. Waterston |
| | | Professor J. E. Webb |

A second open meeting was held on 7th January 1958 at which the committee reported on its work and the motion "That a Science Association of Nigeria be created" was carried unanimously. It was decided that the Inaugural Meeting of the Association should be held in December 1958 at, if possible, University College, Ibadan. A steering committee was elected to arrange this conference, conduct a membership drive, draw up a constitution and continue discussions with the W.A.S.A. on the relationship of the two associations.

# INAUGURAL MEETING

THE Inaugural Meeting was held at University College, Ibadan from Monday 15th December 1958 until Thursday 18th December 1958.

## OPENING CEREMONY

Dr. J. H. Parry, the Principal of University College, briefly welcomed Conference Members and wished the new Association well.

Professor J. Grayson, the Chairman of the Steering Committee then introduced the Science Association of Nigeria. He said that there was an increasing amount of scientific activity in Nigeria and for some time it had been realized that there was a real need for scientists working in Nigeria to come together for talks and discussions. Accordingly a preliminary meeting of scientists living in or near Ibadan was called. A Steering Committee was set up with the task of arranging the Inaugural Meeting and to bring notice of the proposed Association to as many as possible of the scientists in Nigeria.

Throughout all its work this Steering Committee had been in close contact with the existing West African Science Association.Professor Grayson said that it now appeared extremely likely that W.A.S.A. would be re-constituted on an inter-territorial basis and S.A.N. would become affiliated in some way to this organization.

Professor Grayson went on to point out how the Association could be of assistance to Nigeria as a whole. A country whose fundamental economy was based on agriculture needed, he said, to develop agricultural research more in the future. Science though it was divided into various disciplines was a unit and Professor Grayson pointed out as an example that medical research had shown many diseases in Nigeria to be the result of malnutrition and that improved agricultural production could help to remedy this situation.

Finally Professor Grayson paid tribute to his colleagues on the Steering Committee, thanked the University College, Ibadan for its hospitality and welcomed the Hon. Victor E. Mukete, the Federal Minister of Research and Information.

The Hon. Victor E. Mukete then addressed the Association:

"I am most grateful to the Chairman and Members of the Steering Committee for doing me the honour of inviting me to address this distinguished and learned company on the occasion of the inauguration of the Science Association of Nigeria.

"Confronted by this array of scientific talent, I might perhaps be excused some trepidation—though I can at least claim to be qualified for membership of the Association. But in fact I am very glad indeed to have the opportunity of saying how welcome and timely the formation of the Association is; and of offering, on behalf of the Federal Government, every support and encouragement to the new organization.

"In less than two years Nigeria will achieve independent nationhood and it is into a Scientific Age that our new nation is being born. At no time in the history of the world has the prestige of the Scientist and his importance to the community stood higher. Science has, of course, played an important part in the development of this country and will undoubtedly have a much more important part to play in the future. By its aid we have been able to achieve in fifty years, progress which in other countries has taken centuries; but the very rapidity of this progress has brought its own problems, which again we must look to Science to solve.

"Science, of course, has many branches, one or other of which affects almost every field of human activity. These effects are closely inter-related; discoveries in one field may stimulate advance in a totally different field. On the other hand it may sometimes be necessary to call in one branch of science to redress the balance upset by another; the achievements of medicine in preserving life may lead to a rapid increase in population—as indeed is happening in Nigeria—and it is then for the agriculturalists to find new ways of increasing food supplies. It will, I conceive, be an important function of the Science Association of Nigeria to bring together those trained in different disciplines and instil a mutual awareness and appreciation of each other's problems, from which we can hope will develop a fruitful co-operation, which will be greatly to the benefit of this country.

"A heavy responsibility, therefore, lies upon you, ladies and gentlemen, who have gathered here today to inaugurate the new Association; for it is upon you that the future development of this country will very largely depend. Not the least of your responsibilities will be to train Nigerian scientists and to provide the guidance and leadership which is so badly needed here in the fields of science. Nigeria, it is true, already has its own distinguished men of science, but they are at present all too few, and we are very conscious of the weakness of our educational system in this important respect. The Federal Government has introduced the Emergency Science Training Scheme, which we hope will stimulate the flow of science graduates; but your services will be needed for a long time to come. Indeed, we may hope that there will always be an inter-change of scientists between Nigeria and other countries, for Science is international and is most readily fertilized by the exchange of ideas on the widest possible basis. Fortunately, there is no lack of facilities nowadays for such exchanges; we have the various organizations of the United Nations; the Scientific Council for Africa South of the Sahara; and the many branches of the Commission for Technical Cooperation in Africa South of the Sahara. Nearer home, we have the inter-territorial research organisations which have been functioning successfully for several years; and, of course, we have the University College itself, whose premises have so hospitably and appropriately been made available to us on this occasion. May I say here that we look forward to the not too distant day when our own University will take its place amongst the world's most famous centres of learning and intellectual activity.

"There is nonetheless plenty of room for an organisation in which scientists can associate as individuals, rather than as representatives of Governments or Departments or Institutes, and I therefore extend to the Science Association of Nigeria a most sincere and cordial welcome. I congratulate the Chairman and members of the Steering Committee, to whose efforts the Association owes its existence: and I wish the Association every success in the fulfilment of its noble purpose."

## GENERAL PAPERS

Professor N. S. Alexander (*Department of Physics, University College, Ibadan*) **The International Geophysical Year.**

Professor C. W. L. Bevan (*Department of Chemistry, University College, Ibadan*) **Researches in progress in the Department of Chemistry, University College, Ibadan.**

We are fortunate enough to be able to say that fundamental researches are being carried out in each of the three main branches of Chemistry.

The Physical Chemists are studying various aspects of the chemistry of high polymers. These are substances with molecular weights between ten thousand and ten million. They range from the wide diversity of industrially important plastics, some natural like rubber, and a host of synthetics like polystyrene, to proteins, nucleic acids and polysaccharides all of which play a fundamental role in living tissue. Studies of their physical properties assist in the elucidation of the mechanism of their formation, and this in turn apart from its intrinsic interest permits the development of polymers with predictable properties. They can be tailor made to suit the purpose required.

In the field of Inorganic Chemistry interest centres on co-ordination compounds. The simplest are hydrated cations while the more complex examples include many vital enzymes, the main catalysts of chemical reaction in living systems. Vitamin $B_{12}$ has the formula $C_{63}H_{88}O_{14}N_{14}PCo$ and is a co-ordination compound of cobalt. Clearly the investigation of the detailed mode of action of systems as complex as this can only be studied with initial reference to much simpler systems, and it is the physico-chemical behaviour of certain such model substances which is being studied.

Researches in Organic Chemistry fall into three categories. Firstly, improved methods of synthesis of steroid precursors are being studied. Steroids and related compounds include the heart poisons digitoxigenin and strophanthidin and the steroidal hormones, one of which, cortisone, has excited much public interest because of its dramatic powers of relieving the crippling effect of rheumatoid arthritis. Secondly, synthetic studies on azatropolones, which contain a new type of seven membered aromatic ring, have led to the isolation of a large number of new heterocyclic compounds many of which have been shown at Yaba to have anti-viral activity.

Then there is the general problem of the influence of structure on reactivity. Much work has been done during the past three decades on substitution at a saturated carbon atom typified by the equation

$$R_1R_2R_3C-X+Y \longrightarrow R_1R_2R_3C-Y+X$$

Far less is known about the effects of structure, solvents and like influences on analogous reactions at an aromatic carbon atom typified by

$$R.C_6H_4.X+Y \longrightarrow R.C_6H_4Y+X.$$

Various aspects of this general class of reaction are being studied and recently the mechanism of one such process, previously misrepresented in the literature, has been fully established.

Finally, investigations on the chemistry of the West African Flora include examination of the heartwood extractives of various genera of the dicotyledonous trees. In particular, interest is focussed on the important timber producing family Meliaceae. A group of compounds of novel chemical structure have been isolated and investigated structurally, as part of an attempt to establish a pattern of chemical taxonomy. Such heartwood extractives are in many cases powerful fungicides and may well serve as prototypes for the development of systemic fungal compounds.

Finally, what energies are left over from these more fundamental studies are devoted to the chemical examination of medicinal and poisonous plants. A new convulsant alkaloid dihydrodioscorine has been isolated from *Dioscorea dumetorum* and the generous provision of a Research Fellowship by the Ministry of Health should permit of further development in this field.

Professor P. J. Collard (*Department of Bacteriology, University College, Ibadan*) **Microbes in the service of man.**

Only a small proportion of bacteria and fungi are pathogenic; the vast majority of species are either harmless, or beneficial to man. Ever since Neolithic times certain crafts have made use of micro-organisms to produce controlled chemical changes in materials. Thus the use of yeasts for fermentative production of alcohol, penicillia and other fungi in cheese making, and members of the genera *Bacillus* or *Clostridium* in the retting of fibres are universal craft processes. The basis of these fermentations was purely empirical with no understanding of the role played by micro-organisms until the work of Louis Pasteur in the middle of the last century. Examples of domestic and craft fermentations carried out empirically in Nigeria are (1) the production of palm wine, (2) the production of gari, and (3) the retting of various fibre plants to produce "ti-ti".

The Department of Bacteriology, University College, Ibadan, has recently been asked by the Federal Ministry of Commerce and Industry, Lagos, to investigate the fermentation involved in the production of gari as a preliminary to the setting up of a plant for large scale production of this foodstuff. The fermentation of cassava roots proved to be the result of the sequential action of two micro-organisms; firstly *Corynebacterium manihot* and then *Geotrichum candida*. The details of this fermentation have been published in Nature (Vol. 183, pp. 620-621, Feb. 28, 1959). The Department has also investigated the retting of *Urena lobata* on behalf of the Department of Trade and Industry, Northern Region, Mokwa, and has developed a thermophilic aerobic process with which the material is processed in three to five days as against a period of three to four weeks which is required by the traditional methods. Various other industrial problems are at present being investigated in the Department.

Because of the climatic conditions in the country it would appear that Nigeria is ideally suited for the development of industrial fermentations. If such an industry were to grow up it would be of immense value to the country both as a source of fuels and of various organic chemicals which are at present being imported. Considerable fundamental research is, however, required before any specific project is undertaken.

Dr. J. C. Edozien (*Department of Chemical Pathology, University College, Ibadan*) **Blood factors in the study of human races.**

Professor C. A. Hart (*Faculty of Engineering, University College, Ibadan and Nigerian College of Technology, Zaria*) **Aerial survey.**

Air photography, or photographic reconnaissance as it was called during the recent war, contributed very largely to our success, since the study of air photographs provided invaluable information about enemy activities. Air photography became an accepted routine for gathering information for attack and assessment.

For most purposes, including mapping, photographs are taken with the camera axis vertical so that we get a "bird's eye" view. The scale of the photograph is very important, for some magnification must be used in its examination, and the amount of this is limited by the "grain" of the photographic emulsion. For mapping, the best results are obtained when the atmosphere is free from haze, and the shadows are short.

Air photographs are used in preliminary investigation by mining geologists, forestry and so on and by the engineer when selecting routes for new roads and railways and sites for reservoirs. Thus each specialist can make use of air photographs for his own purpose.

The surveyor depends for identification and measurement from air photographs upon stereoscopy, and to obtain the maximum information about the ground, both in plan and height, air photographs are always examined in overlapping pairs taken under conditions such that stereoscopic measurement may be employed.

For mapping the surveyor always wants more and more accuracy and the greater the accuracy with which the air photographer and navigator can provide the "pictures", the simpler, quicker and cheaper become the methods of mapping to a desired accuracy.

Practical air photography was introduced in the 1914-18 War by which topographical details were provided from which reliable maps could be made. Progress was then somewhat retarded but the 1939-45 War saw great advances in air survey and in particular the application of radio and radar aids to navigation and surveying.

In practice many hundreds of thousands of square miles of topographical mapping have been carried out by British surveyors using simple geometrical methods: the Americans also use them. In such mapping, the effort is to keep the photographs as nearly vertical as possible and adjust the geometry to known survey points on the ground.

Automatic pilots and other forms of gyro-stabilisation enable an aircraft to be flown with a tilt less than 1° (depending on aircraft), and we can determine the vertical to about this order of accuracy, but the limitation of tilt and its precise determination for accurate work are still major problems in air survey. Another fundamental difficulty arises from the variations in height of the ground.

The local scale of a photograph is dependent upon the height of any particular section in relation to the Datum Plane, and also upon the tilt of the camera from the horizontal when the photograph is taken. The two fundamental problems arising from tilt and height distortions make it impossible to use photographs directly as maps, or to produce accurate maps from them without appropriate technical adjustments.

Air survey by means of elaborate plotting machines is much more precise. No assumption is made that the photography was vertical, and it is possible by the use of such machines to set a pair of air photographs exactly in their proper positions relative to each other and to the ground. By this means much greater accuracy can be obtained and considerable distances can be spanned accurately in plan and height without ground control. The apparatus is expensive and requires skilled operators, and in many cases the simple methods are quite adequate. Such instruments now play a very important part in the preparation of large-scale survey methods for engineering projects.

The precise navigation of an aircraft so that an area may be covered accurately with overlapping strips of stereoscopic pairs of photographs has always presented some difficulty, and the uncertainty of the position of the aircraft in space at the instant of photograph makes it necessary to fix a number of points by ground survey. During the war experimental work undertaken by the War Office showed that radar navigational aids can be used satisfactorily for this purpose, and this has had a great effect on the scientific approach to air survey.

As a result of the research work during the 1939-45 War, and the intensive work since in developing geodesy, so that positions on the earth are accurately known, these radar navigational aids have turned to the accurate measurement of long distances. By means of a trilateration (a network of measured lines) as distinct from a triangulation (measured angles with a measured base), it has been reckoned that N. Canada has been adequately controlled in ten years, which would have probably taken 200-300 years to do as thoroughly by traditional ground methods in Arctic country.

## Mr. F. E. Joselin (*Technical Institute, Yaba*) **The teaching of science in schools.**

Mr. Joselin brought to the notice of the Conference the fact that there is a grave shortage of Nigerians trained to do scientific work: this shortage exists at all levels, from graduates downwards: unless the shortage can be remedied it will constitute a very serious handicap to the future development of Nigeria, not only in agriculture, medicine, and public health, but also in the growth of the various industries which have recently been started. The speaker maintained that, among a number of causes of the shortage of scientific workers, the one which most urgently needed tackling was the present inadequate teaching of science in the secondary schools of the country. He considered that this teaching was inadequate largely because far too little emphasis was laid on practical work done by the pupils. He referred to the outstanding success in Great Britain of the work done by the Industrial Fund for the Advancement of Scientific Education in Schools: the administrators of the Fund had concentrated on helping selected schools to improve their laboratory accommodation and equipment. After stressing again the importance and urgency of the question, Mr. Joselin concluded by suggesting that the Science Association might, as an independent organisation, be the best body to tackle this question.

A lively discussion followed in which Mr. Joselin's views were generally supported.

## Dr. F. N. Macnamara (*West African Council for Medical Research, Yaba*) **Virus diseases and progress in public health.**

Virus diseases have proved hitherto to be resistant to chemotherapeutic agents and the only defence against viruses has been by employing methods of hygiene and in a few instances by vaccination. It is only within the last few decades that improvement in sanitation and food hygiene has developed to a stage where any significant effect can be shown on the rate of transmission of the enteric viruses, and the effect has been observed largely in the highly developed societies. In some areas mosquito borne virus infections are being reduced by insect control. The transmission of respiratory viruses remains virtually untouched.

When an infectious disease is controlled by hygienic methods the epidemiology of the disease passes through a series of phases. Initially the disease is highly endemic and there is a relatively high risk of an individual becoming infected in a short period of time. As control is slowly introduced the epidemiology becomes unstable. There are periods when there is practically no transmission followed at irregular intervals by epidemics of greater or less severity. This phase is followed by virtual extinction of the disease.

Poliomyelitis has within the last few decades passed into the phase of epidemics in the more developed countries, and serious epidemics have occurred particularly in Scandinavia and America. These epidemics are all the more serious because owing to increasing intervals between them, older persons are becoming infected for the first time, and after the age of about five or six years the severity of the disease increases with the age of the individual. Serological surveys conducted in Nigeria have shown that the infection is very highly endemic and that practically all children have been infected before reaching five years old. Nevertheless hygiene is improving and we are seeing an increasing amount of poliomyelitis particularly among the children of the better educated Nigerian population.

The more severe form of poliomyelitis seen in older children and adults may result in the development of more virulent strains of virus. A similar enhanced virulence may account for the relatively severe diseases which are becoming increasingly evident due to other enteric viruses in the Coxsackie and E.C.H.O. groups.

The arthropod borne viruses including yellow fever are very common in some parts of Nigeria, particularly the forest belt. Here, however, the fact that infection occurs at an early age when the child is more tolerant of infection and the fact that there are also present a number of other arthropod borne viruses which confer a partial immunity against yellow fever result in there being very little clinical yellow fever observed. As mosquitoes, however, are brought under control and the incidence of infection with viruses related to yellow fever is reduced we may observe an increase in small outbreaks of clinical yellow fever, first just outside the forest belt then within it.

In order to avoid the epidemics of enteric and arthropod viruses the phase of unstable epidemiology must be passed as soon as possible, by pressing the pace of public health measures. Vaccines, particularly the "live" vaccines which produce longer immunity than "killed" vaccines will prove of great value when they can be developed and made available on a sufficiently large scale.

In the field of respiratory viruses vaccines may be the only means of control for some time. Nevertheless the influenza A. virus, which causes the worst epidemics, changes its character at frequent intervals so that a vaccine of use one year may not be of any use in subsequent years. The provision of laboratories throughout the world to detect these sudden changes will assist towards the production of efficient vaccines.

## Dr. E. Njoku (*Department of Botany, University College, Ibadan*) **Physiological limitations of crop yield.**

Pot experiments have been carried out with ten species of West African plants, in which the leaf area and dry weight per plant have been determined on two or more sampling occasions. From these data the net assimilation rate, leaf area ratio and relative growth rate have been calculated for the intervals between sampling.

The net assimilation rates are generally high, being comparable to the highest values obtained in other parts of the world. The leaf area ratios are also higher than similar values available for plants of the temperate zone. The high levels of both the net assimilation rate and the leaf area ratio combine to produce high relative growth rates, indicating that plants in this tropical environment grow faster than plants of the temperate zone under similar conditions of nutrient supply and moisture.

The results were discussed in the light of previous work in temperate countries on the effect of light intensity on growth, from which it was inferred that under tropical conditions relative growth rates would be lower, or at most no higher than in the temperate zone. It appears that the higher relative growth rates demostrated here are due to the fact that higher temperatures cause increases in the leaf area ratio which more than compensate for any depressing effect produced by the higher mean light intensity in the tropics.

Attention was drawn to the need in West Africa for work on the quantitative analysis of the growth of crop plants with a view to obtaining more information on the factors limiting growth and yield.

Mr. J. S. Robertson (*West African Institute for Oil Palm Research, Benin*) **The most important disease problem encountered when growing Oil Palm seedlings.**

Blast is the most important disease problem encountered when growing oil palm seedlings in West Africa. A full description of both external and internal symptoms was given. Evidence from the results of laboratory and inoculation trials indicated that the disease is the result of a primary infection of young root tissue by *Pythium* species which is in turn infected by a *Rhizoctonia* species. Once the latter has gained entry into the plant (via the *Pythium* sp.) it assumes the role of an active pathogen.

The disease is associated with a particular time of the year and there appear to be two factors involved: firstly, at this time, the seedlings appear to be passing through a disease susceptible stage and secondly, conditions in the soil are optimum for the growth and development of the fungi.

There is a highly significant negative correlation between rainfall in the months preceding the blast season and the subsequent incidence of the disease.

Dr. J. I. Taylor (*Federal Veterinary Research, Vom*) **Animal disease and animal health in Africa.** (Paper published in full in *J. W. Afr. Sci. Ass.*, 5, 126–132, 1959.)

The course of the Rinderpest epizootic in 1889 in Africa was traced and from this was traced the control of various other small diseases.

While large scale epizootics are now unlikely to occur, the control and final eradication of these diseases is difficult, not through lack of scientific knowledge, but due to the inability to apply control measures. Only by a desire to achieve these ends by the people concerned will there be success.

Even when the major epizootics are overcome there are still diseases which cause economic losses, and often they are associated with a low standard of management or nutrition. Before considering how improvements should take place to improve productivity, a knowledge of the ecological areas and the farming practised therein is necessary.

A review of the ecological zones found in the tropics was given and it was emphasised that the greatest hope of success is to adapt the policy of farming to the natural conditions, when not only the potentialities but also the limitations of the area must be realised. Production schemes should be guided by economics.

Progress in livestock development depends upon sound nutrition and breeding. In the tropics fodder conservation and grassland management are probably the most important nutrition problems. The various systems of breeding were reviewed and it was demonstrated that breeding alone is not a solution to all livestock problems.

The paper concluded by showing that the demand for livestock products is growing, and what is now needed is sound planning and the greatest measure of co-operation and co-ordination both inter-departmentally and inter-territorially.

### Mr. W. O. Tichler (*Shell-BP, Owerri*) **Palynology as used in the oil industry.**

Palynology, the study of pollen and spores, has become over the last thirty years a useful tool solving stratigraphical problems such as time correlation and facies interpretation of ancient sediments. It is for this reason that the oil industry takes an increasing interest in the palynological investigation of sediments in oil prospective basins.

Pollen analysis is based on the following well known facts:-

1. Pollen of different taxonomic groups differ in structure and shape.
2. Plants produce pollen in enormous quantities.
3. These huge quantities of pollen are widely distributed by wind and water.
4. The outer layer of a pollen grain, i.e. the exine, is strongly resistant to natural destructive processes.
5. Vegetational changes in time and space are normally reflected in the composition of the pollen content found in sedimentological rocks.

Pollen is extracted from rock samples by means of chemicals. From the resulting residues the quantitative and qualitative pollen content of each sample is determined. Results of these analyses are plotted in graphical form and these graphs interpreted for their stratigraphical implications.

### Dr. T. W. Tinsley (*West African Cocoa Research Institute, Moor Plantation, Ibadan*) **The problem of cocoa cultivation in Nigeria.**

There are approximately 1 million acres of cocoa in Nigeria and the average annual yield is about 100,000 tons of dry cocoa. This means that the Nigerian farmer produces about 200 lb. of cocoa per acre from his farm. We know that on farms where cocoa trees are planted at regular spacings and where the rules of good husbandry are followed then yields of 2,000 lb. or more can be obtained. Therefore our objective is to find the ways and means of raising this low national average in Nigeria. We have many problems to investigate before we can put our findings into practice. However we have been stimulated by the success of the control measures against insect pests and with the introduction of new vigorous varieties.

The main features of our research programme can be listed as follows:-

1. Control of pests and diseases.
2. Improved methods of planting and management.
3. Introduction of high yielding and early maturing varieties.
4. Application of fertilizers.
5. Breeding of cocoa varieties for resistance to diseases and drought conditions.

If we are to raise the status of Nigeria as a cocoa producing country then we require whole hearted co-operation between the research organisations, the advisory services of the Ministries of Agriculture and the cocoa farmer. I am happy to say that in Nigeria we have now the beginnings of such co-operation and given time and patience, we can achieve our aims.

Professor J. E. Webb (*Department of Zoology, University College, Ibadan*) **Ecology in the tropics.**

## SPECIALIST PAPERS

### *Botany Specialist Section*

Dr. R. H. Cammack (*West African Maize Research Unit, Moor Plantation, Ibadan*) *Puccinia polysora:* **factors affecting the incidence of the epiphyotic in West Africa.**

Dr. B. Hopkins (*Department of Agriculture, University College, Ibadan*) **Olokemeji Forest Reserve.**

A brief description of the physical features, climate and vegetation of the Olokemeji Forest Reserve was given as a general introduction to the field excursion to be held in the afternoon. It was illustrated by colour slides including a series of views of savanna woodland taken at monthly intervals from the same position to show seasonal changes.

Dr. E. Njoku (*Department of Botany, University College, Ibadan*) **Seasonal changes in the growth and development of plants in Nigeria.**

Observations made over a period of two years on twelve species of trees growing in the Botanical Garden of the University College, Ibadan, were presented (*Monodora tenuifolia, Terminalia superba, Sterculia* sp., *Chlorophora excelsa, Bauhinia monandra, Millettia* sp., *Bosqueia angolensis, Funtumia elastica, Bombax buonopozense, Cola togoensis, Anona* sp., and *Cola acuminata*). These observations were concerned with the annual cycle of changes involving the onset and cessation of dormancy of vegetative buds, leaf fall and flowering.

Attention was drawn to the variation in behaviour between and within species, but in general the pattern of changes was shown to be very similar to that in trees of higher latitudes —a long period of dormancy being characteristic of most of the trees studied. A striking feature was the onset of dormancy in vegetative buds in the height of the rainy season (June to July) when growth conditions would be considered very favourable. Bud break, on the other hand, occurred in most cases during the dry season, showing no relation to rainfall or general moisture conditions. A notable feature of the flowering behaviour of most trees was the association of the flower and vegetative buds, both being enclosed in the same bud scales in the dormant compound bud, so that flowering and expansion of new leaves occurred almost simultaneously at bud break. In some of the deciduous trees, such as *Monodora tenuifolia*, the association of flowering with expansion of new leaves resulted in an attractive display of flowers as the flower buds opened a little before the associated vegetative buds at a time when the old leaves had been shed.

The results were compared with general observations on flowering and leaf fall contained in Kennedy's *Forest flora of Southern Nigeria* and Lely's *Useful plants of Northern Nigeria*, and discussed in relation to seasonal changes in evironmental conditions. Reference was made to the possibility that the small seasonal changes in temperature, particularly the relatively low minimum temperatures of harmattan nights in December to January, might constitute a stimulus for bud break. With regard to seasonal changes in daylength, previous work on annual plants had already shown that the small seasonal changes in daylength constitute an effective stimulus for flowering. It was probable therefore that daylength might be an important factor in tree physiology in Nigeria. It was emphasized, however, that these were points on which experimental evidence was necessary. The observations reported in this paper provided a basis for experimental studies which were being undertaken in the Botanical Gardens.

Dr. W. R. Stanton (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **The distribution of sorghum and maize types in Nigeria —a comparison of the past responses of these crops to the environment.**

The study of the distribution of sorghum and maize is divisible into:-

1. The survey phase.
2. The general genecological investigation.
3. The effect of particular factors, detected by the first two studies, on the distribution.

These two crop plants (taxonomically related) show the effects of evolution in Nigeria, under the influence of man, from very distinct origins. Sorghum has evolved and migrated with Neolithic societies from a Near East or East African centre of domestication. Maize was introduced in comparatively recent times, as a highly domesticated plant, into societies which possessed, either in fact or folklore, elements of an extensive and long developed 'sorghum culture'.

The object of the investigations in progress in the Department of Agriculture is to unravel the details of this convergent development, the work being pursued in the phases listed above. In the surveys, attention has been paid to the sociological factors which have been operating. These factors, such as migration, taboos and 'methods of use', have had a large effect in limiting the material available to any one group of people. The redistribution of types, within the limits of social restriction, is an immediate practical outcome of this work.

When the effect of sociological factors is removed, our results, though limited by the fact that the sorghum investigations have only been conducted for a year, show great similarities of developmental pattern under similar environmental conditions. The statistics used have been *length of sequential internodes* and *tassel* (maize) and *head* and *branching* indices (sorghum).

These statistics have been used by a number of workers in the classification of maize races and they appear to be reliable indicators of race even when the plants are grown under different environmental conditions. It remains to be tested whether this phenotypic stability holds for the sorghum races.

In addition to the restrictions commonly placed on the free evolution of the two plants, maize has had the added restriction of limited importation. The author suggests that the Treaty of Tordesillas (1493), which divided the world under a Papal Edict into Portuguese and Spanish spheres of influence, was of far-reaching ethno-botanical significance. The evidence was briefly reviewed for the theory of a two-fold introduction of an 'Early Caribbean' type into the Sudan Zone from the sphere of Spanish influence and, secondly, the introduction of a 'Bahia' type into the Forest Zone from the Portuguese sphere of influence. The effect of these introductions can still be detected in the present distribution pattern.

The problem of the first entry of sorghum into Nigeria is part of the problem, as yet unsolved, of the entry of the 'true negro' into West Africa. Before being pushed into the forest zone by later invasions (from about 500 A.D. onward) the 'negro' was inhabiting the Guinea Savannas and, it is postulated, was growing the GUINEENSIA type of sorghum (the type most extensively grown in West Africa). That this was not a completely 'in situ' development is suggested by the extant acha culture which is a Neolithic culture ante-dating that of sorghum.

It is in the GUINEENSIA types that we are able to study most effectively the geneecological picture. These types are found from the Northern border down to the Derived Savanna. Other types are, we postulate, of later introduction and are more restricted in distribution.

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A field excursion to the Olokemeji Forest Reserve was held in the afternoon.

### *Medical Sciences Specialist Section*

Professor G. M. Edington (*Department of Pathology, University College, Ibadan*) **The distribution of cancer in Africa south of the Sahara.**

Professor J. Grayson (*Department of Physiology, University College, Ibadan*) **Metabolism and blood flow in liver during hypoglycaemia.**

Dr. R. G. Hendrickse (*Lecturer in Paediatrics, University College, Ibadan*) and Dr. E. A. Boyo (*Department of Chemical Pathology, University College, Ibadan*) **Studies on the haemoglobin of new-born babies in Ibadan.**

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A discussion on protein deficiency in the diet of Nigerians and its effects was held under the chairmanship of Professor A. Brown (*Department of Medicine, University College, Ibadan*) and led by Dr. A. Adeniyi-Jones (*Medical Department, Western Region*), Dr. O. Bassir (*Department of Physiology, University College, Ibadan*) and Dr. W. R. F. Collis (*Department of Paediatrics, University College, Ibadan*).

### *Physical Sciences Specialist Section*

Dr. M. Govindjee (*Department of Physics, Nigerian College, Ibadan*) **Angular distribution of nuclear reaction products.**

Excitation functions and angular distributions of the reaction products of $C^{12}$ (d,p)$C^{13}$ and $B^{10}$ (p, *A*) $Be^7$ reactions were measured with respect to the incident beam from 0.8 to 1.6 MeV.

$C^{12}$(d,p)$C^{13}$ Reaction: The relative contribution of the compound nucleus formation and the stripping process to the yield was estimated and it was concluded that only about three per cent of the yield was from stripping reaction. The excitation functions show five resonances at 0.94, 1.13, 1.16, 1.30 and 1.44 MeV. At the lowest resonance (0.94 MeV) the angular distribution is very nearly isotropic. As the energy of the incident deuteron increased the complexity of the angular distribution pattern also increased. The angular distributions were expressed in a series of Legendre polynomials and their coefficient calculated. Since large coefficients were observed for Legendre polynomials of order 1 and 3, it was certain that the interfering levels possessed opposite parities. Calculation on the energy-dependence of the odd-order Legendre polynomials were simplified by the assumption that only the lowest of the possible orbital angular momenta of incident and emerging particle took part in the reaction. The assumption facilitated the assignment of spins and parities of the five levels in $N^{14}$. It is almost certain that the levels 0.94, 1.16 and 1.44 MeV have spin and parity 1+, 2− and 3+ respectively. The two alternative assignments for the 1.13 MeV resonance level are 0− and 1− and for the 1.30 MeV, 2+ and 3+. No estimate of the phase factor involved in the reactions was made since that would involve calculating angular distribution pattern due to three interfering resonance levels.

$B^{10}$ (p, $A$) $Be^7$ Reaction: The resonances at 1.1 MeV and 1.5 MeV are superimposed on a continuous rising background. The overlapping levels in the compound nucleus produce an interference in the angular distribution, whose complete analysis requires an admixture of orbital angular momenta of both incoming and outgoing particle. At the 1.1 MeV resonance level the reaction is very nearly isotropic, near the higher resonances at 1.5 MeV there is a large negative coefficient of the Legendre polynomial of the second order. It is suggested that the level at 1.1 MeV has spin and parity $\frac{5}{2}+$ and the level at 1.5 MeV $\frac{5}{2}-$.

Dr. D. H. Irvine (*Department of Chemistry, University College, Ibadan*) **Co-ordinate chemistry and vitamin B12.**

Dr. A. R. Mathieson (*Department of Chemistry, University College, Ibadan*) **Nucleic acids.**

In neutral solution the deoxyribonucleic acid molecule exhibits extreme asymmetry and a high degree of rigidity. Analytical and X-ray evidence is in agreement with the structure proposed by Crick and Watson in which two strands, coiled in a double helix, are linked together by hydrogen bases. Changing the pH of the solution to either high or low values causes the hydrogen bonds to be broken by titration, causing profound changes in structure, and on returning to neutral pH the original structure is not reformed. It is reformed after only a proportion of hydrogen bonds has been broken at less extreme pH values. This is clearly shown by the titration curves, the hysteresis of which is due to the change in structure at extreme pH. Measurements of viscosity, light-scattering, and streaming birefringence have been used to follow the change in molecular dimensions with pH. The dimensions are unchanged between pH 4.5 and 11, but outside these limits the asymmetric molecule collapses and will not recover its original shape on return to neutral pH. Between pH. 4.5 and 11 insufficient hydrogen bonds are broken to cause structural collapse but outside these limits an irreversible change to a more compact 'denatured' structure occurs.

A brief survey of the importance of nucleic acids in chemistry and biology was given, and recent speculations on their role in inheritance and protein synthesis was mentioned.

Dr. C. A. Onwumechilli (*Department of Physics, University College, Ibadan*) **Equatorial geomagnetism.**

Dr. N. J. Skinner (*Department of Physics, University College, Ibadan*) **Some equatorial ionosphere effects.**

Dr. D. A. H. Taylor (*Department of Chemistry, University College, Ibadan*) **Why make steroids?**

# BUSINESS OF THE ASSOCIATION

## *Steering Committee Report*

In recent years there has been a great increase in the amount of scientific activity in Nigeria. It has been felt that there is a real need for an organisation which will bring scientists together for talks and discussions, and which will also provide a channel through which scientists can explain their work to the country's layman. Unfortunately the existing West African Science Association as originally constituted, valuable though it was, did not fully meet Nigerian needs.

In October, 1957 a meeting was called at the University College, Ibadan to discuss these matters. After a further meeting in January, 1958 it was decided that a Science Association of Nigeria should be formed and hold its Inaugural Meeting in December, 1958.

A Steering Committee of members drawn from various scientific institutes in Ibadan was elected under the chairmanship of Professor J. Grayson. It was asked:

(*a*) to prepare a provisional constitution.
(*b*) to investigate carefully possible relationship with the existing W.A.S.A. particularly with regard to the possibility of a joint publication.
(*c*) to organize an Inaugural Meeting.
(*d*) to bring these proposals to the notice of as many scientists in Nigeria as possible.

Since then the Steering Committee has held twelve meetings at approximately monthly intervals. The results of the Steering Committee's deliberations are well reflected in the succession of circulars which have been sent out. The first, sent out in February, set out our aims and proposed activities and announced the Inaugural Meeting. About 1,250 copies were sent to persons and institutions. As a result of the replies received a regular mailing list of some 300 interested people has been established. It became evident that considerable support was forthcoming, and, in reply to later circulars giving more details of the Inaugural Meeting, an encouraging number of scientists have indicated their intention to attend. One encouraging aspect was the support and encouragement freely forthcoming from the various governments.

The probable future relations with the West African Science Association are now considerably clearer than they were a year ago. The move to form an independent Science Association of Nigeria has been welcomed by the Committee of W.A.S.A.—all of whom are from Ghana. It is intended to establish a Ghana Society of Scientists, a national organisation like S.A.N.;

whilst the West African Science Association intends to alter its constitutio making it truly interterritorial so that it will, in the first instance, consist c the S.A.N., the Ghana Society of Scientists and independent members i countries which have, as yet, no national scientific association.

### *Financial Statement*

The financial position of the S.A.N. at 1st December 1958 was:-

| *Income* | £ | s | d | *Expenditure* | £ | s | d |
|---|---|---|---|---|---|---|---|
| From loans | 48 | 10 | 0 | To Printing | 37 | 17 | 0 |
| From Conference Fees, etc. | 128 | 4 | 0 | To Stationery | 9 | 16 | 11 |
| | | | | To Postage | 9 | 17 | 0½ |
| | | | | To Bank Charges | 2 | 18 | 8 |
| | | | | Cash in Bank and in hand | 116 | 3 | 10½ |
| Total | 176 | 14 | 0 | Total | 176 | 14 | 0 |

### *Inaugural Business Meeting*

At this meeting the Steering Committee Report was accepted, a Provisional Constitution was adopted for one year, subscriptions were fixed anc elections were held.

### *Steering Committee Membership 1958*

| | | |
|---|---|---|
| *Chairman* | : | Professor J. Grayson |
| *Secretary/Treasurer* | : | Dr. B. Hopkins |
| *Members* | : | Mr. D. F. Davies* |
| | | Dr. J. C. Edozien |
| | | Mr. J. H. Elgood |
| | | Mr. T. O. Fayiga* |
| | | Mr. R. W. J. Keay |
| | | Mr. I. T. Nixon* |
| | | Dr. E. Njoku |
| | | Dr. J. M. Waterston |
| | | Mr. D. F. W. Whitfield* |

* Part of the year only.

## SECOND ANNUAL CONFERENCE

THE Second Annual Conference was held at the Zaria Branch of the Nigerian College of Arts, Science and Technology from Monday 14th December until Thursday 17th December 1959.

### OPENING CEREMONY

Dr. B. N. Lahiri, the Principal of the Zaria Branch of the Nigerian College, briefly welcomed delegates and wished the Association a successful meeting.

Mr. H. G. Jelf, the Permanent Secretary of the Northern Region Ministry of Education, then addressed the Association.

"I know that you must be extremely disappointed that neither the Premier nor the Minister of Education of the Northern Region are able to come today to welcome you to this Conference. Important political events now taking place make it difficult for Ministers to attend functions of this nature. As perhaps you may know, the Minister of Education is either in New York or on his way back after attending the United Nations debate on the future of the Cameroons. His absence from this country has been somewhat longer than was anticipated. In his absence the Premier has asked me to express his disappointment that he is not able to come himself and to thank you for the invitation to be present. He wishes me to convey to you his greetings and best wishes for a successful Conference.

"The importance of science in a rapidly developing country like Nigeria needs no emphasis. All the Governments in the Federation fully realise that without the services of qualified scientists, the various development projects which are planned or being envisaged cannot be implemented. The value of scientific knowledge is not confined to the accurate prediction of the whereabouts of various sorts of capsules, rockets and missiles now falling about the world. I hope it will be widely realised that such knowledge is needed to produce real progress in Agriculture, Forestry, Animal Health and the Medical Services, all of which are fundamental to the future material prosperity of our Region. It is for this reason that the Northern Region Government attaches great importance to the teaching of science in schools and colleges so that there will, in the next few years, be sufficient qualified indigenous scientists in the Public Service of the Region.

"I sometimes think that the most important work that a Scientist can do is to teach someone how to be a Scientist. I wish more thought the same, for it is certain that the lack of Science teachers is one of the greatest handicaps to the development of the free world. It is a problem that needs attention, and very quickly too, by all Governments in Africa, Europe and America and I wish I could see more evidence that this urgent need is getting the priority it ought.

With the increase in the amount of scientific activity in Nigeria it is evident therefore that there is a real need for scientists working in the country to come together, periodically, for mutual exchange of views.

"Before I wish you success in your deliberations I want to assure you that the Northern Region Government will continue to support and take an interest in the Science Association of Nigeria and its activities. I now wish you a successful Conference and conclude with the hope that your stay in the North will be both enjoyable and profitable."

Professor E. Njoku then delivered his Presidential Address on

*Science in a modern state**

"Nigeria is an underdeveloped country. This means the she lags far behind more advanced countries in the application of science to the daily lives of the people, i.e. in the application of science to raising the standard of living through increased agricultural production, improvements in transport and communication, and in commerce and industry. If Nigeria is to become a progressive modern state, the rate of scientific application to the affairs of the country must be speeded up and the new Nigerian State must be modernised. But in addition to the improvements in material conditions, modernising a state also involves inculcating into the majority of the people a scientific outlook so that the ordinary citizen can prepare himself or herself to live intelligently in this scientific age.

"With the celebration of independence next year, the Nigerian nation will have come of age, will become an adult nation, no longer a minor under the tutelage of an older nation. In order to live up to her new status, Nigeria must face the two tasks which I have already indicated. First, she must play her part in increasing the knowlege and application of science, and secondly, she must foster a more rational, a more scientific attitude in the mental outlook of her citizens.

"To deal with the second task first. What is the scientific attitude? "Science', it has been said, "is the organised attempt of mankind to discover how things work as causal systems." This approach can be contrasted with other attitudes which have different aims. For instance, it can be contrasted with the magical approach which attempts to make things work not as material systems but as immaterial forces which can be controlled by spells. We are not concerned now with the validity of the scientific approach or with the philosophical implications of causation. The point we want to emphasize is that this interest in things as causally related is the basis of science and has enabled science to make the astounding progress it has made. It has also been the most important factor in man's enlightenment. Knowledge began when mankind started to investigate

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the causes of things instead of merely attributing them to magical or supernatural forces. This inquisitiveness is perhaps the greatest single factor that accounts for the difference between progressiveness and backwardness in the modern world. Contrast for example the prevailing attitude among many Nigerian citizens: that death is caused by mysterious evil forces controlled by wicked men, with the attitude of mind which inspired Ronald Ross and his colleagues to risk their lives in seeking the cause of malaria. The so-called backward areas of the world have this in common: that in the past they have adopted an attitude of resignation to the world around them. Resignation to the inscrutable will of a god or fate, or resignation to supernatural or evil forces such as witchcraft, against which man believed himself quite powerless. This attitude of accepting things as they are is the very antithesis of the scientific attitude.

"As Nigeria becomes adult in a scientific age, how can we ensure that a good majority of her citizens adopt a rational approach to problems arising in their daily lives instead of seeking the comforts of a less adult age, such as charms and incantations? I said "a good majority of her citizens", not necessarily all of them. For it must be emphasized that we are here dealing only with the general level. There is hardly any country in the world, however modern, which does not contain pockets of citizens in whose lives superstitious beliefs play a major part. The difference is one of degree. Our concern here is that the generality of citizens in the new Nigerian State should face their experiences and explain them rationally, and where evils or injustices exist, to study them and seek remedies rather than incantations.

"What remedy can we suggest for the present situation in Nigeria? The obvious answer is education. With increasing deucation, enlightenment will increase and people will gradually adopt a more scientific attitude. The educated man is likely to be more rational than the uneducated. Yet one of the striking things in Nigeria today is that our educational system has not produced this desirable result, at least not in impressive amounts. For example, if you write an article in the popular press today denying the existence of ghosts, you will get a flood of letters—obviously from people who are literate and therefore to some extent educated—telling you how wrong you are and some even offer what they believe to be evidence in support of their point of view. Or if you visit Government offices you will find educated clerks who put charms in each other's seats or believe that their prospects of promotion can be influenced by such charms. It may be argued that these are all people who did not study science at school. But this is not the complete answer, because even people who have studied science in school often appear to put the science they have learned in one compartment of their minds, and other aspects of their daily lives in other compartments, so that they do not mix. And so even here, there is the problem of breaking down these compartments.

Before children get to the stage when they start learning science in schools they have already imbibed from their homes and from their teachers in their early school days, some of the superstitious ideas which they find difficult to shed in later life. Therefore both parents and teachers must be brought into the picture.

"Without pursuing this analysis much further we may reach the conclusion that what is required is not only more science teaching in schools, but that all teachers whether science teachers or not should be strongly imbued, in the teacher training colleges, with the scientific attitude so that they can help children to understand the world around them and train their outlook along more rational lines at the earliest stages in their schooling. Refresher courses for older teachers and Extra-mural classes for other adult citizens and parents could all play useful parts in the process. The Science Association of Nigeria could through its committees play a valuable role in providing speakers and tutors for such courses. By these means we may hope to raise the general intellectual standards whereby the bulk of the population form their judgments not only on scientific matters but also on matters susceptible to personal prejudice and propaganda, such as politics and those changes in social life and in traditional institutions which must result from the new forms of organisation which scientific technique demands.

"I would now like to say a few words about the second task facing the new Nigerian nation—that of playing its full part in the increase and application of scientific knowledge. Science is already being applied to a considerable extent in the development of the country. But by and large these applications of science are generally regarded as the appurtenances of a foreign way of life. Our future progress requires not only a more rapid application of science but that we accept science as something belonging to us and this means that active research and discovery must be pursued in the country. The number of scientific workers in the country in all fields must be rapidly increased.

"Since the first sputnik went into orbit, even very much more advanced countries than ours, such as America and Britain, have been re-examining the whole basis of their scientific education. Recently a Minister for Science has been appointed in the United Kingdom. It is clear therefore that unless we do something drastic we shall find ourselves in ten years' time even further behind than we are today.

"The task of modernising an underdeveloped country such as Nigeria is a tremendous one. It requires a deliberate attempt to produce a scientific society in which the best scientific techniques are employed in various activities. Although the task is a difficult one, the examples of Japan and Soviet Russia in the present century show what can be done. Japan, faced with the need to preserve national independence after the 1867 revolution, and pressed for time as we are in Nigeria, planned ahead and concentrated her energies on the furthering of science and technology, to the extent that within one generation it was able to rank as one of the most advanced countries in the world. Even more ambitious was the attempt at scientific reconstruction which started in the Soviet Union only as recently as 1917, the staggering results of which are plain to everybody. The achievement of these two countries was perhaps made easier by the authoritarian organisation of the state which imposed central direction and governmental pressure. It may well be more difficult to create so great a change in the mentality of the average citizen by mere appeals to reason and self-interest. Yet a democratic state, such as we visualise in Nigeria, given the necessary foresight and planning, should achieve a good measure of success, especially as the more advanced nations are so ready and willing to help us.

"Our resources are small in some respects, it is true. But what is required here and now is a determination to plan ahead and to husband our resources particularly our resource in man-power which is by no means meagre. It is becoming increasingly clear from the example of countries which are in a similar position to ours, that very little useful planning can be done without some sort of manpower survey. What are the country's needs in scientific manpower now, what will they be in five or ten years' time? Even if only rough guesses can be made, they will at least provide some idea of the gap to be filled. Up to now most of the research in the country has been undertaken by overseas officers whose service has been of tremendous benefit to the country. But year by year they are becoming increasingly difficult to recruit because of the scarcity of manpower everywhere. We should continue to recruit as many as we can, but what is the maximum we expect to be able to recruit from overseas in the next few years, how many shall we have to train? Of these how many can be trained locally and how many must be trained abroad and where? All these are questions clamouring for answers.

It may be thought that enough scientific research is being carried out in countries more favourably placed than ourselves; and all we need to do is to apply the results of that research in our own country. This is a misguided notion because the results of scientific research are rarely such that they can be transferred wholesale to a different set of conditions. The importance of research on the spot cannot be over-emphasized. The history of the development of Africa is already rich in cases where neglect of local research has led to disastrous results.

"Overseas research institutions have given valuable service in the past. One recalls with gratitude the activities of the Colonial Research Council both overseas and locally in pursuing research into local products. No doubt the proposed Overseas Research Council which is to replace the Colonial Research Council will continue this valuable service. But however active and successful these overseas research institutions are, they cannot be a substitute for local organisations.

"It must not be inferred from the trend of my remarks that local activity i research has been neglected. On the contrary, there is before us the evidenc of the satisfactory membership of this association drawn as it is from scientifi workers in the country. There exist a good number of semi-autonomou research institutions as well as Government departments in which research c much value is being pursued. And later on the scene have come the institu tions of higher education such as the Nigerian Colleges, the Universit College and the University College Hospital—all places full of promise fo research.

"Two further steps however are in my opinion required. The first is t maintain the standard of existing research activity and to increase its volum considerably by feeding this as yet tender plant at its roots, i.e. by improvin and expanding scientific education so that an increasing number of student of the right calibre may be forthcoming. This is a need of which all Govern ments of the Federation are now fully conscious. The Solaru Committee o Nigerianisation drew pointed attention to this need in its final report. Her one must emphasize that what is required is not only what might be calle academic science, but even more so technical education. The shortage o technicians in all aspects of scientific work is conspicuous. An expansion o science teaching in schools will provide material not only for the scientifi professions in Engineering, Medicine, Agriculture, Industry and Research but also enough people who can be trained in those basic techniques necessary for the successful pursuit of these professions.

"The second step which I think is required now is the formation of an organisation which will emphasize the urgency of the need for scientific activity, bring this urgency home to the Governments of the Federation, anc liaise with them in the provision and allocation of funds for research. Call it a Nigerian Research Council or what you will. Such an organisation would nc doubt embrace subordinate organisations either related to particular sciences or to geographical areas. But it would keep an over-all eye on scientific progress, co-operate in the organisation of the sort of scientific manpower survey to which I referred earlier, and co-ordinate research generally.

"To summarise briefly what I have said.

(1) A citizen living in a scientific age must overhaul his mentality anc adjust it to the age. The magical outlook is an anachronism in the twentieth century. To help the citizen of the modern Nigerian State tc achieve this revolution in his outlook and to co-operate intelligently in the inevitable social change, the scientific attitude must be deliberately fostered through teacher-training colleges and adult classes or University extra-mural work.

(2) To enable the new state to catch up and keep up in the modern world and give its citizens a reasonable standard of living the amount of scientific activity must be tremendously increased. This calls for:-

(*a*) a scientific manpower survey.
(*b*) improvement and expansion of science teaching in schools.
(*c*) a planned training scheme for scientists in all fields.
(*d*) the setting up of a Research Council which will co-ordinate scientific activity and advise on future progress.

"Finally we hope that the humble beginnings which the Science Association of Nigeria is now making will contribute in a small way towards an era of scientific achievement in the new Nigerian State."

## GENERAL PAPERS

Dr. O. Bassir (*Department of Physiology, University College, Ibadan*) **Attempts at producing a synthetic protein rich diet from local carbohydrate foods.**

Professor J. Grayson (*Department of Physiology, University College, Ibadan*) **Observations on the liver.**

Mr. D. A. Lawes (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **Recent investigations in crop-water relations in Northern Nigeria.**

Rainfall is the source of moisture for all vegetation whether received direct or through irrigation. The study of rainfall, the amount and pattern of its distribution therefore forms an essential part of land use and crop planning. Average rainfall figures do not give adequate information for this purpose; the agriculturalist is more concerned with the likelihood of receiving rainfall equal to or exceeding some minimum figure. The calculation of "confidence limits" at some chosen level of statistical probability have been shown to provide a reliable estimate of this.

Calculations using the rainfall records for Samaru indicate that for the period during which the cotton crop is in the ground the lower 1:1 confidence limit, which gives the minimum expectation for three years out of four, is 27 inches.

Other calculations taking into account temperatures, humidity, wind and day length through the growing season (using methods developed by Penman, Thornthwaite and Garnier) indicate that a crop of cotton at Samaru requiries about 25 inches of rain to supply the moisture needed for evapotranspiration throughout its growth.

The rainfall at Samaru may therefore be considered fully adequate for cotton at least three years out of four provided none is lost by run-off from the surface.

Tropical rainfall derived from convectional storms has periods of high intensity; this combined with large droplet size shatters the structure of the surface soil, and an impermeable skin or "cap" is formed on the fine sand soils of Zaria Province. This cap if left undisturbed can be responsible for up to 70% run-off and consequently there will be inadequate soil moisture available for optimum growth. Conservation of rainfall is therefore necessary.

A simple method of rainfall conservation is to ridge the land and put cross ties across the furrows at intervals of a few yards to prevent run-off. During the height of the rains the impermeable cap, as well as preventing infiltration, also prevents gaseous diffusion between the soil and the atmosphere. Periods of standing water cause the carbon dioxide passed out by respiring roots to build up to a level harmful to the roots.

Cross tying alone is therefore not satisfactory; what is needed is a system of cultivation which will not merely retain the rain where it falls but enable it to percolate into the soil and be stored there for the use of the plants.

Treatments which check or entirely prevent the formation of a surface seal, or destroy it repeatedly at short intervals, have been shown to greatly increase the rate of infiltration of rainfall.

Applied to field crops at Samaru some of these have resulted in notable increases in yield. It is suggested that many experiments done in the past showing lack of response to fertilisers or inconsistent results may have been due to the overriding factors of inadequate soil moisture or an unsatisfactory root-soil-water relationship.

Dr. A. J. Lyon (*Department of Physics, University College, Ibadan*) **Some philosophical problems in modern physics.**

The orthodox interpretation of quantum theory, which is closely associated with the philosophical view-point of positivism (and is largely due to Bohr and Heisenberg and their colleagues) has recently been attacked by David Bohm in a monograph "Causality and Chance in Modern Physics." This book also attempts to outline an alternative interpretation which involves the postulation of a "sub-quantum" level, lower so to speak than the quantum level of currently known atomic processes. Processes in this level would occur within smaller distances and shorter times and with greater energies than the ordinary processes of atomic physics, and it may be possible to obtain direct evidence of the laws of this new level from experiments with the very high energy particles which can be produced by modern accelerators. Meantime indirect evidence can be obtained from the characteristics of the numerous "fundamental particles" (electrons, neutrons, protons, mesons, etc.) at the quantum level.

In the orthodox view the behaviour of, for example, electrons cannot be visualized in any consistent way, (because, *inter alia*, they sometimes seem to behave as particles and sometimes as waves), and the notion of causality is said to be inapplicable to individual electrons because of the alleged fundamental and irreducible reciprocal indeterminacy in their position and momentum, expressed in the famous Heisenberg Principle. Bohm however claims to show that a consistent causal picture of the behaviour of quantal particles is quite possible and certainly not excluded by the known facts. As a simple example to prove this point he develops an earlier theory of de Broglie, the "pilot wave theory" according to which electrons are definite particles guided by a real wave (the wave of the Schrdöinger wave function) so that they are drawn to regions where the wave has greatest amplitude. In this way both wave and particle properties can be understood. The apparent indeterminacies are explained by very rapid fluctuations arising in the postulated "sub-quantum" level, somewhat as Brownian particles suffer random fluctuations due to buffeting by molecules of the surrounding fluid.

In this form however the picture is too crude, and in a more sophisticated version the electron is treated as a concentration of energy in a quantized field capable of forming and dissolving again with great rapidity and not having a permanent existence. Bohm claims that developments of the theory are capable of accounting for photons, electrons, mesons, etc., as different modes of oscillation of a single field as the new basic entity.

Whatever the final verdict it seems probable that Bohm's ideas will have a salutary effect in challenging certain too rigid and restrictive notions in current theory, and encourage the development of fruitful new theories which may not require the rejection of the concept of causality, which has hitherto been so fundamental to scientific thought and practice.

Dr. W. R. Stanton (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **Future changes in preference amongst Nigerian peoples for locally grown foodstuffs.**

The study of food crop preference embraces a number of sciences: sociology, economics, anthropology, applied genetics and evolution, and agriculture. Although preference presented a number of difficulties in detection and measurement, its estimation is essential to the planning of agricultural and economic development.

'Preference' was divisible into two types—rational and irrational. The author suggested that the study of the 'irrational" causes of preference was equally important to that of the study of 'rational, causes.

These might be listed as follows:-

*Irrational factors* (viz. those ethnobotanically or animistically developed or a result of the cultural evolution of the community.)

1. Religious dictates.
2. Animistic taboos.
3. Archaic survivals of the eco-biological evolution of the society.
4. Traditional methods of preparations and use.
5. Prestige and status value.
6. Attractiveness (in the sense that attractiveness can be the result of conditioning.)

*Rational Factors*

1. Availability and price.
2. Palatability alone or with other foods. (Palatability was however subject to conditioning.)
3. Ease of culture, harvesting, preparation, storage, handling and marketing: yielding ability: appropriate developmental time in relation to climate, soil and water.
4. Use of the plant as a whole (*gross* as distinct from *nett* utility.)

Examples were cited of the operation of these various types of preference particularly within and between different types of cereal grown in Nigeria.

It was demonstrated that in studying the variation within and between the food crop species in a country, correlation with the biological factors, a convenient index for which was the ecological zone, was incomplete and that a useful stratification was provided by maps showing the cultural units of Nigeria such as those defined by Buchanan and Pugh. The author compared the interaction with ecological zone of the strongly developed 'sorghum' culture of the savannas of West Africa with the development of grain cultures in equivalent zones in East Africa.

He suggested that present observed preference should not be the sole determiner of food crop (species and type) development policy, but that account should be taken of the trend of preference as shown in more developed countries, of the weakening of religious ties and tribal taboos and of the increasing awareness of the urban elements of the community of the *expressed preference* in other countries.

Lack of accurate statistics on food crop production of less developed territories was becoming of increasing concern and the need for more data prior to development planning had been stressed by F. A. O. This lack of data applied to Nigeria. Nigeria was favourably placed at present in respect of her potential productivity in relation to her present population. This was a general situation, but signs of overpopulation, at the present level of agriculture, were already apparent in parts of the Eastern Region and Katsina and Sokoto Provinces in the Northern Region. It was also shown that the mean rate of population increase was approximately 2% per annum. This figure was stated to be higher than that of any other West or Equatorial African territory.

If such a rate of increase were maintained without a concomitant rate of increase of productivity (which postulate demanded a higher rate of increase of productivity than at present), it would vitiate any predictions of changes in food crop consumption based on comparison with that of more developed countries, since opportunity to develop a balanced, highly productive, high plane of nutrition agriculture would be superseded.

The author concluded by stating that other partially developed countries differed in their attitude to the awareness of a close approach to saturation levels of population and contrasted the educational and developmental policies of India and Japan. He pointed out that the latter country was far in advance of others in the active control of population structure by education and birth control measures and that an assessment of the probable future attitude of a people to such measures was of overriding importance in predicting a country's development. Civil and religious leaders of the developed world disagreed on the subject as did also eminent biological scientists. The author regretted that time did not permit his discussion of the causes of these differences and thence possible ways of resolving them.

Dr. K. C. Willett (*West African Institute for Trypanosomiasis Research Kaduna*) **Objectives and planning in research.**

Dr. Willett developed a schematic representation of the distribution of research effort within a single institute. After a brief preliminary discussion of factors relevant to planning, such as the type of research, the type of research institute and the adaptability of the research scientist concerned, he built up a diagram of the parallel routes through different scientific disciplines to the common objective of all the work at a single institute. Making use of the work of his own institute he showed the final object as Control of Trypanosomiasis, achievable either by control of the parasite or of the insect vector. He then showed how the five scientific disciplines of Human and Veterinary Medicine, Biochemistry, Protozoology and Entomology represented in W.A.I.T.R. were interrelated, and, by subdividing each discipline into several research subjects, evolved a diagram of the fields of research covered by each and the ground common to adjacent disciplines. Finally, he showed how all the research projects under investigation at any moment could be entered under their respective discipline and subjects to build up a histogram presenting a general picture of the distribution of the research effort of the whole institute.

## *Atomic Radiation Symposium*

under the chairmanship of Professor N. S. Alexander (*Department of Physics University College, Ibadan*)

Dr. B. N. C. Agu (*Department of Physics, University College, Ibadan*) **Physical aspects of atomic radiation.**

Atomic radiations were known long before the atom bombs fell on Hiroshima and Nagasaki in 1945. These radiations were generally of four main types. (1) The alpha-particles, which are in fact helium nuclei and therefore are positively charged. These particles can hardly penetrate deeply into matter, but are capable of doing great damage to tissue because of their high specific ionisation. (2) The beta-particles, are high-speed electrons with a range of several feet in air, but with less specific ionisation than the alpha-particles. (3) The gamma-radiation is in fact an electromagnetic wave similar to light rays and X-rays, but of very much shorter wave-lengths than the X-rays. This radiation can only be stopped by thick shields of metal, brick or concrete, since it is very penetrating. (4) The neutrons are neutral particles which cannot ionise, but cause damage indirectly by the recoil-protons which they knock out of tissue.

The amount of damage done by a nuclear radiation depends on the dosage. The unit of the radiation dose is the *roentgen* (r). If the whole body receives a gamma-radiation dosage of 1000r, this dose is almost certainly fatal. If a whole body dosage of 400r is received by a large population, 50% of them would die within 60 days. A local dosage of up to 1000r on the skin does no permanent damage, hence the use of X— and gamma— radiations in the treatment of cancer.

The sources of atomic radiations are natural and man-made. Cosmic rays and natural radio-activity constitute the background radiation in any locality, and are responsible for the 'natural' gene-mutations. The man-made sources are the X-ray machines, television tubes, particle accelerators, nuclear reactors and nuclear explosions. The energy of both fission and fusion nuclear reactions arises from the conversion of matter into energy according to the Einstein equation $E=mc^2$, where c is the velocity of light, and m is the mass of matter. In addition to this tremendous energy of nuclear reactions, highly radio-active reaction fragments occur. These constitute the dreaded 'fall-outs' of nuclear explosions. The most dangerous constituents of fall-out are the long-lived isotopes Strontium-90 and Caesium-137, which tend to accumulate in the body.

The general methods of radiation protection are (1) shielding, (2) distance—keeping far away from its source, (3) time—allowing the radio-activity time to decay. Steel and hydro-carbons are efficient shielding for neutrons, but for gamma-radiation, dense material such as lead is the most useful. Common shielding materials are steel and concrete, but these require 5" and 15" respectively to stop 4.5. MeV gamma-rays that would be stopped by only 2½" of lead.

In conclusion, it is reassuring to note that the advantages of atomic radiations far outweigh their disadvantages once proper caution is exercised. Already the employment of radio-isotopes in industry, agriculture and medicine is yielding big dividends.

Dr. H. Schnieden (*Department of Pharmacology, University College, Ibadan*)

## Biological aspects of atomic radiation.

Radiation can kill or damage biological tissues. Depending on the dose, death of tissue may occur in a few hours or weeks. Smaller doses may in humans lead to late sequelae such as sterility, cancerous changes, or foetal abnormalities. The latter two are due to radiation mutations having occurred. The present level of radiation is below that level considered likely to cause genetic damage and a large proportion of such radiation is from non-nuclear bomb sources. Radiation from nuclear weapons can however not only cause immediate death but also late sequelae of a special type. The damage due to radiation can be diminished by certain pharmacological substances.

A lively discussion on radiation hazards to man followed these two papers.

*Kurmis and Riverain Forests of the Savanna Zone*

A joint meeting of the Agriculture, Botany, Medical Sciences and Zoology Sections under the chairmanship of Dr. D. Ramsay (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria.*)

Mr. P. C. Randell (*Forestry Division, Northern Nigeria*) **Problems in sylviculture and forest management in kurmis.**

The paper discussed the possibility of increasing the yield of the kurame forests by conversion to high yield timber plantations but rejected this method owing to lack of success with indigenous species in plantation and the need for further experience in the growth to timber size of exotics.

The difficulties of management owing to incomplete knowledge of the extent and composition, together with the difficulties inherent in survey and sampling in kurame type forests were then discussed.

Finally, reference was made to the need to demonstrate to the timber consumers uses for timber species at present not acceptable to the trade in order to increase the efficiency of management.

Mr. W. Hope (*Soil Survey Department, Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **Introductory remarks on soils.**

Mr. J. Williams, Mr. P. Harris and Mr. D. Clay (*Ministry of Agriculture, Kabba*) read by Mr. D. Grieve (*Ministry of Agriculture, Kaduna*) **Comparison of kurmis and forest from the standpoint of tree crop agriculture.**

Dr. W. A. McDonald (*West African Institute for Trypanosomiasis Research Kaduna*) **Ultra-violet detection of Tsetse flies at night.**

These papers were followed by a useful discussion.

*Agriculture Specialist Section*

Mr. W. Barker (*Nigerian Tobacco Company*) **The work of the N.T.C. Leaf Department.**

Mr. I. Jefferson (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **Changing agricultural pattern in Northern Nigeria.**

Dr. T. B. Miller (*Ministry of Agriculture, Regional Research Station, Samaru, Zaria*) **Studies in the nutrition of Zebu cattle in Northern Nigeria.**

The alternating wet and dry seasons produce changes from high to low quality pasture respectively, which are manifested in the wave pattern of live weight gain when no supplementary feed is given. Under such conditions an animal can lose 10% of its body weight during the dry season. Although the weight loss can be recovered rapidly in the following wet season, when green pasture becomes available, the animal suffers a serious set-back and can easily succumb to disease.

On Government stock farms the object has been to maintain weight during the dry season by supplementary feeding in the form of hay, silage or concentrates. In this manner the mortality rate at the end of the dry season can be reduced, but the wet season live weight gain is not appreciably greater than that of animals fed on dry season supplements.

To raise the level of animal production it is essential to overcome this dry season submaintenance intake of nutrients by feeding supplements. Before a satisfactory system can be adopted, it is necessary to have information on the animal's requirements and the extent to which these can be satisfied by the fodders and feeding stuffs available.

Protein, energy, carotene and phosphate constitute the nutrients which are deficient in the desiccated, bleached pasture in the dry season. In a preliminary experiment the effect of including protein and carotene in equicaloric supplements to young heifers (12-18 months) was studied. The findings showed that with respect to live weight gain, protein + carotene$\longrightarrow$ protein$\longrightarrow$ carotene or nil. Animals on the two latter treatments lost weight to the same extent as the control animals fed no supplements. Protein was therefore the most important factor and any beneficial effect of carotene was evident only when sufficient protein was present in the ration.

The effect of carotene depletion was studied in another experiment when it was found that animals maintained on a ration completely deficient in carotene for a period of six months did not show vitamin A deficiency symptoms, although the levels of carotene and vitamin A in the liver were below the limits when deficiency symptoms normally become apparent. This result may be attributed to the fact that animals conditioned to a low energy intake do not show deficiency symptoms with respect to a specific nutrient. A similar explanation may be offered with regard to the absence of aphosphorosis despite the low phosphorus intake.

Studies of the energy requirements of cows in milk have shown that, on the basis of starch equivalent, the requirements for maintenance and production are appreciably less than those recommended by overseas workers. It is evident that the Zebu can utilize the energy of the crude fibre fraction to a greater extent and starch equivalent intake and requirements agree more closely when the crude fibre correction factor is reduced by approximately 50%.

Digestibility trials have been conducted on some thirty different fodders in the fresh state and on some conserved as hay or silage. Most cultivated grasses studied provided less than maintenance requirements of protein after September with the exception of *Panicum maximum* which contained more than maintenance until late November. *Hyperrhenia rufa* had the lowest nutritive value and failed to provide maintenance protein after July. All legumes examined in the fresh state (*Centrosema pubescens*, *Stylosanthes gracilis* and *Desmodium scrorpiurus*) were deficient in energy though digestible protein levels were sufficient to provide more than maintenance. All grass silages with the exception of *Panicum maximum* were deficient in digestible protein. Sunflower silage was deficient in energy and protein, providing less than maintenance. Of the hays, groundnut haulms, mucuna and soya beans provided more than maintenance with respect both to energy and protein and sorghum leaves were extremely deficient in protein.

It is suggested that progress in animal production can be achieved only when the standard of feeding does not fall below maintenance. Genetic differences are not apparent unless the level of nutrition is sufficient to enable the animal to reach its potential production. The results of digestibility trials conducted at Samaru and Shika provide an indication of the chronic energy and nutrient deficiencies in pastures and in some conserved fodders. Preliminary attempts to estimate requirements indicate that the animals are not necessarily inefficient. Further experimentation of this sort is necessary before animal production can be developed on a sound basis.

Dr. K. C. Willett (*West African Institute for Trypanosomiasis Research, Kaduna*) **The work of W.A.I.T.R.**

## *Botany Specialist Section*

Mr. J. R. S. Lawton (*Department of Botany, University College, Ibadan*) **Problems in the study of translocation in** ***Dioscorea alata*.**

Dr. C. Oyolu (*Ministry of Agriculture, Regional Research Station, Umudike, Umuahia*) *Capsicum* **species of West Africa**

## *Physical Sciences Specialist Section*

Professor N. S. Alexander (*Department of Physics, University College, Ibadan*) **The resistivity method of geophysical survey.**

Dr. M. O. Chijioke (*Nigerian College of Arts, Science and Technology, [illegible]*) **High-Frequency diode space-charge impedence.**

Electron-dynamics in superposed a.c and d.c space-charge fields in planar valves have be[en] extensively analysed. The successful analyses are however all based on the uni-direction[al] field diode rather than on the more frequently employed space-charge limited diode, becau[se] the uni-directional velocity field permits the integration of equations involving the tim[e] variable.

The most useful of the analyses postulate that the a.c. field is so much smaller than the d.[c.] that only first-order effects are significant. This somewhat drastic simplification characterist[ic] of small-signal analyses is justified in practice by their usability and by the crippling limitatio[ns] which large-signal analyses generally suffer. However, the difficulty of analysing a potentia[l] minimal small-signal field has so far excluded from the literature the successful extension [of] the results for temperature-limitation to space-charge limitation.

[illegible] of this paper sets out to supply this deficiency and achieves the setting up of a sma[ll] signal field differential equation which shows clearly

[illegible] that the difficulties of its solution, considerable as they are, stem from the referen[ce] [illegible] and may be overcome by any of the usual approximations;

[illegible] that the space-charge density is a more convenient reference basis than the tran[sit] time of the so-called "Variation Time" method. Indeed only the adoption of this basis h[as] made the final equation at all attainable.

Transit-time methods are one of the classical tools of the literature that are described [in] the [illegible] of the first part of the paper; generalised proofs of certain of these too[ls] [illegible] in the uni-directional field small-signal analysis of the second part.

Some of the analytical results were verified by measuring the effects of electron inertia o[n] the terminal impedance of a coaxial circut by the 'standing-wave' technique. The termin[al] [illegible] of the electron stream in a planar diode or triode. Variation of strea[m] [illegible] the reflected part of an electromagnetic field supported by the coaxial line a[nd] [illegible] a measure of the impedance.

The results show that as the d.c. supplies of a valve are varied it develops regions of negati[ve] and positive resistances and reactances to small signals of a given frequency, but the locatio[ns] of these regions do not agree closely. These results thus emphasize both the usefulness and t[he] limitations of the simplified picture; they also establish tools for the considerable shortening classical methods of analyses in this field and serve to contrast these methods with those needed for the space-charge limited field of the final part of the text.

Dr. E. U. Emovon (*Department of Chemistry, University College, Ibadan*)
## Elimination reactions in the gas phase.

Matter exists in three states—solid, liquid and gaseous. In all these phases chemical reactions have been carried out but the most familiar of the three are the reactions in the liquid phase. The laws governing most types of reactions stem from reactions in solution. In order to examine whether some of the principles which have become well established for reactions in solution can apply to reactions in the gas-phase, olefine-forming elimination reactions of alkyl halides and alkyl carboxylic esters were undertaken.

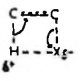
Chemical reactions involve simply the breaking of existing bonds and the formation of new ones. Thus when C reacts with AB to form AC and B, the bond between A and B is broken and a new one between A and C in AC is formed. These bonds are broken in one of two ways:

(*a*) heterolysis in which one of the constituent atoms say A acquires both electrons of a two electron bond thus becoming an anion and B becomes a cation.

(*b*) homolysis in which each of the constituent atoms acquires one of the electrons in the bond, thus forming free radicals.

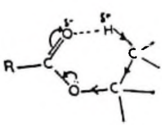
Both these modes of bond breaking occur in solution, the former being very common in polar solvents. Because of the high temperature requirements, gas phase reactions have been regarded as entirely homolytic in character.

Maccoll and Thomas have suggested that olefine forming elimination reactions of alkyl halides are analogous to certain heterolytic reactions in solution such as reactions of elimination (E1) and substitution ($S_N1$) in polar solvents. The evidence for this has been drawn from the effect of structure on the rate and the direction of elimination. They concluded that the breaking carbon-halogen bond determines the course of reaction. They have represented the transition state for a homogeneous gas phase elimination reactions of alkyl halides as



where X=Br, Cl.

The esters decompose in almost the same way as the halides. Like the halides in which the products are hydrogen halide and olefine, a carboxylic acid and olefine are obtained from the esters. The effects of structure and certain polar and unsaturated groups on the rates and the direction of these eliminations have been investigated. The direction of elimination appears to be governed by the Hoffman rule and in this it bears a very formal resemblance to the E2 reaction of onium salts in polar solvents. A closer examination of the ratio of the olefinic products where two olefines are possible reveals that the distribution is statistical. The transition state for the olefine-forming elimination reaction has been represented as:



and this is consistent with the experimental findings.

The general conclusion drawn from the above work is that, temperature differences notwithstanding, certain gas phase reactions can best be interpreted in terms of mechanisms ar structural effects that have been well established for reactions in polar solvents, that is, certa gas phase reactions behave as if their mechanisms involved at least partially an ionic transitic state.

Dr. J. Hospers (*Shell-BP, Port Harcourt*) **Linear tectonics on the Africa continent.**

Rectilinear topographical features, due to faulting or otherwise structurally controlled, ar well developed in Africa.

Krenkel has analysed the distribution of basins and intervening swells on the African con tinent and on the floors of the adjoining oceans. He distinguishes two main directions of whic one runs SW-NE and the other SE-NW.

These directions have been confirmed by later investigators (Sonder, Furon, Venin Meinesz).

The SW-NE and SE-NW directions are strongly developed in Nigeria and adjacent terri tories. Examples are described and discussed of structural features which represent thes directions.

Among the examples adduced is that of the Cameroons volcanic belt. A number of colou slides were shown illustrating the February 1959 eruption of Mt. Cameroon.

## *Zoology Specialist Section*

Mr. K. Harris (*Ministry of Agriculture, Research Station, Samaru, Zaria*) **Lepidopterous stem borers of guinea corn and millet in Northern Nigeria.**

Dr. C. I. O. Olaniyan (*Department of Zoology, University College, Ibadan*) **Seasonal variation in plankton of Lagos harbour.**

## OTHER ACTIVITIES

A Reception in honour of the Association was given by Mr. K. O. Williams, the Acting Rector and Principal of the Nigerian College of Arts, Science and Technology, and Mrs Williams after the formal opening ceremony. A successful Conference Dinner was held on the final night of the Conference in the annexe to the Branch Principal's House (by kind permission of Dr. and Mrs. B. N. Lahiri) at which the Rector and Principal of the Nigerian College (Mr. K. O. Williams) proposed the toast to the Association and the new President (Professor J. Grayson) replied.

Excursions were made to the British Cotton Growers' Association's Ginnery, the Diesel Engineering Workshops, the Nigerian Tobacco Company, The Northern Oilseeds Processing Development, Samaru Agricultural Research Station and there was a historical tour of Zaria township.

Shell-BP and the U.S.I.S. kindly presented a film show consisting of:

*The Ruthless One*
*Malaria*
*Approaching the Speed of Sound*
*The Golden Gate Bridge.*

Exhibits were displayed by the Specialist Sections, various commercial firms, government departments and departments of the Nigerian College.

## BUSINESS OF THE ASSOCIATION

*Report of the Hon. Secretary*

### MEMBERSHIP

Details of Membership on 1st November 1959:-

*Classes of Membership:-*

| | |
|---|---|
| Ordinary Members | 130 |
| Associate Members | 14 |
| Corporate Members | 37 |
| Total Members | 181 |

*Geographical Distribution:-*

| | |
|---|---|
| Lagos | 21% |
| Eastern Region | 13% |
| Northern Region | 17% |
| Western Region (excluding Ibadan) | 9% |
| Ibadan | 37% |
| Southern Cameroons | 3% |

*Occupational Distribution:-*

| | |
|---|---|
| University | 13% |
| Technical Colleges | 9% |
| Schools | 25% |
| Government | 38% |
| Commerce | 10% |
| Others | 5% |

Thus during the Association's first year membership has grown to the figure of 181. This is encouraging but the need to increase this figure is still urgent.

### COUNCIL

Council has held four meetings during the year.

Professor C. A. Hart resigned his office as Vice-President on account of his leaving Nigeria.

Council has prepared a Constitution, Standing Orders for General Busi Meetings and Standing Orders for Council Meetings.

Negotiations with the West African Science Association have been co tinued and have almost concluded. A Ghana Science Association has be formed and a similar association is in the process of formation in Sierra Leo The new constitution of W.A.S.A. is due to come into force on 1st Janua 1960. Council has nominated Professor J. Grayson, Mr. R. W. J. Keay a Professor E. Njoku as S.A.N.'s representatives on the new W.A.S.A. Counc The Journal of W.A.S.A. is still, unfortunately, behind schedule but the fi part for 1959 is due to be published shortly.

Negotiations with the Eastern Nigerian Science Association have al continued.

A joint committee with the Science Teachers Association of Nigeria h been set up to consider ways and means of augmenting the supply of scientif workers in Nigeria.

A committee has been set up to undertake publicity for science in Niger on behalf of the Association.

The report of the Inaugural Conference in Ibadan has been submitted fo publication in the Journal of W.A.S.A. The Second Annual Conference i Zaria has been planned in conjunction with co-operation of an active Loca Committee and Local Secretary in Zaria. The Third Annual Conference, which will be a joint meeting with the West African Science Association, will be held in Ibadan for which a provisional booking of the University College has been made.

The formation of the following five Specialist Sections has been approved: Agriculture, Botany, Medical Sciences, Physical Sciences and Zoology.

## *Report of the Hon. Treasurer*

The financial year of the Association has been fixed by Council as 1st July to 30th June so that the accounts can be audited in good time for the Annual General Meeting in December. This report and accompanying Statement and Balance Sheet cover the period 1st January 1958 to 30th June 1959.

The first money received by the embryonic Association was in the form of loans made at a preliminary meeting in Ibadan on 7th January 1958. Twenty-two persons loaned a total of £48.10.0d. to launch the Association, and of this sum £1.10.0d. was subsequently donated to the Association; this explains the figure of £47 against loans in the Statement.

The accounts for the 1958 conference require some comment. Owing to a number of people booking for accommodation and the dinner but failing to turn up and pay, the Association lost a total of £40.10.6d.; there was also a small loss on the excursions. These losses, together with the cost of Morning

Coffee and the Kuti Hall bar, were borne by the conference fees. The latter, as explained by Professor Grayson at the Inaugural Business Meeting, were intended largely to start off the Association, but the conference losses referred to above reduced the sum available from £173.12.0d. to £127.0.1d. The latter sum has in fact covered the cost of Printing, Stationery, Postage, etc., up to the end of June 1959, leaving only a small balance.

On June 30th 1959 the paid up membership of the Association was:-

| | |
|---|---|
| Ordinary members | 91 |
| Corporate members | 27 |
| Associate members | 12 |

together with 16 ordinary and 2 corporate members who were already members of W.A.S.A., thus making a grand total of 148.

The West African Science Association has had considerable difficulty in publishing the two issues of its excellent Journal each year. The cost of the Journal has been subsidised by the Ghana Government and the University College of Ghana but even so publication has lagged a long way behind schedule. It is expected that formation of a flourishing Science Association of Nigeria will do much to maintain and improve the W.A.S.A. Journal. In the meantime, however, Science Association of Nigeria members, who have paid their 1959 subscriptions, are not likely to receive the first issue of the 1959 W.A.S.A. Journal much before the end of the year. Council decided, therefore, to buy from W.A.S.A. sufficient copies of the second part of the 1958 W.A.S.A. Journal (to be published in July 1959) to send to all S.A.N. members who joined before 30th June. This has left the Association with distinctly slender resources, since of the £201.7.3d. Excess of Income over Expenditure on 30th June, no less than £194. 14. 0d. will be needed to pay for the 1959 issues of the W.A.S.A. Journal which the 91 Ordinary and 27 Corporate members are entitled to receive.

# SCIENCE ASSOCIATION OF NIGERIA

## Income

| | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|
| By Loans ... ... ... | | | | 47 | 0 | 0 |
| Donations ... ... | | | | 2 | 10 | 0 |
| Annual Subscriptions 1959 | | | | 281 | 17 | 6 |
| *1958 Conference* | | | | | | |
| *Fees* | 173 | 12 | 0 | | | |
| *Payments for dinner* | 86 | 5 | 0 | | | |
| *Payments for excursions* | 4 | 9 | 0 | | | |
| *Payments for accommodation* | 146 | 19 | 6 | | | |
| *Sundry payments* | 7 | 4 | 1 | 418 | 9 | 7 |
| *1959 Conference* | | | | | | |
| *Fees* | 6 | 5 | 0 | | | |
| *Payment for accommodation* | 1 | 0 | 0 | | | |
| *Deposit for transport* | 5 | 0 | 0 | 12 | 5 | 0 |
| | | | | 762 | 2 | 1 |

## Expenditure

| | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|
| To Refunds of loans ... ... ... | | | | 47 | 0 | 0 |
| Printing, Stationery, Postage, etc. | | | | 115 | 4 | 5 |
| Purchase of W.A.S.A. Journals | | | | 90 | 0 | 0 |
| Bank charges | | | | 7 | 0 | 11 |
| 1958 Conference | | | | | | |
| Dinner | 108 | 0 | 0 | | | |
| Excursions | 6 | 12 | 0 | | | |
| Accommodation | 165 | 15 | 0 | | | |
| Morning Coffee | 10 | 2 | 6 | | | |
| Kuti Hall bar expenses | 1 | 0 | 0 | 291 | 9 | 6 |
| 1959 Conference | | | | | | |
| Loan to Zaria Sub-Com. | | | | 10 | 0 | 0 |
| Excess of Income over Expenditure | | | | 201 | 7 | 3 |
| | | | | 762 | 2 | 1 |

## BALANCE SHEET

(30th June, 1959)

| | £ | s | d |
|---|---|---|---|
| Surplus income over expenditure 1958–59 | 201 | 7 | 3 |
| Cheque for W.A.S.A Journals not yet presented | 90 | 0 | 0 |
| | 291 | 7 | 3 |

| | £ | s | d |
|---|---|---|---|
| Balance at Barclays Bank (D.C.&O.), Ibadan | 283 | 11 | 8 |
| Cash in hand | 7 | 15 | 7 |
| | 291 | 7 | 3 |

R. W. J. Keay,
Hon. Treasurer

24th July, 1959.

We have audited the accounts of the
... found them correct

## *Constitution*

(*As adopted by the Annual General Business Meeting on 16th December, 1959.*)

1. *Name:-* The Association shall be called the Science Association of Nigeria.

2. *Object:-* The object of the Association shall be to foster the pursuit and understanding of science especially in Nigeria.

3. *Membership:-* Membership shall be open to all who will further the object of the Association. Applications for membership shall be made to the Secretary.

There shall be three classes of membership:

(*a*) *Ordinary Members* who shall receive all the privileges of membership which shall include the right

(*i*) To attend meetings of the Association.
(*ii*) To vote in the election of Officers and Council.
(*iii*) To be eligible for service as Officers or on the Council.
(*iv*) To receive free (or at a reduced price) the publications of the Association and of the West African Science Association.

(*b*) *Associate Members* who shall receive all the privileges of membership except items (ii), (iii) and (iv) above. This class of membership shall be open to spouses of Ordinary Members, bona-fide students, and special cases which the Council may approve.

(*c*) *Corporate Members:* who shall receive all the privileges of membership except item (iii) above. Corporate membership shall be open to Institutions and other bodies.

4. *Officers and Council:-*

(*a*) The Officers of the Association shall consist of the President, the Vice-President, the Hon. Secretary and the Hon. Treasurer.

(*b*) The Association shall be governed by a Council consisting of the Officers, a Representative from each Specialist Section (see para. 6) and six Ordinary Members.

(*c*) Nominations for Officers and Council Members must reach the Secretary at least six weeks before the Annual General Business Meeting. Nominations must be signed by the proposer and by the person nominated to indicate that he is willing to serve.

(*d*) Elections of Officers and Ordinary Council Members shall take place at the Annual General Business Meeting.

(*e*) Elections of Specialist Section Representatives to the Council (see para. 4b) shall take place at a meeting of each Specialist Section held during the Annual Conference.

(*f*) The President and Vice-President shall retire at the end of one year of office and shall not be eligible for re-election until one year after the end of their term of office.

(*g*) The Hon. Secretary and Hon. Treasurer shall retire at the end of each year but shall be eligible for immediate re-election.

(*h*) Ordinary Council Members (see para. 4b) shall be elected for a period of two years and shall not be eligible for re-election until one year after the end of their term of office.

(*i*) Representatives from each Specialist Section (see para. 4b) shall be elected for one year but shall be eligible for immediate re-election for a further year. They shall not be eligible for re-election until one year after the end of this two year term of office.

(j) Council shall have power to co-opt and to form sub-committees.

5. *General Meetings:-*

(a) There shall be an Annual Conference at which shall be held the Annual General Busi Meeting and meetings for the reading and discussion of papers.

(b) Additional meetings for the reading and discussion of papers may be held at the dis tion of Council.

6. *Specialist Sections:-* The Council shall consider for approval applications by group members having similar scientific interests to form Specialist Sections. These Specia Sections should organise their own activities within the Association, and shall each elect representative to the Council.

7. *Subscriptions:-* The amount of the annual subscriptions for the various classes membership shall be determined from time to time by the Annual General Business Meeti Members whose subscriptions are in arrears may, at the discretion of Council, be suspend from membership.

8. *Amendment of Constitution:-* This constitution may be amended by a General Busin Meeting of the Association provided that the amending resolution is passed by a two-thir majority of the members present and voting.

## *Standing Orders For General Business Meetings*

*(As adopted by the Annual General Business Meeting on 16th December, 1959.)*

1. *Ordinary Meetings:-* The Annual General Business Meeting shall be held during th Annual Conference as provided in the Constitution.

2. *Extraordinary Business Meetings:-* If requested in writing by any 25 members of the Association, the Hon. Secretary shall within 28 days after receiving such a request call an Extraordinary General Business Meeting of the Association. The request shall specify the business which the said 25 members wish to be considered at the meeting, and no business not so specified shall be transacted at the meeting.

3. *Notice of Meeting:-*

(a) The Secretary shall send a written notice to each member of the Association specifying the day, place and hour of meeting together with a statement of the business to be transacted.

(b) This notice shall be despatched by the Secretary at least 28 days before the meeting.

4. *Business proposed by members:-* Items for inclusion on the agenda of the Annual General Business Meeting must reach the Secretary at least six weeks before the date of the meeting.

5. *Quorum:-*

(a) The quorum for a General Business Meeting of the Association shall be 30 members.

(b) If no quorum is present within one hour after the time appointed for the meeting, the meeting shall be adjourned.

6. *Chairman:-*

(a) The President shall be Chairman of the business meetings of the Association.

(b) In the absence of the President, the Vice-President shall act as Chairman for the purpose of the meeting.

(*c*) In the absence of the President and Vice-President the meeting shall elect a member of the Council of the Association to act as Chairman for the purpose of the meeting.

7. *Secretary:-*

(*a*) The Hon. Secretary shall be responsible for the keeping of the minutes of the meetings of the Association, for the organising of conferences and for carrying out all correspondence connected with these duties. He shall also present a report to each Annual General Business Meeting.

(*b*) In the absence of the Secretary from a General Business Meeting of the Association, the meeting shall elect a member to act as Secretary for the purpose of the meeting.

8. *Treasurer:* The Hon. Treasurer shall keep the accounts of the Association and present an audited statement of accounts at the Annual General Business Meeting.

9. *Auditors:-* Auditors shall be appointed at the Annual General Business Meeting for auditing the Treasurer's statement of accounts.

10. *Order of Business:-* The order of business at Ordinary General Business Meetings shall be as follows unless the meeting resolves otherwise:—

(*a*) Election when necessary of a member of Council to act as Chairman for the purpose of the meeting.

(*b*) Election when necessary of a member to act as Secretary for the purpose of the meeting.

(*c*) Confirmation and signature by the Chairman of the minutes of the previous meeting.

(*d*) Business arising out of the minutes of the previous meeting unless such business has been separately included in the business announced.

(*e*) Correspondence requiring the attention of the Business Meeting.

(*f*) Business announced with the notice of the meeting.

(*g*) Other business not announced if the meeting agrees to discuss it.

11. *Voting:-*

(*a*) Voting at General Business Meetings shall be a show of hands except for elections when a secret ballot of the members present shall be held.

(*b*) Resolutions shall be passed by a simple majority of those present and voting.

(*c*) If the voting be equal there shall be a re-vote. If votes are equal a second time the Chairman shall have a casting vote.

12. *Causal Vacancies:-* If a vacancy occurs during the year in the membership of the Council, the Council of the Association may fill such a vacancy, the appointee acting only till the next Annual General Business Meeting.

13. *Amendment:-* These standing orders may be amended at a General Business Meeting provided notice of the proposed amendment has been given to all members at least 28 days before the meeting.

## *Second Annual General Business Meeting*

At this meeting the reports of the Hon. Secretary and the Hon. Treasurer were received. The Constitution, as proposed by Council, was adopted as

were, with slight amendment, the Standing Orders for General Busines
Meetings. Elections were held and the meeting agreed that the Associatio
should affiliate with the West African Science Association.

*Council Membership 1959*

| | |
|---|---|
| *President* | Dr. E. Njoku (later Professor) |
| *Vice-President* | *Professor C. A. Hart |
| *Hon. Secretary* | Dr. B. Hopkins |
| *Hon. Treasurer* | Mr. R. W. J. Keay |
| *Ordinary Council Members* | Professor C. W. L. Bevan |
| | Dr. J. C. Edozien |
| | Professor J. Grayson |
| | Mr. F. E. Joselin |
| *Specialist Section Representatives* | |
| *Botany* | Dr. J. M. Waterston |
| *Medical Sciences* | Dr. F. N. Macnamara |
| *Physical Sciences* | Dr. B. N. Lahiri |
| *Zoology* | Dr. C. I. O. Olaniyan |
| *Local Secretary for Zaria Conference (co-opted)* | Dr. D. G. Wilson |

*Resigned during the year upon leaving Nigeria.

# THIRD ANNUAL CONFERENCE

THE Third Annual Conference of the Association was a joint meeting of the whole of the West African Science Association. It was held at University College, Ibadan from Friday 16th December until Wednesday 21st December 1960.

## OPENING CEREMONY

Dr. K. O. Dike, the Principal of University College, briefly welcomed delegates and wished the Association a successful meeting.

The Hon. F. U. Mbakogu, Parliamentary Secretary to the Federal Ministry of Economic Development, then addressed the Association:

"Mr. President, Members, Ladies and Gentlemen,

"It gives me great pleasure to be invited to open this Conference—the first meeting of the West African Science Association to be held in Nigeria. It is a splendid opportunity for me and I am grateful indeed. As you know, the Honourable Prime Minister was originally invited to perform this ceremony but unfortunately he now finds that he is unable to participate due to the pressure of affairs of state. I have therefore been asked to apologize on his behalf and to wish you success in your deliberations.

"The West African Science Association was founded in October 1953 to encourage and promote scientific research and spirit throughout West Africa and to enable scientists in the various territories to keep in touch with each other's work. Twelve months ago it was re-constituted on an inter-territorial basis so that it is now an inter-national organization. It consists of the Science Association of Nigeria, the Ghana Science Association and the Sierra Leone Science Association. In addition to these three National Associations there are also individual members in other West African territories.

"The functions of the West African Science Association are to publish a Journal on behalf of all members and to hold conferences every two or three years. The National Associations vary in their activities. The Science Association of Nigeria has an annual conference in December which is being replaced this year by this West African Science Association Conference.

"This particular conference is important for two reasons: first, it is the first West African Science Association Conference to be held in Nigeria and, secondly, it is the first Science Conference to be held in Independent Nigeria.

"The Science Association of Nigeria has acted as conference host and organizer, but the conference will be, indeed, truly international in scope. Half of the 18 general papers, which account for a large part of the conference, are being read by speakers from outside Nigeria. An encouraging feature for the future of science in West Africa is that seven of these papers are by West Africa[ns]. This is significant enough and is undoubtedly a healthy sign of growth [of] scientific knowledge, ideas and consciousness.

"In addition to these general sessions for all delegates, there will also b[e] specialist meetings where more technical research will be discussed. Meeting[s] will take place of the following specialist sections: Agriculture, Botany, Medical Sciences, Physical Sciences and Engineering, and Zoology.

"The importance of science to the developing countries of Africa cannot b[e] over emphasized. Agriculture alone forms the economic background of mos[t] countries of Africa. There is unfortunately a widespread public failure to understand the nature of scientific research in the agricultural sphere including research in agriculture in the limited sense, together with that concerned with livestock, forestry and fisheries. It is widely believed that, at best, the departments concerned with scientific research work in a rarefied atmosphere far removed from practical affairs, and that such results as they achieve are beyond the comprehension of, and in any case useless to, the ordinary farmer. This is, I believe, the reverse of the truth, which is that there is a great body of knowledge acquired by research which is yet to be applied. Thus, the Director of the West African Institute for Oil Palm Research contends, I believe with justice, that the whole of Nigeria's oil palm and kernels output (probably £40—£50 million per annum) could be produced from one-tenth of the present acreage if existing knowledge were applied.

"This is not necessarily a criticism of the departments responsible for extension work. There are often formidable difficulties in their way, arising from social or legal obstacles, such as reluctance to change customary farming practices, and land tenure systems. There is no doubt a great need to extend the attack on the extension problem and to intensify the application of research results; indeed, Nigeria's economic future may well depend upon success or failure in this task.

"I do not want to take up any more of your time as you have a great deal of work to get through in the next few days but once again I would like to thank you for affording me the honour of opening this conference and I wish you every success in your deliberations.

"Aware of the importance of Science today as the only effective key to the solution of our practical, economic and social problems and realising that advancement born of scientific knowledge can only come as a result of an extensive and intensive application of knowledge, able human efforts and believing that knowledge itself, which is power, is won and achieved through curiosity and the spirit of inquiry, Ladies and Gentlemen, I conclude with charging you, to leave no stone uncovered, in the tone of the following Lucretian passage which says:-

"But this faint spoor suffices for an alert mind: so that thou thysel[f] may'st come at all the rest. For just as hounds, when once they have found the true track, full often search out with their nostrils the lair of the mountain-roaming quarry, hidden though it be with foliage, even so may'st thou, in such things as these, see for thyself one thing after another, work thyself into the secret hiding places and drag out the truth.' "

Professor J. Grayson then delivered his Presidential Address:

"This is the first meeting of the West African Science Association to be held in this country. It is one of the first major international meetings of its kind to be held in independent Nigeria. It is a most important and significant occasion.

"In this Association we have an example of a situation where, with the blessings of their governments, scientists from varying territories are come together to discuss the scientific and technological problems which are common to West Africa. It is an example of genuine international co-operation of a kind which one would like to see extended to other spheres.

"Apart from providing a forum for West African Scientists and apart from bringing together a large number of scientific workers who might otherwise remain in relative isolation for long periods, one of the purposes of this organisation is to emphasise to Government and public alike the basic importance of science in the economy of West Africa. We are not merely an academic body but we must also be concerned with propaganda. It is our task not merely to practice our disciplines but to emphasise as firmly as we can these points—that the whole economy of West Africa, if it is to develop at all, depends absolutely on science and technology.

"Let me examine, therefore, this question—what can science do to aid West African development? What does one mean by development?

"Now one hears the phrase 'underdeveloped countries' a great deal. In the extreme sense of the phrase perhaps all countries are undeveloped to some extent. It depends, in the phraseology of a popular philosopher, exactly what one means by development.

"One approach and probably the most practical from the national point of view is to regard the aim of development as the promotion of the welfare of a nation's inhabitants. From the world point of view it could equally easily be defined similarly in terms of world population.

"Now the phrase 'human welfare' is one with many implications—different implications, too, according to who is the judge. In the beginning, however, I shall simplify the argument by discussing only the question of material welfare. Even that leaves a host of different facets to the remaining question, for in the context of West Africa in particular, this is not just a question of washing machines and television sets but of life and death—of survival itself. For one of the least enviable records of West Africa is its appalling record of death and disease. An infant mortality scarcely to be rivalled—an ad[ult] mortality and morbidity, too, of formidable dimensions. This, then, to [me] is where the question of development begins. First—how to stop the childr[en] dying; second, how to keep them alive when we have done this.

There is much that could be done—immediately—to mitigate the appalli[ng] wastage of human life reflected in West Africa's infant mortality figures. B[ut] this, alone, would be of little permanent value. It might be of immediate b[enefit] to the child to be saved from malaria but it would be of little long ter[m] economic value if a few short years later that same child were to die of sta[r]vation. Development is a total thing. It includes an attack on disease; it mu[st] simultaneously include a big improvement in the development of the nation[al] food resources. Ultimately, too, it must include a general improvement i[n] living standards. The time will doubtless come when no Nigerian home o[f] whatever class will be complete without a washing machine, but I sincerel[y] hope that this will not happen until the urgent problems of health and feeding have first been solved.

It is essential to take a long term view, for what is required is not just an immediate—and possibly transient—amelioration of conditions for the moment, but a steady build up of resources for the benefit of the whole of this and of future generations.

The nature of development must be determined by many factors, not least among them being the availability of capital. The direction of development must be bound up with the nature of West Africa's resources, their distribution and the best way in which they can be tapped, developed and utilised. And these are problems the solution of which depends to a very large extent on modern technology and modern technologists.

At present the West African Nations, freshly come of age, are basking in the glow of independence. Wooed by the older, wealthier nations of the world there is every evidence of increasing property. A great deal of capital has already been poured into the new nations of West Africa and, without doubt, as the fundamental stability of these societies becomes even more evident a great deal more will be available. But we should not lose sight of the fact that the indigenous economy, unbolstered by foreign aid would be very precariously balanced. In the present state of agriculture and industry, West Africa alone, would be hard pressed even to maintain her present living standards, much less to improve them.

If we accept the thesis that the purpose of development is not to build a wealthy state but to better the welfare of the nation's inhabitants then one need only look at the daily toll of infant life in this country—and other West African countries—to see what remains to be done. If modern knowledge had been thoroughly applied many Nigerians would be alive to-day who are not. This is often due not to lack of medical knowledge, but to lack of money.

And this is the point. Medical science has already transformed the disease picture in many countries. Enough is known even now to do much more here than is being done. Ignorance—which is the result of defective education—plays its part, but the distressing conclusion must be drawn that this nation, at present, simply cannot afford to keep its children alive.

"These are problems which must be faced and tackled ruthlessly. But as I have already said, there is not much point in saving children who a short time later are to die of starvation. Medical advance must go hand in hand with advance on a much broader front of agriculture and industrial improvement.

"Make no mistake about it. The developmental problems of this country are great—greater than in many countries—but they are far from insoluble. The potential is here. Even in the present state of knowledge we probably know enough to transform the economy of the whole of West Africa. But again the problem is capital—money—money to plan, money to execute the schemes, money to pay the technologists who run the scheme. Capital investment and effort on a huge and unprecedented scale.

"It is a fine and inspiring thing to see large and beautiful buildings reaching for the Lagos—and Accra—skies. But the final road to economic prosperity does not lie in office blocks—it lies in land development, in the elimination of the tsetse fly, in the damming of rivers—in a host of other development schemes rooted firmly in technology and science. The road to prosperity does not soley lie in the training of economists, lawyers, social anthropologists, classicists, not even in doctors—though all have their part to play in society—it lies far more in the training of scientists and technologists. Men and women who are qualified to recognise the nation's practical problems and to solve them.

"Even at this stage one must learn to discriminate between the prosperity of the individual and the prosperity of the community. Careers in science in West Africa do not offer sufficient attraction. It is far more tempting for a young man or woman on the threshold of adult life to study law, economics, even medicine than science.

"One of the fundamental faults in the structure of our society—not just in West Africa but in many parts of Europe too, is that the biggest rewards seldom go to the working scientist. His rewards compare unfavourably with those of business and many other activities, including medicine. The encouragements offered to those who would teach science in the schools are meagre, indeed. Even within the heirarchy of a scientific department one so often senses a lack of understanding of its purposes. Only too often does one see a brilliant worker at the peak of his scientific career torn from his laboratory bench and seated at a desk. Because that is promotion, the only avenue to greater prestige and money.

"Now I have no wish to decry the importance of efficient administration even in the running of a purely scientific institute. I am merely complaini that the present system is wasteful of training, experience and brilliance. should be possible for a scientist working in his speciality to reach financ and prestige heights as great as any to be gained in administration. Unfo tunately it is not, and promotion if it is sought must only too often lead tc cessation of his scientific activity.

"All this, of course, has its bearing on the prestige of science as a career. It obvious for all to see that the best a scientist can become is an administrato He might just as well train as an administrator from the beginning. And th is the sort of reasoning which governs the choice of career in many cases.

"One answer which I have heard suggested is the creation in these nev countries of the equivalent of a scientific civil service such as exists in Unite Kingdom. But even this is not the answer for even there the highest paid an highest sounding posts are practically purely administrative. What is callec for is a reappraisal of values.

"One must begin by a recognition of the obvious, that the economic expansion of these countries can only be based on scientific and technological development. The fantastic, even frightening rise of Russian science and technology is due to precisely this recognition. In that vast country the scientist—using the phrase to cover a wide field from engineering to plant physiology—is the highest paid and most respected of all its citizens, politicians not exempted. There is no human activity more rewarding; there is no occupation more sought after by the country's young.

"In Europe and America—where technology is far advanced—the scientist is not so highly regarded, but there it probably does not matter so greatly. Here in West Africa where the resources have scarcely been tapped and so much needs to be done it is immensely important. The problems are greater even than Russia's in the 1920's. More of the country's brains must be encouraged to study science.

"This cannot be achieved, though, unless science is made an attractive career—complete in itself, not just a stepping stone to higher civil service posts. It must carry the financial rewards and prestige which at present it does not.

"One can surely no longer doubt the need for action. But first there must be a reappraisal at two levels. In the first place the general public must be made to realise the truth of what I have said—that prosperity, even survival, must depend on science and technology; that there is no time to lose; that West Africa must co-ordinate and enormously accelerate its present haphazard, piecemeal development, that its sons and daughters must train in their thousands to be scientists, to be technicians, to be the creators of the future.

"For the present, though, it is perhaps even more vital that Governments, too, should appreciate these things.

"Some time ago, one of this country's most distinguished scientists, Professor Eni Njoku put forward a plea for the creation of a special ministry whose sole job would be the co-ordination and furtherance of scientific activity within Nigeria. He coupled that plea with a further suggestion that an advisory body—a Council for Scientific Policy—be also set up in association.

"Now these are such obvious and necessary steps in this year of grace, 1960 that one would scarcely have thought they needed further stress. The unfortunate fact remains that they do. It is still not understood that economists do not make money, they only advise on how to spend it. A ministry of economic planning is all very well, but unless its actions are guided by co-ordinated scientific planning it cannot begin to be effective.

"Speaking for Nigeria, now, I would strongly urge, myself, the immediate creation of Professor Njoku's Council for Scientific Policy—I might even rename it and call it the Council for Scientific Development. Let this council examine the whole prospect of future development. Let it formulate a plan for the future. Let it advise the government—through the appropriate ministry. And above all, let the government take heed of its advice."

## GENERAL PAPERS

Mr. G. A. Bennet (*Territorial Controller, P. & T. Ibadan*) **Traffic engineering in the telecommunications field.**

The successful operation of a telephone company as a commercial enterprise depends largely on "tailoring" the equipment to fit the projected service needs of the public, which calls for the application of traffic design factors based on the probable pattern of telephone behaviour of that public. The manner in which these factors are derived and applied was described, and attention was called to the consistently repetitive behaviour of "public in the mass". Drawing a parallel with railway traffic (in which a consistent pattern of mass behaviour is also discerned), the author posed the problem of how it comes about that apparently random behaviour on the part of independently-acting individuals should coalesce to form a regular and predictable pattern of mass behaviour.

Professor D. P. Craig (*Professor of Theoretical Chemistry, University College, London*) **What is a chemical bond?**

The classical definition of a chemical bond in the sense of a specific stabilizing interaction between two adjacent atoms does not fit at all easily into the explanation of the binding forces at work in some kinds of molecular situation currently being studied. For example, there are cases in which the stabilization of a molecule is due to electrons normally regarded as non-bonding, and others in which molecule cohesion essentially requires a co-operative interaction of a large number of electrons. Some changes which these developments call for in the models used by chemists to vizualise chemical bonding were discussed.

Professor G. M. Edington (*Department of Pathology, University College, Ibadan*) **A medical survey of an African village.**

In 1958 a medical survey taking social conditions into account was undertaken in a village in the forest belt of West Africa. Each villager underwent a complete physical examination. Haematological, serological, entomological and parasitological investigations were also undertaken. The findings of this survey were discussed in the light of recent advances of our knowledge of medicine in West Africa.

Mr. S. O. Fadahunsi (*Ministry of Works and Transport, Ibadan*) **The problems of road construction in Western Nigeria.**

1. **Introduction:** History of development, need for development, classification of roads, financing for road construction and maintenance.

2. **Need for adequate roads:** Increased traffic intensity has been steadily noticed in the trunk road system of the country. Increase has been accompanied by steady structural deterioration.

3. **Research into problems of providing adequate roads:**

(*a*) Selection and classification of naturally occurring materials: lateritic and quartzitic materials, typical profiles, Benin sands, sandy soils at the coast—their engineering properties and suitability for cement or bitumen stabilisation.

(*b*) Study of moisture conditions under road bases: their effects on road performance and on the thickness of road pavement.

(*c*) Study of road performance under traffic: the determination of *in situ* density and moisture content periodically.

(*d*) Study of the technique of building stronger road bases.

Mr. A. Gilchrist (*Meteorological Service, Lagos*) **Typical synoptic sequences in West Africa.**

Lantern slides of synoptic charts, illustrating the occurrence of harmattan haze, a line squall and coastal monsoon rain, were shown. Some indication of how these phenomena are forecast were given.

[illegible] H. Hill (*Department of Agriculture, University College, Ibadan*) **Skin and [illegible] structures in relation to heat tolerance studies in cattle.**

[illegible] differences in responses of temperate and tropical breeds of cattle to a hot environment [illegible] been noted. One of the more important of these studies has been to [illegible] lower rate of heat production in the tropical breeds, although the [illegible] by which this is achieved is not yet clear. Other studies of responses to thermal [illegible] related to the form and possible functions of skin and hair structures. [illegible] of the presence of sweat glands of a sort was presented many years ago. [illegible], in the true sense of the word, as in man, was for a long time [illegible] from the skin being ascribed, for the most part, to insensible [illegible] published by workers during the past decade have tended to alter this [illegible] studies on changes in morphology and histochemistry of active cattle sweat glands have been attempted and a new approach to the subject has developed from the field skin biopsy techniques used by Australian workers. Similarly, hair is no longer considered simply as an insulating covering of different length, density and thickness, varying according to breed and season, but also in relation to the integral structure of the individual hair fibre. Hair and skin studies are of interest in comparing the performance of European and tropical breeds of cattle in a hot environment. In West Africa, however, opportunities present themselves to study the skin and hair of indigenous breeds of *Bos taurus* and *Bos indicus*, as well as descendant Hamitic longhorn types, in an environment to which, with some modifications, these distinct cattle types have become acclimatized over the centuries.

Mr. A. W. Ireland (*Meteorological Service, Lagos*) **The rainfall of Nigeria.**

The present state of knowledge of the physical and statistical characters of the rainfall regime of Nigeria was briefly surveyed. Recent analyses of the diurnal and seasonal variation of rainfall were discussed with particular reference to the 'little dry' season. Rainfall variability and some of the difficulties involved in defining the length of the rainy season were considered.

Professor R. Jones (*Department of Engineering, University College, Ghana*) **Concrete shell roofs.**

The construction of thin shell concrete roofs in the form of barrel vaults and an infinite variety of domical shapes has made astonishing progress in the last decade. This paper gave a brief account of the historical background, the analytical studies, the laboratory investigations, the field tests and the recent advancements in which reinforced and pre-stressed concrete have made it possible to construct thin shell structures with very large clear spans.

It illustrated the results of co-operation of theory and practice, since the present advance arises from developments of theories originally advanced by Lamé, Clapeyron and more particularly by Love in his treatise on the mathematical theory of elasticity.

Mr. P. G. Konstam (*Department of Surgery, University College, Ibadan*) **On the geography of disease.**

A discussion of the environmental and genetic factors which might help to shape disease patterns in different geographic areas.

Rev. Dr. J. R. Koster (*Department of Physics, University College, Ghana*) **The equatorial ionosphere.**

A brief description is given of the main characteristics of the ionosphere at the equator. The F region movements and irregularities are presented as far as these are known from studies of spread-F echoes, radio star scintillations, the flutter fading of radio signals, fluctuations in the geomagnetic field and variations in telluric currents. Practical engineering considerations rising from this information are mentioned.

Dr. T. A. Lambo (*Aro Hospital, Abeokuta*) **The influence of cultural factors on epidemiological surveys in Africa.**

In epidemiological study of any disorder it is necessary to identify and count all those affected in a given population. Recent studies have shown that people of different social class, from different parts of the country, of different ethnic groups, different religious allegiances, different age-groups, different medical facilities, or different cultures, vary in attitudes to any given illness and its management. This is much more so in disorders of behaviour.

A knowledge of the culture (and the prevailing attitudes) of a given population is not only essential in epidemiological studies but it is the culture which determines that which is a "disease". It is also the culture which permits or hinders the sick person to come forward for treatment.

The value of attitude survey is essential to medical research. Attitudes towards homosexuality, drug addiction, alcoholism and various types of character disorder, vary a great deal from community to community, from culture to culture, and within the same culture at different times.

Mr. J. I. Menzies (*Bo School, Bo, Sierra Leone*) **The climate of Bo, Sierra Leone, and the breeding behaviour of its toads.**

In Bo *Bufo regularis* breeds only in the dry season. Heavy rainfall lasts until late September; the toads start to breed in October and finish about March. Most of the male toads do not spend more than a few nights at the pool (where the observations were made) and on certain nights more toads appeared than on others. Meteorological records indicate a greater fall in temperature from day to night on these days than on the others.

Webb states that this toad has, in Nigeria, a larval life of 10 weeks. In Bo the young toads leave the water after 30 days. This short larval life may be an adaptation to dry season breeding as many of the pools used are shallow and are liable to dry up.

Dr. J. K. Morton (*Department of Botany, University College, Ghana*) **Past changes in the climate of West Africa—evidence from plant distribution.**

Our knowledge of the past history of the earth is not confined to the results of archaeology and geology. Other disciplines have much to contribute. Such is the case with botany where the study of fossils, pollen and plant distribution have added greatly to our knowledge of the past. From a study of the present day distribution of West African plants, particularly those of the upland regions, it is possible to gain some indication of probable past changes in the climate of Africa. This talk presented, through a series of colour slides, some of the data and explain its significance.

Mrs. Letitia E. Obeng (*Biological Research Institute, Achimota*) **Parasites and parasitic infections in tradition and culture.**

There is a rich source of material for investigation in Africa. Some of the subjects may not be of much economic importance but they deserve attention for other reasons. A field which is of interest because of its possible ethnologic importance is the attitude of early human communities to parasites and parasitic infections. This was briefly discussed in connection with traditional customs and superstitious beliefs and practices with special reference to Ghana. This general paper further commented on the part played by individuals, universities and various research institutions in promoting scientific research in West Africa.

Dr. C. Oyolu (*Agricultural Research Station, Umudike*) **The mechanics of technology in agriculture.**

As agriculture grows away from subsistence level, it becomes necessary to increase productivity through the application of technology and more efficient methods of production. Technology in agriculture develops in progressive stages which normally require reorientation of human, natural and capital resources, and should fall within the framework of the national socio-economic programme. Under normal circumstances it is a gradual process, and takes time.

Countries like the West African nations have the advantage of the accumulation of the knowledge of technology in agriculture that has evolved from other lands. We are naturally anxious to make rapid progress which often entails jumping stages in the sequence. The urge to progress too rapidly could impair sound judgment and planning.

To have effective values, the application of such knowledge to a nation's agriculture calls for a farming population that appreciates the value of scientific methods as well as a large number of scientifically trained personnel engaged in developing and spreading new knowledge.

Mr. J. Phipps (*Department of Zoology, University College of Sierra Leone*) **Migration.**

Striking long-distance migratory movements are carried out by many birds and mammals, and have been studied for some time. They are often related to the breeding cycle and to the availability of food at different times of the year.

Some insects also make mass movements over considerable distances, the most obvious being locusts and aphids. It has recently been shown that these movements depend on wind direction. It has also been shown at Fourah Bay College that sedentary grasshoppers appear to wander, apparently for short distances, at certain stages of development of the ovaries. This makes it extremely difficult to define migration precisely.

Mr. A. S. B. Wilson (*Department of Agriculture, University College Ghana*), **Problems of animal production in Africa south of the Sahara.**

Consideration was given to some problems concerning animal production in West Africa. The point was stressed that population pressure and certain changes in the economic and social structure of most countries in West Africa will call shortly for a change in emphasis including greater intensification of productive effort and a drift away from the extensive methods presently in use.

Reference was made to a few lines of approach which might form the pattern for increased production of beef, milk, mutton and eggs, and the effects which such a policy change might be expected to have on the scientific and development approaches needed to support this evolutionary change.

Dr. J. Y. Wilson (*Department of Botany, University College, Ghana*) **The *Capsicum* peppers of West Africa.**

1. Collection and study of the cultivated *Capsicum* peppers from various parts of West Africa has revealed an enormous range of variation within the species of the genus.

2. A third species, *Capsicum sinense* has been isolated from the collection, but here this species seems to have a wider range of number of pedicels per node (one to seven) than in America (three to five). This brings to three the number of species in West Africa, the others being *C. annuum* and *C. frutescens*.

3. With the discovery of *C. sinense*, the importance of the pedicel number per node in distinguishing between the species is now superseded by

(*a*) the nature of the calyx in fruit and

(*b*) the disposition of the pedicel(s) on the plant.

A new key on this basis is proposed for the three species.

## SPECIALIST PAPERS

### *Agriculture Specialist Section*

Dr. D. H. Hill, (*Faculty of Agriculture, University College, Ibadan*) **Observations on the growth, reproduction and carcass quality of Nigerian dwarf sheep.**

The West African dwarf sheep is ubiquitous south of latitude 14°N and in the coastal areas it is the only breed of any consequence. Its position as an integral part of the religious, social and economic life of the community is well known and it has received increasing interest during the past few years, particularly in Ghana, at University College, Ibadan, on government agricultural farms in Nigeria and elsewhere in West Africa. The College flock was established in 1950 and has been maintained since that date as a small breeding nucleus for the study of growth rate, reproduction and carcass quality. Reference to other experimental flocks in Nigeria was also made. The main purpose of this paper was to supply additional data on dwarf sheep breeds which may be used for comparison with results obtained by other workers in this field in West Africa.

Mr. J. Longworth, (*W.A.C.R.I., Moor Plantation, Ibadan*) **The importance of mirids and swollen shoot disease in causing die-back of cocoa in Nigeria.**

The degeneration of cocoa trees in swollen shoot outbreaks has usually been attributed solely to the effects of virus. After the introduction of chemical control measures against Miridae (capsids) it was realised that these insects and the associated dieback fungus, *Calonectria rigidiuscula* (Berk. and Br.) Sacc., largely determined the condition of virus infected cocoa in Nigeria. Spectacular improvements in growth and yield followed mirid control operations even in farms in which many trees were infected with cocoa swollen shoot virus.

Several workers have co-operated in studying this multifactor problem, and their results were discussed in this paper.

Dr. A. W. Moore (*Faculty of Agriculture, University College, Ibadan*) **The influence of a legume on soil fertility under a grazed tropical pasture.**

The inclusion of centro (*Centrosema pubescens*) in a giant stargrass (*Cynodon plectostachus*) pasture at University College, Ibadan, resulted in significantly higher levels of organic matter, total nitrogen and nitrifiable nitrogen in the underlying soil. Total soil nitrogen under the mixed pasture was 250 lb. per acre—ft. per annum higher than that under the pure grass stand. This is attributed to symbiotic nitrogen fixation by the centro and is of the same order of magnitude as values reported for nitrogen fixation by temperate legumes.

There were no differences in C: N ratios under the two pastures; this emphasizes the importance of a legume in tropical pastures and leys if they are to build up soil organic matter satisfactorily.

The inclusion of centro raised the nitrogen percentage of the associated stargrass from 1.8% to 2.4%.

### Mr. R. Nash (*Forestry Department, Northern Region*) **The role of forestry in relation to local farming needs in the savanna zones.**

### Mr. E. Ogor, (*Ministry of Agriculture, W. Region*) and D. W. Hedrick, (*I.C.S. team, Moor Plantation, Ibadan*) **Management of natural pasturage (range grazing) in Western Nigeria.**

Range (extensive) grazing schemes have not been pursued vigorously in Western Nigeria. Research and economic data are urgently needed as a basis for developing a sound livestock industry.

Range or natural pasturage offers the best immediate possibilities for livestock development in the savanna. Limited forage may be produced on arable land in the forested zone in order to promote integrated crop and livestock farming on lands used intensively.

Establishment of successful range grazing schemes depends on knowledge of carrying capacity, season of best use and how to control livestock distribution. Methods for evaluating management practices, animal health and husbandry facilities and recognition of socio-economic problems must all be considered if profitable livestock enterprises are to be started.

### Mr. B. N. Okigbo, (*Faculty of Agriculture, University College, Ibadan*) **Preliminary studies on seed production in giant stargrass** (*Cynodon plectostachyus*)

Giant stargrass is widely used alone or in mixtures with *Centrosema* as a pasture grass in southern Nigeria. It is chiefly vegetatively propagated in this country. These studies were aimed at investigating the possibility of seed production in giant stargrass to replace the more costly and less convenient vegetative propagation method.

Results of a survey on the natural fertility in Nigeria indicated that the natural fertility ranges from 0 to 20%. The seeds were found to exhibit dormancy which could be broken by temperature and potassium nitrate treatments in petri dishes under laboratory conditions. In soil under laboratory and field conditions the nitrate treatment was not very effective and temperature in the field was found to be a limiting factor to seed germination in the rainy season.

### Mr. A. J. Smyth and Mr. R. F. Montgomery (*W. Region Ministry of Agriculture, Moor Plantation, Ibadan.*) **Soil quality and land-use in a major part of the cocoa-growing area of the Western Region of Nigeria.**

This paper presented an analysis of soil and land use data obtained in the course of a reconnaissance soil survey covering over 8,000 square miles of the main cocoa-growing area of the Western Region, Nigeria. The methods of survey and analysis were briefly described and the basis of assessment of soil quality in terms of suitability for cocoa explained. Finally the relationship between the distribution of some land use groups (cocoa; arable farming and grassland) and the distribution of soil in four quality classes was discussed.

Mr. R. Waddell, (*P.A.O., Katsina*) **The Kadendani farming scheme in Katsina Province.**

*Botany Specialist Section*

Dr. B. Hopkins (*Faculty of Agriculture, University College, Ibadan*) **The role of fire in promoting the bursting of buds in some savanna species.**

A series of savanna plots were burnt on different dates during the 1959/1960 dry season and the bud activity of the four commonest tree species (*Butyrospermum parkii. Daniellia oliveri, Lophira lanceolata* and *Pterocarpus erinaceus*) was observed weekly. Most species showed a good correlation between the date of burning and the date of bud burst and a fairly constant period of time between these two events The effect of tree size, pre-burning bud burst and rainfall on this period were discussed. The behaviour of the two commonest grass species (*Andropogon schirensis* and *Monocymbium* ceresiiforme) was also described.

Mr. J. I. Menzies (*Bo School, Sierra Leone*) **The Tingi Hills, Sierra Leone.**

The Tingi Hills from a plateau 4,000 to 5,000 feet high surrounded by peaks rising to over 6,000 feet. The slopes below 3,000 feet are clothed in high forest but this is restricted on the plateau itself to galleries along the streams where *Parinari* is dominant. On the swampy floors of galleries *Cyathea camerooniana* forms a mass of spiny stems rising to 30 feet. Its reproduction appears to be purely vegetative.

The leveller parts of the plateau are covered with shrub savanna but on the steepest slopes the only plants that grow form a distinct sedge flora in which *Catagyna* is dominant.

Dr. Morgan (*Adisadel College, Ghana*) **Biosynthesis of carotenoids in higher plants.**

Dr. J. K. Morton (*University College, Ghana*) **Incidence of polyploidy in a tropical flora.**

Dr. C. Oyolu (*Eastern Region Research Station, Umuahia*) **Metabolites in heredity complex.**

Mr. A. R. Rees (*W.A.I.F.O.R.*) **Recent work on the germination of oil palm seed.**

Germination of oil palm seed has always presented difficulties which have now been largely overcome by carefully controlling temperature and seed moisture content which are extremely critical during germination. It is often difficult for these conditions to be controlled accurately at outstations where the germinated seed is required, and attempts made to produce heat-pre-treated seed were described.

Mr. L. D. Sparnaaij (*W.A.I.F.O.R.*) **Botanical problems in the production of improved oil palm seed.**

Some unusual botanical features of the oil palm complicate breeding and selection work in this crop. These features are:-

(*a*) The monoecious character of the oil palm.
(*b*) The impossibility of vegetative propagation.
(*c*) The antagonism between various desirable characters.
(*d*) The varying degree of female sterility in certain forms which are indispensable for seed production.

The practical problems arising out of these features were discussed and an account was given of present and future botanical investigations aimed at improving the effectiveness of oil palm breeding and selection.

## *Medical Sciences Specialist Section*

Dr. F. O. Dosekun (*Department of Physiology, University College, Ibadan*) **The measurement of metabolic and vascular responses in the thyroid gland with observations on its responses to insulin, glucose and adrenaline.**

The method of internal calorimetry has been applied to the study of vascular and metabolic heat production in the thyroid gland when glucose, adrenaline, insulin and glucose combined with insulin were administered intravenously to the anaesthetized Nigerian domesticated dog (*Canis familiaris*).

Insulin was found to depress metabolic heat production of the thyroid gland whilst producing no significant change in the blood flow of the organ. On the contrary, glucose increased both metabolic heat production and blood flow of the gland whereas glucose combined with insulin produced an effect on heat production which seemed to potentiate its depression by insulin. Although the exact mechanism of these effects has not been elucidated by these experiments, it has been suggested that the site of action of insulin on the metabolism of carbohydrate by the thyroid gland is the thyroid cell, the net heat production of which has been depressed probably because the thyroid cell has no other carbohydrate substrate stored within its cytoplasm on which to draw other than the blood glucose.

Adrenaline can safely be concluded to be a vasoconstrictor substance for the thyroid blood vessels although its effect on metabolic heat production is difficult to interpret from the varying responses produced in the present experiments.

Dr. J. C. Edozien (*Department of Chemical Pathology, University College, Ibadan*) **Urinary excretion of B-amino isobutyric acid in man.**

B-amino isobutyric acid (BAIB) was first identified in human urine in 1951. The quantity of this amino acid excreted daily by any one person appears in normal circumstances to remain relatively constant. It is hardly at all influenced by ordinary dietary variation and can reasonably be regarded as an individual characteristic. Indeed under ordinary conditions its concentration in the urine appears to be genetically controlled and it is convenient to classify individuals into high and low excretors of BAIB. In most European populations 5-10% of normal people are high extractors. Appreciably higher frequencies of high excretors than are found in European populations have been encountered in studies of Apache Indians, British Honduras Carib Negroes, certain Chinese and Japanese populations, and in Africans in Gambia.

Feeding experiments in the rat and in man have pointed to thymine as the probable precursor of BAIB, and its daily excretion rate may therefore be a pointer to the rate of synthesis and turnover of deoxyribonucleic acid.

Recent studies have shown that there is increased excretion of BAIB in kwashiorkor. In this condition there is also an increase in the serum uric level and in the activities of "tissue" enzymes such as in GOT, GPT and ICD plasma. The large amount of BAIB in kwashiorkor is therefore thought to arise from increased tissue breakdown. In this connection it is of great interest that increased excretion also occurs in starvation, in liver disease, in leukemia and in other neoplastic conditions. It now appears, therefore that the difference in the frequency of high excretors among population groups may not be a true genetic marker but may be a function of the status of protein nutrition of the particular community.

Dr. H. M. Gilles (*Department of Medicine, University College, Ibadan*) **The existence of the glucose—6—phosphate dehydrogenase deficiency trait in Nigeria and its implications.**

The glucose—6—phosphate dehydrogenase deficiency trait occurs in about 20% of Nigerians. The trait is sex-linked with full expression in male hemizygotes and female homozygotes and variable expression in female heterozygotes. The existence of the trait in Nigeria raises several interesting problems:-

1. Subjects lacking the enzyme may exhibit a relative resistance to falciparum malaria.
2. The presence of the trait may determine the onset of haemolytic anaemia induced by dapsone in some Nigerian leprosy patients.
3. The presence of the trait should be looked for in cases of unexplained haemolytic anaemia with or without haemoglobinuria.
4. Deficiency of the enzyme may be responsible for some cases of unexplained neonatal jaundice.

Dr. H. M. Gilles and Dr. E. J. Watson-Williams (*Departments of Medicine and Pathology, University College, Ibadan*) **Observations on the aetiology of anaemia in hookworm infestation.**

As part of a general study of anaemia due to hookworm infestation we have investigated the relationship between blood loss and hookworm load in 10 subjects. The patients were randomly selected from a larger group of consecutive cases of hypochromic anaemia.

It was found that all patients had between 500 and 3,200 adult worms and lost from 30 to 160 ml of blood each day. Immediately after the worms were expelled bleeding became insignificant. The anaemia can be adequately accounted for by the amount of iron lost as a result of chronic haemorrhage. It is stressed that hookworm infestation is the commonest cause of hypochromic anaemia in Ibadan and that expulsion of the worms is necessary for adequate treatment.

Professor J. Grayson and Dr. D. Mendel (*Department of Physology, University College, Ibadan*) **Studies on the myocardial circulation in rabbits, dogs and baboons.**

The technique of internal calorimetry (Grayson and Mendel, 1960) has been applied to the study of myocardial blood flow in animals. The method depends on the use of a fine heated thermocouple implanted at open operation in the myocardium of the left ventricle. Recording is of thermal conductivity— a function of mean blood flow—and of temperature change due to metabolic activity.

This approach involves far less trauma than any previous method for the determination of coronary blood flow.

The relationship between systemic blood pressure and mean myocardial flow was studied in all three species. A linear relationship was established and it was clear that no effective autoregulation occurs in heart muscle. Nor was there any evidence of effective critical closing at low blood pressures.

The effect of adrenaline, nor-adrenaline and acetylcholine was complex. In no instance was it possible to determine the actual effect of these substances on the vessel wall. The overall action depended in part on the effect on mean systemic blood pressure, in part on the effect on rate and force of cardiac contraction.

Dr. S. P. Lapage (*Department of Bacteriology, University College, Ibadan*) **The classification of enterobacteriaceae and aspects of bacterial taxonomy.**

An account of the earlier classifications and of enterobacteriaceae and of classification for special purposes for example plant pathologenicity, water bacteriology, medical diagnosis is presented and these classifications related to changes in views on bacterial classification and the introduction of new techniques and media.

Dr. E. J. Watson-Williams (*Department of Pathology, University College, Ibadan*) **Megaloblastic anaemia in Ibadan.**

At University College Hospital during 1959, 296 patients were found to have megaloblastic erythropoiesis. 220 of these were pregnant or puerperal women. Studies in a proportion of these showed no evidence of vitamin B12 deficiency, but the majority gave in vitro and in vivo evidence of folic acid deficiency. The response to folic acid was usually satisfactory, but in 57 women it was not complete. These can be divided into two groups:-

(*a*) some showed evidence of co-existent haemolytic anaemia

(*b*) in others the appearances were of hypolastic panaemia.

The importance of these findings was discussed.

Seven children with sickle cell anemia (homozygus haemoglobin S) and four adults with an auto-immune haemolytic anaemia had megaloblastic erythropoiesis. These patients were all found to have folic acid deficiency and the suggestion that this was a result of increase demand due to a high rate of red cell turn-over is supported by laboratory study.

That folic acid deficiency is particularly likely to occur when two factors increasing folic acid demand co-exist was shown by the finding of megaloblastic erythropoiesis in 30 of 80 pregnant women with haemoglobin S/C disease.

Evidence was presented that megaloblastic anaemia in infants was due to nutritional folic acid deficiency.

Classical Addisonisan pernicious anaemia has not yet been observed in our African patients.

*Table*

Distribution of 296 cases of megaloblastic anaemia 1959

| | |
|---|---|
| Pregnancy and puerperium | 220 |
| Haemoglobin S/C in pregnancy | 30 |
| Infants | 31 |
| Homozygous hb S disease | 7 |
| Homozygous hb C disease | 1 |
| Auto-immune haemolytic anaemia | 4 |
| Others | 3 |

[illegible] (*Department of Physics, University College, Ibadan*) **Radioactive fall-out in Nigeria.**

[illegible] (*Ministry of Works and Transport, Ibadan*) **The factor of safety in engineering.**

The circumstances in which most engineering materials are used on construction do not satisfy the basic assumptions in the fundamental laws of physics employed in the design of engineering structures. Certain factors essential to design are variable from place to place and from time to time, and their values in a particular design job are assumed to bear a known relationship to their known values in some other jobs. To make allowances for these unknown factors structures are designed to carry only a certain fraction of the load which in theory they are capable of carrying. In this paper the use of the factor of safety and allowances is examined against a background of safety and economy.

Dr. J. Beetlestone (*Department of Chemistry, University College, Ibadan*) **Magnetochemical study of equilibria between high and low spin states of metmyoglobin complexes.**

Complexes of transition metal ions may be divided into two groups according to whether the magnetic susceptibility corresponds to a spin paired or spin free arrangement of the d electrons. Metmyoglobin hydroxide has a magnetic susceptibility intermediate between the high and low spin values for ferric iron complexes, and Griffith has shown on theoretical grounds that this complex is probably a mixture of the two forms. The present paper described the measurement of the variation of the magnetic susceptibility of metmyoglobin complexes with temperature. The assumption of previous workers that the Curie Law is obeyed by these complexes was shown to be invalid, and the results strongly support the hypothesis that metmyoglobin complexes are mixtures of high and low spin forms in thermal equilibrium. Enthalpy and entropy changes for this high to low spin transition were discussed.

Miss R. Hutton (*University College, Ghana*) **Equatorial geomagnetic micropulsations.**

A brief survey was made of the different types of phenomena which can be detected by a earth current measuring system or by a very sensitive magnetometer, when the recording speed in either case is at least 5 mm./min. Examples of these phenomena obtained at equatorial and other observatories were shown.

The properties of some of the phenomena—in particular, regular pulsations, pc, pulsational [illegible] effects, s.f.e.—and their relation to other geophysical measurements were discussed. Particular attention was paid to certain anomalous features of equatorial data.

[illegible] Ward (*University College, Ghana*) **Radioactive fall-out in Ghana**

Radioactive fall-out measurements were started in Ghana in October, 1959. Recorded [illegible] rates were extremely low. An unexpectedly large increase in air-borne dust radioactivity was observed at all stations 3-4 days after the first Reggan atomic test. Some of the maximum levels briefly approached genetic tolerance levels so were carefully followed. Both the rate of arrival of fresh fall-out dust and the natural radioactive decay of the fission products decreased rapidly. Gamma-analyses of the fission products, and relevant Sahara wind maps, agreed with an origin of February 15 in the North Sahara. A much smaller increase was observed after the second Reggan test. All levels now have returned to near—"background."

## *Zoology Specialist Section*

Mr. E. Dunn (*West African Cocoa Research Institute, Tafo, Ghana*) **Two minor pests of cocoa, *Earias biplaga* Wlk. and an unidentified nematode on cocoa seedlings.**

The larvae of *Earias biplaga* Wlk. have caused severe damage to young cocoa at W.A.C.R.I., Ghana. The damage is confined mainly to the buds and young flush leaves; this results in excessive branching; in some instances attack is associated with severe die back. The larval population of *Earias* has been found to be greater on unshaded cocoa than on cocoa grown under shade.

A species of root knot eelworm has been found attacking young cocoa seedlings at W.A. C.R.I., Ghana. It has been provisionally identified as *Meloidogyne incognita* var. *acrita*. Seedlings grown in baskets, in which soil infested with the root knot eelworm was used, showed severe symptoms of growth retardation.

Mr. P. F. Entwistle (*West African Cocoa Research Institute, Nigerian Sub-Station, Ibadan*) **Some observations on the biology and morphology of four species of Psychidae (Lepidoptera) in Western Nigeria.**

The habits of Psychidae (bagworms) are little known in West Africa. Some information was given on their mode of dispersal, the factors involved in selection of a host plant, methods of construction of larval cases, and the nature of their parasites.

The taxonomic value of spinules on the abdominal segments of pupae were considered and the structure of the adult females, which are wingless and often legless, described.

Mr. M. J. Mann (*Federal Fisheries Service, Maiduguri*) **The fisheries on Lake Chad.**

Lying partly within Nigeria, the vast expanse of Lake Chad is the site of one of the most primitive fisheries remaining in Africa. Yet the poor quality smoked fish products derived from the lake are an important item in the diet of the people of the densely populated areas of the Eastern Region. Development of this fishery along more vigorous lines could lead to the establishment of extensive industry in the presently little-developed Province of Bornu.

Mr. J. Phipps (*Department of Zoology, Fourah Bay College, Freetown, Sierra Leone*) **Some observations on *Eudrilus eugeniae* Kinberg.**

An account was given of the anatomy of *Eudrilus eugeniae*, with some descriptions of histology and of its Gregarine parasites.

Dr. E. E. Sandison (*Department of Zoology, University College, Ibadan*) **The fouling barnacle, *Balanus amphitrite*, in Lagos.**

The harbours in Nigeria are notorious for fouling of ships by the barnacle, *Balanus amphitrite*. Closer observation of the life history of this barnacle has shown that it will settle in Lagos harbour during the dry season, but with the onset of rains causing a rapid drop in harbour salinity, settlement ceases, and by October most of the barnacles in the harbour are dead.

*B. amphitrite* is found to survive the wet season in Kuramo Creek, and from here repopulation of the harbour takes place.

An analysis of *B. amphitrite* from the Lagos area and from Port Harcourt and Accra shows that colonisation of the harbour does not take place from outside the Lagos area; furthermore the Accra variety is different from Lagos, and Port Harcourt barnacles are sufficiently isolated from Lagos to begin to show distinctive characteristics.

## OTHER ACTIVITIES

A Reception in honour of the Association was given by the Federal Ministry of Economic Development after the formal opening ceremony. A Conference Dinner was held on the penultimate night of the Conference in Tedder Hall (by kind permission of the Master, Dr. J. C. Edozien) at which the Dean of Arts at University College (Professor J. Ferguson) proposed the toast to the Association and the new President (Dr. J. C. Edozien) replied.

Excursions were made to Lafia canning factory, Moor Plantation agricultural station, Nigerian Tobacco Company factory, Nipol plastics factory, Odutola Tyresoles factory, University College Hospital and the Western Nigeria Television/Western Nigeria Brodcasting Services studios. On the Sunday longer excursions were made to Ile-Ife and Oyo.

Two film-shows were held at which the following films were shown:-

| | |
|---|---|
| *The Revealing Eye*<br>*Unseen Enemies*<br>*Light in Nature*<br>*Living Soil* | presented by the Shell Company of West Africa Ltd. |
| *Coffee Growing*<br>*Ergot—the story of a parasitic fungus*<br>*The Story of Antrycide*<br>*William Harvey and the circulation of the blood* | presented by the British Council and I.C.I. |

In addition to various Specialist Section exhibits there was a General Exhibition of displays by commercial firms and government departments.

*Report of the Hon. Secretary*

This report covers the period 1st November 1959 to 1st December 1960.

*Membership*

| Type | 1959 | 1960 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Gain | Loss In Membership | | | | | | Net | Total |
| | | | By Resignation | | By Unpaid Subscriptions | | | Total | | |
| | | | | | | S.A.N. | | | | |
| Of | Total | In | | | | | | | Increase | |
| | | | | Still | ex- W.A.S.A. | | Still | | In | |
| Member- ship | Mem- bers | Member- ship | On Leaving Nigeria | In Nige- ria | Not Transfer- red | Left Nige- ria | In Nige- ria | Loss | Mem- bership | Mem- bers |
| Ordinary | 130 | 65 | 3 | 1 | 6 | 6 | 16 | 32 | 33 | 163 |
| Associate | 14 | 1 | 1 | 0 | 0 | 1 | 4 | 6 | −5 | 9 |
| Corporate | 37 | 26 | 0 | 0 | 12 | 0 | 2 | 14 | 12 | 49 |
| TOTAL | 181 | 92 | 4 | 1 | 18 | 7 | 22 | 52 | 40 | 221 |

The data in the above table call for little comment. All but one of the resignations have been by members leaving Nigeria. It is expected that many of the ex-W.A.S.A. members who have failed to transfer will do so and it is possible that some of these may have paid their 1960 subscription to W.A.S.A. The S.A.N. members who have failed to pay their 1960 subscriptions have been informed that Council has decided to suspend them from membership (under para. 7 of the Constitution) on 31st December if their subscriptions are not paid by then. Thus during the year the Association has gained 92 members and lost 52; an increase of 40 bringing the total to 221.

The geographical and occupational distributions of Ordinary Members are shown in the following tables. The figures in brackets for 1959 refer to all classes of membership.

*Geographical Distribution of Ordinary Members*

| | | Number | Percentage | 1959 Percentage |
|---|---|---|---|---|
| Lagos | | 18 | 11% | (21%) |
| Eastern Region | | 19 | 12% | (13%) |
| Northern Region excl. Zaria | 14 | | 9% | — |
| Zaria | 33 | | 20% | — |
| Total | | 47 | 29% | (17%) |
| Western Region excl. Ibadan | 12 | | 7% | ( 9%) |
| Ibadan | 61 | | 37% | (37%) |
| Total | | 73 | 44% | (46%) |
| Southern Cameroons | | 3 | 2% | ( 3%) |
| United Kingdom | | 3 | 2% | ( 0%) |
| Total | | 163 | | |

*Occupational Distribution of Ordinary Members*

| | Number | Percentage | 1959 Percentage |
|---|---|---|---|
| Universities | 27 | 17% | (13%) |
| Technical Colleges | 22 | 13% | ( 9%) |
| Schools | 26 | 16% | (25%) |
| Government | 83 | 51% | (38%) |
| Others | 5 | 3% | (15%) |
| Total | 163 | | |

These figures show that a large part of the increase in membership has come from Zaria, especially from the Nigerian College of Technology and from Samaru Agricultural Research Station.

These increases account for some of the decreases, which are proportional rather than actual, in these tables. New members from Lagos and from schools have, however, not been so great as from other groups. Also the non-inclusion of Corporate and Associate Members has caused a decrease in members from Lagos (especially Corporate Members) and from 'others' (especially housewife Associate Members).

*Council*

Council has held five meetings during the year.

Professor N. S. Alexander, Dr. J. I. Taylor and Dr. J. M. Rowson resigned from Council upon leaving Nigeria.

Council has co-opted Mr. J. H. Elgood (Chairman, Local Committee), Dr. M. Godvinjee (Nigerian College of Technology, Ibadan), Dr. A. J. Lyon (Secretary, Physical Science and Engineering Specialist Section) and Mr. P. O. Park (Secretary, Publicity Committee).

Council has nominated Dr. J.C. Edozien, Mr. R. W. J. Keay and Dr. C.A. Onwumechilli as members of the Council of the West African Science Association for the period from the present until its next conference. The Journal of W.A.S.A. is still, unfortunately, behind schedule, but the first part for 1960 is due to be published soon.

The Publicity Committee was without a secretary for the first half of the year. An energetic secretary was appointed and has arranged a series of radio and television programmes on the general need for science in Nigeria scheduled to take place around the time of the Ibadan Conference.

A committee is still considering the ways and means of augmenting the supply of scientific workers in Nigeria.

Council submitted a memorandum to the (Ashby) Commission on Post-Secondary and Higher Education.

On behalf of the West African Science Association, Council has planned, with the co-operation of an active Local Committee in Ibadan, the first W.A.S.A. Conference to be held in Nigeria.

Preliminary arrangements have been made to hold the Fourth Annual Conference at the Nigerian College of Technology, Enugu.

Council has recently decided to publish reports of all three Annual Conferences. These reports will include abstracts of the papers read as well as the Association's business.

The Agricultural Specialist Section held a successful weekend meeting in May at Vom.

Council has approved that the Physical Sciences Specialist Section should be renamed the Physical Sciences and Engineering Specialist Section.

With the financial year running from 1st July to 30th June, subscriptions were received both for 1959 and 1960. For each Ordinary and Corporate member's subscription the Science Association of Nigeria pays 33/-d. to the West African Science Association for the purchase of a copy of the W.A.S.A. Journal. The liability for the 1959 issues of the Journal was met during the year 1959-60 by the payment of £242.6.0d., but the bill for the 1960 issue of the Journal had not been received by 30th June 1960.

The £416.11.6d. received for 1960 subscriptions before 30th June 1960 came from 135 Ordinary, 42 Corporate and 6 Associate members; liability for 177 copies of the Journal had therefore been incurred, viz. £292.1.0d. This liability must therefore be set against the £350.5.7d. Surplus of Income over Expenditure, thus making a net surplus in the General Account of £68.4.7d., which is distinctly better than the £6.13.3d. net surplus on 30th June 1959.

We are most grateful to the Federal Government for a subvention of £500 to enable the Science Association of Nigeria to establish itself on a firmer basis and to meet its contribution to the publication costs of the West African Science Association's Journal. £300 of this amount was used to subsidise the Journal and £200 was used to establish a Fund for Speakers' Fares. In connection with the Journal it should be mentioned that the 33/-d. paid by Science Association of Nigeria for each member annually is considerably below the cost price. Publication in the past has only been possible through generous subventions made by the University College and Government of Ghana, now Nigeria is able to contribute its share and this will, we hope, make it possible to expand the Journal.

A Savings Bank Account was opened towards the end of the year 1959-60 so that a small amount of interest will in future be earned on the Association's account.

## GENERAL ACCOUNT

| Income | £ | s | d | Expenditure | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Annual subscriptions 1959 ... ... ... | 71 | 18 | 0 | To Printing ... ... ... ... ... ... | 31 | 0 | 0 |
| Annual subscriptions 1960 ... ... ... | 416 | 11 | 6 | Typing ... ... ... ... ... ... | 1 | 0 | 0 |
| Surplus from 1958-59 ... ... ... | 201 | 7 | 3 | Postage ... ... ... ... ... ... | 12 | 19 | 6 |
| Cash held on 1/7/59 by Conf. Secretary ... | 10 | 0 | 0 | Stationery ... ... ... ... ... | 12 | 2 | 0 |
| | | | | Bank Charges ... ... ... ... ... | 9 | 8 | 1 |
| | | | | "Nature" reprints ... ... ... ... | 2 | 18 | 0 |
| | | | | Mainland Hotel for Press Conference ... ... | 3 | 1 | 0 |
| | | | | Kuti Hall for 1958 Conference ... ... ... | 19 | 15 | 0 |
| | | | | Loss on 1959 Conference ... ... ... | 15 | 1 | 7 |
| | | | | Purchase of W.A.S.A. Journal (1959) ... ... | 242 | 6 | 0 |
| | | | | Excess of Income over Expenditure ... ... | 350 | 5 | 7 |
| | 699 | 16 | 9 | | 699 | 16 | 9 |

## FEDERAL GOVERNMENT SUBVENTION ACCOUNT

| Income | £ | s | d | Expenditure | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Federal Government Subvention ... ... | 500 | 0 | 0 | To Subsidy for W.A.S.A. Journal (1959) | 300 | 0 | 0 |
| | | | | Fund for Speakers' Fares ... ... ... | 200 | 0 | 0 |
| | 500 | 0 | 0 | | 500 | 0 | 0 |

## FUND FOR SPEAKERS' FARES

| Income | £ | s | d | Expenditure | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Transfer from Federal Government Subvention Account ... ... ... ... | 200 | 0 | 0 | To Balance in hand for 1960 Conference ... ... | 200 | 0 | 0 |
| | 200 | 0 | 0 | | 200 | 0 | 0 |

## 1959 CONFERENCE ACCOUNT

| | Income | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|---|
| By | Conference fees: | | | | | | |
| | Rec. by Hon. Treasurer ... ... | 10 | 2 | 6 | | | |
| | Rec. in cash by Conf. Secretary ... | 18 | 10 | 0 | 28 | 12 | 6 |
| | Accommodation, Dinner and other meals: | | | | | | |
| | Rec. by Hon. Treasurer ... | 139 | 18 | 7 | | | |
| | Rec. in cash by Conf. Secretary | 126 | 6 | 4 | 266 | 4 | 11 |
| | Deposits for Transport, etc.: | | | | | | |
| | Rec. by Hon. Treasurer ... | 24 | 0 | 0 | | | |
| | Rec. in cash by Conf. Secretary | 23 | 0 | 0 | 47 | 0 | 0 |
| | Guide Books, etc.: | | | | | | |
| | Rec. by Hon. Treasurer ... | 1 | 8 | 6 | | | |
| | Rec. in cash by Conf. Secretary | 6 | 14 | 0 | 8 | 2 | 6 |
| | Nett loss on Conference ... | | | | 15 | 1 | 7 |
| | | | | | 365 | 1 | 6 |

| | Expenditure | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|---|
| To | Accommodation, Dinner & other Meals: | | | | | | |
| | Paid by Hon. Treasurer ... ... | 168 | 2 | 6 | | | |
| | Paid in cash by Conf. Secretary ... | 112 | 11 | 8 | 280 | 14 | 2 |
| | Refunds on Deposits, etc.: | | | | | | |
| | Paid by Hon. Treasurer ... ... | 28 | 0 | 0 | | | |
| | Paid in cash by Conf. Secretary ... | 23 | 8 | 7 | 51 | 8 | 7 |
| | Guide Books, etc.: | | | | | | |
| | Paid in cash by Conf. Secretary ... | | | | 11 | 1 | 6 |
| | Stationery: | | | | | | |
| | Paid in cash by Conf. Secretary ... | | | | 6 | 6 | 7 |
| | Printing: | | | | | | |
| | Paid in cash by Conf. Secretary ... | | | | 10 | 5 | 0 |
| | Transport of Exhibit: | | | | | | |
| | Paid in cash by Conf. Secretary ... | | | | 3 | 11 | 4 |
| | Unaccounted loss on Conf. Secretary's Cash a/c ... ... ... | | | | 1 | 14 | 4 |
| | | | | | 365 | 1 | 6 |

## 1959 CONFERENCE SECRETARY'S CASH ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Conference Fees, Accommodation, Meals, etc. ... ... ... ... | 174 | 10 | 4 | To Payments for Conference ... ... ... | 167 | 4 | 8 |
| Subscriptions ... ... ... ... | 20 | 0 | 0 | Cash for cheques ... ... ... ... | 30 | 0 | 0 |
| Advance from S. A. N. Hon. Treasurer ... | 10 | 0 | 0 | Cash balance forwarded to Hon. Treasurer ... | 5 | 5 | 10 |
| | | | | Unused stamps forwarded to Hon. Treasurer ... | – | 5 | 6 |
| | | | | Unaccounted loss ... ... ... ... | 1 | 14 | 4 |
| | 204 | 10 | 4 | | 204 | 10 | 4 |

## 1959 CONFERENCE: HON. TREASURER'S ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Conference Fees, Accommodation Meals, etc. ... ... ... ... | 175 | 9 | 7 | To Conference Accommodation, Meals, etc. ... | 196 | 2 | 6 |
| Cash balance from Conf. Secretary ... ... | 5 | 5 | 10 | | | | |
| Unused stamps from Conf. Secretary ... | – | 5 | 6 | | | | |
| Nett loss on 1959 Conference ... ... | 15 | 1 | 7 | | | | |
| | 196 | 2 | 6 | | 196 | 2 | 6 |

## BALANCE SHEET

(30th June, 1960)

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Surplus of Income over Expenditure ... ... | 350 | 5 | 7 | Balance in Current a/c at Barclays Bank (D.C. & O.), Ibadan ... ... ... | 172 | 4 | 6 |
| Balance in hand on Fund for Speakers' Fares ... ... ... ... | 200 | 0 | 0 | Balance in Savings Bank a/c at Barclays Bank (D.C. & O.), Ibadan ... ... ... | 600 | 0 | 0 |
| Cheque not yet presented ... ... ... | 222 | 18 | 6 | Cash in hand ... ... ... ... | – | 19 | 7 |
| | 773 | 4 | 1 | | 773 | 4 | 1 |

R. W. J. Keay,
Hon. Treasurer.

30th November, 1960.

We have audited the Accounts of the Association and found them correct

R. G. Donald
C. A. Onwumechilli
Hon. Auditors

At this meeting the reports of the Hon. Secretary and Hon. Treasurer were received and elections held.

*Council Membership for 1960*

| | | |
|---|---|---|
| *President* | : | Professor J. Grayson |
| *Vice-President* | : | Dr. C. Oyolu |
| *Hon. Secretary* | : | Dr. B. Hopkins |
| *Hon. Treasurer* | : | Mr. R. W. J. Keay |
| *Ordinary Council Members* | : | Dr. J. C. Edozien |
| | | Mr. M. J. Etuk |
| | | Professor E. Njoku |
| | | Dr. C. A. Onwumechilli |
| | | *Dr. J. M. Rowson |
| | | *Dr. J. I. Taylor |

*Specialist Section Representatives*

| | | |
|---|---|---|
| *Agriculture* | : | Mr. P. C. Randell |
| *Botany* | : | Mr. C. F. A. Onochie |
| *Medical Sciences* | : | Dr. K. C. Willett |
| *Physical Sciences and Engineering* | : | *Professor N. S. Alexander |
| *Zoology* | : | Dr. C. I. O. Olaniyan |
| *Chairman of Local (Ibadan) Committee (co-opted)* | : | Mr. J. H. Elgood |

*Resigned on leaving Nigeria.

## [illegible] SECTION SYMPOSIUM IN VOM

[illegible] *breeding policies applicable to a developing* [illegible] Nigeria.

[illegible] the Federal Department of Veterinary Research, [illegible] 20th May 1960.

[illegible] the symposium with a paper reviewing the investi- [illegible] in Nigeria and compared the result with experi- [illegible] other tropical territories. Mr. Wilder followed with a [illegible] aims of the cattle improvement policy for the town [illegible] projects in the Western Region.

[illegible] covering the technical problems of a fluctuating [illegible] the extent to which one could equip an animal with [illegible] factors in the environment, for a fraction or the whole [illegible] to incorporating such resistance in the hereditary [illegible]

[illegible] problems were raised related to the collection of statistics [illegible] and to the application of disease eradication or control [illegible] findings of the recent survey of meat type preference in [illegible] in the Journal of the West African Science Association, [illegible] to the discussion.

[illegible] viewpoint (usually opposed to the veterinary interests) [illegible] that, in certain provinces, the forest reserves were an [illegible] grazing pattern and that some ingress by herds into these [illegible] by the foresters as an integral part of the complex nomad/ [illegible] system of the area concerned.

★

[illegible] also made to the Panyam fish farm.

PROCEEDINGS OF THE

# SCIENCE ASSOCIATION OF NIGERIA

*Volume* 4 1961

PUBLISHED MARCH 1963

CONTENTS

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EDITOR

Dr. B. HOPKINS

*University of Ibadan*

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AND PRINTED AT THE

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UNIVERSITY OF IBADAN

## FOURTH ANNUAL CONFERENCE

THE Fourth Annual Conference of the Association was held at the Enugu Branch of the Nigerian College of Arts, Science and Technology from Thursday 14th December until Monday 18th December 1961.

### OPENING CEREMONY

Mr. A. V. Lawes, the Principal of the Enugu Branch of the Nigerian College, briefly and aptly welcomed delegates and wished the Association a successful meeting.

The Hon. Dr. M. I. Okpara, Premier of Eastern Nigeria, then addressed the Association on *Science in the service of a young nation.*

After welcoming delegates to Enugu, the capital city of Eastern Nigeria, the Premier gave an outline of the size, population and natural resources of Nigeria.

It was necessary to raise the present per caput income of about £30 in Nigeria tenfold in a decade by the shortest possible route and, the Premier stated, it was his considered opinion that this could only be achieved by the aid of science. It was not only necessary to use modern scientific, technological and medical techniques to achieve this increase, it was also necessary to educate the people into the scientific and technological age. Science could be used for the service of man: it could also be used for man's destruction. Scientists, the Premier said, had a moral duty not to use their knowledge for destruction.

In view of the need for scientific advancement in the next decade the importance of science cannot be overemphasised. With this in mind, the Eastern Region Government had spent over three quarters of a million pounds this year on the construction and equipment of science laboratories in secondary schools and has heavily weighted scholarships in favour of scientific studies.

Progress in science is impossible without research, the Premier went on, but it was necessary to co-ordinate both the actual research and its financing. Perhaps the Science Association of Nigeria could assist with such co-ordination.

Finally the Premier congratulated the Association on its four years of progress and wished it a successful conference.

Professor J. C. Edozien then delivered his Presidential Address on *The organization of science for development in Nigeria.*

"At the annual conferences of the Science Association in 1959 and in 1960 both the past presidents, Professor Eni Njoku and Professor John Grayson, spoke about the development of science in Nigeria. The underlying theme in these addresses was the great contribution which science can make to the development of this country and as a result consideration was given to the formation of a Council for Scientific Development, an advisory body to advise the Governments of the Federation about the development of Science in Nigeria. I make no apologies for speaking on the same general theme even if it appears to be a repetition because it is a very important subject and I hope that repetition in this case may have the force of emphasis. One of the principal aims of the Science Association of Nigeria is to foster science in our community and to promote the application of science and technology to the problems of national development and we should therefore not relent or relax our efforts until we have succeeded in infecting those who control the destinies of our country with our enthusiasm for science.

"Nigeria, like several other countries in Africa, has recently regained its independence. The people were repeatedly told during the march to independence that self-government was not an end in itself; rather that it is a means to an end, to the building of the good life to the benefit of all. The ordinary men and women who supported the fight for self-government naturally hope and rightly expect that independence will be followed by a period of rapid and unprecedented rate of development which will usher the life more abundant which they believed that self-government will bring. The economic history of several countries during the last half century show only too clearly the tremendous importance of science and technology to economic growth: indeed it is no exaggeration to say that the advancement of science and technology have virtually become synonymous with economic development. We cannot in this country ignore the lesson of history that we must promote science vigorously if we are to satisfy the legitimate aspiration of the people for more food, better housing and water supply, good health and the other good things of civilized existence.

"In order to advance science and promote technology in Nigeria we must train the scientists required for research and for industry and we must promote scientific research.

*Investment in Science Education*

"The report of the Ashby Commission on post-secondary and higher education in Nigeria contains bold and imaginative proposals for meeting Nigeria's need for skilled men and women, for the commissioners have rightly rejected the idea of making cautious proposals of what Nigeria can afford and instead addressed themselves to Nigeria's needs. The report recommended two new Universities in addition to the two already in existence. In fact since the report of the Commission was published the foundations of three new Universities have already been laid and it is evident that the Governments of the nation are determined to make the massive investment in education which the Ashby Commission recommended in order to meet the future needs of our country for high level manpower. The establishment of universities, however, is only one aspect of the problem. It is equally important to ensure that these universities give the correct emphasis to science. This latter need is not so easy to achieve especially in a country which has a background of literary education. It may prove difficult in practice for a University Senate dominated by professors in the humanities to give science and agriculture the emphasis which the circumstances of our country demand that they must receive. One way of meeting these difficulties might have been the creation of separate institutes for science such as Technological Universities. But the Commission has understandably preferred the development of Universities with all faculties because of the educational value of contact between students in different disciplines. In order to achieve the proper balance and ensure that the size of the faculties in our Universities reflect national needs it is important to establish without delay a system of consultation between the National Economic Council on the one hand and a Committee of Vice-Chancellors of Universities in Nigeria as well as the Universities Grants Commission on the other hand and in this way the authorities who shape the policies and those who control the funds of the Universities would be kept constantly aware of the economic programmes and the manpower needs of the nation.

*Investment in Research*

"Research is the pillar of progress in science and technology. Yet one finds in several quarters in this country the unfortunate impression that scientific research is a waste of money at our present stage of development. There is a widespread belief that there is a tremendous backlog of research available from the more highly developed countries awaiting to be applied immediately in the developing areas of the world. Those people who accept this judgment therefore argue that our resources should not be put into research as this could be more effectively pursued elsewhere. But those who are familiar with the practical application of science to the problems of any country and in particular to the problems of a developing country know that this is not so. Although it is true that the developing countries are heirs to the whole heritage of science and scholarship, it is equally true that to enter into this heritage a country must have its own scientists engaged in research for it is only by doing research oneself that one can interpret the research done by others. Further, in order to apply the results of scientific research to any situation local factors must be taken into full account and hence the most readily applied research is that carried out under local conditions. Take what appears to be a relatively simple matter like improving the nutrition of the people. It is well known that the diet of the people in most of the under-developed countries of the world is deficient in protein. The obvious solution is to produce more protein foods at prices which the people can afford and as this has been attempted in so many other places in the world it looks as if we should have a ready made formula for solving this kind of problem. Yet when one comes to deal with the matter it becomes clear that the issues involved are far more complex. The pattern of dietary deficiency differs in detail from one area to another: the pattern in any locality must be investigated before a rational scheme of improvement can be evolved. In introducing new sources of protein the dietary habits and the prejudices of the people must be considered. The peculiar problems of animal health in the locality must be solved. An intimate knowledge of the soil must be available to determine the best crops to introduce. All this requires a tremendous research machinery involving experts in the social sciences, medicine, chemistry, agriculture, and veterinary science. And in the same way we find that in every sphere of our economic development a good deal of research is necessary—in building, in road construction, in the oil industry, in the coal industry, etc.

"Hence in order to ensure the rapid rate of progress which we envisage it is essential that while taking full account of the research work being done elsewhere we must also make a massive investment in scientific research.

*Financing of Research*

"Where is the money going to come from for research? First and foremost, local resources must be fully utilized. Because scientific research is so basic to the development of our national economy, more funds must be found to invest in this type of activity. Less than half a million pounds is spent annually at present in all types of research in this country and most of this money comes from outside sources. Although Nigeria has limited resources at present, it is a potentially rich country and if future progress and development is to be guaranteed a much larger share of the present meagre resources must be put into scientific research. Most of this additional fund for research has to come from other sectors of government expenditure. Recently I read in the public press that the Premier of Eastern Nigeria is to cut the cost of running the regional legislatures in order to make more funds available for development projects in the region. This is a most welcome and admirable announcement which we hope that other governments will note because it often raises anxiety in many minds that a young country like ours can maintain over 1,000 legislators and about 100 ministers while being unable to finance relatively inexpensive research projects which are vital to the development of our country. There are other sectors of the national expenditure from which savings may be diverted to finance research and let us all hope that in the coming years there will be a critical reappraisal of our pattern of expenditure.

"The other big source of money for research is contribution from various international agencies. A considerable amount of money is currently available from international agencies for scientific research in developing countries but, as Professor Eni Njoku pointed out in a recent article, we have up till now failed to derive much benefit from these organizations. The main reason for this is that we have not yet evolved a well planned national science policy. Although several scientists in institutions in the country are doing valuable work in attracting outside money for their research it is clear that if Nigeria is to benefit on a much larger scale than at present scientific research must be better organized.

"What then is the most effective organization for the stimulation and promotion of scientific research? Here fortunately we have the experience of several countries both within the Commonwealth and in other countries to guide us. And the answer clearly is that firstly, scientific research must be actively encouraged in our institutions of higher learning and, secondly, we must create as soon as possible a National Research Council which is not purely advisory but has executive power as well as a considerable budget of its own. In creating this Council we should look to the newer countries like Australia for inspiration rather than to the older countries like the United Kingdom. In the circumstances of Nigeria at present the functions envisaged for the National Research Council are as follows:

1. Formulate a national science policy.
2. Promote and improve the teaching of science in schools and the training of scientists at all levels.
3. Promote and finance research especially applied research in universities, in industry and in other spheres.
4. Establish, equip and operate a limited number of national laboratories for both fundamental and applied research in those areas of scientific activity which are not adequately covered by existing institutions.
5. Ensure the rapid utilization of the results of research going on both locally and abroad by establishing comprehensive liaison and information services.

"I estimate that in order to stimulate scientific research on the scale required to make a decisive impact on the pace of economic development of this country an expenditure of the order of £4,000,000 per annum may be necessary. If the National Research Council is created now and carefully formulated research programmes are prepared it is possible that 25% or more of this sum can be found from Industry and from international agencies. The balance would have to be derived from national revenue.

*Summary*

"To summarize, it seems to me that if science and technology are to make maximum contribution to our economic development, we must invest on a big scale in science education and in scientific research. These will be worthwhile investments for it is only by investment in science on this massive scale that we can hope in the foreseeable future to make self government really meaningful to the ordinary men and women of this country."

Shortly after the Presidential Address the Association had the privilege of listening to Sir Julian Huxley who delivered an Evening Discourse entitled *The science of evolution.**

## GENERAL PAPERS

Dr. K. Lawton (*College of Agriculture, University of Nigeria, Nsukka*) **New Fertilizers for the Agronomist.**

Fertilizers can play an important role in increasing agricultural production in the highly populated, developing countries of the world. It is the responsibility of the agronomist to be familiar with the use of fertilizers in soil management and crop husbandry, to know of their benefits and limitations under different conditions, and to be cognizant of new developments in fertilizer technology.

The nitrogen fertilizers most widely used are ammonium sulphate (20% N) and ammonium nitrate (32% N) with smaller amounts of urea (45% N), calcium nitrate and calcium cyanamid available for special conditions. Anhydrous ammonia (82% N), one of the cheapest sources, and nitrogen solutions are being efficiently used on large farms under conditions of mechanization. The development of newer materials such as ureaformaldehyde and oxamide $(CONH_2)_2$ which release their nitrogen slowly may lead to a new concept of fertilization for high value crops.

Many changes have occurred in the technology of phosphate fertilizers. For example, ordinary superphosphate (20% $P_2O_5$) is rapidly being supplanted by concentrated or treble superphosphate containing 45% $P_2O_5$. Diammonium phosphate and highly ammoniated superphosphate have developed as a result of demand for high nitrogen-phosphate materials. A new higher analysis superphosphate (54% $P_2O_5$) has been produced by action of superphosphoric acid on rock phosphate, and analyses as high as 6-24-24 have been successfully made.

Perhaps the most interesting recent development is the metaphosphates of potassium and ammonium. These fertilizers contain from 60 to 70% $P_2O_5$ and the results of field trials indicate they are generally comparable with other available phosphates when applied to acid soils for medium to long season crops.

Recent studies with coated fertilizer suggest that coatings may reduce leaching losses of nitrogen in soils and luxury consumption of potassium by crops.

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*The Association posesses a tape recording of this discourse. It may be borrowed on application to the Secretary.

## Mr. N. A. Nwosu (*Ministry of Agriculture, Enugu*) **The farm settlement scheme and the promotion of agricultural change.**

In the under-developed countries of the world there is justifiable anxiety to raise the standard of living of the masses of the people as quickly as possible. Since the great majority of the people of these countries live in rural areas and derive their livelihood from agriculture, they will benefit greatly from agricultural development schemes.

Several countries have, at one time or another, included in their agricultural development programmes the establishment of a number of farm settlements in order to alleviate certain socio-economic conditions. The value of a farm settlement as a demonstration farm to the surrounding district may well be greater than its high capital cost. In the long run there would be a tendency towards the reversal of population drift to the towns and an increase in the agricultural productivity of the country.

In order to ensure success in the farm settlements, certain basic principles would have to be followed:

(*i*) co-operative ownership of the means of production.
(*ii*) central management.
(*iii*) the provision of incentives to mitigate the shocks of early life in the settlement.
(*iv*) the provision of a training scheme either before the admission of the settlers or in the form of intensive agricultural extension work during the early stages of settlement.

Some of the problems which are likely to arise in settlement schemes were discussed.

## Dr. E. M. Poulton (*W.H.O., Enugu*) **Famine relief in the Congo.**

I was sent at short notice and with the utmost urgency to assist in famine relief among the Baluba of South Kasai during January and February, 1961. The famine was due to tribal migration, in particular the return of Baluba as refugees from all over the Congo and Ruanda Urundi to their homeland around Bakwanga. This had the effect of increasing the population of the area by fifty percent in a period of four months.

Local food supplies were quickly exhausted and the next harvest was not expected to start until April—8 months after the first refugees arrived. The area was surrounded by tribes hostile to the Baluba, so that food sent to the area by road failed to arrive. The United Nations therefore organised a colossal air lift of food—rice, maize meal, fish, beans, palm oil and dried milk—to Bakwanga airport and supplied trucks, oil and petrol for its distribution to the villages and rural dispensaries.

The chief manifestation of famine was an acute form of kwashiorkor, of which slides were shown, consisting of oedema, early ascites, with late developing but severe skin changes, and death if not remedied. The age group affected were from 3-4 years (when breast feeding was terminated) to young adult life, and oedema of the legs with ascites was also seen in the old. Affected families were collected into camps and feeding centres, and the outbreak was brought under control, but not before some thousands of children had died.

## Mr. F. W. Soper (*Shell-BP Petroleum Development Company, Port Harcourt*) **The mohole project.**

It is planned to drill a hole through the earth's crust to discover the nature of the Mohorovicic Discontinuity. This hole will be drilled through the floor of the ocean, since the crust is only 4-5 km. thick there, compared with over 35 km. under the continents. This means that drilling must be done from a ship through some 5 km. of water.

Techniques for doing this were succesfully tested in 1961 off the Mexican Island of Guadalope. Positioning a heavy drillship with ordinary anchors would be impossible in such a depth of water. Signals from sonar transponders attached to a ring of submerged taut-line buoys indicate accurately the position of the ship on a screen, and the pilot maintains this position by controlling four 200 h.p outboard engines, placed around the ship, simultaneously from a single consul. Special guide shoes have been developed to limit the curvature of the drill pipe where it leaves the hull of the drill ship, and where it enters the ocean bed. Turbo drills, as opposed to rotary drills, may be used for Mohole, since the pipe stress is less and the rate of penetration higher. It is hoped to take more or less continuous cores throughout the Mohole. Several logging devices will be run in the hole for measuring resistivities, elastic wave velocities, temperatures, magnetic field strengths, etc. These cores and readings should give information concerning the history of the ocean basins, the nature of the sub-oceanic crust, and the nature of the Mohorovicic Discontinuity.

Mr. P. Tuley (*Agricultural Research Station, Umudike*) **Agricultural research in Eastern Nigeria.**

Agricultural Research in Eastern Nigeria can be said to have started with the establishment, early in this century, of two Botanic Gardens—one at Calabar and the other at Onitsha. The former is well known and the remains of the Gardens can still be seen, but now there is regretably no trace of the latter. The Gardens flourished until the 1920's when the depression arrived in Nigeria and they had to be abandoned for lack of finance. They were responsible for the introduction and trial of many of the economic and ornamental plants which we take for granted today. *Calabar* 256 one of the major parents of the improved oil palm seedlings being distributed by the thousand today, is a palm still existing in the Calabar Gardens Selection Plot.

Prior to regionalisation of the country in 1953 there were two main research stations; one for the south at Ibadan and one for the north at Zaria. With the political changes at that time it became necessary to establish a third station in Eastern Nigeria. The then Departmental Farm, Umudike was chosen as the site of the new station. Since 1956 the station has built up its facilities and now has a staff of ten primarily directed towards the study of soil fertility and crop production.

In the next five-year period a large expansion of the station is planned to bring it in line with accepted international standards. In addition it will also accommodate units of the Federal Research Organisation. We sincerely trust that in future, Umudike may gain an enhanced reputation in the world of tropical science.

*Chairmen*

Protein and Nutrition in Nigeria—Professor E. Njoku
Selected Topics —Mr. H. Hardie

*Contributors*

Dr. J. G. Beetlestone (*Department of Chemistry, University College, Ibadan*) **What is a protein?**

Dr. V. A. Oyenuga (*Department of Agriculture, University College, Ibadan*) **The source of protein.**

Professor J. C. Edozien (*Department of Chemical Pathology, University College, Ibadan*) **The status of protein nutrition in Nigeria.**

Dr. W. R. F. Collis (*Institute of Child Health, University College, Ibadan*) **Protein deficiency and human health.**

Dr. W. R. Stanton (*Regional Research Station, Samaru, Zaria*) **Increased production of plant protein.**

Dr. S. G. Wilson (*Ministry of Animal Health and Forestry, Kaduna*) **Increased production of animal protein.**

Dr. E. J. Watson-Williams (*Department of Pathology, University College, Ibadan*) **Recent advances in knowledge of human haemoglobin.**

Mr. I. A. Akinrele (*Federal Institute of Industrial Research, Oshodi, Lagos*) **Manufacture and utilisation of leaf proteins.**

Dr. Beetlestone pointed out that substances as different as enzymes, antibodies, hormones, haemoglobin and hair were all proteins, accounting for three-quarters of an animal's dry weight. Chemically a protein is a series of α-amino acids joined together. An amino acid being a central carbon atom to which are attached an amino group ($NH_2$), a carboxylic group (COOH), a hydrogen atom and a radical which determines the name of the amino acid. The radical may be simply a hydrogen atom (glycine) or a methyl group or may contain another amino group, as in lysine, or a sulphur atom as in cysteine. The amino acids are joined by a reaction between the carboxylic acid group of one and the amino group of the other. Two amino acids so joined form a dipeptide whereas several form a polypeptide.

A protein molecule consists of one or more polypeptide chains and its properties are a result not only of the radicals composing the chains but also of the way the chains are arranged in relation to each other. The polypeptide chains of each molecule are coiled in a characteristic way. If this three dimensional structure is destroyed the protein loses its characteristic properties (i.e. it is denatured) although the polypeptide chains remain intact.

Although knowledge of the detailed structure of a protein was important the most important thing for this symposium was the fact that all proteins are broken down, during human digestion, into their constituent amino acids, which are absorbed and synthesised into the new proteins required by the human. Thus when we come to consider protein requirements we are really concerned with amino acid requirements.

Prof. Edozien described methods of evaluating the status of protein nutrition of an individual and of a community. He said that it was generally realised that protein deficiency was common in Nigeria, but few people were aware of its extent and severity. The obviously recognised child with kwashiorkor is the severest form, but important minor degrees of protein deficiency only come to light when methods more sensitive than clinical observation are used. Dietary surveys, even though by their nature they must be relatively crude, have pointed to the low level of protein intake in Nigeria. Not only is the total protein intake important but so is the actual amino acid content of the proteins consumed. Most important are those like methionine (the so-called essential amino acids) which cannot be synthesised from other amino acids. The serum albumin is the most sensitive biochemical index of protein deficiency. Prof. Edozien showed that whereas healthy subjects have 3.2-4.5 g. albumin per 100 ml. of serum, in cases of kwashiorkor there is nearly always less than 2.5 g. per 100 ml. He showed evidence that an intermediate serum albumin level (2.5-3.2 g./100 ml.) is indicative of a state of subclinical protein deficiency.

In figure 1 are shown the serum albumin levels of children of well-to-do Nigerians compared with symptom-free children from the rural areas around Ilesha. Between the ages of 2 and 6 years the mean of the village children is below the critical level of 3.2 g./100 ml. Less than 15% have values within normal limits. Even in apparently healthy adults a figure of less than 3.2g./100 ml. is not uncommon and amongst hospital patients it is very unusual to find levels above this critical value. Prof. Edozien concluded that the protein reserves of the average Nigerian are so poor that the slightest ill-health results in protein malnutrition and that this was the usual state of village children.

Dr. Collis, working with the same villagers from Ilesha, had studied their health, nutritional state and diet. He found that they seldom had enough calories and never enough protein so that the vast majority were in a permanent state of protein imbalance. In particular the children were considerably shorter than children of well-to-do Nigerians. He stated that kwashiorkor represented gross protein deficiency, but for every case of kwashiorkor there were 100 cases of protein imbalance. Thus the fact that 300 cases of kwashiorkor were seen every year at the Wesley Guild Hospital Ilesha, supported his observations on the frequency of protein deficiency.

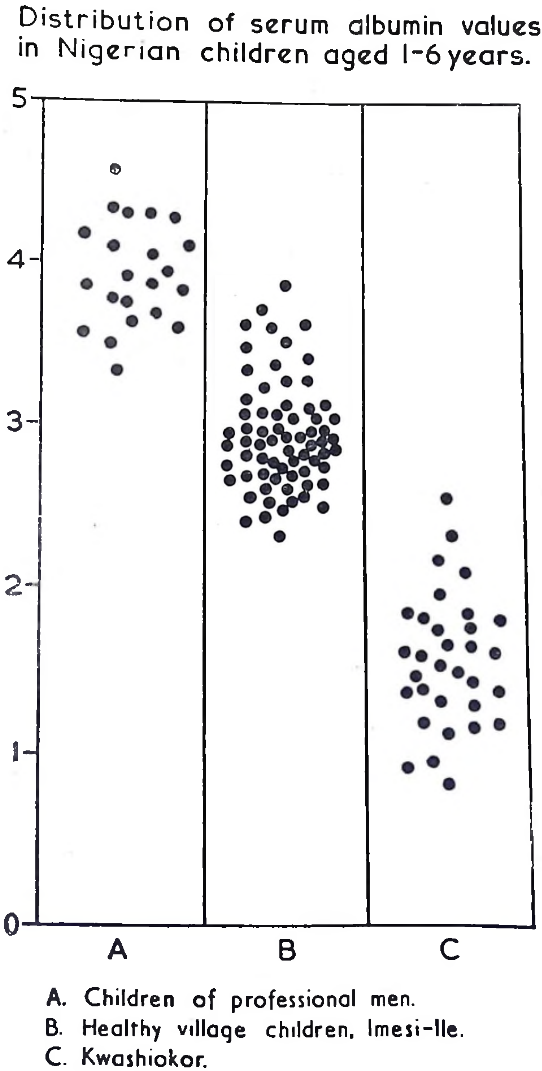


*Fig. 1.* Serum albumin in g./100 ml.

Protein imbalance results when the diet is high in carbohydrate but low in protein. A protein intake of less than 20g. a day resulted in failure to grow, mental depression and a low serum albumin. If the child in this state of protein malnutrition received large amounts of carbohydrate, or was subjected to measles or other infection, the condition of kwashiorkor was likely to develop. The earliest sign is oedema, followed by skin changes, areas of hypopigmentation alternating with areas of hyperpigmentation, which are characteristic. The areas of hyperpigmentation are actually places where the skin has begun to peel, when complete the site is painful and weeping, resembling a first degree burn. The child is miserable, crying ceaselessly and eventually refuses all food even from the mother. If untreated, death occurs rapidly.

Having seen the extreme frequency and seriousness of protein deficiency in Nigeria, the conference now turned to the consideration of what could be done to alleviate the position.

Dr. Oyenuga (in a paper read by Dr. Opeke) reviewed the sources of protein. The most valuable proteins are from animal sources. They are complete in all the essential amino acids, are easily assimilable and are present in a higher concentration than is the case with plant proteins. However, animals, with few exceptions, have to be supplied with amino acids for protein synthesis; it is only the plants that can synthesise protein from such simple sources as nitrate, nitrite and ammonium. Agricultural economy depends on the channelling of nitrogen so that plants obtain what they need for growth and also to synthesise protein required by animals. The synthesis of ammonium, nitrate and nitrite ions in turn depends upon the activities of micro-organisms in the soil. This synthesis may be symbiotic, as in the case of the *Rhizobium* bacteria and roots of leguminous plants, neither of which separately is capable of nitrogen fixation, or it may be achieved by some bacteria acting independently.

Plants, having absorbed nitrogen in the form of simple inorganic compounds, synthesise protein in the cell sap of the leaves and, to a lesser extent, in the roots and tubers. There are four large groups of plant products which serve as sources of protein for animals, viz., legume seeds, oilseeds, vegetable leaf and grasses. Legume seeds, with a protein content varying between 18 and 30% form a very important source. Some, like groundnut and soya bean, are also rich in oil. The high commercial value of groundnut oil results in the relatively low cost of the residual cake, which, although deficient in methionine and tryptophan, is a very valuable source of protein. When used for animal feeding the cake should be supplemented with blood meal or some other source of methionine to produce optimum results. The cowpea, particularly when mixed with fish or eggs as in moin-moin, is another valuable source of protein, but there is need to encourage its cultivation so as to maintain the low cost.

Palm kernel meal is one of the cheapest protein meals, because it is a by-product of the very valuable oil. Its protein content is low compared with that of groundnut, but the amino acids are more balanced; because it is unpalatable its use is confined to animal feeding. Cotton seed is widely used for cattle feeding but has the disadvantage of containing a phenolic substance gossypol, which is toxic to certain animals, but preparations suitable for human consumption have been prepared. Coconut seed, water-melon seed and the African locust bean are other oil seeds important as protein sources. So also are the by-products from the processing of rice and maize for human consumption, the bran obtained containing a large proportion of the total protein.

The dry matter of leaves contains a fairly high proportion of protein and makes a considerable contribution, via animal feeding, to man's protein supply.

Amongst animals it is the ruminants that are most important as a source of protein. Micro-organisms in the animals rumen assist in the conversion of grass protein and non-protein nitrogen into ammonia and amino acids, the latter being converted to animal protein. Some of the ammonia, after conversion to urea, is again presented to the rumen via the saliva and thus forms a further source of protein.

Dr. Stanton said that the legumes are Nigeria's pre-eminent plant source of protein and it is on their increased production that we must concentrate. The Northern Region Government, with the help of F.A.O., is active in this attempt.

When increased production is considered various aspects, not at once obvious, have to be investigated. It is not just a question of increased agricultural efficiency, but also of what the farmer can be persuaded to grow, of what the consumer can be persuaded to eat and of how storage, transport and marketing facilities can be improved. These matters were all under investigation but in this symposium he was concerned with the improvement of legume crops. As an example he described the results of a survey of different areas intended to discover the variations in the economics of the cowpea. Individual farmers completed a questionnaire and submitted a sample of seed. Analysis of this material was made in the laboratory. The types of cowpea which predominate in the guinea and sudan savannas have qualities that are admirably suitable for current farming practice. Their photoperiodic response of approximately 12 hours conforms well to the day length. They have a prostrate habit. The seeds are large and having a crinkled and papery coat, require a very short cooking time. This specification may not be so suitable, however, when one wishes to increase production by changing density of cultivation, time of planting and harvesting and husbandry methods.

Although the groundnut is an important protein source, it would be unwise to concentrate much effort on its increased production for food, because its high cash value might result only in increased exports. Other legumes which might profitably be encouraged however are the soya bean, the bambara groundnut and the lima bean.

Increased legume production should be phased. Firstly, by the use of insecticides the yield of cowpeas had been increased from 100 lbs. to 500-1,500 lbs. per acre. Secondly, new crops might be grown and made acceptable; in this connection it had been shown at Samaru, that the lab-lab bean has a large potential as a human and animal nutrient. Also from India are black and green gram beans which, from experiments at Samaru, Ilorin and Kano, give promise of being a highly nutritious crop. Species of *Phaseolus* are likely to be valuable in areas with a low rainfall. Finally we should consider new plants produced by plant breeding as a result of species crossing and chromosome complement alteration.

Dr. Wilson's paper (read by Mr. Hardie) dealt with the increased production of animal protein. He outlined the economic factors which resulted in a relatively low animal protein intake; 11 kg. per person per year in Nigeria compared with 40-90 kg. per person per year in Europe and North America. Whereas this would rise as a result of increased wealth, it must also be tackled by reducing the cost of meat in general. The animal which, because of religion, established preference and husbandry knowledge, is most important is the cow. Whilst increased production of milk and milk products was important it was likely to follow the increased production of meat. We must see that the vegetable protein fed to cattle resulted in the maximum yield of animal protein. Wastage was occasioned by disease, by poor growth, by seasonal variation of food and by poor marketing methods. Disease resulted at present in the annual loss of 4% of the total herd of 500,000 head of cattle in Nigeria. This represents a loss of 65 million kilo, or 1.5 kg. of meat per head of the population every year. Eradication of the tsetse fly and rinderpest was now possible.

Cattle in Nigeria are not usually marketed until they are 6-7 years old (compared with 1-3 years in Europe). This slow growth could be avoided by supplementary feeding and selective breeding. A further saving of waste could be achieved by improvements in the distribution and marketing of cattle. The use of feeding ranches and holding grounds before slaughter demands immediate investigation. So also does the problem of transporting animals from the area of production in the north to consumption in other parts of the country. The use of air and rail transport must be increased as losses from disease during the trek from north to south amount to millions of pounds sterling annually.

Turning from cattle, Dr. Wilson mentioned the possibilities of increasing poultry and egg production and the stimulus given to this by battery methods and briefly touched upon problems of disease in goats and sheep. Pig production was increasing rapidly in the country and was a potentially very valuable source of protein.

Discussion of all these papers was wide and mainly concerned subjects not mentioned by the speakers. The meeting considered increased fish production to be vitally important. The question of breeding indigenous wild animals as a food source and the use of husk and other waste products as a protein supplement were also mentioned. Prevention of waste of protein as a result of animal and human parasitic infection was said to be as important as increasing human consumption.

The second half of the symposium was devoted to two specialised papers. Dr. Watson-Williams described the steps which led to the complete analysis of the amino acid sequence of the haemoglobin molecule and mentioned the genetically controlled substitutions which resulted in sickle cell anaemia and related deseases, and the new knowledge that the detailed structure of an individual haemoglobin molecule was the result of the interaction of five pairs of genes.

Dr. Akinrele described the methods that had been used for the extraction of protein from leaves. These had resulted in yields of up to 60% of the total protein in a form suitable for human consumption. The protein was as good as fish meal as a dietary supplement and its source was waste products. The flavour could be completely removed and up to 20 g. a day could be eaten. At the moment the cost of extraction meant that the leaf protein was uneconomic but it is important that this enormous potential reserve of protein should not be forgotten in case future technical developments or social changes altered this situation.

## SPECIALIST PAPERS

### *Agriculture Specialist Section*

Mr. D. G. Coursey (*Federal Institute of Industrial Research, Oshodi, Lagos*)

**The deterioration of palm oil in storage.**

The economic and technical background to the problem of the deterioration of palm oil during storage, which results from hydrolytic decomposition of the glyceride components and resulting liberation of fatty acids was discussed. The investigations carried out by a number of workers in various countries were reviewed, with particular reference to recent work on the chemical aspects of the reaction in the Congo, and that on microbiological factors in Eastern Nigeria. Apparent inconsistencies between the various theories were discussed and elucidated, and consideration was also given to practical problems related to palm oil storage.

Dr. A. N. A. Modebe (*University College, Ibadan*) **Preliminary studies on the effect of limited and unlimited systems of feeding and of tropical-type grass legume clippings fed in dry-lot, on the growth rate, economy of gain and carcase quality of growing fattening pigs.**

Three trials involving a total of 44 pigs were carried out to test the effect of limited and unlimited systems of feeding and of West African legume/grass clippings fed in dry-lot, on the growth rate, economy of gain and carcase quality of growing fattening pigs.

The results indicated that unlimited meal feeding, while not producing significantly greater liveweight gains in pigs than was obtained from pigs fed on the University College, Ibadan feeding scale, resulted in poorer food conversion, higher feed cost and inferior carcasses. The results also indicated that, while there were no statistically significant differences in liveweight gain between pigs fed varying proportions of legume/grass clippings in their ration and those fed an all-meal ration, with regard to feed conversion, carcase quality, and cost of feeding, the pigs fed supplementary legume/grass clippings gave better results. The most profitable treatment group was for the group fed a maximum meal ration of 4 lbs./pig/day plus legume/grass clippings ad-lib. The practical significance of these results was discussed.

Dr. B. N. Okigbo (*University of Nigeria, Nsukka*) **The use of multiple comparisons in significance testing.**

The LSD as a test of significance following significant differences of at least 5% has become a regular practice in the analysis of variance procedure. More powerful tests are now available for as many comparisons as desired or for comparisons of several means with a control. The advantages and disadvantages of these so-called multiple comparisons were discussed.

Mr. B. S. Oloruntoba (*Federal Office of Statistics, Keffi*) **Some problems in the pilot study of the labour time involved in the growing of some major crops in Northern Nigeria.**

The object of the study was to throw some light on the obstacles to the development of agriculture in Northern Nigeria. The study was divided into two phases of which phase I was described. The problems of selection of sample villages, household enquiry, farm survey, yield measurement and of farm operation recording were discussed.

Dr. C. Oyolu (*University of Nigeria, Nsukka*) **Plant development pattern and cultural practices in Nigerian arable crop farming.**

Cultural practices in agriculture are generally intended to expose crops to conditions favourable to maximum production. Consequently they should, ideally, be designed to fit in with the growth and development patterns of crops. To achieve this presupposes a good knowledge of the growth habits and development phases of the crops concerned.

In Nigeria farmers have built up cultural practices based on experience without scientific background. These practices naturally could be improved in the light of scientific studies. With this objective, the growth habits and development phases of yam (*Dioscorea* spp.) and maize (*Zea mays*) which are, respectively, important root and grain food crops in Nigeria have been studied in the past three years.

The results of these studies indicate that:

(*i*) Both crops are shallow rooters, with roots up to 6 ft. or more long in yam.
(*ii*) Yam has its rapid growth rate between 12th and 21st week from planting and the tuber attains maximum growth (measured by increase in dry matter) about the 24th week.
(*iii*) Maize has its rapid growth rate between 4th and 8th week from sowing, the inflorescence emerges between the 6th and 8th week and the plant attains maximum size between the 11th and 14th week.

Some of the recommendations of the extension services, as for example the time and method of fertiliser application to yam and the encouragement of ridging, as opposed to hilling, need re-examination. However, the local cultural practices appear to have a sound basis on which future development could be based.

### Dr. G. P. Tewari (*University of Nigeria, Nsukka*) **A field study to investigate the photoperiodic response of the cowpea** (*Vigna Sinensis* **L.**) **varieties in relation to flower formation and grain yield.**

A field experiment was conducted to evaluate the photoperiodic response of three cowpea (*Vigna sinensis* Linn.) varieties (Paraguay 6, 6247, V-36-1 and 6460, V-106-10) to six planting dates (April 14, May 14, June 14, July 14, August 14 and September 14).

Results showed that the varieties, Paraguay 6 and 6247 V-36-1 were the early flowering types, whilst 6460 V-106-10 appeared to be a late flowering type. It was also noted that the June and April plantings of all three varieties yielded considerably higher than those planted at other times. No clear-cut association between the flowering times and yields performance was observed. It appears that the yielding behaviour of cowpeas is influenced by several other factors in addition to day-length.

## *Botany Specialist Section*

### Mr. J. R. S. Lawton (*Department of Botany, University College, Ibadan*) **Some studies on the translocation of sugars in the stem of** *Dioscorea alata* **Linn.**

### Mr. R. G. Lowe (*Department of Forest Research, Enugu*) **On the histology of the wood of** *Triplochiton scleroxylon* **K. Schum.**

An interim report was given of an investigation of growth-rings in *Triplochiton scleroxylon* from Nigeria. The growth rings appeared to be annual, and were made conspicuous by iodine staining which revealed the pattern of starch deposition in the wood.

Cambial activity, which reached a peak during the rainy season, became sluggish in the dry season. During two months at the end of the dry season xylem differentiation ceased.

Unusual features in the histogenesis of the secondary xylem of *Triplochiton* were the presence of two kinds of parenchyma only one of which contains starch, and the development of spiral thickenings in the fibres which disappear when lignification is complete.

Professor E. Njoku (*Department of Botany, University College, Ibadan*) **Propogation of *Dioscorea* spp. by cuttings.**

Dr. C. Oyolu (*College of Agriculture, University of Nigeria, Nsukka*) **Cultivated yams (*Dioscorea* spp.) of Nigeria.**

Yams are indigenous to Nigeria and have been under cultivation for several centuries. The commonly cultivated yams belong to the following five species:

1. *Dioscorea alata* Linn. (Water yam, has a winged stem).
2. *D. bulbifera* Linn. (Aerial yam, produces bulbils).
3. *D. dumetorum* (Kunth) Pax. (trifoliate yam, trifoliate leaves).
4. *D. rotundata* Poir. (white guinea yam, white flesh).
5. *D. cayenensis* Lam. (yellow guinea yam, yellow flesh).

*D. rotundata* and *D. cayenensis* are the two most important but, unfortunately, their classification is unsettled. Burkill assigned these two species occurring in Nigeria to types originally named by Poiret and Lamark respectively, but he later decided that there was no specific difference between them.

From studies of the five Nigerian cultivated species since 1956 I have come to the conclusion that *D. alata*, *D. bulbifera* and *D. dumetorum* fit into the normal yam classification whilst *D. rotundata* and *D. cayenensis* do not. I do not, however, find any evidence that they belong to one species. The current names appear inappropriate on the basis of my observations and new names were suggested.

## *Physical Sciences and Engineering Specialist Section*

Dr. O. Awe (*University College, Ibadan*) **Irregularities of ionisation in the ionosphere.**

The existing knowledge of irregularities of ionisation in the ionosphere was surveyed. While some types of irregularities are caused by known agencies, much remains obscure and speculative about the origins of other types.

Meteors leave behind them a trail of ionisation as they fall rapidly through the ionosphere. So do the high energy charged particles which invade the earth's atmosphere during magnetic storms and aurorae. These irregularities are pencil-like in shape and are able to reflect back to earth radio signals which would otherwise have escaped into outer space. Meteor trails of ionisation probably move with the unionised gases present at the heights at which they occur, while auroral irregularities are thought to move relative to the unionised gases.

There are isolated irregularities of ionisation which travel large distances in the ionosphere without undergoing any appreciable changes of form. They are thought to be large scale (sometimes extending over 1,000 km.) travelling disturbances which propagate through the ionosphere and distort the normal distribution of ionisation.

The irregularities which cause the fading of medium and high frequency radio signals are present at all heights and are randomly distributed throughout the ionosphere. Their shapes and sizes vary with height and with geographical location.

The patches of ionisation which occur near a height of 100 km. constitute what is referred to as the Sporadic E layer, a name which derives from the sporadic nature of the time and place of occurrence of this layer in the E region of the ionosphere.

There are also the irregularities of ionisation which cause the phenomenon known as Spread F. Probably these irregularities are the cause of the scintillations of radio stars and of signals from artificial earth satellites. These irregularities are elongated along the lines of force of the magnetic field of the earth.

Apart from auroral irregularities, all irregularities which occur below a height of about 90 km. probably move with the same velocity as the neutral air, while the relative velocities which exist between the irregularities and the neutral gases above this height are thought to increase with height.

### Dr. D. Goddard (*University College, Ibadan*) **Stability of metal complexes.**

The stability constants of metal complexes can be correlated with various properties of the metal ion and ligand. The influence of factors such as basicity of ligand, chelate ring size, steric interference, electronegativity of the metal ion, polarisability of the ligand, nature of the donor atom, will be considered.

Direct proportionality between the stability constant and basicity of the ligand is found to apply only to a very restricted range of ligands. This is because metal ions differ from hydrogen ions in having much higher electronegativity and also the capacity for forming double bonds. The effect of chelate ring size and steric interference can be simply explained in terms of geometry of the complex.

Irving & Williams have shown that for a wide variety of ligands the stability order for complexes of the divalent metal ions of the first transition series is $Mn < Fe < Co < Ni < Cu > Zn$ and that this order corresponds with that of the electronegativities of the metal ions as measured by the sum of their first and second ionisation potentials. The rise in stability along the series is particularly marked with ligands linking via nitrogen rather than oxygen which suggests that it is due to enhanced covalent rather than ionic bonding. The ligand field theory interpretation of this rise in terms of the stabilisation of d-orbitals will be discussed.

Chatt has considered the effect of the nature of the donor atom on the stability of complexes. He found that metals could be divided into two classes, class 'a' metals which formed their most stable complexes with first member of a group of the Periodic Table (e.g. O, N, F) and class 'b' metals which formed their most stable complexes with the second or subsequent member of the group. Chatt explains this division in terms of class 'b' metals possessing the capacity to form double bonds with the heavier donor atoms, but this explanation is not universally accepted, others preferring to regard class 'b' metals as possessing ions of high polarising power which naturally form their strongest bonds with the heavier more polarisible donor atoms.

So far not much work has been done on the stability of complexes involving the heavier donor atoms (e.g. P, S, Se) owing to experimental difficulties but there are indications that the study of complexes with these donor atoms may be of much help in understanding the nature of bonding in complexes. Stability studies are not only of theoretical interest but may lead to the design of new complexing agents for analyses and to a greater understanding of the role of metal complexes in biological systems.

### Mr. E. H. McKoy (*University College, Ibadan*) **Some aspects of instrumentation in physical research.**

The initial application of many of the current devices found in the electronics industry led to a general expansion in the type and quality of instruments available and in turn created an increasing demand for improved components as well as completely new components better suited to given applications.

Many of the components which have far reaching significance, not only in the field of general communication, but in the design and development of computing devices were reviewed including transistors, zener diodes, tunnel diodes, silicon junction rectifiers, ferrite cores and electronic scaling and indicator tubes, electro-luminescent devices and the cathode ray tube. In addition, the demand of satellite vehicle instrumentation has led to the development of new sources of electric power, which were briefly summarized.

Prof. R. C. Mitchell-Thome (*University of Nigeria, Nsukka*) **Preliminary estimates of average annual available ground water supplies in Nigeria.**

Adequate basic data on various hydrologic parameters for Nigeria as a whole are not available and it is not possible to gauge with reasonable precision the annual increments to the water table. However, from scattered information a preliminary estimate may be attempted, with full awareness of the imperfections of the results obtained.

These calculations, nevertheless, serve a purpose in relation to various aspects of water development and consumption. The realizations of an increasing population, expansion in industry and agriculture, proposed irrigation schemes, augmentations for municipal needs, all hinge upon the presence of adequate quantities of water.

The possible annual groundwater supplies were estimated.

## *Zoology Specialist Section*

Dr. D. A. Dorsett (*Department of Zoology, University College, Ibadan*) **The flight of hawk-moths.** (Paper read by Dr. Olaniyan)

The problems presented to the physiologist by the flying insect are somewhat different to those of an aeronautical engineer dealing with a flying aeroplane. The major differences are that the wings of the insect are providing by their movement both the lift force and the forward motion, and these forces are varying continuously throughout the wing beat cycle.

As in vertebrates, muscular activity in the insect is accompanied by a rise in temperature. This is particularly noticeable in the thorax where the flight muscles are located. Prior to flight, many Lepidoptera find it necessary to warm up the flight muscles, and this presupposes that at normal ambient temperatures the power that can be developed by the flight muscles is insufficient to sustain controlled flight. Warming is achieved by slow flexions of the wings in *Vanessa* which raise the temperature by 3—5°C., and by a more rapid quivering of the wings of hawk-moths which may raise the temperature of the thorax as much as 25°C.

The hawk-moth takes off vertically and therefore the power developed by the wings is concerned only with raising the weight of the insect. The thrust is dependent on the density and volume of the air moved by the wings, the latter varying with the area and angle of attack, the amplitude of the wing stroke and its frequency. The principal effect of the temperature rise in the thorax is to allow the muscles to work more rapidly thus affecting both the frequency and the amplitude of the wing beat.

Experimental evidence leads to the conclusion that with the possible exception of gravid females, most hawk-moths have plenty of power in reserve at take off and in flight. The implications of this in the large distances covered during flight and the small degree of intraspecific variation within the family throughout the entire geographical range were discussed.

Dr. J. C. Ene (*Department of Zoology, University College, Ibadan*) **Parental care and gregarious behaviour shown by a West African mantis:** *Tarachodes* (*Barbachodes*) *afzelii* **(Stal).**

Records of parental care behaviour among the Dictyoptera are very scanty indeed. Only two instances of rudimentary care for their oothecae have previously been recorded in the Mantodea—one in Bali island, the other in South Africa.

Gregarious behaviour on the other hand, is hitherto unknown in the group. *Tarachodes afzelii* is a primitive and somewhat rare West African mantis, which not only guards its egg mass throughout the incubation period, but also during the early part of the first instal period of the resulting nymphs. The nymphs remain aggregated during the first two days after eclosion, and show group behaviour which probably reduces their mortality rate. The behaviour of parent and offspring during their association are described, the survival value is assessed, and the evolutionary implications discussed.

*Tarachodes* is a homogenous genus, most females being brachypterous and thus incapable of flight, cryptically coloured, and little known. It is possible that, contrary to accepted opinion, the behaviour patterns described here are common amongst them.

Any manifestations of gregarity would be of interest as they throw some light on the possible origins of social life in insects.

Mr. R. M. Gambles (*Veterinary School, Vom*) **The larval stages of the Nigerian dragonflies, their biology and development.**

Very little is known about the larval stages of African dragonflies and what information there is, is almost entirely concerned with the full grown larvae. This paper is based upon various observations made during the past twelve years.

A brief description was given of the life history of the dragonfly and of the features of the three main types of larvae found, with special reference to the feeding mechanism, the respiratory apparatus, and the secondary use of this latter for locomotion.

There are two main methods of studying the life history: the detailed method of obtaining eggs and rearing these up to the adult stage, and the synthetic method of collecting material of various stages in the natural habitat, rearing these through at least one moult, and piecing the results together in hopes of obtaining the complete picture. The truest picture can be obtained by a combination of the two methods.

For ecological study, it would be desirable to identify both the species of any larva found and the stage which had been reached. The former would be done mainly by morphology, and the latter mainly by measurement. The number of larval stages is not constant even between individuals of the same species, but each group appears to have a basic pattern to which it more or less conforms. Additional stages may be intercalated, or others suppressed. One measurement commonly used, total length, is unsatisfactory as the length of the abdomen varies from moment to moment. The width of the head is far more satisfactory. As this increases by roughly 25% with every moult, and the wing rudiments which start as something infinitesimal at about the fourth stage roughly double their length every time, the ratio of head width to length of hind wing rudiment is a very useful figure to use. It is much less likely to overlap from one stage to another by individual variations, than any single measurement.

Specialised adaption to particular environments, structural or physiological, was discussed.

The respiratory mechanism and the associated structures seen in the Zygoptera and in the Anisoptera were compared and correlated in an attempt to trace the origin of these specialisations.

## OTHER ACTIVITIES

A Reception in honour of the Association was given by the Eastern Premier (Dr M. I. Okpara) at his Official Residence following the formal opening ceremony. A successful Conference Dinner was held on the final night of the Conference at the Catering Rest House, Enugu, at which the Branch Principal of the Enugu Branch of the Nigerian College (Mr A. V. Lawes) proposed the toast to the Association and the retiring President (Professor J. C. Edozien) replied.

Excursions were made to the Ekulu Coal Mine and Pottery and to the Oji River Leper Settlement, Power Station and Rural Health Centre. On the Sunday two longer excursions were made: one to Abakaliki where the poultry farm and the cement factory at Nkalagu were visited; the other to visit the carvers at Awka, the caves at Ogbunike, the erosions at Agalu and the initial stages of the Niger Bridge at Onitsha. Two post-conference excursions, each lasting a few days, were held. One of these visited Umudike, including the Agricultural Research Station, Ikot Ekpene and Port Harcourt where the Headquarters of the Shell-BP Petroleum Development Company and an oilfield were visited. The other proceeded to the Obudu Plateau where the Eastern Region Development Corporation cattle ranch was visited.

Film shows took place on several evenings during the Conference when the following films were shown:

| | |
|---|---|
| *Energetically Yours*<br>*More Power from the Atom*<br>*Ways of Water*<br>*World of Plenty* | presented by the United Kingdom Information Service |
| *Harvest for Tomorrow*<br>*Hold Back the Sea*<br>*New Explorers* | presented by the Shell-BP Development Company Ltd. |

There was a General Exhibition of displays by commercial firms and government departments, etc.

*Report of the Hon. Secretary*

This report covers the period 1st December 1960 to 1st December 1961.

*Membership*

| Type of Member-ship | 1960 Total Members | 1961 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gain in Mem-bership | Loss in Membership | | | | | Net Increase in Member-ship | Total Members |
| | | | By Resignation | | By unpaid Subcriptions | | Total Loss | | |
| | | | On Leaving Nigeria | Still in Nigeria | Left Nigeria | Still in Nigeria | | | |
| Ordinary | 163 | 30 | 1 | 1 | 2 | 34 | 38 | — 8 | 155 |
| Associate | 9 | 5 | 0 | 0 | 1 | 1 | 2 | 3 | 12 |
| Corporate | 49 | 12 | 0 | 0 | 0 | 6 | 6 | 6 | 55 |
| TOTAL | 221 | 47 | 1 | 1 | 3 | 41 | 46 | 1 | 222 |

The main feature for comment in this table is the large number of members who have not paid their 1961 subscriptions. Subscription reminders went out later this year than usual and subscriptions are still coming in. Thus many of these members are only 'lost' on paper. Of those who are actually lost, several appear to have left Nigeria without informing the Association.

The geographical and occupational distributions of Ordinary Members are shown in the following tables.

*Geographical Distribution of Ordinary Members*

| | | Number | Percentage | 1960 Percentage |
|---|---|---|---|---|
| Lagos | | 20 | 13 | (11) |
| Eastern Region excl. | Enugu | 22 | 14 | — |
| | Enugu | 8 | 5 | — |
| | Total | 30 | 19 | (12) |
| Western Region excl. | Ibadan | 11 | 7 | ( 7) |
| | Ibadan | 56 | 36 | (37) |
| | Total | 67 | 43 | (44) |
| Northern Region excl. | Zaria | 14 | 9 | ( 9) |
| | Zaria | 16 | 10 | (20) |
| | Total | 30 | 19 | (29) |
| Overseas | | 8 | 5 | ( 4) |
| Total | | 155 | | |

*Occupational Distribution of Ordinary Members*

| | Number | Percentage | 1960 Percentage |
|---|---|---|---|
| Universities | 8 | 18 | (17) |
| Technical Colleges | 17 | 11 | (13) |
| Schools | 30 | 19 | (16) |
| Government | 66 | 43 | (51) |
| Others | 14 | 9 | ( 3) |
| Total | 155 | | |

These figures show that there has been a considerable loss in members from Zaria many of whom were attracted to join by the Second Annual Conference and whose interest has not been maintained. A large gain in membership has come from the Eastern Region.

The decrease in 'Government' and increase in 'Others' in the occupational table is largely due to members leaving Nigeria.

*Council*

Council has held six meetings at two-monthly intervals during the year.

Council have co-opted Professor J. Grayson (ex-President), Mr H. Hardie (Chairman, Local Committee), Mr K. H. Hatherly (Secretary, Local Committee), Dr A. J. Lyon (Chairman, Physical Sciences and Engineering Specialist Section) and Mr A. M. Oseni (Public Relations Officer).

Because of its more frequent meetings, Council decided to take over the work of the Publicity and the Supply of Scientific Workers Committees. It has appointed a Public Relations Officer to deal with publicity on its behalf.

Council has considered reports both from Nigeria and overseas on the formation of a national Council for Scientific Development and has approached the Federal Government with its views.

Council decided to encourage the formation of Branches which would be complementary to the Specialist Sections. Council decided that it would consider for approval applications by groups of members, based on a large town, to form a Branch. Branches would be known as: Science Association of Nigeria (name of town) Branch. Branches would organise their own activities within the Association.

The Hon. Secretary has had an informal discussion with the Hon. Secretary of the Eastern Nigeria Science Association concerning the affiliation of the two Associations. Council invited the Eastern Nigeria Science Association to become a Branch of S.A.N. and agreed, that for this particular case only, the regulation that the Branch should be based on a large town would be waived. No reply to this invitation has yet been received.

A committee to enquire into the availability of scholarships for Nigerian scientists at all educational levels has been set up but has not yet completed its investigations.

The first issue of the *Proceedings* of the Association, which deals with the first three Conferences, is in the hands of the printer.

The Ibadan Conference of the West African Science Association was discussed in a leading article entitled *Science in West Africa* published in *Nature* of 1st April 1961. Unfortunately, reprints of this Editorial were not available. Permission to reprint has now been received from the Editors of *Nature* and the article is in the hands of the printer.

Council has planned the Fourth Annual Conference to be held in Enugu. In this it has been admirably assisted by an active Local Committee who have been working under the strain of organizing a Conference in an institution which has changed its status and governing body.

Preliminary arrangements have been made to hold the Fifth Annual Conference in Lagos.

Council decided that the Specialist Sections should be really specialized and has therefore arranged that Specialist Section meetings should take place simultaneously during the Enugu Conference. Council has, however, suggested that where topics which would interest more than one Specialist Section are to be discussed, joint meetings should be held.

Council has refused a request for the formation of a Science Education Specialist Section as it was felt that this would only lead to duplication of efforts by S.A.N. and the Science Teachers Association of Nigeria.

The Association now receives *Scientific Abstracts* monthly from the Federal Institute of Industrial Research. This together with a wide variety of miscellaneous pamphlets are forming the nucleus of a library.

# *Report of the Hon. Treasurer*

Income has remained about the same as last year, but as there was a slight excess from the December 1960 Conference the financial position is slightly better.

The balance of £160 from the Federal Government Subvention a/c has been earmarked for publication of the Proceedings of S.A.N. The balance of the Cocktail a/c has since been refunded to the Federal Government.

Two important items of expenditure, Fund for Meetings, and Secretarial Help are bound to increase from year to year. At present there is no cause for anxiety in view of the Federal Government Subvention.

The Savings a/c of the Association has fallen to about £400 but continues to yield some interest.

## GENERAL ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|---|---|---|---|
| B/Forward 1959/60 | 350 | 5 | 7 | Printing | 11 | 5 | 0 | | | |
| 1959 Subscriptions | 2 | 2 | 0 | Stationery | 35 | 17 | 1 | | | |
| 1960 Subscriptions | 109 | 4 | 0 | Stamps and Postage | 16 | 17 | 11 | | | |
| 1961 Subscriptions | 419 | 1 | 0 | Bank Charges | 9 | 11 | 6 | | | |
| Interest on Savings | 14 | 2 | 2 | Secretarial Help | 17 | 19 | 9 | | | |
| Sundries | 7 | 4 | 6 | Vol. VI W.A.S.A. Journal | 366 | 6 | 0 | | | |
| | | | | Sundries | 9 | 5 | 2 | | | |
| | | | | To Fund for Meetings | 7 | 13 | 9 | 474 | 16 | 2 |
| | | | | Excess Income | | | | 427 | 3 | 1 |
| | 901 | 19 | 3 | | | | | 901 | 19 | 3 |

## FEDERAL GOVERNMENT SUBVENTION ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|---|---|---|---|
| From Federal Government | 500 | 0 | 0 | W.A.S.A. Journal Subvention | 300 | 0 | 0 | | | |
| | | | | Fund for Meetings | 40 | 0 | 0 | 340 | 0 | 0 |
| | | | | Excess Income | | | | 160 | 0 | 0 |
| | 500 | 0 | 0 | | | | | 500 | 0 | 0 |

## FUND FOR MEETINGS

| *Income* | £ | s | d | *Expenditure* | £ | s | d |
|---|---|---|---|---|---|---|---|
| Brought Forward | 200 | 0 | 0 | Transport and Passages | 195 | 13 | 9 |
| From Federal Government Subvention | 40 | 0 | 0 | Speakers accommodation | 52 | 0 | 0 |
| From General a/c. | 7 | 13 | 9 | | | | |
| | 247 | 13 | 9 | | 247 | 13 | 9 |

## COCKTAIL PARTY ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d |
|---|---|---|---|---|---|---|---|
| From Federal Government | 300 | 0 | 0 | 200 Guests at 7/6d each | 75 | 0 | 0 |
| | | | | Flood Lighting | 2 | 5 | 10 |
| | | | | Excess Income | 222 | 14 | 2 |
| | 300 | 0 | 0 | | 300 | 0 | 0 |

## 1960 CONFERENCE ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d | £ | s | d |
|---|---|---|---|---|---|---|---|---|---|---|
| Conference Fees | 66 | 10 | 0 | Conference Office Expenses | 7 | 15 | 1 | | | |
| 132 Dinner Tickets | 132 | 0 | 0 | Exhibition | 1 | 6 | 3 | | | |
| Accommodation | 168 | 19 | 6 | Invitation Cards | 12 | 10 | 0 | | | |
| Sundries | | 18 | 0 | Stationery | 25 | 0 | 4 | | | |
| Bus Fares | 2 | 4 | 0 | Printing | 9 | 0 | 0 | | | |
| | | | | Notice Boards | 6 | 14 | 6 | | | |
| | | | | Coffee | 12 | 0 | 0 | | | |
| | | | | Bus Hire | 3 | 8 | 0 | | | |
| | | | | 120 Dinners at 15/- each | 90 | 0 | 0 | | | |
| | | | | Miscellaneous Refunds | 4 | 16 | 6 | | | |
| | | | | Accommodation Refunds | 10 | 0 | 0 | | | |
| | | | | Conference Accommodation | 135 | 7 | 0 | | | |
| | | | | Sundries | 4 | 15 | 7 | 322 | 13 | 3 |
| | | | | Excess Income | | | | 47 | 18 | 3 |
| | 370 | 11 | 6 | | | | | 370 | 11 | 6 |

## BALANCE SHEET
(30th June, 1961)

| | £ | s | d |
|---|---|---|---|
| General a/c. | 427 | 3 | 1 |
| Federal Government Subvention a/c. | 160 | 0 | 0 |
| Cocktail Party a/c. | 222 | 14 | 2 |
| 1960 Conference a/c. | 47 | 18 | 3 |
| Cheques not presented | 8 | 11 | 7 |
| | 866 | 7 | 1 |

| | £ | s | d |
|---|---|---|---|
| Cash in Current a/c. at Barclays Bank (D.C. &. O.), Agodi, Ibadan | 444 | 0 | 11 |
| Cash in Savings a/c. Barclays Bank (D.C. & O.), Agodi, Ibadan | 414 | 1 | 2 |
| Cash in Hand | 8 | 5 | 0 |
| | 866 | 7 | 1 |

C. I. O. Olaniyan,
*Hon. Treasurer.*

I have audited the accounts of the Association and found them correct.

C. A. Onwumechilli *Hon. Auditor.*

At this meeting the reports of the Hon. Secretary and Hon. Treasurer were received, elections held and the two following amendments to the Constitution passed:

(*i*) item 4 (b): that the word "six" be amended to read "eight".
(*ii*) item 4 (c): second sentence: that the phrase ",which may be made either by Council or by members of the Association," be inserted between the word "Nominations" and the word "must."

*Council Membership for 1961*

*President* : Dr. J. C. Edozien (later Professor)
*Vice-President* : Mr. G. E. O. Okiy
*Hon. Secretary* : Dr. B. Hopkins
*Hon. Treasurer* : Dr. C. I. O. Olaniyan
*Ordinary Council Members* : Mr. T. O. Fayiga
Father J. A. Fitzpatrick
Mr. R. W. J. Keay
Professor E. Njoku
Dr. C. A. Onwumechilli
Dr. W. R. Stanton

*Specialist Section Representatives*
*Agriculture* : Dr. D. H. Hill
*Botany* : Mr. C. F. A. Onochie
*Medical Sciences* : Dr. E. J. Watson-Williams
*Physical Sciences and Engineering* : None
*Zoology* : Dr. D. A. Dorsett
*Ex-President* : *Professor J. Grayson
*Chairman Local (Enugu) Committee* : *Mr. H. Hardie
*Secretary Local (Enugu) Committee* : *Mr. K. H. Hatherly
*Chairman Physical Sciences and Engineering Specialist Section* : *Dr. A. J. Lyon
*Public Relations Officer* : *Mr. A. M. Oseni

*co-opted.

PROCEEDINGS OF THE

# SCIENCE ASSOCIATION OF NIGERIA

*Volume* 5 1962

PUBLISHED OCTOBER 1963

## CONTENTS

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EDITOR
Dr. B. HOPKINS
*University of Ibadan*

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UNIVERSITY OF IBADAN

## FIFTH ANNUAL CONFERENCE

The Fifth Annual Conference of the Association was held at King's College, Lagos from Saturday 15th December until Wednesday 19th December 1962 on the general theme of *The Role of Science in the Industrial Development of Nigeria.*

### OPENING CEREMONY

Mr. P. H. Davies, the Principal of King's College, briefly welcomed delegates and wished the Association a successful meeting.

Senator Dr. the Hon. E. A. Esin, the Acting Minister of Health in the Federal Government read the following message from His Excellency, the Right Honorable Dr. Nnamdi Azikiwe, P.C., Governor-General and Commander-in-Chief of the Federation of Nigeria:

"I deem it a great honour to have been invited by the Council of the Science Association of Nigeria to perform the official opening of this year's Conference. I regret that absence from Lagos makes it impossible for me to be physically present with you on this happy occasion.

"I understand that your Conference will discuss generally "The Role of Science in the Industrial Development of Nigeria" and will give prominence to a symposium on "Harnessing the Niger". I am sure the country will benefit immensely from your deliberations, realising that our political autonomy must be complemented with economic freedom.

"Nigeria as a developing country has been handicapped not only because it depended mainly on rural agriculture, but because, in our educational system, emphasis was not sufficiently placed on scientific knowledge, the result is that the production of Nigerian scientists is far below those in other fields of learning. Experience is beginning to make us realise that basic knowledge in science is fundamental to industrialisation and expansion of the agricultural sector of our economy.

"I, therefore, share the ideals of this Association and hope that through its activities, the dissemination of scientific knowledge will be increased so that Nigeria may produce more scientists and research workers. I hope that the Science Association of Nigeria will extend its frontiers of operation so that in future it may be possible to establish our own National Academy of Sciences with branches all over the country.

"I welcome the delegates to your Conference and wish them a happy stay in Lagos. I now have the honour to declare this Conference open."

Dr. E. Njoku then delivered his Presidential Address:

"Hon. Minister, Ladies and Gentlemen,

"The President of the Association for this year is Mr. R. W. J. Keay. But because of his retirement and his leaving Nigeria in September of this year, the Council of the Association asked me to fill the role of President for the remainder of the year.

"I should therefore make it clear at the outset that the affairs of the Association during the year have been guided by Mr. Keay and not by me. The organisation of the meetings of the Council during the year and the planning of this conference have all been carried out under his wise guidance.

"Mr. Keay is well-known in Nigeria for his scientific work. His achievement as a taxonomic botanist has been highlighted by his work in the revision of the *Flora of West Tropical Africa*. We are familiar with his ecological work through his *Outline of Nigerian Vegetation* and numerous articles. As Director of the Federal Department of Forestry Research he showed administrative ability of a high order. He sponsored the recent progress made in that Department in improved organisation such as the addition of new sections of Forest Soils and Forest Production, in scientific work as shown by the work of the Forestry Herbarium which is practically the Nigerian national herbarium, and the recent publication of *Nigerian Trees* in collaboration with other members of his Department.

"Keay was also a great enthusiast for the proper organisation of scientific work in Nigeria. He was an enthusiastic supporter of the West African Science Association from its foundation and has served it both as Secretary and as a member of the Editorial Board of its Journal. When later the Science Association of Nigeria was launched he was one of those whose untiring efforts made it possible. He has been continuously on the Council of the Association and has retired as President. Clearly, Science in Nigeria owes a great debt to Ronald Keay and his early retirement has left a gap which will be difficult to fill. I am sure all members of the Association will join me in wishing him well in his new work with the Royal Society of London. Although his work there will be mainly administrative we all hope he will continue to take an interest in Science in Nigeria.

"Hon. Minister, Ladies and Gentlemen, I would now like to read to you a message which Mr. Keay has sent to this Conference:

'When the Science Association of Nigeria honoured me last year by electing me President, I fully expected to be at this Fifth Conference in Lagos. I am, however, now working at the Royal Society, London, and can only apologise for my absence and send greetings.

'These annual conferences of the Science Association of Nigeria certainly provide a most valuable opportunity for scientists of different disciplines and from different parts of Nigeria to meet together and to exchange ideas. But they also focus attention on the ever-growing importance of science in our national life.

'It is right that scientists should be enthusiasts for their own subjects, and in these days each scientist's energies must be concentrated on a narrow front if progress is to be made. But this does not mean that he is unaware of the relevance of his studies, and indeed of science as a whole, to the needs of the nation. The Council of the Science Association of Nigeria has, in fact, given a good deal of thought to the wider issues, and members of the Association are playing active and often leading parts in many of the most important enterprises of the day. I refer particularly to primary production (agriculture, forestry, mining, fisheries etc.), education, health and nutrition, transportation and power, and the special theme of this Conference—Science in the industrial development of Nigeria.

'Your Excellency, during your travels, you will, I am sure, have met scientists at work in many parts of the Federation—in the universities and colleges, in government departments and institutes, in industry and hospitals and in many other public enterprises. The sum total of this scientific effort in Nigeria is quite considerable, though certainly inadequate, and the Science Association of Nigeria has long felt that some overall planning is needed if the fullest use is to be made of our available resources.

'Many countries have found it valuable to have a high level council of distinguished scientists to advise government on scientific matters. This cannot be the function of a single Ministry, for so many different Ministries and non-governmental organisations are concerned with science. The relative importance of the many different fields of science can only be determined at the highest governmental level, but decisions of such far-reaching consequence ought to be based on the best possible scientific advice.

'May this conference be a stimulus to all who attend, and a significant contribution to the economic development of Nigeria.'

"In this message, Mr. Keay has struck a note which has persisted throughout all the annual conferences of this Association. I refer to that part of his message where he says that "the Science Association of Nigeria has long felt that some overall planning is needed if the fullest use is to be made of our available resources" and where he goes on to suggest that a high-level council of distinguished scientists should advise the government on scientific matters. When I gave the first Presidential Address at Zaria in December, 1959, I called for just such a council, a National Science Council. In his Presidential Address at Ibadan in December, 1960, Professor John Grayson again made this plea and last December at Enugu Professor Edozien in his Presidential Address strongly reinforced the proposal that a scientific body should be set up to co-ordinate scientific work in the country and advise the Government on scientific policy.

"Unfortunately, nothing has resulted from these requests which have been put to the Federal Government through the Ministry of Economic Development by means of memoranda, reprints of presidential addresses and by delegations. It is acknowledged on all sides that scientific achievement is a feature of an advanced modern society and provides knowledge and techniques which are necessary for the development of young countries like ours and for the general welfare and strength of society. Nigeria has just launched a six-year development plan the success of which will depend on the application of scientific techniques, and yet the promotion of scientific effort does not receive sufficient attention. The morale of scientists working in government research institutes has been allowed to fall to abysmally low levels. The uncertainty of the future of those research institutes which were run on a West African basis has made matters even worse not only for the direction of policy but for the individual research workers. Now that it is clear that these institutes are no longer going to be run inter-territorially but on a Nigerian basis, is this not the right time to overhaul them and put their administration under well-organised Research Councils in the membership of which scientists will predominate? A number of such Research Councils working under the general aegis of an advisory and co-ordinating National Science Council would seem to be the ideal arrangement.

"As far as the Research Institutes themselves are concerned, it is becoming more and more obvious that their future lies in their close association with the universities. Such an association will benefit not only the scientific work of these institutes and the prospects of the scientists working in them, but it will also contribute to a solution of the problem of the acute shortage of scientists for both university and research institute work since it would lead to a more flexible and a more rational use of our scarce resources. In this connection it is interesting and gratifying to note that the Northern Regional Government Agricultural Research Station at Samaru is now going to be closely associated with the Ahmadu Bello University. One hopes that more of such marriages will take place.

"Although previous appeals to the Governments for a more rational organisation and support of scientific work appear to have fallen on deaf ears, the Science Association of Nigeria must not tire of making representations on this matter. Other underdeveloped countries have found it necessary to mobilise their scientific effort for increasing the rate of development—India, Pakistan, Middle East countries and, nearer home, Ghana. All these countries have either on their own or with the advice and assistance of the United Nations organisations, such as UNESCO, set up National

Science Councils, or National Academies. Nigeria cannot long lag behind in this respect if she hopes to take the lead which her size and natural resources can support.

"Meanwhile, the Science Association of Nigeria must continue to carry out what is indeed its main function, that of providing a forum on which scientists working in Nigeria can meet and discuss their work. This is an essential function because progress in science, like progress in political affairs, Mr. Minister, depends on an enlightened public opinion. This Association provides the public opinion of science in Nigeria to which individual scientists can submit their work and benefit by the expressed opinion of other scientists. Moreover, as has been amply shown in the history of science, the work of any one scientist depends on his knowledge of the work of others. And so through these annual conferences and through the publication of the Association's Journal and Proceedings scientists in Nigeria can keep in touch with each other. In this work we have been more successful in getting Government support and we acknowledge with gratitude the subvention which the Federal Government is giving us.

"Before I end this address, I would like to refer briefly to the important theme of this Conference: *The role of science in the industrialisation of Nigeria.* The various papers which are going to be read and discussed at this Conference underline what I said earlier about the importance of scientific work for the economic development of the country. The general papers range from those dealing with food technology, rubber production, timber science, building research, and industrial health, to the papers which make up the symposium on the all-important Niger dams project, and then there are also the papers in the specialist sections as well. I am sure that not only will this Conference be an enjoyment to the scientists taking part, but the proceedings will indicate some of the lines along which future research will most assist the economic development of Nigeria."

Shortly after the Presidential Address, the Association had the privilege of listening to Professor A. R. J. P. Ubbelohde, F.R.S., who delivered an Evening Discourse on *Education and science in the nation's future.*

"One of the advertising slogans recently used by the publishers of a popular Encyclopaedia of Science is 'Science, the Passport to Progress'. At the present time this contention, that the conservation and progressive improvement of a nation's wealth and prosperity can be enormously helped by applied science does not need much vindication. Governments of many countries faced with very different kinds of problems have accepted the responsibility to promote the fullest use and development of science, as one of the primary concerns of good administration. This responsibility is obviously linked with other primary concerns of good government, such as prosperous commerce and trade, education and public health. But although these concerns are of course linked together, experience shows that science must be protected as an independent human activity, and needs to be cultivated as one of the modes of human knowledge, to be most richly fruitful even for application to many urgent practical needs. Any balanced and comprehensive view of the role of science in a nation's future needs to include learning as well as practice in the scientific approach to nature. Scientific progress needs to be continuously generated by new research, which demands special provision and protection in centres of learning such as the universities or research institutes.

"You may think that to begin an introductory address with such an academic requirement shows a gross lack of practical perspectives. Here we are in Nigeria, one of the most exciting countries in Africa, big with all kinds of possibilities. We all know that in proportion to its population its natural resources look unusually promising, with no obvious obstacles to technological progress. Practicable reserves of power are already established, both in respect to hydro-electric generation, and in respect to indigenous sources of oil and natural gas. Mineral deposits are well-known for at least one commodity of world importance, tin. As means of transport are developed, other mineral resources are practically certain to be discovered. Agriculture is a primary source of natural wealth, and obviously holds out the promise of handsome returns for suitable applications of scientific knowledge. In all, these national advantages warrant urgent development by practical men, suitably trained of course as power engineers, or mining geologists or agricultural scientists. Why should I insist on science as one of the universal objects of learning, as one of the goals of human knowledge about the world we live in? The reason for this insistence is that we are concerned with national growth. Growth of a nation has often been compared with growth of a human being, particularly when the aim is to stress the proper balance between different parts of the body politic, and to focus attention on the forms of communication which ensure their working helpfully together. Movements of the hand must be co-ordinated with movements of the foot and head, with hearing and sight and speech, even in a single body, for a man to be effective and to live happily. In a similar way, balance and co-ordination are of supreme importance for national greatness.

"Thus, in discussing science and education in the future of a nation we can never at any time forget problems of co-ordination between different individuals fulfilling different specialist functions. Co-ordination of parts of the body in learning to ride a horse or to play cricket or to use a musical instrument is very definitely a matter of training and education. Great natural geniuses sometimes learn a finished art with astonishing speed but the average man for whom the normal educational programmes are designed requires a considerable period of time to reach competence. Various aspects of the time factor in growth are of particular importance for Nigeria's future. One has to consider time factors in the growth of individuals, time factors in the growth of co-ordinated activities between individuals in any organisation, time factors in the growth of co-ordinated activities between organisations. It takes time to invest physical capital in developing the natural wealth of a country. This aspect of growth is familiar for individuals since mistiming in the growth of any part of the human body can be a dire misfortune. Can anything useful be said about the time factors in the growth of education and science in a nation's progress?

"One general comment about growth rates in technological progress is often made, but nevertheless warrants repeating. Natural science in its modern quantitative and experimental approach to the world in which mankind has to live is relatively extremely recent. The fraction of the world's population that is trained to a recognisable level of competence in the understanding and in the application of any branch of science has increased so rapidly, that in any one of these branches, often more than half of all scientists since the world began are alive now. This extremely rapid multiplication of scientists and technologists in every country means that in one respect all are faced with problems which rapid growth always brings with it. In respect of rates of change of material conditions of living, Africa's growth problems in science and education are not really exceptional. So far as can be foreseen in the decades ahead, all the nations of the world are faced with the increasing tempo of technological progress, and with consequent rapid changes in material conditions of living.

"But although rapid change is taking place everywhere through applications of science to the material needs of living, Nigeria has the advantages as well as all the extra problems of being nearer its own beginning with respect to this kind of growth. From one aspect, being nearer the beginning simplifies the decisions about priorities in the national effort. Obviously, the country needs technically competent people of all kinds. This applies to the most highly educated scientists and technologists, the men—and women too—with university training. The country's need is quite as important on a much larger scale numerically, for technicians with less complex training. A sense of realism shows that an army with only generals and colonels is useless for fighting. Trained rank and file are just as important for attack on poverty and disease as for more obvious and more primitive forms of warfare. A pyramid to be stable needs many more stones at its base than at its apex. When it is required to plan the training in science for various national needs, suitable provision must be made obviously for education of the future leaders; but it is quite as important to train and educate the rank and file who are to work with them.

"In the extremely rapid technological progress taking place everywhere, keeping these different levels of activity reasonably well co-ordinated and in reasonably harmonious relationship presents many human, social and political problems all over the world. It is important to visualise African problems of growth and co-ordination at different levels, in the perspectives of political wisdom, and in relation to analogous problems in countries elsewhere, even when these appear to be at very different stages of technological progress.

"First, to refer to university education. For Nigeria, a substantial part of the necessary education and training can obviously be obtained in the short term by sending her keenest young men and women to study abroad. Particularly for those who need training up to university levels, the numbers are not overwhelmingly large; though undoubtedly the cost is high, the rewards for properly designed programmes are very high. As a member of London University I am proud to refer to the many young Nigerians who have made use of its broad range of educational opportunities, and trust they will continue to do so. I like to think that the remarkable fusion of four quite different peoples in Britain—English, Scots, Welsh and Irish—has bred as it were a special aptitude for understanding and making allowances for the other man's point of view even when and particularly when it is annoyingly different. Nigeria is endowed with somewhat similar internal differentiation of constituent peoples. Granted the will to co-operate, this controlled diversity can be a source of political wisdom and national greatness. Certainly in education it adds richness of diversification to the strength of local pride and enterprise.

"But you need not tell a University Professor that the obtaining of a university degree in any subject, even with high honours, does not by itself qualify the student to become a useful member of the community and to make a return to his country for the costly education received. Questions of how to bring men and women with university training into practical affairs need much thought and care, not only in Nigeria but in Britain too. I could speak at great length on this really vital matter, but only at the risk of distorting some of the other considerations about science and education which I want to bring forward.

"There are many reasons for welcoming the growth of Nigerian universities. One reason is that bringing them into full and effective activity as centres of teaching and research should help to deal with some of the problems of integrating the university graduate into the community, provided the need to deal with such problems is clearly realised and that practical wisdom is brought to bear. One wants to send the keenest youth overseas for advanced training at their most receptive age; but for many this will be immediately after taking their first degree in Nigeria; increasing change to this practice may help the best use of trained graduates. And I want again to stress that except perhaps in medicine and law where experience is ancient, problems of integration of university graduates into productive national life call for sustained thinking everywhere. In certain fields of applied science satisfactory completion of prescribed practice years can be made a condition for obtaining the professional qualifications. Possibly in other branches of science and technology, the traditions of a scientific civil service will give the answer.

"Education at the highest levels can be planned by a judicious combination of students sent overseas, and those at universities of high standard at home. For the much more numerous class whose training in various technologies is not intended to be as profound, plans must be largely based on opportunities in the country itself. Here the help of various powerful overseas commercial organisations can prove to be of great value; this is particularly important in view of the essential need to integrate trained people in the midst of their less-advanced fellows. In Africa, with all its great opportunities for improving the material conditions of life, the problems of human adaptation may well prove to be particularly stubborn in this respect. Somehow in any large-scale enterprise eighteen-year-olds have to learn to work in harmony with many of thirty, forty-five and sixty. This so-called problem of management is not made any easier if the eighteen-year-olds and possibly the thirty-year-olds have received training in modern technologically advanced methods, which their seniors can hardly hope to acquire by the same means.

"In fact, practical wisdom and new methods of co-operation must be exercised to meet these novel difficulties which can arise from the rapid rate of technological change. If it is any comfort to Nigerians, analogous problems arise elsewhere. Novel solutions need to be worked out here and present an obvious challenge to good government. We shall watch with interest and sympathy as well as co-operation the way in which Nigeria tackles these problems.

"Many of the ways of dealing with national problems of science and education are of general applicability all over the world: they have often been discussed in countries both young and old in respect to political experience and technological advancement. It is nevertheless useful to single out certain matters that call for distinctive African treatment. It is also useful to remind ourselves of fields where opportunities for outstanding achievement are particularly promising in the African continent, and especially in Nigeria.

"Amongst these problems which seem to demand distinctive treatment in Nigeria, I have already spoken about time factors in growth in various activities of national importance. To remain balanced, any education simply cannot be unduly compressed in time. This is obviously true for schooling and for higher education. It is less obvious though equally true for the many changes in ways of living that result from technological progress. Individuals need to learn to adapt themselves to new circumstances and better opportunities, not only when at school and possibly at the university, but at various later stages where adaptation is often less welcome and certainly is less easy. In view of these problems of adaptation high priority should be given to various forms of adult education: there is great scope here for refresher instruction courses in wide diversity. To a large extent methods of in-service education can usefully follow practices well tested elsewhere in the world. But in addition, this is a field where vigorous experimentation in methods of adult education can and should have distinctive African characteristics. Socially acceptable and effective methods of education for the not so young and for those whose primary schooling is for various reasons not fully adequate present exciting opportunities for research, from which useful practices well adapted to Nigeria will undoubtedly emerge. Comment was made in the Ashby report on the possibilities of a distinctively Nigerian degree, the Bachelor of Arts in Education. At a more advanced stage, holders of such a degree have wide open fields for research in Africa on the communication of knowledge, and in methods of craft training. This kind of educational research needs to be protected and provided for at the national universities, and possibly also in connection with teacher training colleges—provided these are sufficiently strong and well staffed, to make their research work effective.

"Because of the rapid growth taking place now, and which can be foreseen in the future, it is important to repeat my warning as a university teacher, about avoiding giving out of balance or excessive importance to the obtaining of university degrees. A university degree is a very valuable witness of success in courses of advanced study and in examinations, but it does not automatically guarantee that any particular graduate will use his learning and training advantageously, either in management or professionally. Personality, experience, and character are obviously factors of great importance, and these can often be found in men and women of eminent quality who for one reason or another have not got a university degree. In this matter as in so many others a sense of realism is vital. On the one hand a proportion of adult education and refresher courses could well lead to the obtaining of diplomas and certificates, which could help to lessen the gap between graduates of the university and graduates of life. On the other hand, university teachers must be constantly on the watch to ensure that graduates of the university can be smoothly and usefully integrated into the nation's real needs. Watchfulness at governmental levels is likewise necessary to distribute scholarships with realism in proportion to the relative urgency and opportunities for Nigeria of various branches of knowledge. I need only remind you that at one time in Germany their universities were producing far too many lawyers and historians, in relation to other less fashionable studies. When the state pays the fees, it can reasonably exercise a measure of guidance in the distribution of studies; whilst avoiding any breach of academic self-government this distribution should be distinctively African.

"A third comment about science and education in Nigeria refers to the choice of the most rewarding subjects for national support up to the most advanced levels of study. In science, advanced studies cannot be sustained without very substantial expenditures of national funds on research. This calls for a certain degree of deliberate choice at the highest governmental levels. It is necessary to concentrate limited resources to make their impact effective.

"To some extent, basic scientific disciplines such as chemistry, physics, mathematics, botany and zoology impinge on so many fields of applied science and engineering that they must be included in any university and must be given adequate government support to develop research as well as teaching of high quality. But I need not stress to those attending this conference that the African continent generally and Nigeria in particular offers certain opportunities that simply cannot be found elsewhere in the world. It would be unwise and unstatesmanlike not to encourage somewhat above the average those branches of knowledge where Africa has a clear vocation of leadership.

"To quote only one example from the field of science, research and development in African agriculture presents a field of obvious national importance for Nigeria. This cluster of subjects is also of tremendous interest for agricultural science and social science generally. We look forward to the time when these natural endowments will have been brought into full fruition scientifically as well as economically. Although much help in this field can be obtained from abroad, the primary effort cannot help being predominantly African.

"In conclusion, I will return to the academic point I stressed at the beginning of this discourse. Although much of the urgency and scope for education in science refers to applications in various fields of technology, natural science is also a mode of knowledge and an inheritance of learning for its own sake. No great nation can afford to consist entirely of practical men, active in the fields of government, technology or commerce. Scholars and visionaries in various branches of learning need to encounter and to dispute with scientists of comparable stature. Scientists need to live and work as good neighbours with leaders in the fields of art and religion, law, history, philosophy, and of course, politics. This consideration that natural science leads to disinterested knowledge as well as to practical power is easily overlooked when the practical needs are so obvious and so urgent. Nevertheless sustained originality and fruitfulness even in applied science calls for the protection of pure science. And in the harmonious co-operation and integration of quite diverse human activities, a proper balance is of abiding importance, influencing growth throughout various stages well beyond what we can see in the present."

## GENERAL PAPERS

Mr. A. S. Cook (*Federal Institute of Industrial Research, Oshodi*) **Rubber production and utilization in Nigeria.**

Nigeria produced 55,000 tons of rubber in 1961 valued at £11 million on 450,000 acres and it has been argued that efficient utilisation of the total acreage devoted to *Hevea brasiliensis* should produce at least 100,000 tons of dry rubber, yielding an income to Nigeria of £25 million (calculated on 1961 prices). The rubber was exported in the form of blanket crepe (44%), smoked sheet (36%) and other grades mainly air-dried sheet (20%). If only good quality smoked sheet were produced there could be an additional income of several million pounds.

Rubber is found in the latex obtained by tapping the bark of the *Hevea* tree. The nature of latex and rubber production methods were discussed. Latex is a colloidal suspension of 30% rubber particles and dry rubber is obtained by coagulating, squeezing and drying. The rubber molecule is a cis 1:4 polyisoprene of molecular weight 300,000 and its elastic properties are obtained by crosslinking with sulphur. The nature and uses of synthetic rubbers were also indicated.

The 1961 imports of manufactured rubber articles costing £4.5 million were mainly vehicle tyres and tubes, and rubber footwear. Present manufacturing industry (October 1962) in Nigeria is confined to tyre retreading and rubber-soled canvas shoes, with a small quantity of foam rubber products. However, by the end of 1962, two large tyre and tube factories will commence production. Local industry is expected to consume 5,000 tons of rubber each year leaving over 90% of the production to be exported. The price of the exported product depends on world market conditions and there is keen competition with synthetic rubber, but there is no cause for doubting the saleability of efficiently produced natural rubber.

It was suggested that there is considerable scope in Nigeria for improved efficiency of production especially among small farmers who farm a total of 400,000 acres. To this end the proposed Rubber Research Institute should play a very important part in stimulating interest, advising on replanting and conducting research on planting and production methods.

Mr. C. J. Davis (*Building Research Institute, Zaria*) **Building research.**

An outline was given of the birth of building research in the world, its beginnings in West Africa and the present position in Nigeria.

The important part building plays in the development of a country and the large proportion of the gross national product devoted to building were discussed together with the importance of value for money in building and its corollary, the need to relate the design of buildings to their environment (climatic, social, economic). The part building research can play in achieving these ends and the role scientists can play in this as in other fields of national endeavour was expounded: the opportunity to be first in the field in the tropics and the consequent enhancement of Nigerian prestige abroad was mentioned.

A tentative programme was suggested for the early years of building research in Nigeria in which was stressed, the desirability of catering for all members of the building team: the client (Government and private), the practitioner (architect, engineer, quantity surveyor), the contractor and the building materials producer or supplier.

## Mr. B. Z. Diamant (*W. H. O., Ibadan*) **Public health engineering aspects in the industrialisation process of developing countries.**

Most newly independent states are adopting large-scale industrialisation as a means of solution for urgent national problems such as the high rate of unemployment and for the build-up of sound economic conditions.

Modern large-scale development of industrialisation consists of a complex of factors which are related not only to financial and economic aspects but also to other community methods such as environmental sanitation and public health.

This complex of factors is one combined unit and neglecting or overlooking one of them might affect the stability of the unit as a whole.

Experience has shown that the environmental sanitation factors are too often overlooked by the authorities responsible for the development of industrialisation.

Experience has also shown that environmental sanitation factors might be overlooked awhile, but cannot be neglected in the long run. The cost of restoring the affected conditions has been found to be so high that more than one industry went bankrupt; being legally obliged to compensate affected neighbours and to instal expensive constructions and equipment to fulfil the needs for maintaining satisfactory environmental sanitation conditions.

Regarding the public health engineering role in the development of modern industrialisation, the following factors should be considered:

1. Water supply and water resources
2. Treatment and disposal of industrial wastes
3. Air pollution problems
4. Common sanitary nuisances (smell, noise, scenery)
5. Town planning
6. Vector control problems
7. Housing
8. Industrial hygiene
9. Maintenance and restoring of recreation facilities.

Considering these factors in the early stages of industrial planning might cause only a relatively small increase in the proposed budget of the planning, but might save tremendous sums in the future by creating preventive methods and insuring an unaffected healthy environment.

The newly independent states might and should enjoy the knowledge of long experience achieved by the industrialised developed countries, and build up their industrialisation programme on a sound basis for the development of the country and the well-being of the people.

Mr. M. R. Hadrys (*Ministry of Works, Lagos*) **Refrigeration and industrialisation.**

This paper did not present the applications of refrigeration in Nigeria so much as these and other applications in use in the world today.

The major section of the paper dealt with food preservation, a subject of prime importance to mankind and which caused the growth of mechanical refrigeration.

Applications of various types used in industry were discussed and it was shown that the use of refrigeration had enabled certain industries to expand—aircraft is an example—and, in some cases, had brought an industry into being.

The increase of efficiency in air-cooled and conditioned offices and factories is proof that refrigeration is not a luxury but a necessity.

Mr. A. C. Hayes (*West African Portland Cement Co., Ewekoro*) **The manufacture and industrial importance of cement.**

The naturally occurring raw materials used as the basis of cement manufacture consist of a calcareous or other lime-bearing material and an argillaceous or other silica, alumina or iron oxide-bearing material.

These materials are finely ground together with the addition of water to form a slurry of the desired chemical composition.

After passing through a filtration process, which removes over half of the water, the resultant cake is processed to produce small nodules. These are preheated to remove the remaining water and pass into a rotary kiln which is heated by the combustion of oil fuel.

As the nodules reach the hottest part of the kiln, chemical combination takes place and various compounds are formed which give the finished cement its hardening and setting qualities.

The material leaving the kiln is known as cement clinker, and after passing through a cooling process the hard rubbly clinker is ground to a fine powder in a cement grinding mill. A small quantity of gypsum is added as a set controller during the grinding.

The cement is pneumatically conveyed to storage silos from whence it is drawn for packing into bags.

To ensure that the cement complies with the standards laid down by the British Standards Institution, frequent samples are taken throughout the process and subjected to chemical and physical examination.

Little need be said of the industrial importance of cement as it is mostly self-evident; the expansion of the cement industry throughout the world being a guide to its importance.

Mr. P. F. Prevett (*W. A. S. P. R. U., Kano*) **The problem of food storage.**

The scientific study of problems of food storage is necessary in order that losses and deterioration in quality of local foodstuffs and export crops may be reduced to a minimum. The predominant causative factor of such is infestation by insects and it is towards their effective control that the major part of stored products research is directed. The problem as it affects Nigeria was briefly discussed and an outline was given of the scientific approach to food storage problems in order to indicate the part that this aspect of science can play in the future of this country. The export of agricultural products is of vital importance to the economy of Nigeria and it is natural that an emphasis should have been placed upon the investigation of means to improve their quality. An account was given of this work, with particular reference to groundnuts. Nevertheless more time is now being devoted to the study of problems relating to storage of local foodstuffs and it was suggested that this work will become increasingly important in future years as improvements in the standard of living increase the demand for high-quality food and as industrialisation results in the need for larger scale centralised storage.

Dr. G. von Wendorff (*Federal Department of Forest Research, Ibadan*) **Timber science.**

The scope of timber science was explained. It was formerly regarded as a branch of forestry, but it is now realised that it has very little in common with forestry in the temperate zones, and has even less in tropical areas.

In timber science, pure science, engineering and economics are involved, and it constitutes a special university course in several countries; although unknown to the British scheme of university training.

The case was argued for the establishment of timber science courses in a tropical university, possibly Nigeria.

## *SYMPOSIUM: HARNESSING THE NIGER*

Mr. H. C. Frijlink (*NEDECO*) **Hydrology of the Niger Dams.**

1. *Introduction*

A river serves primarily to discharge to the oceans a part of the rainfall or precipitation that has fallen on its catchment area or drainage basin. Other parts of the precipitation evaporate, either directly or through vegetation (evapotranspiration). In the Niger basin, the total evaporation often amounts to about two-thirds of the depth of rain that has fallen; the remaining one-third flows as surface run-off through the various creeks and tributaries into the main Niger River.

However, parts of this surface run-off may be temporarily stored or accumulated in lakes or as groundwater, and thus we arrive at the main equation of the hydrological budget for a river basin:

$$P = E + \triangle S + R$$

or the total precipitation P on the basin during a certain time interval $\triangle t$ equals the sum of the evaporation plus evapotranspiration E, the change in storage $\triangle S$, and the run-off R during that same interval.

In the Niger catchment area (see Figure 1) several basins can be distinguished, each having different hydrological features and imposing different characteristics on the rivers draining these basins. The Upper Niger from its sources in Guinea to Mopti in the Mali Republic, the Middle Niger between

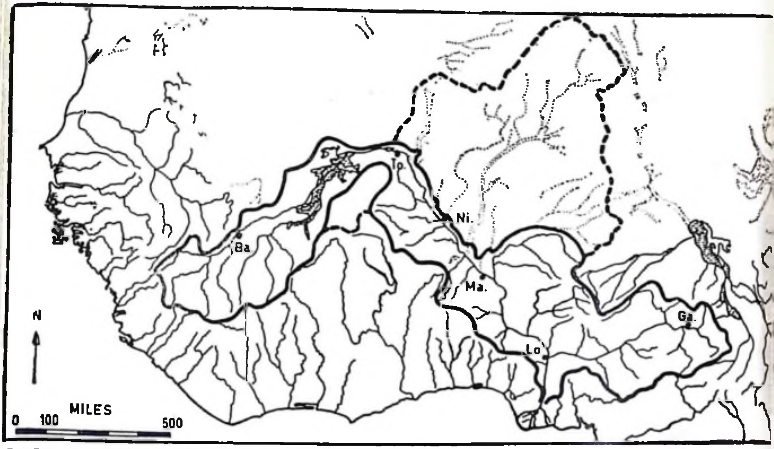


*Fig. 1. Drainage Basins of the Niger*

Mopti and Niamey in the Niger Republic, the Lower Niger between Niamey and the Benue Confluence at Lokoja, and the Benue River will all be briefly and separately discussed here from a hydrological point of view. Downstream from Lokoja the actual catchment area that is added to the above basins is very small indeed: the Niger River, here in its full and mighty size and over a mile wide, drains a narrow basin 10 to 50 miles in width. Finally, the river divides itself below Aboh into many distributaries and branches which form its Delta.

2. *The Upper Niger, upstream from Mopti*

This stretch is about 785 miles long, i.e., less than one-third of the 2,550-mile main Niger River. The river has its sources in the Futa Jallon Mountains close to the Atlantic Ocean and at a height of only 2,500 feet above sea-level.

The orographic rainfall in the mountains is high (some 100 inches a year) but this decreases rapidly to a rain depth of only 40 inches near Bamako, the capital of the Mali Republic (see Figure 2). Moreover, the distribution of the rainfall over the year is varied: at Kouroussa in the Guinea headwaters there are two rainfall peaks, in June and September respectively. This can, roughly speaking, be attributed to the fact that all places in the tropics have

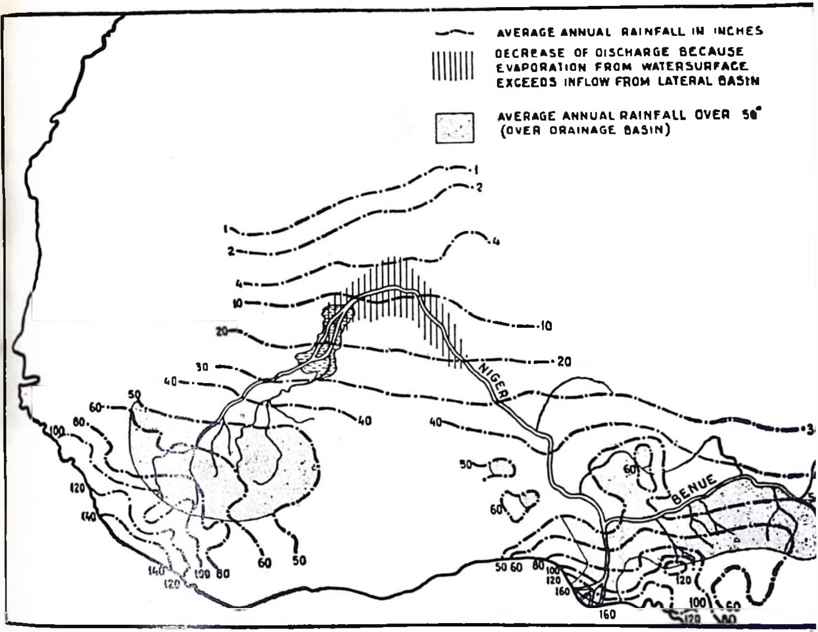


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*Fig. 2. Mean annual isohyets over the Niger Basins*

the sun right overhead in the zenith twice a year. In Lagos, at $6\frac{1}{2}°$ northern latitude, this occurs early in April and early in September, and the maximum rainfall is one or two months after the zenith position of the sun. At places nearer the Tropic of Cancer these two peaks tend to coincide to a single rainy season, and all places north of that Tropic have only one day of maximum sun's elevation. The result is that rivers originating from catchment areas near the Equator may show two separate flood periods each year. This is, indeed, the case of the Niger in Guinea.

Nearer Mopti, at 14° latitude, this effect is less marked and the peak discharge occurs in the second half of September or early October. It averages some 9,000 cubic metres a second, or more than 300,000 cubic feet a second (cusecs). In the dry season, from December to April, there is almost no run-off, and the average annual discharge is therefore less than 3,000 $m^3$/sec or 100,000 cusecs.

### 3. *The Middle Niger, between Mopti and Niamey*

This stretch is 770 miles long, or again just under one-third of the total length of the main Niger. The drainage basin is characterized by a low rainfall: less than 20", and in places even less than 10" per annum, and by an exceedingly high potential evaporation of over 100" per annum from open water surfaces. Evaporation, indeed, exceeds the inflow from the lateral basin in this area. Moreover, the basin between Mopti and Tosay is very flat: the area is called the Interior Delta where large areas are annually flooded and there are many swamps and lakes.

This Interior Delta probably drained about 200,000 years ago towards the Ocean in a westerly direction, by way of the Senegal River. Some 100,000 years later, this outlet was severed from the Upper Niger, and the Interior Delta formed an endoreic basin or internal drainage area like the Chad Basin, without any outlet. Later again, in geologically very recent times during a humid era (probably the Gamblian Pluvial, simultaneously with the Würm I glacial period some 60,000 or 70,000 years ago), the Upper Niger filled the Mopti and Timbuctu lakes and overflowed the rocky sill between Tosay and Niamey, eroding a gap in the underlying rocks. Only from this time on has the Upper Niger formed the headwaters of the Nigeria Niger.

The regime of the Niger River still shows very marked and important effects of this historical delta area between Mopti and Timbuctu. Firstly, the Niger loses by evaporation and infiltration about two-thirds of its yearly run-off: the average annual discharge near Timbuctu is some 1,150 $m^3$/sec or 40,000 cusecs. The flood discharge is reduced to about 2,400 $m^3$/sec or 90,000 cusecs. In the second place, there is a very important natural storage and a consequent retardation of the flood, propagating only very slowly in the wide flooded areas. The result is that the highest levels near Timbuctu occur towards the end of December, as against the end of September in Mopti. There is a further evaporation and deceleration in the stretch Timbuctu-Niamey, where the river flows virtually in a semi-desert area, although its potential catchment basin in the desert is extensive (see dotted line in Figure 1).

There are several valley narrowings and rapids between Timbuctu and Niamey. They have no effect on its hydrological regime, but are important features in connection with the navigation possibilities. These will be discussed later.

### 4. *The Lower Niger, between Niamey and Lokoja*

The catchment basin receives here an increasing amount of precipitation: Niamey averages only 20" per annum as against 50" near Lokoja, resulting in a new flood being superimposed on the regime of the Middle Niger.

This flood reaches its peak again in the second half of September, just as the flood of the Upper Niger near Mopti, although the latter flood, being reduced and retarded in its semi-desert course in the Interior Delta, reaches Niamey only in January. The important result is that the Lower Niger shows two floods: the main flood, originating from the local rains, with a peak occurring around the first of October and an average magnitude of some 8,000 $m^3$/sec or 280,000 cusecs just above Lokoja, and a second, subdued, flood in February and March averaging 1,750 $m^3$/sec or 60,000 cusecs.

This latter flood, coming from the headwaters, has lost all its silt by sedimentation during the slow propagation in the Interior Delta. By consequence, its waters have a clear and dark appearance, so that it is generally called the Black Flood, in contrast to the silt-laden waters of the local White Flood.

The phenomenon of the Black Flood is most important for the life and economy of Nigeria, because it results in sustained discharges during the dry season early in the year, long after the local run-off has dried out. This means that utilization of the Niger water is possible over a much longer period than with a purely monsoon-type of river as the Benue. Navigation can be maintained until April, i.e., when the main crops have to be evacuated. Use of water for irrigation and human and industrial consumption is also possible in the dry season and, indeed, the proposed hydropower station at Kainji will greatly benefit from the Black Flood.

The local White Flood rises in July, after the first rains on the Plateau have fed the Kaduna River, the main tributary in this stretch. In August also the Rima River rises and September-October are the main flood months. Because of the relatively northern latitudes of the drainage basins here (between 10° and 14°) there is no equivalent of the "little dry season" described for the Upper Niger.

In this stretch of the Niger, between Yelwa and Jebba, there are a number of valley narrowings and rapids that render navigation virtually impossible. On the other hand, this rocky section offers opportunities for the construction of large dams, such as the Kainji and Jebba Dams.

5. *The Benue River*

The Benue, 810 miles long and by far the largest tributary of the Niger, rises in the Cameroon Republic at about 4,400 feet above sea-level. In its drainage area the average annual rainfall varies from 120" in the upper reaches of the Katsina Ala River to 35" in the middle course of the Gongola River.

Over the first 20 miles the river falls 2,500 feet, and along the next 90 miles another 1,200 feet, leaving for the remaining 700 miles to the Niger Confluence a fall of only 700 feet.

The hydrological regime of this monsoon-type river is simple: the summer rainfall causes a main flood period with a peak around the first of October. However, the "little dry season", as described for the headwaters of the Upper Niger in Guinea, is also noticeable along the Benue, as the main catchment is in the area with high rainfall south of the river (see Figures). This means that after the first rise of the river in June and July, there is often a fall in river levels in August, followed by the main flood rise. In some years there is not a pronounced August fall, but rather a levelling out of the first rise, or a retarded rise.

This effect is particularly disturbing for navigation: the first ships from the Niger Delta ports can often reach Garua in the Cameroon Republic only late in August when the main rise of the Benue has produced sufficient depths. On the other hand, the river falls rapidly, often at a rate of a foot per day, at the end of the rains in October, and from December to May there is only a very low discharge in the Benue (only a few hundred cubic metres per second or some 10,000 cusecs). This is in great contrast to the Lower Niger, where the Black Flood provides for sustained discharges until April.

The peak flood of the Benue, just above Lokoja, averages 12,000 $m^3$/sec or 425,000 cusecs. This flood, therefore, exceeds the average Niger flood (also measured above Lokoja) by 50%. In spite of the Black Flood which increases the average annual discharge of the Niger, the average Benue discharge (3,400 $m^3$/sec or 120,000 cusecs) still exceeds the average Niger discharge which above Lokoja is 2,700 $m^3$/sec or 95,000 cusecs.

The Benue basin is flat and, except in its headwaters, there are no rapids in the river, which flows in an alluvial bed.

### 6. *The Main Niger below Lokoja*

In spite of the relatively high rainfall over this area, increasing from 50" per annum near Lokoja to over 160" near the coast of the Delta, the discharges of the Niger show only a slight increase over the combined discharges of the Lower Niger and the Benue. This is due partly to the limited size of the catchment area, and partly to the fact that below Onitsha the river banks gradually become lower, so that during the flood period much water flows over the adjacent plain into the Orashi River to the east and the Ase River to the west. The annual discharge of the Niger reaches its maximum at Onitsha, where it averages 6,350 $m^3$/sec or 225,000 cusecs. This means that in an average year a total quantity of 200 milliard cubic metres, or 7,000 milliard cubic feet, flows through the Niger to the Ocean. The average peak discharge is 20,500 $m^3$/sec or 725,000 cusecs, but the maximum flood on record, in 1955, was 40% higher, or just one million cusecs.

The regime shows the combined characteristics of the Niger above Lokoja and the Benue: the waters rise in June, mainly due to the Benue rise; the rise is accelerated in July and August when also the Kaduna and Sokoto add their waters; the peak comes early in October; and the river then rapidly falls to the Black Flood discharge which is maintained from December to April or May. In May the waters drop to a minimum of about 1,500 $m^3$/sec (50,000 cusecs); the ratio between maximum and minimum discharge is thus about 15:1. This favourably low ratio for a tropical river (cf. the Benue with a ratio of about 50:1) can be attributed to the influence of the Black Flood.

Another favourable condition attributable to the Black Flood is that, for the Lower and Main Niger, water-levels and discharges in the period from December to the end of April can be predicted many months ahead, due to the slow propagation of the flood wave in the Interior Delta. The end of the Black Flood in April, for instance, can already be predicted from the Mopti readings in November of the preceding year.

7. *Sediments*

Rivers discharge not only water but also the solid erosion products that are entrained by the run-off in the catchment area and by the discharge in the river-beds. In the Niger this debris consists mainly of sand and silt.

The average grain size of the sand in the Upper Niger and in the Benue is close to one millimetre; in the main Niger below Lokoja this is reduced to 0.7 mm and near the Delta even to 0.3 millimetres. This reduction is partly a result of wear: the grains perform a rolling and saltatory movement along the river-bed. But there is also a continuous exchange between particles in movement and those in the river-bed, and the decrease in grain size in the lower parts of the rivers may well be attributed to a deposition of the larger grains and selection of the smaller ones, as the current velocities and the tractive forces of the river decrease in a downstream direction.

The annual transport of sand discharged by the main Niger and deposited in the Delta and along its beaches is estimated at an average of 2.7 million cubic metres, or almost 100 million cubic feet.

The particle size of the silt discharged by the rivers is in the order of magnitude of twenty microns; the particles remain in quasi-suspension through the action of the turbulence of the water. Contrary to the amount of bedload, which is largely determined by the characteristics of the river-flow, the amount of suspended silt depends primarily on the quantities washed into the rivers by the rains. Especially during the first rains after the dry season, fine particles loosened by the drought, as well as dust-particles, are carried into the rivers by the surface run-off and then transported with the flow as "wash-load".

The total amount of wash-load carried down to the Niger Delta in an average year is about 15 million cubic metres (530 million cubic feet or 30 million tons). Some of this is deposited in the Delta, but the greater part reaches the sea through the main Niger outlets: the Nun, Brass and Sengana in the central part, and the Ramos and Forcados in the western delta. The silt is deposited over a wide area in the coastal seas along the Delta.

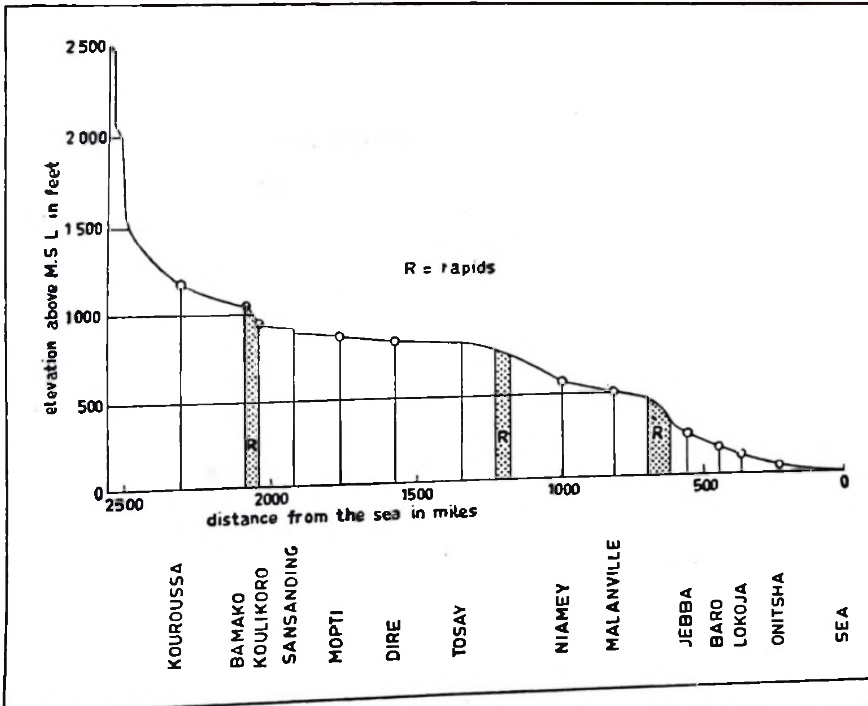
The combined volume of sand-discharge and wash-load is about 15 thousand acre-feet, and over the entire drainage area of the Lower Niger and the Benue this is equal to an average degradation of the basin of only a few millimetres per century. This is a low value; indeed, the silt discharges of the Niger rank low amongst those of other major rivers in the world. On the whole, soil erosion is fortunately not a great problem in Nigeria, although there may be detailed areas where it is a nuisance or even a danger.

8. *Longitudinal profile and cross-sections*

The subdivision of the Niger according to longitudinal profile is determined by three marked discontinuities in the longitudinal section. These are the rocky sills between Bamako and Koulikoro in the Mali Republic, between Ansongo and Tillabery in the Niger Republic and between Yelwa and Jebba in Nigeria (see Figure 3). This subdivision, therefore, differs from the above-described division in catchment areas.

The rocky sections are marked by the presence of rapids, so that these sections are not navigable for commercial vessels, even during the high-water period. Upstream from the rapids, and near the Delta, the gradient is generally flat: one in 10,000 to one in 100,000. Over the rapids there is an irregular and steep gradient which levels out further downstream to values of one in 5,000 and less. This levelling-out of the gradient in a downstream direction is very gradual and regular. It answers a semi-logarithmic equation if there are no irregularities in the alluvial bed, and no recent changes in the regime of the river. The longitudinal profile of the Niger downstream from the Bajibo Rapids (above Jebba), and of the Benue within Nigeria, answer the same equation. From Idah to the sea this equation is slightly modified, reflecting a historical change in the level of the ocean.

The navigability of the rocky sections can be improved either by blasting a relatively narrow navigation channel across the rapids, by constructing a dam and lock at the downstream end of the rapids, or by making a by-pass canal with a lock. Until such measures are taken at the three rocky sections of the Niger, there can be no through-navigation over its entire length. The Kainji Project includes all three types of measures for the Yelwa-Jebba stretch. There have been projects for improving the rapids between Bamako and Koulikoro by constructing dams, but the economic feasibility of these latter projects is at present doubtful.


2 500
2 000
1 500
1000
500
0
elevation above M.S L in feet
R = rapids
R
R
R
2500
2000
1500
1000
500
0
distance from the sea in miles
KOUROUSSA
BAMAKO
KOULIKORO
SANSANDING
MOPTI
DIRE
TOSAY
NIAMEY
MALANVILLE
JEBBA
BARO
LOKOJA
ONITSHA
SEA

The cross-section of the rivers depends on the other basic elements discussed in the foregoing paragraphs. In general, the regime of an alluvial river is determined by six main elements:

| | |
|---|---|
| the water discharge; | the gradient; |
| the sand discharge; | the depth; and |
| the grain size of sand; | the width. |

The first three elements are normally imposed by climate and geography, i.e., by Nature. The other elements then follow from three conditions which can be expressed in hydraulic and morphological formulae. From the basic elements of the Niger (large water and sand discharges and medium-sized sands) it follows that the cross-sections are wide and shallow. Indeed, the width in the alluvial sections is at least 100 times the average high-water depth, and sometimes the ratio is even 250 over areas appropriately termed "flats".

Other characteristics of the river involve the alignment and detailed morphological features. The Niger can be described in general as an alluvial monsoon-type of river with a composite high and low-water bed, the former showing fairly straight banks ("reach"-type of bed) with the latter assuming a meandering course within the limits of the high-water bed. The river has a clear tendency to form midstream islands. In some places the low-water channels are braided (the "flats"), and towards the Delta the rivers and distributaries are distinctly meandering. The lowest available depth is less than the average depth, due to the natural shoals in the inflexion points between two opposite meander loops.

### 9. *Human modification of the hydrology of the Niger*

In principle, man can modify all elements of the hydrological budget: rainfall can be provoked by artificial seeding of the clouds; evaporation can be increased or reduced by enlarging or reducing the surface area of water exposed to evaporation; and storage can be increased by constructing accumulation basins in the river valleys.

The latter possibility is certainly the most important means of modifying and improving the distribution of river run-off over the year. In particular, there is an opportunity to regulate discharges when there is an abundancy of water during the flood period and a deficiency in the dry season. The benefits of such a discharge regulation are manifold: the floods are reduced and controlled downstream from the storage basin, so that human life and agriculture are no longer jeopardized; the increased discharges in the dry season can be utilized for human and industrial consumption, for irrigation and for navigation; and the regime of the river is in general improved by the regulation.

If the storage basin is obtained by the construction of a dam across the river valley, then the head of water thus created, together with the regulated discharges, can be utilized for generating electricity. The production of hydro-power is, indeed, one of the most remunerative utilizations of accumulated water.

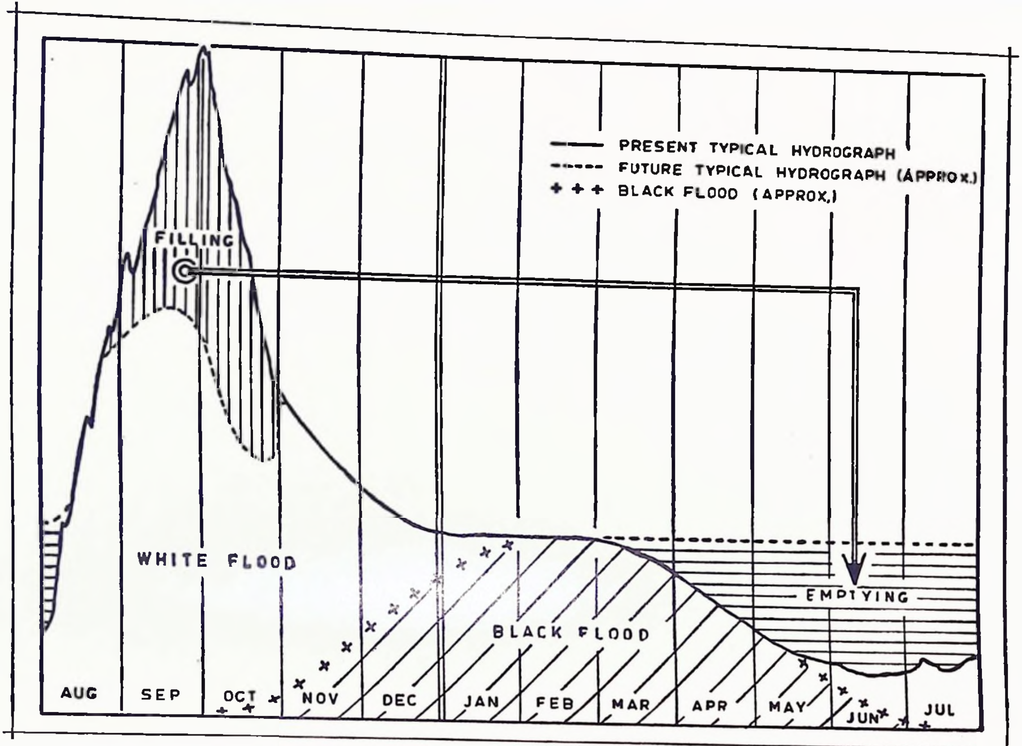
10. *Harnessing the Niger within Nigeria*

There are several feasible sites for multiple-purpose storage projects in Nigeria. Kainji is by far the most attractive and ambitious of these: a gross storage of 15 milliard cubic metres and a net storage of 12 milliard cubic metres (10 million acre-feet) is provided, which is equivalent to 20% of the annual discharge of the Niger at that place. The storage basin is formed by the construction of a 175-ft high dam across the valley, so that a lake of 100 miles length comes into existence. Evaporation from this lake will amount to some 70" per annum. Together with the favourable Black Flood phenomenon, this storage could regulate the Niger discharges downstream from the dam to magnitudes between 4,000 and 1,500 cubic metres per second, whilst the present unregulated discharges vary between 7,000 and 500 $m^3$/sec.

The operation of the reservoir has been determined by the joint requirements of electricity production, flood control, and the improvement of navigation and fisheries conditions. The reservoir will be full at the end of the White Flood, i.e., in November. The Black Flood will then pass the reservoir unaffected and in the early years of reservoir operation, electricity demands permitting, the Black Flood can even be supplemented with water from the storage. The reservoir will be further emptied in the low-water period after the Black Flood has receded, thus maintaining a minimum discharge in normal years of 1,500 $m^3$/sec (53,000 cusecs). The water-level in the reservoir will be lowest in August. The White Flood from the new rainy season will then again fill the reservoir, whereby it will be possible to store and subdue the normal peak floods to magnitudes lower than 4,000 $m^3$/sec (140,000 cusecs).

A total electricity generating capacity of 960 Megawatts can be installed, capable of producing four milliard kilowatt-hour units per annum, and which would satisfy the demand for electricity of the greater part of Nigeria until about 1982.

The increased low-water discharge of the Niger will render commercial navigation downstream from Jebba possible on a year-round basis. The Bussa and Yelwa Rapids will be drowned by the waters of the reservoir. Together with some local improvements of the rapids between Kainji and Jebba, this would mean that Yelwa could be reached almost throughout the year, and Niamey and Tillabery, at more than 1,000 miles from the ocean, reached from the Delta Ports in Nigeria during some eight months


PRESENT TYPICAL HYDROGRAPH
FUTURE TYPICAL HYDROGRAPH (APPROX.)
BLACK FLOOD (APPROX.)
FILLING
WHITE FLOOD
BLACK FLOOD
EMPTYING
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL

a year. Accessibility from the ocean to these Delta Ports is now being improved by the construction of the Escravos breakwater.

Flood control by the Kainji reservoir implies that agriculture in the Niger Valley can be carried out under improved conditions. It should be pointed out, however, that the Kaduna and Benue floods will remain for the time being uncontrolled, and the flood-reducing effect of Kainji, therefore, less noticeable below the Kaduna Confluence and almost absent downstream from Lokoja. The effect of the greatly increased low-water discharges, on the other hand, will extend right down to the Delta, while together with the eventual availability of economic off-peak hydro-power for pumping the regulated discharges will provide opportunities for irrigation.

In the Niger valley between Jebba and Lokoja, some 500,000 acres are potentially suitable for estate and peasant agriculture, i.e., over 50% of the total flood-plain area in this section. Because of the present condition of annual flooding, only an estimated 0.3% of the total area is now cultivated. Once the floods are controlled by the Kainji Dam, the situation will change fundamentally, as on large areas of the flood-plain intensive agriculture will become possible. Completion of the Kainji Dam will also free from flooding land near the Bacita Sugar Estate that may in future be developed for growing sugar-cane.

Finally, there are excellent opportunities for developing fisheries in the vast lake created by Kainji Dam. The annual catch of fish which will be possible after the establishment of an organized fishery industry may be as much as 10,000 tons.

The local improvements of the rapids between Kainji and Jebba, consisting of a by-pass canal with a lock at Awuru and local blasting at Kpatachi and Bajibo, are only temporarily necessary. When the demand for electricity will have exceeded the capacity of Kainji, which will presumably be in the 1980's, a second dam will be constructed at Jebba. The reservoir here, with a volume of two milliard cubic metres (1.6 million acre-feet), will reach upstream to the toe of Kainji Dam, and thus drown the above-mentioned rapids. Jebba Dam will in its turn help to satisfy the demand for electricity until about 1987, when it is expected that a dam in the Kaduna River near Shiroro will be constructed.

These three dams will then operate in conjunction with one another, which will mean that their total capacity for generating electricity will exceed the sum of their capacities if operated separately. This can be explained in a simple way by referring to the different hydrological regimes: as mentioned above, the Kaduna rises in the rainy season earlier than the Niger above Jebba.

Due to the favourably low sand and silt-discharge of the Niger, there is no fear of a high sedimentation rate in the reservoirs: the storage capacity of the Kainji reservoir will be halved only after a thousand years.

There are probably further opportunities for reservoirs on the Benue, and on the Main Niger. Dams may be constructed near Yola and near Makurdi on the Benue to provide a complete regulation and control of the discharges, with year-round navigability. Generation of large additional amounts of electricity would be possible at these sites. The almost complete flood-control of the Niger and Benue which would then be achieved is of great importance also for the Niger Delta, which now suffers from annual floods as well as from penetration of the saline waters from the ocean when the Niger discharges are low.

One of the benefits deriving from a storage reservoir on the Benue is that the ill-effects of the "little dry season" and subsequent August fall can be overcome.

The feasibility of the Makurdi site, however, has not yet been fully proved, and as far as now can be judged it will take a long time for the Benue dams to be economically justified.

Smaller dams on the Benue tributaries Gongola, Taraba and Katsina Ala, mainly for serving irrigation purposes, will also be a possibility.

Finally, a U.N.-sponsored hydrological investigation is being carried out to evaluate the irrigation potential and the feasibility of a control of the Rima River in Sokoto.

It is thus likely that a complete control and harnessing of the Niger and Benue within Nigeria is technically within the realm of possibilities. Such a control is now being commenced by the construction of the Kainji Dam. Subsequent steps can and will be carried out whenever there is an economic justification for any or all of the beneficial purposes that would result from such a step.

## 11. *Harnessing the Niger outside Nigeria*

There is already one project in operation aiming at a utilization and control of the Niger water: the large irrigation project near Sansanding in the Mali Republic.

A movable weir with 14 openings each about 50 metres (165 feet) wide was completed in 1948. The total length of this structure, together with an earthen dam to close the river-bed of the Niger, is more than a mile. This makes it possible to raise the river about 5m. (16 ft.) above low-water level, and as a result a part of the discharge of the river can be forced to flow through two branches of the old Interior Delta which are used as main irrigation canals. Roughly 1.25 million acres of land could be irrigated through this system, but in 1957 only 6% of this vast area was under cultivation.

Because of the difficulties experienced in attracting sufficient numbers of well-trained farmers and labour, a reduced scheme of only ¾ million acres is now being aimed at. But even for irrigating this area, the low-water discharge of the Niger at Sansanding is not large enough: a minimum discharge of about 400 $m^3/sec$ (14,000 cusecs) would be needed during February, March, April and May to obtain two rice crops a year, to grow Egyptian cotton and to apply crop rotation.

The building of a storage reservoir in the upper reaches of the Niger or in one of its tributaries is the planned solution to overcome the deficiency of the low-water discharges. Such a reservoir could also serve to improve the low-water navigability of the Niger between Koulikoro and Ségou. Preliminary investigations have shown that a dam could best be built in the Niandan tributary, where a storage of 5 milliard cubic metres (4 million acre-feet) can be obtained.

There are further projects for reclamation and irrigation along the left bank of the Niger near Mopti, for which a 30-mile dike would have to be constructed. For the irrigation of this area, large quantities of water would be required in the dry season, necessitating the operation of a storage reservoir as described above. The effect of this reclamation on the hydrology of the Upper Niger is interesting: apart from the water consumption in the irrigated fields, the evaporation in the present swampy area would be reduced, giving smaller net losses of water than would follow from the irrigation requirements. Moreover, the propagation of the flood in the thus narrowed Niger bed would be accelerated, so that the Black Flood would arrive in Nigeria some time earlier than at present. This might to some extent affect the operation of the Niger Dams scheme in Nigeria by widening the low-water gap between the end of the Black Flood and the beginning of the White Flood. As this gap has to be filled with accumulated water from the storage, a less efficient use would be made of that storage, whenever the Black Flood would be appreciably advanced.

However, these works at Mopti will probably only be executed after the construction of a dam in the Niandan, and take many decades to be realized. This gives ample time for further and detailed study of the most suitable way to overcome the ill effects by a proper coordination, acceptable to all parties concerned.

Another project near the Interior Delta in Mali consists of regulating the inflow into a number of lakes for the benefit of agriculture. A part of this project is already under execution. It will ultimately result in an increase in discharges of the Middle and Lower Niger in wet years, and a decrease in dry years.

Finally, there are projects or possibilities for constructing dams in the Niger between Bamako and Koulikoro for navigation purposes across the rapids; dams near Timbuctu or Tosay for irrigation; and a dam at the "W"-loops of the river between Niamey and Malanville for hydro-power. None of these dams, if they materialized, could affect the hydrological regime of the Niger to any great extent.

The technical possibility of a dam with a reservoir of 6 milliard cubic metres (5 million acre-feet) in the Upper Benue near Lagdo (Cameroon Republic) has been proved. This project could improve navigation conditions between Garua and Yola by doubling the present Garua shipping season, but it would hardly influence hydrological conditions downstream from Makurdi. A Lagdo project could, however, very well be integrated with the Yola and Makurdi schemes mentioned in Section 10.

It will be clear from this summary that there are many possibilities for utilizing and harnessing the waters of the Niger, and that there is a great interdependence of these schemes. With this in mind, the United Nations have sponsored an investigation into the consequences that the various Niger projects may have on the regime of the river. The preliminary findings of this investigation stress the necessity of each water utilization being put under general and strict control in order to prevent changes in the type of hydrograph that might jeopardize the efficiency of projects in the lower reaches. A further preliminary consideration is that, in view of the fact that the upstream irrigation systems will take a long time to be implemented, the Kainji project will not be affected, at least for a long period, by serious negative consequences deriving from such upstream irrigation.

12. *Conclusions*

(*i*) The Niger River, at present almost unharnessed, offers to the economy of the riparian countries extensive opportunities for developing hydro-power, agriculture, irrigation and navigation.

(*ii*) These opportunities derive from the large total volumes of water available.

(*iii*) The hydrological regime of the Niger, though not unfavourable in the distribution of the discharges over the year, will for the purpose of development be improved by providing storage basins. The Kainji Dam will be the first project of this nature.

(*iv*) Each development project on the Niger should by itself serve as many purposes as possible, and the feasibility of combined multiple-purpose projects should always be investigated.

(*v*) Separate Niger development projects should be mutually coordinated or even integrated to warrant or increase the efficiency of each project; the future integrated operation of the Kainji, Jebba and Shiroro Dams shows the benefits that can thus be achieved.

(*vi*) Water utilization of the Niger in the widest sense should be a subject of international consultation between the riparian States, in order to increase the efficiency of separate projects and to avoid harmful effects.

Dr. C. S. Hitchen and Mr. M. Kosten (*Balfour, Beatty & Co. Ltd.*) **Geological aspects of the Niger Dams project.**

Surprise has occasionally been expressed at the extensive amount of geological investigation which has been undertaken in connection with the Niger Dams Project. This, however, is in accordance with modern civil engineering practice in which increasing emphasis is placed on the results of geological exploration and soils technology. Such methods of investigation have, of course, always been necessary to ensure the safety and efficiency of a project but have latterly become even more significant as a result of high construction costs which demand that only the most economical site be chosen and that all unnecessary features of design be eliminated. This can only be achieved, however, if accurate and detailed information is available about subsurface conditions and local construction materials. Moreover, stoppages caused by unexpected happenings, such as a sudden inrush of water, are not only far more costly than formerly but can play havoc with construction programmes. Here again, the best safeguard lies in a detailed appraisal of site conditions.

Before describing the geological conditions present at the Kainji dam site and the problems they present it may, perhaps, be helpful to outline the geological aspects of dam construction. In simple terms, a dam may be defined as a wall which impounds water for an economic purpose. This definition, though simple, will be seen to involve five major considerations, namely, (a) the wall itself, (b) the foundations on which it stands, (c) the materials of which it is built, (d) the lake or reservoir that it creates and (e) economic considerations.

The wall itself must retain water efficiently and any percolation through it must be known and controlled and such that it presents no danger to the materials of which the wall is constructed. In fill dams containing a certain proportion of clay, controlled percolation is, indeed, essential since drying out would lead to shrinkage and cracking and might produce failure of the dam. The emphasis here is on the behaviour and properties of the local construction materials.

The foundations must not only fulfil the same leakage criteria that apply to the wall but must be competent to sustain the weight of the wall and the water that it impounds and to withstand with absolute safety the stresses so produced. It is in connection with the investigation of foundation conditions that geology plays its most important role in determining the competence of the underlying rock or other material, and the possibilities of leakage.

The materials used in the construction of a dam may consist of earth, gravel, sand and clay, readily excavatable by mechanical equipment, or of rockfill and coarse aggregate that require quarrying. In the latter case, the quality of the rock and the sizes and shapes that can be produced, have to be carefully studied while the availability and properties of the soil materials need to be determined in even greater detail in accordance with the methods and principles of soil technology.

The lake or reservoir created by the dam must be reasonably water-tight otherwise the overall efficiency of the project is jeopardised. In some instances otherwise excellent dam sites have had to be discarded because of the risk of leakage from the reservoir which was likely to be too great or too expensive to prevent. Prospects of reservoir leakage are assessed on the results of a geological survey of the area to be inundated which usually reveals a likelihood or otherwise of serious loss.

The economic problem raised by dam construction are usually involved and difficult and can become formidable if a choice of several sites exists, as on the River Niger. For example, the economic advantage of a comparatively small volume of fill required by Site A may be largely offset by difficult foundation conditions, involving costly methods of treatment and construction, which may cause it to be discarded in favour of Site B with good foundations but which requires a larger volume of fill. Investigation may show, however, that the amount of fill available locally is only sufficient for Site A. In this event, the choice would seem to revert to Site A, but it may be possible to economise in the volume of fill required by adopting a design with rockfill shoulders and the choice swings again in favour of Site B. The selection of a site and final adoption of a design for a dam is the outcome of a long series of estimates and evaluations but the really important point is that these would not be valid without reliable and detailed information about site conditions and the quantity, quality and situation of local construction materials. It is the geologist's function to provide this information.

Many of these points were well illustrated during our investigations into the prospects of establishing dams on the River Niger. These investigations began in 1958 when, first, the area immediately upstream of the Jebba Bridge was reconnoitred, since some fairly obvious sites were present here and clearly none was available in the broad valley downstream of the bridge and towards the Niger Delta. Topographical and hydrological surveys, which were carried out concurrently with our geological work at Jebba, soon indicated, however, that a dam sited at Jebba could not retain sufficient storage water to ensure sufficient control of the River Niger and reconnaissance was extended upstream as far as Bussa, a distance of about 95 miles along the river.

In this section, a number of potential dam sites were identified by topographical survey methods, including those utilising air photography, and rapid geological assessments of these sites were made. From examination of the rocks exposed and other surface features, deductions were made regarding strength of the foundations, the extent and nature of joints and fissures and the existence or otherwise of faulted zones along which weakening and possible decomposition of the rocks might have occurred. At this preliminary stage, exploration below the surface was limited to the digging of test pits and to hand boring which was used to probe for bedrock through the soft alluvial deposits.

The results of these initial investigations showed that the Niger Valley between Jebba and Bussa is underlain by hard, crystalline ancient rocks, fully capable in their fresh, unweathered state, of supporting any kind of dam structure. It was also ascertained that these rocks would underlie any reservoir created by a dam at Jebba or upstream of Jebba and because of their generally impermeable character, the risk of any serious reservoir leakage could be discounted. Surface exposures of rocks at Jebba all showed intense fracturing and, although the indications were that such fractures tightened sufficiently at reasonable depths to render a dam feasible here, this had to remain in some doubt until confirmed by power drilling and other more costly methods of investigation at a later stage.

Important as these preliminary investigations were in disclosing the general conditions for dam construction on the River Niger and in enabling some obviously defective sites to be eliminated, they were incapable of indicating the depth at which sound bedrock occurred beneath the alluvium in the main river channel(s). Hand drilling methods were, of course, quite inadequate for this task and bedrock profiles across the several potential sites were, therefore, incomplete. Nevertheless, because of the generally favourable conditions for a multi-dam scheme on the Niger that the preliminary investigation of 1958 revealed, the Federal Government of Nigeria and the Electricity Corporation of Nigeria authorised a full and complete investigation of the possible dam sites both at Jebba and between Jebba and Bussa. For this purpose rotary drilling and other methods of exploration were employed to produce data for a comprehensive scheme for harnessing the Niger.

One of the most promising sites for the principal dam was located at Kurwasa about seven miles downstream of Garafini and it was here that detailed exploration commenced with three diamond drilling rigs in November 1959. Some initial difficulties were encountered in mounting the rigs on suitable pontoons for drilling in the river and in developing a satisfactory technique for drilling through the alluvial deposits forming the river bed but, by the end of February 1960, four boreholes had been drilled to bedrock across the site. These disclosed an excessive thickness of alluvium consisting of medium to coarse sand which, in the centre of the river attained 254 feet.

This discouraging result left no alternative but to seek a site where conditions were more favourable and a period of reconnaissance ensued during which the 38-mile stretch of the Niger between Bussa and the Awuru bend was critically examined and explored by boring, echo sounding and electrical resistivity probes, in an effort to locate a site where favourable topography coincided with high-standing bedrock in the river itself; where, in fact, engineering and geological conditions combined to give the most satisfactory and economical site.

After about six weeks of wide-ranging and intensive search during which 1,660 feet of drilling were expended in exploring the river bed, high bedrock was proved about 3,500 feet upstream of the southern tip of Kainji Island which divides the Niger into two channels. In the wider right channel, bedrock lay between 43 and 79 feet below low water level and was covered by between 10 and 71 feet of sand while in the narrower left channel, it lay from 18 to 56 feet below low water level and was either bare or covered by up to 30 feet of sand. The location of such a site now appears to have been particularly fortunate as subsequent information has indicated that such high bedrock levels are rare if not unique in this part of the Niger.

The division of the river into two channels offered obvious advantages for cofferdamming and construction while estimates of the amount of fill required showed that this Kainji site compared favourably with the other sites that had been assessed. Kainji Island, here 1,700 feet wide, appeared to consist of sound, highly competent rock suitable for accommodating a combined concrete gravity-section dam and power house which it was proposed to adopt for the central portion of the project, the wings consisting of rock or earth fill or a combination of these.

From May 1960 onwards efforts were directed to the thorough exploration of the Kainji site which involved a comprehensive drilling programme assisted by the seismic method of geophysical exploration. Fifty vertical boreholes were drilled in the right and left channels of the Niger involving nearly 5,000 feet of drilling, while a further 71 borings representing 3,860 feet of drilling were made to explore the right and left abutments of the dam and the main foundation zone on and adjacent to Kainji Island. In addition, a considerable amount of both diamond and shell-and-auger drilling was undertaken to locate and investigate the quality and quantities of construction materials in the vicinity of the site. A total of 57,114 feet of seismic traversing was performed to indicate the depth of soil and decomposed rock along the proposed dam axis while a further 30,856 feet was used to estimate the quantities of earth fill available for construction. In addition to this full programme of investigation at the principal Kainji site, the prospects of siting a secondary dam at Jebba were also investigated by drilling and seismic traversing.

Brief reference should be made to other activities involved in this full programme of site exploration. Geological studies were, of course, of paramount importance in directing the general course of the investigation and in interpreting site conditions from both surface exposures and borehole cores. The various rock types had to be identified and their structural relationships carefully worked out. Core samples from the boreholes representative of the principal rock types present were despatched to London where their density, porosity, compressive strength and other physical characteristics were determined. Over 450 samples of the various soils near the dam site were obtained and a total of about 1,500 tests of various kinds was carried out to ascertain the suitability of this material for earth fill. The prospects of leakage in the rocks underlying the site were assessed by sealing off sections of the boreholes, applying water at a pressure of 75 lbs per sq. inch—equivalent to the static head of the reservoir when full—and measuring the rate at which water escaped. A detailed geological survey had to be undertaken of the reservoir area, extending 80 miles upstream of the dam site, to assess the possibilities of leakage. Finally, a photo-geological interpretation of the whole area of the project was made to check geological structures, fault zones, shatter belts, etc. since these are often more readily detected from the air than on the ground.

This full and detailed investigation of the Kainji and Jebba dam sites was completed in March 1961, having occupied a little under a year, but further drilling was undertaken from both banks of the left channel at Kainji between September 1961 and January 1962 to furnish further data for detailed design and in the river itself between July and September 1962 to explore sites for cofferdams and foundations for the permanent road bridge connecting Kainji Island with Mokwa.

It now remains to describe the more important results of these investigations and to indicate the various ways in which geological conditions and the quality and quantities of locally available construction materials influenced the siting and design of the projects.

The rocks present at the Kainji site and extending up into the reservoir area were found to consist of a complex series of ancient crystalline metamorphic and igneous types which included quartzites, gneisses, granites, granodiorite and amphibolite. In their fresh state all are extremely hard and strong, indeed, tests carried out in London showed them to be among the strongest rocks known. Although they showed numerous joints and fissures at and near the surface, these tended to disappear at modest depth rendering the rocks virtually impermeable. The water pressure tests in boreholes, already mentioned, usually showed only small losses indicating that only moderate grouting would be necessary to render the foundations watertight.

In the vicinity of the river and across Kainji Island the hard fresh bedrock is covered with fine sand and silt between 7 and 20 feet thick. On the rising ground away from the river, which forms the abutments, there is often a varying thickness of decomposed rock beneath the soil. Seismic traverses checked by borings at frequent intervals indicate that, up to 3,000 feet from the river on both banks, this cover of soil and decomposed rock varies between 10 and 20 feet. Higher up on the abutments, at greater distances from the river, there is a tendency for the thickness of this overburden of soil and decomposed rock to increase somewhat and, locally, it may extend down to 50 or 60 feet. Compared with other dam sites in Africa and elsewhere, this thickness of overburden is very moderate especially when the length of the main dam axis of 14,500 feet is taken into consideration.

The most interesting and important feature revealed by the drilling operations was the existence of two faults, one in each channel of the Niger. These lay buried beneath the alluvium and could not have been detected by any other means. The fault in the right channel was the larger of the two with a soft zone filled with clay and rock fragments, between 30 and 70 feet wide, flanked by highly fractured rock. By intersecting this fault at different levels with inclined boreholes it was possible to show that it was inclined at an angle of about 60° northeastwards beneath Kainji Island. The fault in the left channel has a soft zone only 12 to 15 feet wide and was either vertical or inclined at a very steep angle exceeding 80° to the horizontal.

It had originally been intended that the central part of the Kainji dam should consist of a concrete, gravity-section spillway over the right channel flanked by a combined gravity-section dam and power house occupying Kainji Island and the left channel. The major fault in the right channel rendered this arrangement undesirable, however, because of possible settlement of the soft zone of the fault under load. To safeguard the concrete structure against this, it would have been necessary to remove the clay and soft decomposed rock, replace it with mass concrete and strengthen and seal the adjacent shattered rock by extensive grouting—altogether a very difficult and costly undertaking. On the other hand, such settlement would not be so serious in the case of a fill dam and although the fault would require treatment this would be neither so costly nor so extensive as in the case of the concrete structure. To overcome this problem, therefore, the spillway was shifted on to the left bank away from the influence of this fault with a fill dam occupying the right channel. The left channel fault being smaller and practically vertical did not present the same risk to the concrete and its treatment should be neither very costly nor unduly difficult.

The proposed Kainji dam was conceived as a composite dam with a central concrete section, as described, and with earth or rockfill wings. A survey of the materials available showed that plentiful supplies of suitable earth

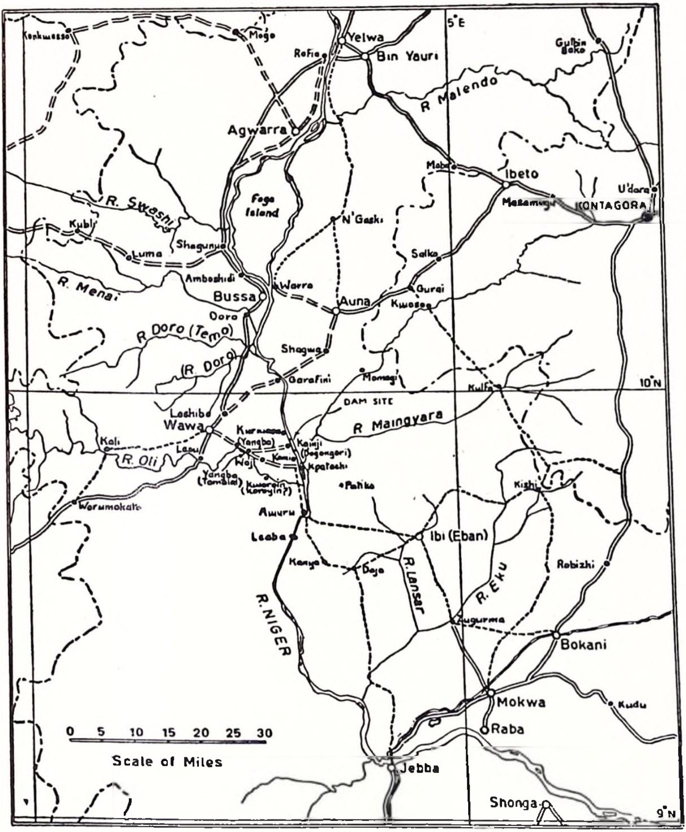



*Fig. 5. Map of the area around Kainji*

fill existed high up on the left bank but that the amount of such fill on the right bank was inadequate. On the other hand, a very good source of rock for rockfill was proved about two miles from the dam on the right bank while large quantities of rockfill would also be available on the left bank from the excavations for the dam. To avoid the cost and confusion of transferring earth fill across the site, therefore, a central broad core of earth supported by shoulders of rockfill was adopted for the wings of the dam, thus making the most efficient use of the materials available.

The investigations at Jebba were not as detailed as those at Kainji since a dam here would not be required for twenty years. Nevertheless, for an overall assessment of the Niger Dams Scheme it was necessary to ascertain whether a dam at Jebba was feasible and, if so, to estimate its cost. The preliminary investigations at Jebba in 1958 had resulted in the location of one possible dam site but, as in the case of the other sites upstream, doubt existed about the depth of alluvium overlying bedrock in the river channel. It was known that a deeply excavated channel, now infilled with alluvium, existed downstream of Jebba and hand drilling from sandbanks at low flow had indicated that such a buried channel existed also at the Jebba site. It was feared that the alluvium might be too deep for an economic design and this was, unfortunately confirmed by borings which showed the bed sand to be between 150 and 160 feet deep. The search was continued and resulted in the finding of another site about 4,000 feet downstream of the first, just above the Juju Rock, where the depth of alluvium, mostly sand, was between 90 and 100 feet. This was deeper than at the Kainji site but still within the bounds of economic design. Meanwhile, other aspects of a dam on this site were investigated and found to be generally favourable.

There were other instances, especially in connection with the Kainji investigation, where the information obtained enabled improvements and economies in design to be effected but sufficient have been mentioned to indicate the importance of geology in the design of this project.

Mr. J. P. P. Gibbs (*Ministry of Economic Planning, Northern Nigeria*) **Some problems of resettlement of the displaced population.***

*The People*

The Kainji Dam causes the formation of a reservoir approximately 100 miles long by at its widest point 20 miles wide, and of an area of approximately 507 square miles. Narrow at the top and the bottom, it bulges out in the centre to cover the large but low-lying Foge Island. It necessitates the evacuation of all persons living below the 470 feet contour, or in flat country to a point 300 feet beyond the 470 feet contour. Where the 472 feet contour is less than 300 feet from the 470 feet contour, then people will be evacuated up to the 472 feet contour. The water line is not yet demarcated on the ground, but the Federal Survey Department is undertaking this task beginning in January, 1963.

The areas affected lie mainly in Borgu Emirate of Ilorin Province and Yauri Emirate of Sokoto Province. To a very much lesser extent, Gwandu

* Published by permission of the Government of Northern Nigeria.

Fig. 6. *Detailed map of the Kainji area*

Emirate of Sokoto Province and Kontagora Emirate of Niger Province are affected. The actual estimates are Yauri 318 square miles, Borgu 138, Kontagora 41 and Gwandu 10 square miles.

A preliminary survey in March 1961 of the population affected showed the following:—

| | *Taxpayers (i.e. adult males)* | *Total Population* |
|---|---|---|
| Yauri Emirate | 6,904 | 28,094 |
| Gwandu Emirate (approximate) | 80 | 500 |
| Borgu Emirate | 3,004 | 11,601 |
| Kontagora Emirate | 228 | 786 |
| Total | 10,216 | 40,981 |

This survey was based on a detailed check, hamlet by hamlet, of the 1960/61 tax assessment lists with the District and Village Area heads of the units affected. A study of the 1962 Census figures for the area showed however an increase over these figures varying between 10% and 20%. This could be accounted for in several ways—the tax count is not always accurate in respect of women and children, who do not pay tax, nomadic Fulani cattle herdsmen were still on Foge Island and other marshy grazing grounds, and it was not easy to reconcile the reservoir boundaries with the administrative boundaries used in the Census. The exact number to be moved will not be known until the detailed personnel and property census of each town, village and hamlet has been carried out immediately prior to the move. Allowing for the natural increase of 2% per annum together with a probable undercount of women and children in the tax assessment lists, the final figure will probably be in the region of 49,000 souls. This compares with the 50,000 for the Volta Dam, although this figure is also by no means final.

Having dealt with the statistics, let us look at the people and area involved. The land is, as might be expected, mostly the fertile alluvial soil of the river valley, providing crops of onion, corn, rice, pepper and other high-value market garden crops. This is mostly along the banks of the river and the smaller islands. Foge Island itself is mostly scrub savanna and marsh with some exploitable timber. Above Foge the river is characterised by numerous islands, nearly all of which are closely cultivated by the Gungawa. Below Foge, from Bussa down to the dam site, the river narrows with higher banks, rocky outcrops and denser vegetation. The area is comparatively sparsely inhabited, hamlets of some 300 to 400 people being scattered along the river banks and the islands. The only towns of any size affected are Yelwa at the northern end of the reservoir and Bussa in the centre. Yelwa of some 8,000 inhabitants is the administrative headquarters of Yauri Emirate, and Bussa of some 3,000 inhabitants that of Borgu Emirate. Bussa is completely flooded, but Yelwa will be protected by a bund 25 feet high around the portion of the town fronting the river. The only road affected is the Bussa-Rofia-Yelwa Trunk B Road, completed a few years ago. This, besides giving trunk access to Sokoto from South Western Nigeria, opens up the comparatively populous northern part of Borgu Division.

The peoples affected are engaged very nearly wholly in agriculture with some fishing as a secondary occupation. Normally one farming family will have two types of farm, one upland wet season farm, most of which will not be affected by the reservoir, and one smaller dry season farm for high-value crops on the banks of the river, often irrigated by shadoof. Fishing is mainly carried out in the creeks, tributaries and marshes, the busiest time being as the Black Flood drops when farming is virtually at a standstill in the dry season. Other trades and crafts are carried on particularly in the larger towns and villages of Bussa, Warra, Mahuta and Agwarra, but these in the main service the farming community. Many of the tradesmen farm as well, the demand for their services being insufficient to provide a full-time occupation. A few professional fishermen live in the area (the Salkawa), and others from as far away as Niger Republic and Eastern Nigeria visit the area in pursuit of their livelihood.

The main tribes affected are the Gungawa, living mainly on the islands, alleged by one chronicler to be the descendants of a great Songhai army that was routed by Borgu soldiery; the Yaurawa from Yauri, once one of the *Banza Bakwai*—the seven great non-Hausa kingdoms of the Nigerian Sudan, matching the seven Hausa kingdoms; the Kamberi, of magnificent physique, independent, indefatigable farmers, given to moving their compounds every decade or so; the Lopawa living in the main on Foge and nearby villages on either bank of the river; and of course the Bussawa or men of Bussa. The whole are characterised by Gunn as "mild and merry", and even as far back as 1832 Clapperton and the Landers described the "Cumbry" (among whom they included the Gungawa) as an attractive, ingratiating people, even under the excruciating pressure of those times when they were the victims of the Kontagora slave raids.[1]

The settlement patterns of the two main tribes, the Kamberi and Gungawa, are distinctive and have had considerable influence in the framing of the resettlement proposals. The largest "tribally" homogeneous local grouping is generally the hamlet or ward, each hamlet considering itself independent. There is as such no tribal administrative organisation or chief. While administratively both for centuries have been integrated into the local states, it is remarkable how they have been able to maintain a relatively high degree of general cultural and linguistic distinctness, despite a very close association with the states. A guess may therefore be hazarded that despite the impact of industrialisation brought by the dam and their uprooting from their present homes, this distinctness will remain.

The characteristic house type of the Gungawa is the stilt hut, a mud and thatch mushroom-type hut, uniquely mounted on stone stilts against the floods which annually are liable to cover their land. Flooding is no new thing to the Gungawa, and indeed the abnormally high White Flood in 1959 caused some to move to the mainland. Unfortunately they did not move much beyond the banks of the river and will have to be moved again in due course. It does however make the concept of a permanent flood, the reservoir, easier to accept in their minds.

Compared to dams in other parts of the world, resettlement of the displaced population in the Kainji Project presents relatively few problems. As

[1] H. D. Gunn and F. P. Conant: *Peoples of the Middle Niger Region, Northern Nigeria*, International African Institute, London, 1960. pp. 15 and 25.

Similarly it is not proposed to force the people into regulated agricultural settlement. The Northern Government has had some experience of agricultural settlement schemes, and the only ones that have proved a success are where the people are under a natural pressure to move—pressure of population or exhaustion of land in the hills—and where they are moved as complete units. One might say that these conditions could be fulfilled at Kainji. Nevertheless the nature of the Kamberi, for example, who live in family hamlets and like to move every decade or so, and who are very independent, would make any such scheme an expensive farce. They would just not move into the settlement area. Having forced people to move from their present homes, it would not be good sense to impose on them the additional shock of living in conditions alien to their way of life. Should it be desirable in the future as part of the development of the dam area, then it should be undertaken as a separate exercise at the time.

Within the limits indicated by the soil and water surveys, farming land will be alloted to villages or hamlets, who will then suballot to individual farmers. These farmers will clear and plant their own farms, with the advice and practical assistance of teams from the Ministry of Agriculture extension services. These services will include the setting up of master farmers, demonstration farms and improved seed multiplication schemes; the establishment of mixed farms and small irrigation systems; and the distribution of fertiliser. As it is planned to move villages after the harvest each year, compensation for destroyed crops should not be necessary, but compensation for his flooded farm will be paid to each farmer on the basis of £5 to £7 per acre, which is approximately the cost of clearance. In addition he will be paid compensation for any economic trees on his farm or his compound on the basis of the value of three year's fruit. This varies from 5/- for a guava to £10 for a large mango tree.

Other resettlement schemes, and in particular Kariba, provided for the feeding of the displaced population by the Government for up to two years. This is made necessary by the long distance of the new location from the old. The short distances involved in the Kainji scheme will make it possible for people to continue to feed themselves, provided they are moved in the dry season after the harvest and in sufficient time to clear and plant for the next. No special arrangements are therefore envisaged for their feeding under normal circumstances, but as an insurance it is proposed to keep a reserve of staples such as corn at New Bussa and at Yelwa. This will serve a double purpose, to alleviate hardship in the case of any village not being able to re-establish itself in time for planting, and as a means of controlling food prices in the markets of the construction camp at New Bussa and at Yelwa. The holding of reserves of foodstuffs by Government for release if prices go up was a device used successfully during the tremendous influx of people into Kaduna during the Royal Visit in 1956 and the Self Government celebrations in 1959.

Compensation is also envisaged for disturbance and in certain cases for loss of livelihood due to the changed circumstances of the river. Compensation for disturbance will take the form of a remission of tax for two years. It is only the '*haraji*', or income tax which is remitted, licences for brewing, guns or bicycles remaining to be paid. Compensation for loss of livelihood may be necessary for people such as canoe owners earning their living ferrying traders to and from markets on the river bank. The market itself may disappear, or the reservoir be too wide for his canoe. In such a case compensation would take the form of a larger canoe capable of crossing the reservoir. Other professional fishermen may need training for the different types of fishing in the waters of the reservoir. Each case will be dealt with sympathetically as it arises by the Resettlement Authority working in close co-operation with the Native Authorities.

A further problem is that of the cattle. Foge Island and the smaller islands provide during the dry season a grazing area for vast numbers of cattle. The Borgawa and the Bororo Fulani use the bank marshes until the White Flood is at its height and then move inland to feed on the harvested farms before coming to settle again on the deep marshes on the banks and the islands as the Black Flood starts to fall. Here they eat the vast areas of floating grass (*burgu*) which is peculiar to the marshy area. Other Fulani, mainly Ba'aji and Dauraji, move down from their traditional grazing grounds in north Kontagora, Zaria or Kano Provinces as the dry season approaches and camp slightly inland, driving their cattle onto the dried-up marshes during the day. They do not venture into the deep marshes, and so do not rely on the *burgu* grass. Both are however affected by the reservoir. Firstly, the *burgu* grass is drowned; whether it will re-establish itself on the banks of the reservoir is impossible to say until research is done into the problem. Secondly, the resettlement of the population further inland will impinge upon the present traditional wet season grazing grounds (*mashekari*), forcing the Fulani to move elsewhere out of the district, and possibly out of the country.

To counteract this, it is proposed as a result of the soil surveys to establish new grazing areas in the district, and by clearing these areas of tsetse make them sufficiently attractive to hold the Fulani in the area. The first stage is to ascertain exactly how many cattle are affected, and this will be done by a West German firm by means of aerial survey, as part of a plan to count the whole cattle population of the Northern Region. At the same time soil surveys will indicate which areas would be suitable. Finally clearance and spraying and possibly sowing will be undertaken in those areas.

Other services which will be supplied by the Resettlement Authority are of course water supplies and a replacement of road communications to

Nothern Borgu. With so much water in the reservoir it may seem anomalous to say that some difficulty is anticipated in providing water supplies for some of the new villages, particularly on the west or Borgu bank. The basement rock here is fairly near the surface and the existing wells often dry up towards the end of the dry season. Further it is believed that the rock is of such a type that boreholes may not be feasible as it is unlikely that underground water exists. The soil survey teams at present operating in the area are providing preliminary information on this problem, and a full-scale water survey is due to take place in October, 1963. Until its report is available the full extent of the problem will not be known.

Road access to northern Borgu will be restored by the construction of a new road to Trunk B standards from Wawa to a point on the dry season track from Shagunu on the reservoir to Babana near the Niger Republic border. This track will be improved to all-season administrative standards and will continue from Babana northwards to Tungan Jatau thence eastwards to Mogo and to the Rofia ferry. This ferry, although having to cross a much wider stretch of water, will be kept in commission to provide an outlet for the export produce from north Borgu to the port of Yelwa.

*The Towns*

*Bussa*, as already noted, goes completely under the water with the exception of the District Officer's house which will perch on a tiny island almost in the centre of the reservoir which is nine miles wide at that point. An almost unique arrangement is proposed for its new situation. It is planned to site new Bussa in the centre of the construction camp some five miles from the dam itself. There were several reasons for this decision. Firstly, the construction camp, although only temporary, has many amenities in the way of electricity, a treated water supply, sewage system, a hospital, post office, banks, shops and all the appurtenances of a modern town. The present Bussa is sadly lacking in these. So it seemed natural that advantage should be taken of this manna from heaven. A nucleus of a permanent settlement in any case has to be kept on the site after the construction of the dam to accommodate the operating and maintenance staff. Secondly, Bussa in its present site is somewhat to the north of the extensive Borgu Division of which it is the administrative headquarters. By moving some 37 miles south it will be placed more centrally, as well as being close to the Niger crossing afforded by the bridge. Thirdly, Bussa has lost its importance as a river port in the last few years after the construction of the Bussa-Rofia-Yelwa road diverted the carriage of goods from the river to the road. It may re-establish itself in the future as the town of the Dam, as a staging point on the main road north over the river, and as a tourist centre for the game park which the Northern Nigeria Government plans to establish nearby.

As the construction camp is being built to a high standard to ensure continuity of labour, and as the camp will necessarily become somewhat of a cynosure of visiting eyes, New Bussa must also be of a high standard of town planning and construction. To this end designs for the complete town, including the ordinary peoples' compounds have been drawn up by the Consultants to the specifications of the Borgu Native Authority Council, and it is intended that the whole should be built by the contractor for the camp. A householder will have built for him the outside wall of the compound, the entrance porch, one main living quarter and kitchen and sanitary facilities (to tie in the water and sewage). He will also receive compensation at the normal rates for any other huts, etc. in his former compound to enable him to build wives' quarters in his new compound himself—behind the compound wall. By these means the town plan is preserved, which otherwise uncontrolled private building would not allow. It will also allow Bussa to be moved *en masse* over two or three days since all facilities will await them in their new homes.

The insertion of an established town into the middle of a construction camp, which is normally under the contractor's sole control, presents unique problems. The new town has been gazetted as a township and will be administered for the five-year period of the construction of the dam under the Townships Ordinance. This means that operating in the town will be five separate authorities—the Township Local Authority, the Divisional Officer, Borgu, the Borgu Native Authority, the Niger Dams Authority and the Contractor's Camp Commandant. Careful integration of the powers and responsibilities of these five will be necessary if confusion is not to arise. The presence of the Native Authority in the township has the advantage of providing the traditional authority which was lacking in the Kariba camp. There, the lack of a traditional authority left a leadership vacuum which was filled by agitators, leading in turn to labour unrest and eventually a strike.

*Yelwa*, at the northern end of the reservoir, is not flooded with the reservoir at its normal level. To protect it against peak heights of the water, a sand and clay bund or levee 25 feet high is to be built round the town fronting the river. As Yelwa becomes the port of Sokoto and North Western Nigeria, accessible to barges the year round, a quay is incorporated in the bund, and an area behind the quay will have to be cleared to provide space for the warehouses to store export produce while awaiting shipment. This involves the redevelopment of part of the town and includes the removal of the Emir's Palace which is right up against the bund and overlooked by it.

The game problem, which attracted so much publicity at Kariba, virtually does not exist at Kainji. Owing to the activities of professional hunters, the game has been much reduced in quantity in the last decade, and is now concentrated mainly in the uninhabited bush in north Borgu which it is proposed to turn into a game reserve. A certain amount of smaller game such as antelope may exist on Foge and it may be necessary in the final stages of the filling of the reservoir to put out patrols to guide any game off. No such campaign as 'Operation Noah' is however envisaged.

*The Programme*

To move nearly 50,000 people scattered along 100 miles of river bank and islands in one operation at the same time would require such a concentration of staff and equipment, vehicles and boats, that it is scarcely feasible in the light of what is available. The time of any move is limited to the dry season from October/November to April/May, and within that period it is further limited to the period between the harvesting of one crop and the clearing and planting for the next, unless heavy expenditure is to be incurred on feeding. Again if the operation was done at one time, the inflation caused by the injection of the compensation payments in the area would be severe. This would be particularly true of building materials, such as poles, thatching grass etc. Accordingly it is proposed to move the population in five phases over five consecutive dry seasons.

The first people to be moved are the 620 souls in the actual construction area of the dam itself, in the hamlets of Kainji, Komi and Tungan Amfani. This will probably take place next dry season and will afford an ideal opportunity for the Resettlement Authority to test out its procedures before taking on the greater numbers in subsequent years. Phase II will be the two towns, Bussa and Yelwa, the people moving in Yelwa being of course only those displaced in the warehouse area. Phase III is the most important and the one presenting the greatest problem. It is the Gungawa in Shanga and Kunji Districts of Yauri Emirate and comprises approximately 18,500 persons. Phase IV takes in the southern district of Yauri on the east bank, Ngaski District, and the two village areas of Kontagora Emirate. Finally the last phase will move the villages and hamlets on the west bank in Borgu Division. The final phase is planned to be complete by February/March 1968, after which the reservoir begins filling with the 1968 White Flood.

The total cost of the resettlement is expected to be in the region of £3,000,000 or £61 a head. This compares with the £47 per head for Kariba, and £70 a head for Karnafuli (assuming the Pakistan rupee to convert to 2/2d.).

*Conclusions*

What of the future for the resettled people? Will their way of life be changed permanently by the dam and the lake? If so, will it be changed for the better? Certainly the townspeople of Bussa and Yelwa will benefit by the change. The prospects offered to Bussa, not only of living in a modern town with all its amenities, but also of increased economic prosperity, make the future very inviting to its inhabitants, and there is already an eagerness to see the project started. The inhabitants of Yelwa can expect the increased economic benefits which the port facilities will bring, but not all are enamoured by the thought of the great bund dominating the town. Yelwa may also develop as a fishing centre. As far as the rural farmer is concerned, life will go on very much as before for the bank dwellers. The islanders on the other hand may face a radical change in their farming methods if sufficient alluvial land cannot be found for them. Certainly the concentration of Ministry of Agriculture assistance and supervision over the six-year period should increase production, and thus increase incomes by the end of the period.

It is not anticipated that the area will become industrialised as a result of the dam to any large extent. The logical area for industry wishing to take advantage of the electricity and water transport provided by the dam is in the Jebba area, where access by rail to the big markets of Ibadan and Lagos is also possible. Kainji is too remote and has no rail access. Nevertheless it is possible that a fish-processing industry will be feasible on the reservoir to treat the 10,000 tons of fish expected from the lake. This could be combined with the processing of market garden crops and citrus grown by local irrigation from the reservoir. The possibilities of tourism, taking into account the nearby game reserve, have already been mentioned. Agricultural development as a result of the formation of the lake is more likely to take place below Jebba, between there and Lokoja, taking advantage of the controlled flood of the Niger. Irrigation from the lake itself will more probably be confined to the market gardens and citrus plantations along its edges or close thereto.

All in all, the Kainji resettlement scheme poses relatively few major problems, as far as can be seen at present. These are:

(*a*) The finding of sufficient alluvial land on which to resettle the island dwellers in order that production of high-value crops, particularly onions, may be continued on its present scale.

(*b*) The necessity for adjustments to Emirate boundaries in the event of there being insufficient land within the boundaries of existing Emirates.

(*c*) The co-ordination of the various authorities in New Bussa and the administration of the camp with a permanent town in its centre.

No doubt others will arise in the course of the operation, as no planning dealing with such a number of human beings can be infallible and all-foreseeing. The Resettlement Authority must remain sufficiently flexible to deal with these promptly as they arise.

Dr. A. E. Boyo (*Federal Ministry of Health, Lagos*) **Medical problems of the Niger Dams project.**

The author, who was not intimately connected with the project and could consequently give the detached view of an outsider, posed the question: how will the Niger Dams project affect the general disease pattern?

The increase in population would increase the danger of epidemics. This was considered from three aspects: susceptible cases, disease vectors and the endemic disease reservoir.

River blindness, trypanosomiasis, schistosomiasis and malaria were discussed as being the major diseases which might increase in the area. The dangers of each were stated together with methods for their prevention and control which, if introduced, should prevent any anxiety over the health of the present population or of the immigrant labour force.

**Discussion**

Dr. E. Njoku, the Chairman of the Symposium and former Chairman of the Electricity Corporation of Nigeria, commenced the general discussion which followed these four papers. He reviewed the history of the project and referred to the fact that the running costs of hydro-electricity production were considerably less than those of electricity production by thermal plant. The major financial disadvantage of hydro-electricity was the high capital cost.

For the remainder of the discussion a wide variety of questions from delegates were answered by a panel of the four speakers.

Delegates wished to know whether the project would lead to cheaper electricity for the consumer and if the cost of transmission from the dam site to areas of heavy load had been considered. It was stated that the transmission costs were economic and that although the production cost of electricity would decrease only part of this would be passed on to the consumer until the whole project had been financed and until the demands of the resulting industrial developments were known.

Doubts were expressed as to the value of such multi-purpose, as opposed to single purpose, projects. It was agreed that electricity production and flood control often required opposing types of management, but a careful analysis of the hydrograph showed that a schedule of operations could be determined at which the electricity output is not adversely affected by the flood-control requirements.

Analysis of the flood probability shows that an incoming flood fifty per cent greater than the highest on record would have a frequency of occurrence of once in ten thousand years, but there will be a spill race which could cope with twice the greatest flood on record. Normal floods downstream from the dam would be considerably lower than before construction of the Kainji project, and in the Niger valley the prevention of floods is more important for agriculture than eventual irrigation. Still, future water consumption for irrigation in the Niger valley will not jeopardize the efficiency of the multipurpose scheme.

Delegates, possibly influenced by recent events at the Kariba Dam in Rhodesia, were obviously worried by certain dangers but in all cases the panel were optimistic. The Niger Dams project would not be affected by upstream dams outside Nigerian territory even if all the proposed schemes materialized. Flash floods occurring during construction could not cause a dangerous rise in water level (even should one of the two channels be blocked at the time) since the site is not in a gorge. Research is being carried out on methods for controlling the spread of the water fern *Salvinia*. Any game in the area to be flooded will be driven into the new Borgu Game Reserve.

Most delegates seemed satisfied with the answers provided by the panel. Eventually the Chairman had to bring the discussion to a close because of shortage of time. He thanked the speakers, not only for their papers but also for the way in which they responded in the discussion and reminded delegates of the excellent model of the project which was on exhibition.

## SPECIALIST PAPERS

### *Agriculture Specialist Section*

Mr. I. A. Akinrele (*Federal Institute of Industrial Research, Oshodi*) **The development of gari into a wholesome food.**

Cassava (*Manihot utilissima*) is mainly processed in Nigeria in the form of a fermented food known as "gari". It is eaten extensively in West and Central Africa, but it is frequently unwholesome because it is processed in the village under unhygienic conditions, and also on account of its poor nutritive value. The various attempts made to correct these, including the mechanisation of the traditional process and the fortification of the product with suitable and cheap protein and vitamin concentrates prepared at the Federal Institute of Industrial Research were reviewed.

Mr. D. G. Coursey (*Federal Institute of Industrial Research, Oshodi*) **Recent investigations on yam storage in Nigeria.**

In spite of the great economic importance of the yam crop (*Dioscorea* spp.) in Nigeria, little information on the storage behaviour of yams was available prior to the investigations carried out during recent years by the West African Stored Products Research Unit.

These investigations have shown that very substantial losses in weight and quality occur during normal storage of a few months in yam "barns", figures of 10% after three months and 20% after five months being normal even when no rotting and sprouting occurred. This loss is largely due to the natural respiratory processes of the tubers. Treatment with fungicides and respiratory inhibitors resulted in slight reductions in storage losses in some cases. The distribution of moisture in the tubers has also been investigated.

Mr. E. C. Hislop (*W.A.C.R.I., Ibadan*) **The chemical control of black-pod disease of cocoa.**

Black-pod disease probably causes as much as twenty per cent loss of the cocoa crop in Nigeria. The chemical control of this disease has been the subject of research at the Nigerian Station of the West African Cocoa Research Institute for the last four years. Attempts have been made to answer four basic questions: what chemicals are toxic to *Phytophthora palmivora* the causal organism? what factors influence the efficiency of these chemicals? when should the chemicals be applied? how should they be applied?

Three methods of answering the first question were described and the results compared. Of the copper fungicides tested the order of efficiency is probably Bordeaux mixture > cuprous oxides > copper oxychlorides. The only organic fungicide to show any great promise so far is triphenyltin acetate.

In attempting to answer the second question the tenacity of various fungicides to pods has been examined, and a general relationship between leaching of deposits and rainfall has been established. It has been demonstrated that poor tenacity in the field is frequently due to the incomplete drying of the deposits.

Theoretical considerations and evidence from field trials indicate that spraying must be repeated every 2—4 weeks during the wet season. Three different types of spraying machinery for applying fungicides to cocoa have been examined. Low volume application from mist-blowers was more costly and less effective in controlling the disease than high volume application from simple pneumatic knapsack machines.

Mr. E. O. Jaiyebo (*Faculty of Agriculture, University of Ife*) **Seasonal variations in soil nitrate under five different cover treatments in a tropical rainforest environment.**

Seasonal fluctuations in the amounts of nitrate and nitrifiable nitrogen in the upper 10 cm. of soil under five different cover treatments (no vegetation, no vegetation and a mulch of *Imperata cylindrica*, cover of *Cynodon plectostachyus*, cover of *Pueraria phaseoloides*, and regenerated bush cover) were studied.

The level of soil nitrate was higher in the dry season than in the wet. Soon after the first rain following the dry season the nitrate level increased sharply, reached a peak and then dropped to a low level which persisted throughout the wet season in all plots except in the bare plot. After the initial flush the level of nitrate tended to decrease with increasing soil moisture, but there appeared to be no simple relationship between soil moisture and soil nitrate.

Giant Stargrass (*Cynodon plectostachyus*) and grass mulch appeared to repress nitrification. Significant positive correlations were observed between the level of nitrifiable nitrogen and the total rainfall in the fortnight preceeding sampling.

The bare plot had a lower nitrifiable nitrogen content and a relatively higher nitrate level than the plots under cover. Non-accumulation of nitrate in the plots under vegetation during the wet season was not due to a shortage of nitrifiable nitrogen but to such factors as the inhibition of the process of drying and re-wetting of organic material, leaching, denitrification and nitrate absorption by plants.

Dr. L. K. Opeke (*Faculty of Agriculture, University of Ife*) **Soviet genetics and methods of plant breeding.**

The principle of Soviet genetics was developed by Michurin and Lysenko in their theories of agrobiology. Darwin, in his origin of species, showed how plants and animals can be improved by selection. Michurin's agrobiology, continuing Darwin, studied the organism as a unit in relation to its environment, and heredity as a history of ecological adaptation. It further claimed that man cannot wait on nature for the production of new forms, that organisms have the ability of rapid adaptation to new environments, and that this is greatest at seedling stages. Lysenko developed this theory into the principle of directed training, which is being widely applied by Soviet breeders. Immediate environmental factors as well as crossing and grafting are employed to loosen conservative heredity since organisms with unstable heredity respond more to direct training.

The process of fertilisation from the point of view of Michurin's agrobiology is not a mechanical fusion of gametes on the basis of an accidental meeting as postulated by chromosome theory of heredity: it is a process of mutual assimilation by parts of the substances of one sexual cell by another on the basis of interselectivity. Sexual process as any other biological process is a metabolic process. Fertilisation not only establishes hereditary units, but creates vitality. Vitality was explained by Darwin in terms of chromosomal heterogeneity obtained by crossing plants of different varieties and species. Michurin contended that the environmental variations over a field of a variety of a crop are sufficient to produce heterogeneity in sexual cells. A crop variety is better maintained by repeated intravarietal crosses rather than the classical method. This method is widely used in cotton breeding in the Soviet Union.

Michurin's agrobiology acknowledges that grafting can produce hereditary variation with equal efficiency as sexual crossing. Darwin himself accepted the possibility of producing hereditary variations by grafting. This idea has been developed into the practice of vegetative hybridisation and vegetative mentor by Soviet plant breeders. These Soviet concepts possibly represent a high level of the integration of genetics and physiology in the field of plant breeding.

Mr. H. Toxopeus (*W.A.C.R.I., Ibadan*) **The first Nigerian cacao breeding programme: history and main results up to 1956.**

In 1930 a selection programme was started in two cacao orchards planted in 1912 on Moor Plantation. The seed source is unknown but it is assumed that it was Agege. Selection criteria and results were presented. Selfed and cross-pollinated progenies of the selections were planted out on various sites. Despite difficulties in establishment and frequent capsid attacks the programme was continued. None of the progenies showed an outstanding yielding capacity, but it was concluded that the selfed progeny of N38 (T38; T(N)38 one of the selections) was very satisfactory and clonal orchards of N38 were planted to obtain large quantities of seed. Around 1935 introductions were made from Trinidad and Ceylon to obtain new parent material. Crosses of some of these introductions with N38 gave very vigorous and high yielding progenies. Clonal orchards of the parents of two of the best progenies, CF176 x N38 and CF62 x N38, were planted in 1956 to produce seed on a large scale. As none of the parents was self incompatible hand pollinations had to be made to produce the seed. At this time the programme was outdated by W.A.C.R.I. breeding work, however the results were fully used to the benefit of the W.A.C.R.I. breeding scheme.

Dr. S. O. Alasoadura (*Botany Department, University of Ibadan*) **Fruit-body development and glebal-mass discharge in** *Sphaerobolus stellatus* **(Tode) Pers.**

*Sphaerobolus*, a genus of the Gastromycetes, grows readily in pure culture and, provided there is sufficient illumination, fruits on malt agar and on oatmeal agar. Fruiting occurred after about 40 days on 2% malt agar but was delayed at higher concentrations. On oatmeal agar, only about 21 days were necessary for fruiting. A chemically defined medium with starch as carbon source allowed fruiting but at a low level.

Oatmeal agar cultures were used in experiments aimed at finding the effects of temperature and light on fruiting. Temperature has a profound effect on basidiocarp development; above 25°C no fruit-bodies are normally formed although vegetative growth is approximately optimal at that temperature. At 20°C, light above 100 lux is necessary for fruit-body production and light remains a limiting factor up to about 1000 lux.

There is a periodicity in fruiting under continuous light and at a uniform temperature. A number of developmental stages of the basidiocarps can be recognised. The final stage—glebal-mass discharge from stellately-opened fruit-bodies—is indifferent to light, but all other stages are affected by light. The light intensity for effective stimulation falls during development and for the penultimate stage, an intensity as low as one lux is effective.

Only light with wave-lengths below 500 m$\mu$ is active in basidiocarp development. In the sensitive region between 400 m$\mu$ and 500 m$\mu$ there appeared to be peaks of sensitivity around 440 m$\mu$ and 480 m$\mu$.

In alternating light and darkness, simulating natural conditions, glebal-mass discharge occurs in the light periods. With a regimen of 24 hours' light and 24 hours' darkness, however, discharge is mainly in the dark periods.

Phototropism of basidiocarps leading to glebal-mass discharge towards the incident light, has been studied. There is an indication that mature unopened basidiocarps can still respond phototropically.

Mr. J. A. Mackenzie (*Federal Department of Forest Research, Ibadan*) **Mast years in** *Triplochiton scleroxylon* **K. Schum.**

Dr. S. H. Z. Naqvi (*Botany Department, University of Nigeria, Nsukka*) **Biochemical investigations of the root rot disease of cotton.**

The present studies were carried out in two phases; first to determine and establish the causal organism and their pathogenecity and secondly to investigate the extracellular cellulolytic and pectic enzymes of the fungus which disintegerate the root tissue of the plant. Pathogenecity representative cultures of many fungi including *Rhizoctonia solani*, *R. bataticola*, *Fusarium coeruleum*, *Phymatotrichum omnivorum* and *Trichoderma lignorum* were tested for their pathogenecity on cotton plant. On repeated tests under different conditions of light and temperature, *Rhizoctonia bataticola* was fairly pathogenic, whereas *R. solani* was slightly pathogenic. Other fungi did not cause infection. High temperatures favoured infection.

Other experiments were carried out to adjust the inoculum potential and the interaction of *R. bataticola* and *R. solani* with migratory soil nematodes (*Pratylenchus*, *Paratylenchus* and *Tylenchorhincus*) and *Trichoderma lignorum*. With nematodes the incidence with disease increased whilst with *Trichoderma lignorum* it decreased.

Studies of fungus infection with regard to age of plant revealed that susceptibility of plants decreased with the increase of age.

Greenhouse studies were made to test the extent of control of these diseases by means of fungicides including PC NB, 8-Oxyquinolinol Sulphate, Dithane D-14, Fernesan and two compounds bearing the code Nos. 512 and 514. None of them was effective. The coded compounds were toxic to cotton plants.

A study was undertaken of the production of cellulolytic and pectic enzymes by *Rhizoctonia bataticola* and the ability of this fungus to degrade native cellulose and whether cellulase could be produced on living host tissue.

*R. bataticola* produced relatively large amounts of extracellular cellulase when grown on CMC-30, but little on cotton cellulase and none on dextrose. The fungus was able to degrade native cellulase and was capable of producing cellulase on living host tissue. The cellulase activity was also determined in relation to the pH of the culture medium. The fungus produced little polygalacturonase in sodium polypectate but none on any other sources of pectin.

## Mr. T. O. Orebamjo (*Biological Research Unit, University of Lagos*) **Studies of the variation in the leafshape of *Sphenocentrum jollyanum*.**

Studies of the variation in the leafshape between current-year shoots and successive shoots on the same plant were compared from three different localities chosen with respect to decreasing light intensities—the sites being an open habitat, a moderately shaded habitat and a deeply shaded habitat.

Determination of mean number of lobes per leaf from each habitat indicated reduced lobing with increased shading. The difference between the open habitat and the two shaded ones was significant, but the difference between the two shaded sites did not reach a significant level at 5%.

Leaf areas were measured and analysed in four ways. First, the mean leaf area of all leaves from each site was compared with those from other sites. There was no significant difference between sites.

Secondly, the mean leaf area of lobed leaves from each site was compared with the mean leaf area of entire leaves from the same site and from other sites. The area of the lobed leaves was always higher than that of entire leaves but only in the heavily shaded site was the difference significant at the 5% level.

Thirdly, all the lobed leaves from the three sites were pooled together and treated as one sample and the entire leaves were similarly treated. The difference between the mean area of lobed and entire leaves was highly significant, even at the 1% level.

Finally, lobed and entire leaves were grouped separately into 10 $cm.^2$ area-classes. The frequency of each group was plotted against its area class. The graph indicated that small leaves were mostly entire, medium leaves were either lobed or entire, large leaves were mostly lobed.

Shoots grown from cuttings revealed that leafshape was determined very early probably during initiation and there was little or no modifying environmental influence on the subsequent development.

Transition from juvenile ovate leaves to adult lobed or lanceolate forms takes three or more years.

The factors responsible for leaf lobing are not clear and were briefly discussed in the light of previous similar experiments by different physiologists. It was suggested that lobing may be caused by a quantitative light factor produced by the plants in light and subject to exhaustion by the production of lobed leaves. This suggestion partially explains decreasing mean number of lobes per leaf as well as the reduced lobing up the shoot of each season's growth.

Dr. G. S. Puri and Miss M. A. Jadesimi (*Botany Department, University of Ibadan*) **Preliminary studies on some microfossils recovered from Tertiary lignites of Nigeria.**

In the Benin-Asaba area De Swardt and Piper of the Geological Survey of Nigeria found extensive deposits of lignites, probably of upper Tertiary age. Samples were collected from the moist evergreen forest near Ehor, in Benin district. Geological and lithological features of these have been given by De Swardt, but so far no botanical studies have been done on the lignites of Nigeria.

The typical samples are brown to black in colour, and are light and compact, sometimes showing traces of lamination, but are generally structureless: no recognisable macro-plant remains are present.

The maceration of lignite samples with a weak alkali or even shaking up with water releases a large number of micro-plant fossils. These range from pollen grains, fungal hyphae and spores to pieces of cuticle and wood.

Preliminary studies, following Hemmen's nomenclature have revealed the presence of the following form genera: *Pleuricellulites, Tetradites, Monocolpites, Monoporites, Inaperturites* (with *Diporites* and *Triporites*), *Triletes,* fungal spores and *Pleuricellaesporites.*

The few forms already discovered have also been found from Assam Tertiary deposits by Puri and South American Tertiary deposits described by Hemmen.

Mr. J. F. Redhead (*Chemistry Department, University of Ibadan*) **A study of mycorrhizal associations in some trees of Western Nigeria.**

The investigation of the incidence of mycorrhizal associations in fifty tree species indigenous to the lowland forest of Western Nigeria and in fifteen exotic tree species were described. All the exotic species and forty-five of the indigenous species were found to have endotrophic mycorrhizal associations and one indigenous species an ectotrophic association. The significance of the latter was discussed. The types of association and their occurrence were described. Their incidence did not appear to be related to the conditions of light and shade nor to the vigour of the tree, but endotrophic associations are most frequent in older trees and least frequent in seedlings growing in newly-formed nurseries.

The effect of additional supplies of mineral nutrients on the development of endotrophic mycorrhizal association in tree seedlings has been investigated and the results were described. They suggest the addition of a balanced supply of the major mineral nutrient does not result in a reduced incidence of mycorrhizal association but that an unbalanced supply of mineral nutrients may. This finding is considered in relation to previous work on the effect of additional mineral nutrient on the incidence of other types of mycorrhizal association.

## *Physical Sciences and Engineering Specialist Section*

Professor W. J. Hickinbottom (*Queen Mary College, London*) **Recent contributions of organic chemistry to the chemical industry.**

Mr. R. Hutchinson (*Shell B.P., Port Harcourt*) **The mechanism of corrosion.**

The magnitude of the losses inflicted by corrosion on private industry and the nation as a whole are not always fully appreciated. An indication of the magnitude of these losses was given and the mechanism of corrosion and the methods employed to mitigate it discussed.

The basic principles of metallic corrosion and its prevention were described and illustrated from oil-field experience. Emphasis was placed on the corrosion and protection of buried or immersed iron and steel structures such as pipelines, marine platforms and ship hulls.

While much of what was said was equally applicable to other types of corrosion, there were many aspects of the subject which were not considered; for example, high temperature corrosion, corrosion by chemical solutions, stress corrosion, corrosion fatigue, etc., all of which are common problems in for example a petroleum oil refinery. Ordinary atmospheric corrosion was not considered in detail as this in most cases can be combatted by the suitable use of the wide range of conventional and special paints available on the Nigerian market.

### Mr. I. Igiehon (*University of Ibadan*) **Electrical earthing and application.**

In the distribution of electrical power the earth has for long been used both for stabilising voltages and as a return conductor for a d.c. system. Earthing for the purposes of protection against shocks and fire hazards due from leakage currents has received considerable attention. It is recognised that for a back-up fuse protection to operate, the current through a fault circuit must be greater than the fuse rating. The impedance on the route of the fault leakage, known as the Earth Leakage Impedance, is made up of various sections of which the consumer and supply earth electrodes' impedances are important. In order to keep this as low as possible efforts have been made to construct effective earth electrodes of various types. Methods of the impedance measurement have also been developed and the current injection method is the most easily employed. It is recognised that the true fault circuit differs from the test one and that errors are liable to occur. The multiple earthing system calls for numerous earthing points and is therefore expensive to adopt. Further, stray currents from the system could constitute a nuisance to telecommunication systems.

### Mr. M. N. Nwaji (*University of Ibadan*) **Structure of extracts from some Nigerian plants.**

Wood chemistry has until recently been concerned with the chemistry of commercially exploitable products extractible from woods. Now, however, interest has started turning to the chemical investigation of the constituents of woody species having less obtrusive properties. In our investigations of the heartwood constituents of trees of the family Meliaceae a number of new compounds have been isolated. Some of them, e.g. khivorin, on boiling with alcoholic alkali liberate B-furfuraldehyde, and detailed investigations have revealed that a number of them have structures related to that of limonin, but with ring A of the typical triterpenoid nucleus intact. Efforts are being made to correlate khivorin with gedunin. The structure assigned to the latter has been independently established by X-ray crystallographic studies.

### Mr. O. Okereke (*Federal Institute of Industrial Research, Oshodi*) **Utilisation of solar energy.**

The performance of a solar water-heating unit designed at the Federal Institute of Industrial Research was reported. The unit whose thermodynamic efficiency is about 40% has a 20 sq. ft. flat plate heat absorber fitted to a 20-gallon storage tank and operates on the principle of thermosyphon. Tank temperature of 65°C have been attained.

The economic factors involved were discussed and although initial cost of a unit may be high it is in the long run a profitable investment.

Finally an outline of future research plans in this field of the Institute were given.

Dr. M. B. Hill & Dr. E. E. Sandison (*University of Ibadan*, and *Westfield College, London* respectively) **The fouling of boats in Lagos harbour; its cause and treatment.**

Certain sessile animals, the most important of which are barnacles, oysters and serpulid worms, settle on ships' hulls, causing the condition known as fouling. As they grow the vessel is slowed down, and in order to regain normal speed more fuel is consumed, causing considerable economic loss.

Lagos harbour is notorious as one of the worst ports in the world for fouling. A study was undertaken to measure the seasonal variations in degree and rate of fouling in different parts of the harbour. It was observed that, although fouling occurs to a small extent throughout the year, it is greatest during the dry season. The heaviest settlement and greatest volume of fouling occurs in the upper region of the harbour where the main docks are situated. In these areas, Iddo and Apapa, barnacles and oysters predominate, and the oysters are responsible for the greatest extent of fouling. At Dejection Jetty, in the lower harbour, fouling consits almost entirely of serpulid worms. These settle in large numbers, but their volume is only half that of the fouling organisms of the upper regions of the harbour. At East Mole, at the harbour entrance, all the major fouling organisms occur.

In the wet season fresh water kills off many of the fouling organisms, but the large oysters live for some time and the barnacles thrive. Even when the animals die, their shells constitute fouling. Furthermore, the empty shells of barnacles attract the settlement of barnacle larvae. It is, therefore, necessary periodically to scrape boats clean from the fouling organisms and apply anti-fouling paint to deter the settlement of a new generation of animals.

It is suggested that the scraping and painting of boats would be most effective before the peak periods of settlement, i.e. in January for boats moored in the upper reaches of the harbour and in April for those at the harbour mouth.

Mr. A. M. A. Imevbore (*University of Ibadan*) **Some hydrological data from Eleiyele Reservoir, Ibadan.**

A description was given of the variations in the transparency, temperature, pH, dissolved oxygen and their vertical distribution during different seasons in Eleiyele Reservoir, Ibadan. This was based on data obtained at bimonthly intervals from a selected station between October 1961 and November 1962.

The biological significance of the observed data was discussed.

## OTHER ACTIVITIES

A Reception in honour of the Association was given by the President (Dr. E. Njoku) at the Technical Institute, Yaba, following the formal opening ceremony. A successful Conference Dinner was held on the final night of the Conference at the Federal Palace Hotel at which Mr. M. Kosten proposed the toast to the Association and the new President (Professor C. W. L. Bevan) replied. There was also an enjoyable informal Social Evening at the Yaba Technical Education Recreation Club on the Tuesday evening.

In the Apapa and Ikeja Industrial Areas visits were made to the factories of the following companies: Apapa Chemical Industries Ltd., Asbestos Cement Products, British Paints Ltd., Clay Products of Nigeria, Coca Cola and Carbon Dioxide, Flour Mills of Nigeria Ltd., Imperial Chemical Industries Paints Ltd., Lever Brothers Soap Ltd., Metal Containers of West Africa Ltd., Nigerian Enamelware Ltd., Shell Oil, Star Breweries Ltd. and Tower Aluminium Ltd. Longer visits were made to the Federal Institute of Industrial Research and to the Technical Institute, Yaba. On the Sunday there were, in addition to short tours of Lagos, day excursions to Abeokuta, where places of historical and cultural interest as well as recent developments were seen, and to Badagry where the old part of the town and the Topo Island Coconut Plantations were visited.

Film shows took place on various evenings during the Conference when the following films were shown:

| | |
|---|---|
| *The Microscope* | — presented by F. Steiner |
| *Britain's Nuclear Power Programme* | — presented by the U.K.A.E.A. |
| *Energy Picture*<br>*Glass* | — presented by the U.K.I.S. |
| *Friendship 7* | — presented by the U.S.I.S. |

There was a General Exhibition of displays by commercial firms and government departments, etc.

## BUSINESS OF THE ASSOCIATION

### *Report of the Hon. Secretary*

*Membership*

The present total membership of the association as on 1st December 1962 is 291 made up as follows:

| | | |
|---|---|---|
| Ordinary members | 204 | (155) |
| Associate members | 12 | ( 12) |
| Corporate members | 75 | ( 55) |
| Total | 291 | (222) |

Figures for 1st December 1961 are shown in brackets.

*Geographical distribution of ordinary members*

| | Number | Percentage | 1961 Percentage |
|---|---|---|---|
| Lagos | 24 | 11 | 13 |
| Enugu & Nsukka | 20 | 10 | 5* |
| East (excl. Enugu and Nsukka) | 27 | 13 | 14 |
| Ibadan (incl. Ife University) | 71 | 35 | 36 |
| West (excl. Ibadan) | 16 | 8 | 7 |
| Zaria | 16 | 8 | 10 |
| North (excl. Zaria) | 20 | 10 | 9 |
| Overseas | 10 | 5 | 5 |

*Occupational distribution of ordinary members*

| | Number | Percentage | 1961 Percentage |
|---|---|---|---|
| Universities | 68 | 34 | 18 |
| Schools | 45 | 22 | 19 |
| Government | 65 | 32 | 43 |
| Others | 26 | 12 | 9 |

Increase in percentage for Universities is due mainly to the conversion of Colleges of Technology to Universities, and the absorption of the Regional Research Station at Samaru by Ahmadu Bello University.

Distribution by nationality of ordinary members is as follows:

| | Number | Percentage |
|---|---|---|
| Nigerians | 77 | 38 |
| Non-Nigerians | 127 | 62 |

*Council*

*Council meetings.* Council held meetings at bi-monthly intervals during the year. For the first time a meeting was held in Onitsha in August and another in Lagos in October.

*Co-options.* The following members were co-opted on to Council during the year: Mr. A. M. Oseni in his capacity as Publicity Officer; Mr. N. Abeles as Chairman of the Lagos Local Committee; Mr. R. S. G. Agiobu-Kemmer, and Mr. D. G. Coursey as Secretary and Publicity Officer respectively of the Lagos Local Committee; Dr. C. Nwokolo, President of the Eastern Nigeria Science Association.

*Acting appointments.* The President of the Association for 1962, Mr. R.W.J. Keay, left Nigeria on retirement in September and in the absence of the Vice-

*For Enugu only

President who was in America, Dr. E. Njoku, Vice-Chancellor of the University of Lagos, and Professor D. H. Hill of the University of Ibadan served as President and Vice-President respectively. The Secretary was away in Britain from April to August and Dr. B. Hopkins, former Secretary of the Association acted in his place. I wish to express the thanks of the Association to these gentlemen who served in the capacities mentioned above.

*Proposals to Federal Government.* Council has made concrete proposals to the Federal Government through the Minister of Economic Development for the formation of a Council for Scientific Development; and through the Minister of Health, for the formation of a Food and Nutrition Board.

*International Council of Scientific Unions.* An application for membership of ICSU has been forwarded with the consent of the Federal Government on the understanding that our membership will cease when a national research body, such as a National Research Council, is formed.

*Relationship with ENSA.* The relationship between the Association and the Eastern Nigeria Science Association continues to be uncertain. There was a meeting between Council and some officials of ENSA after the Enugu meeting during which various points raised by ENSA were clarified. The invitation to ENSA to become a branch of SAN still stands.

*Proceedings of SAN.* Dr. B. Hopkins was appointed Editor of Proceedings of SAN and is assisted by an Editorial Board. The first issue (Vols. 1-3) was distributed to members during the year, and the Vol. 4 which covers the Enugu meeting is in the press.

*Conference.* The Lagos Conference has been ably organised by a Lagos Local Committee, and plans to hold the next conference in Zaria are in hand. Invitations to attend the 2nd Conference of the West African Science Association at Kumasi (22nd-26th March) have been circulated to members with the hope that as many members as possible would attend.

## *Report of the Hon. Treasurer*

Income has remained about the same as for last year. £300 out of the indicated excess income would be spent on W.A.S.A. Journal Publication Subvention, which in the past had been paid early in the year, but had not been paid to the W.A.S.A. Treasurer before June this year.

The adverse balance on the 1961 Conference at Enugu was mainly due to the high cost of stationery and payments which had to be made to the typists and other workers for the duplication of all Conference papers. The practice of duplicating texts of full talks has now been discontinued.

Expenditure on secretarial help and postage continues to increase with the expansion of the work of the Secretary and the Editor of the Proceedings.

Expenditure on Bank Charges could be reduced further if all members remember to endorse all cheques for the Association "Commission to drawer's account".

We are grateful to the Federal Government for its constant interest indicated in many ways, but specifically by the £500 subvention granted annually. It is the grant which made it possible to publish the first issue of the Proceedings without depleting our resources dangerously. Out of the balance of about £188 we have transferred a sum of £100 to the Funds for Meetings Account for this Conference. The next issue of the Proceedings will also be paid for partly from the current year's subvention.

The Savings Account of the Association is now slightly above £420, and it continues to yield some interest, which is just below the total sum paid on bank charges for the year.

The work of the Auditors and the Treasurer will be easier, if *one* of the Auditors were a trained accountant, so that his professional knowledge and advice might be available to the Treasurer and the other Auditor.

### *Fifth Annual Business Meeting*

At this meeting the reports of the Hon. Secretary and Hon. Treasurer were received, elections held and the following amendments made to the Constitution and Standing Orders:

Constitution: item 4 (f) was amended to read as follows "The President shall retire at the end of two years of office and shall not be eligible for re-election until two years after the end of his term of office. The Vice-President shall retire at the end of one year of office and shall not be eligible for re-election until one year after the end of his term of office."

Standing Orders: Standing Order number 12 was amended to read as follows: "*Vacancies on Council.*

(*a*) A vacancy of an officer of the association or of a member of the Council, caused by death or resignation may be filled by Council, the appointee serving only until the next Annual General Meeting.

(*b*) A vacancy caused by the temporary absence of an officer may be filled by Council among its members the appointee acting only until the return to duty of the officer concerned.

(*c*) The appointment of a member to a vacancy shall not be considered as an election."

| | | |
|---|---|---|
| President | : | *Mr. R. W. J. Keay |
| Vice-President | : | *Mr. F. Oyewole |
| Hon. Secretary | : | Dr. C. I. O. Olaniyan |
| Hon. Treasurer | : | Mr. T. O. Fayiga |
| *Ordinary Council Members* | : | Mr. T. Anderson |
| | : | Professor J. C. Edozien |
| | : | Dr. J. C. Ene |
| | : | Father J. A. Fitzpatrick |
| | : | Mr. K. H. Hatherley |
| | : | Dr. B. Hopkins |
| | : | Mr. T. M. Leach |

*Specialist Section Representatives*

| | | |
|---|---|---|
| Agriculture | : | Dr. D. H. Hill (Later Professor) |
| Botany | : | Dr. C. Oyolu |
| Medical Sciences | : | *Dr. E. J. Watson-Williams |
| Physical Sciences and Engineering | : | Mr. D. Oyewole |
| Zoology | : | Professor N. Bolwig |

*Co-opted Members:—*

| | | |
|---|---|---|
| Acting President | : | Dr. E. Njoku |
| Publicity Officer | : | Mr. A. M. Oseni |
| Publications & Publicity Adviser | : | *Mr. P. B. Collins |
| Chairman Medical Sciences & Specialist Section | : | Dr. A. E. Boyo |
| Chairman Local (Lagos) Committee | : | Mr. N. Abeles |
| Secretary Local (Lagos) Committee | : | Mr. R. S. G. Agiobu-Kemmer |
| Local (Lagos) Committee Publicity Officer | : | Mr. D. G. Coursey |
| President, Eastern Nigeria Science Association | : | Dr. C. Nwokolo |

*Resigned on leaving Nigeria.

## GENERAL ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d |
|---|---|---|---|---|---|---|---|
| By Balance from 1961 | 427 | 3 | 1 | Printing and Stationery | 72 | 17 | 11 |
| By Annual Subscriptions 1961 | 179 | 6 | 0 | Secretarial Help | 61 | 3 | 0 |
| By Annual Subscriptions 1962 | 396 | 3 | 6 | Bank Charges | 7 | 19 | 10 |
| Sundry Receipts | 1 | 14 | 6 | Sundry Debts | 15 | 7 | 1 |
| Interest on Savings Account | 7 | 5 | 11 | Additional payment for WASA Journal | 24 | 15 | 0 |
| | 1,011 | 13 | 0 | Stamps and Postage | 19 | 11 | 2 |
| | | | | To Conference Account | 76 | 14 | 11 |
| | | | | | 278 | 8 | 11 |
| | | | | Excess Income | 733 | 4 | 1 |
| | | | | | 1,011 | 13 | 0 |

## FEDERAL GOVERNMENT SUBVENTION ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From Balance from 1959/60 | 160 | 0 | 0 | Proceedings Account | 371 | 2 | 8 |
| From Federal Govt. 1960/61 | 500 | 0 | 0 | Funds for meetings | 100 | 0 | 0 |
| | 660 | 0 | 0 | | 471 | 2 | 8 |
| | | | | Excess Income | 188 | 17 | 4 |
| | | | | | 660 | 0 | 0 |

## 1961 CONFERENCE ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Conference Fees | 61 | 0 | 0 | 110 Dinners and Drinks | 115 | 0 | 0 |
| 110 Dinner Tickets | 110 | 0 | 0 | Transport | 19 | 9 | 11 |
| Accommodation and Meals | 147 | 16 | 0 | Sandwiches and Coffee | 19 | 16 | 8 |
| Sundries | 40 | 18 | 2 | Tips | 4 | 15 | 0 |
| | 359 | 14 | 2 | Conference Publicity | 11 | 6 | 11 |
| Deficits | 76 | 14 | 11 | Refunds to Members | 29 | 13 | 2 |
| | 436 | 9 | 1 | Conference Accommodation | 135 | 6 | 4 |
| | | | | Printing | 20 | 1 | 9 |
| | | | | Postage, Stationery and Secretarial Help | 76 | 11 | 3 |
| | | | | Conference Expenses unaccounted for | 4 | 8 | 1 |
| | | | | | 436 | 9 | 1 |

## FUNDS FOR MEETINGS ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From Federal Government Subvention Account | 100 | 0 | 0 | Transport for Speakers etc. | 61 | 18 | 6 |
| | 100 | 0 | 0 | Accommodation for Speakers etc. | 15 | 0 | 7 |
| | | | | | 76 | 19 | 1 |
| | | | | Balance Carried Forward | 23 | 0 | 11 |
| | | | | | 100 | 0 | 0 |

## PROCEEDINGS OF THE SCIENCE ASSOCIATION ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From Federal Government Subvention Account | 371 | 2 | 8 | Typing of Scripts | 5 | 2 | 8 |
| | 371 | 2 | 8 | Printing | 366 | 0 | 0 |
| | | | | | 371 | 2 | 8 |

## COCKTAIL PARTY ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From Federal Government | 222 | 14 | 2 | Refunded to Federal Government | 222 | 14 | 2 |

## BALANCE SHEET
(30th June, 1962)

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From General Account | 733 | 4 | 1 | Cash in Current a/c. at Barclays Bank (D.C.O.), Agodi, Ibadan | 589 | 4 | 6 |
| From Federal Government Subvention Account | 188 | 17 | 4 | Cash in Savings a/c. at Barclays Bank (D.C.O.), Agodi, Ibadan | 421 | 7 | 1 |
| Cheques not presented | 20 | 4 | 7 | Cash in Hand | 2 | 13 | 7 |
| Fund for Meetings | 23 | 0 | 11 | | | | |
| 1960 Conference Account | 47 | 18 | 3 | | | | |
| | 1,013 | 5 | 2 | | 1,013 | 5 | 2 |

Theo. Ola. Fayiga,
*Hon. Treasurer.*

We have inspected the account books and other relevant documents of the Science Association of Nigeria and we are satisfied that the above statements represent the true state of the finances of the Association up to 30th June, 1962. We include recommendations in our report.

A. Onwumechilli
J. E. M. Horne } *Auditors*


The Scientific choice is

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PROCEEDINGS OF THE

# SCIENCE ASSOCIATION OF NIGERIA

*Volume* 6 1963

PUBLISHED OCTOBER 1965

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EDITOR

Dr. B. HOPKINS

*University of Ibadan*

BUSINESS MANAGER

Dr. J. C. ENE

*University of Ibadan*

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SCIENCE ASSOCIATION OF NIGERIA
AND PRINTED AT THE
IBADAN UNIVERSITY PRESS
NIGERIA OCTOBER 1965

## THE PROCEEDINGS

The first four volumes of the *Proceedings* published Opening and Presidential Addresses in full and other papers delivered at Conferences of the Association as abstracts only. In Volume 5, which dealt with the 1962 Lagos Conference, the Evening Discourse and most of the papers on the *Harnessing the Niger* Symposium were published in full. In this present volume an attempt has been made to publish in full all the papers read at the Conference on *Science and the Agricultural Resources of Nigeria*. To a large extent this has been achieved but it has caused considerable delay in publication.

The Association is now launching a new journal called the *Nigerian Journal of Science*. Therefore, it has been decided that, in future, the *Proceedings* will be discontinued and this will be the last volume to appear. Accounts of Conferences will appear in the *Nigerian Journal of Science* and items concerning the business of the Association will continue to be circulated to members. It is also hoped that many of the papers presented at Conferences will be suitable for publication in full in the new journal.

## SIXTH ANNUAL CONFERENCE

The Sixth Annual Conference of the Association was held at Ahmadu Bello University, Zaria from Wednesday 18th December until Saturday 21st December 1963 on the general theme *Science and the Agricultural Resources of Nigeria*.

### OPENING CEREMONY

Dr. N. S. Alexander, C.B.E., the Vice-Chancellor of Ahmadu Bello University, aptly welcomed delegates and wished the Association a successful meeting.

The Hon. Alhaji Othman Ladan Baki, M.H.A., the Zaria Provincial Commissioner, read the following message from His Excellency, Sir Kashim Ibrahim, G.C.O.N., K.C.M.G., C.B.E., LL.D., Governor of Northern Nigeria:

"Mr. President, Members, Ladies and Gentlemen: It gives me great pleasure to be invited to open this Annual Conference of the Science Association of Nigeria. I consider it a privilege for me to be given the opportunity of addressing so distinguished and so learned a large group of Scientists as are gathered together here at this Conference; and I am most grateful to the members of the Council of the Association for doing me this honour.

"It is especially appropriate that this Sixth Annual Conference of the Science Association of Nigeria should be held here in Zaria. For it is in Zaria that we have seen in the past year the establishment of the Ahmadu Bello University, incorporating as it does the long-established Institute for Agricultural Research at Samaru. How fitting then that a Conference on

'Science and the Agricultural Resources of Nigeria' should be held here at this new University.

"The membership of the Science Association of Nigeria consists very largely of agricultural scientists. This is no accident. Agriculture is the largest and most important of the industries of this country; it is the backbone of Nigeria's economy and most of our other industries are associated with one kind of agricultural product or another. Properly, therefore the greater part of our scientific resources is devoted to improving the efficiency of this vital industry.

"To say that the majority of our scientists are engaged on agricultural research is not to suggest that our scientists include only a narrow range of specialists. On the contrary, the range of scientific disciplines represented here today is very wide. An attack upon the problems confronting agriculture in Nigeria calls for the concerted effort of a large team, a team at least as diverse as that of the contributors to this Conference. Chemists, botanists, physicists, entomologists, meteorologists, mechanical engineers, statisticians—there are few specialisations that cannot play a part in agricultural research. And it would appear from the programme of this Conference, that few facets of its theme have been neglected.

"Indeed, those of you who will be able to attend the whole of this Conference, I venture to suggest, will enjoy a feast of topics as varied as the industry the contributors serve. But this is only a part of the value of such a Conference. Those specialists who are able to be present right through until the closing session on Saturday will, I am sure, learn much that is new to them and much that will broaden their outlook upon their own work. There are, however, other benefits to be obtained from such a Conference as this.

"Scientific research cannot be successfully pursued in a vacuum; it is important that the public, those who will ultimately reap the benefit of that work shall also be kept informed of the developments that are taking place. I understand that through the press, radio and television—in fact by all available means—the public are going to be kept informed on the proceedings of this Conference. And I am pleased that this will be so. Education has always been close to my heart—and I do not interpret the word 'education' narrowly.

"The necessity for educating the farmer is rightly given a high priority by my Government. I think all the Governments of the Federal Republic pay special attention to the conservation of agricultural resources and to increasing agricultural productivity in drawing up their development plans. During the last decade my Government in Northern Nigeria has been laying great emphasis on the provision of efficient extension services to farmers to enable them to benefit from the results of agricultural research. Much effort is also being put to the investigation, control and eradication of animal and plant diseases and to improving animal husbandry. It is quite proper to devote the greater part of our scientific resources to improving the efficiency of agriculture in order to increase our export earnings and to provide adequate raw materials for the new industries that are being established in various parts of the country. Many of those concerned in this work are with us today and I hope they will be encouraged by the fact that this gathering fully appreciates the great service they are doing to our nation.

"The Science Association of Nigeria, a young organisation, but one growing in strength and stature, was founded to foster the pursuit and understanding of science especially in Nigeria. It is the wish of the Association that news of the work of its members should be brought to the ears of the public. What better way of achieving this aim than to organise its Annual Conferences, to extend a welcome to all who wish to take part in them, and to give the widest publicity to their deliberations?

"The Conference that begins today is no exception. I support this aim of the Association and pray that God will bless the fruits of your deliberations. It is with great pleasure, therefore, that I declare this Sixth Annual Conference open."

Professor C. W. L. Bevan then delivered his Presidential Address:

"Some time ago it was remarked by the French philosopher Rousseau that it is agriculture which ultimately pays the taxes of a country. To-day this is perhaps less true in the highly industrialised parts of the world, though basic independence still hinges on the capacity to be agriculturally self supporting.

"In Nigeria the standard of living of everyone and the capacity to accumulate capital for industrialisation depends directly on agricultural productivity and by this one means production of the right things in the appropriate proportions.

"Agricultural efficiency is not high and output could be at least doubled by the proper application of existing knowledge; more fertilisers, better animal production and health services, a determined application of what is known about water and land use and conservation come immediately to mind. This raises the vast sociological problems of land tenure and at a more immediate level the question of agricultural extension; how what is known can be handed on to the farmer in the Nigerian scene in such a way that he believes in it and derives maximum use from what he learns.

"There is however danger in over-emphasis on the application of existing knowledge, much of which derives from countries with a very different total ecology from that of Nigeria. Such application must go hand in hand with the mastery of new knowledge won from the local environment. This is where we must squarely face the necessity for basic research.

"Aside from the large field of agricultural economics and sociology there is an unimaginably vast range of interrelated problems awaiting exploration by all manner of scientific specialists—by the geophysicist, the meteorologist, nearly all types of chemist and certainly every biologist from the veterinary pathologist to the plant physiologist—and one requirement from all in these disciplines is that they should think as biologists.

"For the maximum effectiveness of the efforts of such a range of specialists it is important that one and all know of the problems and methods of each other; and that where a joint attack on problems is possible this be done in an atmosphere of full co-operation and mutual respect.

"We have thus, as an experiment, minimised the time set aside for specialist sections in the hope that we can all share in the complete range of papers and perhaps through the all-embracing view presented, be stimulated to offer the resources of our own specialism to the solution of problems facing others.

"Next, there is the matter of how to sustain and develop this mutual awareness with its immense possibilities for discovery unimagined by the specialist with objectives limited by his own canalised thinking.

"Certain possibilities within our means come to mind:

(*i*) The adoption by each Nigerian University of a particular part of the country with a wide variety of climate, vegetation, crops, peoples and communications, as the living laboratory for a long-term co-ordinated research project in land use and social studies.

(*ii*) The publication of a *Nigerian Journal of Science* embracing the physical and biological sciences together with agriculture and forestry.

(*iii*) The compilation of a directory including information about all forms of scientific research going on in Nigeria.

"This is what one can do now, to serve as a beginning. But all this is so much talk unless we generate within Nigeria the high-level scientific manpower, the Nigerian manpower to take the creation and application of ideas forward; to search for knowledge and to apply it to the needs of man.

"This can only be done if vigorous schools of research grow up in the country and above all in the Universities. By this I do not mean beautiful buildings full of expensive equipment with a few administrators passing the files around; I mean any reasonable sort of building occupied by men to whom science is a delight, surrounded by younger men themselves learning the fascination of enquiry.

"From this atmosphere of scientific enquiry will come Nigeria's contributions to the common pool of fundamental knowledge, the solution of Nigeria's immediate scientific and agricultural problems and above all the men to provide scientific and technological leadership. They will be produced in Nigeria and in a fertile environment where teaching, research and application go hand in hand to immense mutual advantage.

"This needs money for equipment, for research staff and for technicians, but given the right start the Universities and Research Institutes can generate their own manpower by post-graduate schools and technician training schemes. What we all need is generous support initially, sustained support for really vigorous growth, and above all faith in our ability to carry this through.

"The Federal Government has been magnificent in its implementation of the imaginative Ashby Report; we trust it will be as magnificent in the support of basic research from the anvil of which will emerge the men to catalyse Nigeria's scientific and technological development."

Shortly after the Presidential Address, the Association had the privilege of listening to Professor R. L. Wain, F.R.S., who delivered an Evening Discourse entitled *Some recent developments in agricultural research.*

"It was with great pleasure that I accepted the invitation of the Royal Society to come here as their representative and to address this meeting of your Association. As some of you know, I have visited Nigeria on several occasions as a London University Examiner and as Nuffield Visiting Professor at the University of Ibadan. On these visits I have met many scientists and discussed problems with them which are of basic importance to West Africa. Coming to this country always stirs in me a feeling of excitement, for events, particularly in the educational field are moving so quickly; the rapid strides you have taken in developing your Universities, for example, are certainly very impressive, though this expansion has itself created special problems and difficulties.

"Since the community needs well-trained and well-educated people of all types, many disciplines must be catered for within the University, but in a rapidly developing country such as yours, with such an urgent need for graduates, what proportion of student places should be allocated to the various Faculties and how should Science stand in relation to the Arts? Careful thought and forward planning are needed to answer these questions but there can surely be no doubt that in the scientific age in which we now live, every country must depend heavily for its economic growth and development on its science and its technology. This plain truth is unfortunately not always realised by some who are directly concerned with University affairs, yet it cannot be emphasized too strongly that in any country, scientific education and research represents one of the best possible investments in its future.

"Everyone, of course, accepts the importance of the humanities and the arts and it is generally agreed that no one can give of his best in science if he has not been trained to read, write and listen intelligently, has some cultural background, and a knowledge of foreign languages. The schools are, of course, directly concerned here and it is for them to do all they can to ensure that able students in sufficient numbers come forward to read science courses at the University.

"In Nigeria you are now training scientists along well-tried and orthodox lines so that they may take their place in teaching, research and other necessary activities within the State. These key members of your society are capable of understanding and utilizing all the wealth of knowledge which has accumulated from research and experimentation carried out in the past. Some of them, having learned the basic disciplines of research themselves, are ready to make their own contribution to knowledge in their chosen field. Not all of those who lean towards research, however, are of the highest calibre—the Michael Faradays of this world are, unfortunately, rare—but in any large community genetic variation alone will ensure that there are some men of exceptional creative ability and it is most important that they be discovered. It is criminal if such an individual with a flair for science is not recognized and given the opportunity and encouragement to follow a career in research. Indeed, one of the responsible tasks of teachers of science is to recognize such an individual and to see that he gets the best advice, teaching and opportunity to develop within the right environment. It should not be forgotten too that a first-rate scientist may well make important discoveries of benefit to mankind which in turn may bring international fame and possibly material wealth to his country. All these things are of course well known to you, for indeed, one of the primary aims of your Association is to promote science and its application within Nigeria. Your interests, however, must surely be more closely defined than just Science in the widest sense. Prospects of space travel and rockets to the moon excite the imagination and fascinate us all, but in this country you cannot justifiably plan to make basic contributions to research within this field; in any case, it is very doubtful whether mastery of space will add anything to man's well-being and contentment. In our world today the scourges of disease still remain and problems of providing balanced and adequate nutrition for all are crying out to be solved. Winning battles against these and other human afflictions is surely far more satisfying and urgent than seeing the other side of the moon. There are of course problems in all branches of science and technology which must claim your attention, but the plain fact is that many people in Nigeria today do not get enough to eat or, at least, not enough food of the right kind. Some of your worst medical problems are agreed to be basically nutritional and would largely disappear if the right quantities of the right foods were available. For these and other urgent reasons, your agriculture must be made much more efficient. Not only will standards of nutrition then improve but the country itself will benefit, for agriculture must, for many years to come, form the main economic background of Nigeria. In my view more of your students should be encouraged to read Agriculture. There must be agriculturists at all levels, from the one- or two-year Institute-trained person to those possessing a University degree in Agriculture. All have their part to play in the agricultural structure of the country whether they be working on farms, as Extention Officers, or employed in commerce, teaching or experimentation. Between them the important task of utilizing existing scientific knowledge and applying it to Nigerian agriculture can, with time, be accomplished. But this army, wide though their combined agricultural potential may be, is not enough. In order to make real progress in solving problems which are basic to rapid agricultural development science must be geared to agriculture on an ever-increasing scale. This means you need more chemists, physicists, biologists and scientists from many other disciplines to apply their specialized skills and knowledge to problems of the soil, crop and animal production and improvement, the control of weeds, and of pests and diseases of crops and livestock. In basic research of this kind the agricultural graduate will have some contribution to make but such work is primarily the domain of the pure scientist. It is by studying the really fundamental problems, for example, those being tackled by geneticists, physiologists and biochemists at cell level, that we are going to get spectatular agricultural advances in the future.

"Some of the big problems of agriculture have been with us through the ages. We read in the Bible of the Plagues of Egypt for which the locust was mainly responsible. Yet even now, locusts cause vast losses of food every year in the African Continent and other parts of the world. Pests and diseases continuosly threaten crops and stock, weeds growing with our crops are stealing available moisture and nutrients from them; every year soil erosion takes its toll of the land. This century, however, has seen rapid developments in agricultural science; the application of Chemistry to Agriculture has led to the development and widespread use of artificial fertilizers and hence to greatly increased yields of crops. The chemist working with the biologist provides more and more substances to the farmer for the destruction of his insect pests, plant diseases and weeds. There has been tremendous progress in the application of genetics to agriculture. The importance of all these developments cannot be over-estimated for whilst medical science is ensuring a longer expectation of human life, world population is increasing to such an extent that we have already reached a stage where, if all the world's food were equally divided amongst its people, everyone would go hungry. In spite of scientific developments which have taken place, world losses of human and animal food due to pests, diseases and weeds are still enormous. In trying to reduce these losses with chemicals it must be remembered that research workers are facing dynamic problems; they must not only try to develop new and improved chemicals to attack a pest or disease, but must constantly be aware that new and resistant strains of the organism might develop. In the team work which is so essential in basic research, each member must always appreciate the problems and difficulties of the other; each must be a specialist, drawing continuously upon a reservoir of basic knowledge.

"It would perhaps be appropriate now if I try to illustrate this approach by discussing some aspects of research in agricultural science with which I have been associated. Firstly, I will refer to the control of plant growth with chemicals. As you know there have been tremendous developments within this field since indole-3-acetic acid (IAA) was recognized to be a plant growth hormone by Kögl in 1935. It was this discovery which led rapidly to the preparation and testing of large numbers of compounds of similar structure amongst which a number of very highly active substances have been found. Most of these are either aryl or aryloxy carboxylic acids such as 1-naphthylacetic and the well-known compound 2,4-dichlorophenoxyacetic acid (2,4-D). All these synthetic compounds are best referred to as plant growth substances or auxins. They are not hormones—the term "plant hormone" should be restricted to the "natural" growth substances—that is, those which are elaborated by the plant itself and which can induce physiological responses in parts of the plant some distance from the tissues in which synthesis takes place. It is now generally agreed that indole-3-acetic acid, for example, is a true plant growth hormone. In general, when we come to agricultural uses, we are not directly concerned with hormones. It is the synthetic product, made in the laboratory or factory, upon which such a large amount of applied research is based. The remarkable thing about these materials is their potency. They are often capable of exerting physiological effects when applied to plants at concentrations of only a few parts in a million of water.

"Research work on plant growth substances is proceeding on many fronts. Fundamental investigations on the relationships between chemical structure and growth-regulating activity pave the way to the discovery of new active materials and are of vital importance in studies on mode of action. Again, for a substance to exert such physiological effects when applied to a plant, its molecule must possess the necessary physical properties such as solubility, diffusibility and surface activity to enable it to penetrate into the tissues and move to the centres from which the growth response is to be initiated. All these physical properties depend on the chemical structure of the compound and within limits can be modified by the introduction into the molecule of substituent groups and other means. It must also be remembered that the compound, once within the plant, must possess adequate stability to reach the site of action within the living cell. It is clear therefore that studies on the capacity of compounds to survive within such a system, in which many complex biochemical reactions are proceeding, are of paramount importance in this field of research. Then we have to know something of the precise physiological changes which are brought about by growth substances acting within the plant. Effects on rate of respiration, on water uptake and membrane permeability are all important in this connection. Sufficient has been said to indicate the importance of team work in fundamental studies. The organic chemist, physical chemist, biochemist and plant physiologist have all a big contribution to make.

"In collaborative work of this kind, the structural features which are necessary for the activity of auxin molecules have been established and much is now known of their mode of action. These investigations in turn have led logically to the discovery of new active compounds and to a better understanding of the problems of competitive antagonism and synergism. All these compounds have potential uses in agriculture. They are used, for example, in the vegetative propagation of cuttings, for setting fruit and for preventing the pre-harvest drop of apples and pears. They are also used for preventing sprouting in potatoes and stored nursery stock and for controlling the time of flowering in the pineapple. By far their greatest agricultural use, however, is in selective weed control for which purpose the compounds are applied at rates of 1 lb. per acre or less to over 100 million acres of the world's surface every year. Their main application is in cornlands; cereal and grasses being much less susceptible than most weed species to the action of 2,4-D and other related compounds. Such substances, however, are very damaging to clover, lucerne and other legume crops. Selective weedkillers for use in legumes were discovered in 1955 at Wye College. It is of interest to mention that the work was not originally concerned with weed control; it was a more fundamental study in biochemistry designed to determine whether or not plants were able to break down fatty acids in a way that these chemicals are known to be broken down in the animal body. In order to examine this possibility further, a number of chemicals were prepared which are related both to powerful herbicides like 2,4-D and to the fatty acids. These chemicals, harmless to plants in themselves, were nevertheless found to be systemic, entering through the leaves or the root system and moving in the tissues. Strong evidence was obtained, however, that once absorbed, certain of these harmless chemicals could be slowly converted by $\beta$-oxidation to a powerful herbicide which killed the plant.

"It was established in these experiments, not only by observing biological responses, but by chemical analyses and chromatographic investigations, that plants and animals are able to break down fatty acids in a very similar manner. Whilst some plant species were killed by our chemicals, however, others remained unharmed, and in these cases there was no evidence of breakdown to the herbicide. The two compounds MCPB ($\gamma$-(2-methyl-4-chlorophenoxy) butyric acid) and 2,4-DB ($\gamma$-(2,4-dichlorophenoxy) butyric acid), for example, appeared to be broken down readily in the cells of some plants but not in others. For this and other reasons they were selective weedkillers, killing only those weeds and crops which had the capacity to absorb them and break them down in their tissues to release the toxic chemical. The results of many glasshouse and field experiments indicated that a number of important legume crops such as clover, lucerne and peas do not readily effect this vital conversion, and these butyric acids are now proving useful and very specific herbicides in such crops.

"This use of MCPB and 2,4-DB then, illustrates a new principle of selectivity which depends primarily upon basic differences in the chemical activity of susceptible and non-susceptible plants. The compounds are now finding use in many countries for the control of weeds in legumes and undersown corn crops.

"Studies within recent years have revealed that in addition to auxins, other potent chemicals are involved in regulating the growth of plants. It is now known, for example, that gibberellins, of which nine have so far been discovered, also play an important role in promoting cell elongation whilst a group of adenine derivatives known as the kinins, which are strongly active in promoting cell division, are also thought to operate in plant growth. Compounds which inhibit or reduce the activity of auxins also occur in plants and such substances may be concerned in promoting the dormancy of seeds and buds. It is clear from all this, that the controlling systems which operate in the growth of plants, involving an interplay of all these widely different physiologically active substances, must be exceedingly complex. Yet we must depend on scientific research for an understanding of these processes which are absolutely basic to agriculture, and our efforts to produce more food for man and animals.

"Hormone imbalance can often lead to abnormal growth effects and a good example of this is shown in Iroko (*Chlorophora excelsa*) which is grown extensively for its timber in Nigeria. The nymph of the gall bug (*Phytolyma* sp.) causes a rapid development of large galls on young Iroko shoots which shelter and feed the insect until, after passing through five instars, the adult is ready to emerge. The gall, by now very turgid, then bursts, leaving tissue which is open to fungal and other infection which in turn leads to a die-back of the shoot as far as the woody tissue. After two seasons of such attack nurseries of Iroko can become completely moribund. It occurred to us that the rapid growth of gall tissue might indicate high levels of endogenous auxin and Dr. Wright in my laboratory has confirmed this. Not only is there present an unusually high level of IAA but an unidentified growth-promoting substance is present as well. There is also a compound showing the properties of an auxin inhibitor. Dr. Wright is continuing his work on this problem with the co-operation of the Forestry Research Department at Ibadan. Several problems present themselves apart from the need to identify these unknown physiologically active materials. How do the high levels of hormone appear? Are they supplied by the insect or does the insect attack stimulate the plant material itself to produce these substances? The question also arises whether the build-up of hormone can be suppressed. If this could be done then the gall formation would presumably not take place.

"I should now like to deal very briefly with some new developments in the chemical control of plant diseases. Protective fungicides such as Bordeaux mixture have of course been available for many years and are still widely used on cocoa and many other crops. Such materials, however, provide no control of the vascular wilts and other soil-borne diseases. Furthermore, when such a fungicide is applied to a plant, only those parts of the leaves and stem which are covered by the deposit are protected against invading fungi; indeed, any parts which have been inadequately sprayed or from which the chemical has been removed by weathering are liable to attack, and so is all new growth. Such disadvantages might be overcome by using a chemical which can act systemically—that is, one which can move in the plant and exert its action from within the tissues.

"Whilst the difficulties of controlling a plant disease by internal therapy are considerable, spectacular successes have been achieved by chemotherapy in the control of certain human and animal diseases using such materials as sulphonamides and antibiotics. The plant, however, differs markedly from the animal which has a central circulatory system with blood and lymph to transport the defensive materials; the distribution of any applied chemical throughout the tissues of a plant following application to roots, leaves or stem is a slower process depending largely upon diffusion from cell to cell. In spite of this limitation, the control of insect pests with chemicals acting systemically has been successfully accomplished and a number of materials are used commercially for this purpose. To control a plant disease by chemotherapy presents greater problems, and in spite of interesting developments in this field of study, in no case has complete protection yet been achieved by this means.

"A considerable amount of research, however, has been carried out on systemic fungicides by chemists working with plant pathologists at Wye College over the past ten years. Unfortunately, in this paper I can only deal with one aspect of this work which developed from considerations on natural disease resistance in plants. In nature, most plants are resistant to most pathogens; any crop plant, for example, is only attacked by one or perhaps two of the many fungi to which it is continuously exposed in the field. Thus, resistance is the rule rather than the exception in nature. Such resistance can sometimes be related to morphological characteristics, such as hairy leaves or a thick waxy leaf epidermis. With some diseases the secretion by the fungus of pectic enzymes may be an important factor in relation to susceptibility to attack. Such enzymes, by their effect on the tissues of the host, can facilitate the entry of the pathogen; since inhibitors of pectic enzymes occur naturally in certain plants these susbstances may account for varietal differences in susceptibility to disease. Again, initial attack by the fungus may lead to a rapid death of cells which then form a barrier through which the fungus cannot penetrate. Certain fungi also have specific nutritional requirements, and disease resistance may well arise in cases where these cannot be provided by the host plant.

"Natural resistance to infection may also be associated with the presence of protective chemicals within the plant. There are a number of examples bearing on this; we have shown, for example, that leaf surfaces can exude fungicidal substances and fungicidal compounds have been extracted elsewhere from rye, maize and wheat plants. Another development has been the discovery in my laboratory of an antibiotic with potent fungicidal properties which is present in the stem and root tissues of broad bean seedlings (*Vicia faba*). All such findings provide further indication that a plant's resistance to disease may be due in some cases, to the presence of specific naturally occurring chemicals within its tissues. These considerations provide another line of approach to systemic fungicides. Work on the isolation of the bean antibiotic has proved lengthy and difficult but with the combined efforts of chemists and biologists, it has now been obtained in the pure state and its chemical structure has been established. Its fungicidal spectrum and possible uses in plant chemotherapy are now receiving attention.

"I have attempted to describe just one or two lines of research to illustrate how progress has been made over the past twenty years in applying science to agriculture. Many other examples could be cited—in genetics and plant breeding, the study of viruses and host parasite relationships, animal physiology and nutrition and so on. I am sure I have said enough, however, to support my thesis that the big advances in agricultural research must depend more and more on the efforts of specialists in the pure sciences working together as a team and not too concerned about finding an immediate solution to some practical problem.

"My hope is that more and more pure scientists in Nigeria will be encouraged to make their careers in agricultural research. In such work they will not only be serving their country but also the welfare of mankind."

# GENERAL PAPERS

## *Science and the Agricultural Resources of Nigeria*

Mr. G. E. O. Okiy (*Federal Department of Agricultural Research, Ibadan*) **The role of research in the development of Nigerian agriculture.**

SUMMARY

The highly developed countries derive their prosperity and progess from the application of science and technology to their agriculture and industry; the under-developed countries are behind in the application of scientific findings to their agriculture.

Progress in agricultural productivity in a country depends on the speed with which the results of research findings are utilised by the majority of the farmers in the territory.

Nigeria depends on agriculture as her mainstay since almost three-quarters of the adult labour force depend upon this industry from which the country derives about 80 per cent of her revenue.

In order to make full use of the country's resources an inventory of the basic data is essential, several visiting missions have tried to do this for Nigeria. Agricultural research in Nigeria has produced many valuable results applicable to agricultural development. Many high-yielding varieties of crops, for example, oil palm, cocoa, rice, maize and cassava have been bred for distribution to farmers for planting. Some of the schemes in the country's six-year development plan are based on all these results, for instance, the oil palm rehabilitation scheme in Eastern Nigeria, control measures for crop pests and diseases, and the introduction of exotic breeds of livestock.

Research will help to minimize unnecessary waste of funds for agricultural development in the country. An agricultural development programme executed without previous research is like a leap in the dark. Research saves time: a few years of research may bring to light useful results applicable to agricultural development. Research will provide the basic data for future agricultural development plans in this country.

The application of research findings to industry has become the main agent of progress in the world today. The difference between the developed and the underdeveloped countries will be accentuated if research remains the privilege of the former and is still neglected by the latter. Transposition of research results is not always an easy exercise and in agriculture it requires long and costly experimentation. Carrying the results of research to farmers requires a special approach which is provided by extension staff.

Research calls for material means and qualified personnel which are often in short supply in this country. There is an urgent need to expand existing research facilities and establish new ones. In order to allow for the easy flow of information from the research worker to the farmer, research must accord to a suitable organisation pattern. The need for the re-organisation of agricultural research in Nigeria calls for the establishment of a Nigeria Agricultural Research Council which will co-ordinate the work of the research bodies in the country.

## INTRODUCTION

The world is today divided into the highly developed countries and those which are underdeveloped; most of the newly independent countries in Asia and Africa are in the latter class. Generally the rich countries are highly industrialised and their agriculture is also well developed; examples of these are the United States of America, U.S.S.R., Great Britain, Canada, Australia, New Zealand and most countries of Western Europe: in these countries agricultural production is at the highest level. In the underdeveloped countries agriculture is still in its elementary stage of development and agricultural production is at the lowest level. The question may be asked why is there such a high level of agricultural production in the most advanced countries compared with that in the less developed countries? The answer is that the former benefit from the practice of scientific agriculture; this is the result of agricultural research which these countries have carried on for many decades. The Governments of these countries devote large sums of money to agricultural research and some of the most highly qualified and competent scientists are to be found in the agricultural research establishments.

Progress in agricultural productivity is closely connected with the speed with which advances gained in scientific research are utilised by the largest possible number of farmers. In general, the utilisation of research findings is a slow process; even in the advanced countries there is still room for improvement in the application of science and technology to industry. In particular biological research is very much in advance of its general industrial application, more especially in agriculture. As one scientist put it, "Relatively, today, there is great over-production of knowledge, great under-production of users of knowledge on the public behalf". A wide gap exists in many countries between advanced scientific knowledge and its application to large-scale production. Scientific literature produced in different parts of the world shows that vast discrepancies exist between what could be produced through the application of the results of researches and what is actually being produced through traditional methods used by the farmers. If this is so even in the advanced countries the situation is much more acute in a country like Nigeria for many obvious reasons. Farmers in this country, like farmers all the world over, are conservative and not very receptive of progressive ideas: the situation is much more difficult here owing to the fact that the vast majority of the farmers are illiterate. There is no doubt that the application of the findings from our limited researches in Nigeria would result in substantially increasing the agricultural productivity in this country. For instance the yields of oil palm could be doubled, that of cassava trebled and those of other crops such as rice, maize, cocoa and rubber increased several times, if the findings from agricultural research were adopted by the farmers—just as the development of the hybrid maize in the United States has revolutionised maize cultivation in that country. Many examples similar to the case of the hybrid maize could be given with reference to the technological advances not only in regard to seed quality but also in methods of cultivation, use of fertilizers, herbicides, pesticides and mechanical equipment of the right type for various operations.

## THE IMPORTANCE OF AGRICULTURE IN NIGERIA

Nigeria depends on agriculture as her mainstay; it provides 50 per cent of the National Income; and supplies some 85 per cent of her exports. The practice of agriculture enables Nigeria not only to feed herself but also send some surplus food abroad; foodstuffs at present account for about 80 per cent of the country's agricultural production. Apart from this Nigeria depends on agriculture for about 80 per cent of her revenue and about 75 per cent of her adult labour force is directly or indirectly engaged in agriculture. Research therefore has a very important role to play in the development of agriculture in this country; it may be regarded as the coner-stone of Nigerian existence. Agricultural development is the means of raising the living standard in Nigeria, and will continue to be the most important industry for many years to come. Even if Nigeria should become industrialised, it is still necessary that she should continue to provide most of the food required to feed 55 million inhabitants instead of trying to import food from abroad. It must be emphasised that whether or not Nigeria catches up on the advanced countries of the world in the next few years depends on the general mobilisation of the country's natural resources. This in turn depends on how much the country is able to make use of the knowledge obtained by agricultural research and by the intelligent application of scientific methods and modern technology to agriculture.

## INVENTORY OF NIGERIAN NATURAL RESOURCES

To make full use of the country's potentialities, an inventory of the basic data of her natural and human resources is essential. Such an inventory should include the country's climate, soil, vegetation, fauna, water and human population. There have been several missions organised by such bodies as F.A.O., the World Bank, U.S.A.I.D., the Ford Foundation, and so on: each conducting enquiries on one aspect or other of Nigerian natural resources. Some of them have produced very useful reports, others have done no better than tell us what is already known. These missions may cover one Region or the whole country: the most recent of these is the F.A.O. Planning Mission, 1962-63. This was a 16-man team led by Mr. H. S. M. Ishaque, which included among its members an agronomist, two economists, experts on land use, land tenure, livestock, research and institutions, water resources, nutrition and food processing, marketing, fisheries, forestry and statistics. The report is still awaited: but from the composition of this mission it is expected to be a well-documented report, similar to the Ashby Report on Education.

In a big country like Nigeria it is not easy to decide the field where researches aimed at developing agricultural production are most urgent. Agriculture is a highly specialised industry in which each sphere has its importance. What may be important in one Region of the country may be less important in the other Regions. Hence the necessity for determining order of priorities for the whole country as well as for each Region.

In the world the areas where the most spectacular increases of agricultural production have been achieved have coincided with countries where basic and applied research are given the greatest possible attention. The developing countries usually give top priority to applied research for economic and social reasons. This may be justified because basic research is international in scope and in most cases its findings can be directly applied over a wide area. The less industrialised a country is the higher the priority to be accorded applied research; in countries where agriculture has not gone beyond the traditional subsistence stage, applied research must solve the urgent problems which have direct influence on agricultural production.

## PRODUCTION FACTORS IN AGRICULTURE

It is necessary here to give a brief account of the factors which play an important role in agricultural production: soil, water, climate, seed, livestock etc.

*Soil*—It is a well-known fact that a healthy soil condition is the most important prerequisite of high agricultural production. The soil is the product of the underlying geological strata, with an inter-play of climate and vegetation. Nevertheless soil conditions depend to a great extent upon the influence of human activities and man is able to influence the soil for good or bad. The basic condition for the wise use of soil is to have a knowledge of the soil conditions. The way to obtain this information is from a detailed soil survey of the country. It is necessary to have detailed large-scale soil maps in addition to small-scale maps for practical planning for agricultural development.

Soil productivity can be influenced in three ways: the supply of additional nutrients and organic matter; tillage; and crop husbandry. Most of these cannot be used without the findings of research which will determine the best methods of applying them.

Soil fertility is usually a function of the humus content: the findings of research determine to what extent it will be possible to utilize the vast reserves in the soils of this country for maximum agricultural production. Here studies of soil chemistry, soil micro-biology and hydrological conditions in different soil types would be necessary.

Soil survey has been carried out in different parts of Nigeria for some time, but this is a vast country and the areas yet untouched are still very large.

The Regional Ministries of Agriculture have been doing many soil surveys in their areas: the Federal Government has secured the services of a Canadian firm of aero-surveyors to survey some parts of the country using electro-magnetic methods to produce aerial photographs from which detailed large-scale maps are made.

*Water*—Water is another important factor in agricultural production. The extensive areas of Nigeria covered by swamp which were hitherto left unused have been found to be valuable for rice production and today produce most of the rice required for home consumption. This has been made possible by research findings on the crop, swamp soils and methods of cultivation within the last two decades.

It is known that for about half the year nothing can grow in most parts of this country because of drought. It should be possible to correct this situation in most areas with the practice of irrigation: vast areas could produce two crops a year of groundnuts, maize, rice and other food crops. The effect of irrigation on the production of various crops or even total crop rotation system could be investigated; the findings may yet revolutionise the farming systems of this country. That is why it has been proposed to establish an Institute for Irrigation in connection with the Niger Dams Project where various irrigation methods can be investigated.

*Climate*—The determination of the influence of climate on crops is an aspect of research which may lead to fruitful results. Shading, mulching, establishing wind breaks and other methods of controlling the effect of climate have been found to be very helpful in agricultural production. The knowledge of this can be extended considerably. The Meteorological Service is arranging to carry out extensive agrometeorological observations in conjunction with agricultural departments throughout Nigeria. These observations can lead to fruitful results in agricultural development in this country.

*Seed*—One way of increasing agricultural production is by the use of improved seed: this can be obtained by plant breeding. From the earliest times man has learned to increase the yield of useful plants through positive or incidental plant selection. The aim of plant breeding is to change the various hereditary characters of cultivated or wild crops in order to increase their usefulness and value for human consumption by suppressing their undesirable characters. The chances of doing this are unlimited and these changes in characters may affect the quality, quantity, plant habit or resistance to diseases. By plant breeding man is able to produce new varieties of crops.

As a result of plant breeding, based on physiological and genetic research, high yielding varieties of most crops have been evolved. Thus, contrary to Malthus's prediction, there is now a substantial food surplus in some countries resulting from the new species and varieties of crops that have been developed in the past 60 years or so. In the United States due to hybrid maize, yield increases over the past 15 years have amounted to 41 per cent. In Nigeria the new varieties of oil plam bred at WAIFOR have increased yield by over 50 per cent. Prior to 1930 Nigerian farmers mainly used wild oil palm seedlings for planting. These were very few in quantity and the quality was generally poor. With the establishment of the Oil

Palm Research Station near Benin in 1939, systematic research on the crop was undertaken in this country: very high yielding strains of oil palm have been bred and the resultant seedlings are being distributed for planting in the oil palm growing areas of the country. It has been estimated that utilising the high yielding oil palm seed, the amount of oil being produced can be obtained from one-tenth of the area now occupied by the wild oil palms. It is as a result of this knowledge that a scheme for the rehabilitation of wild oil palm groves has been included in the 1962-68 development programme in Eastern Nigeria.

Similarly the establishment of the Cocoa Research Institute has led to the discovery of some improvements in the production of cocoa: the introduction of *Amazon* cocoa has led to considerable increase in yield. The *Amazon* type has some advantages over *Amelonado* cocoa; it matures earlier and flowers and fruits in 2 or 3 years while the *Amelonado* type takes 5 or 6 years to reach maturity. The *Amazon* cocoa also gives about double the yield of the *Amelonado* type.

The result of investigations has led to the adoption of a method of controlling black pod and swollen shoot diseases and Capsid pests of cocoa. Cultural methods of planting, shading and selective thinning have resulted in greatly increased production. The production of cocoa has increased from about 30,000 tons to nearly 200,000 tons a year in Nigeria over the past few years. It is as a result of these investigations that it is now possible for large cocoa plantations to be established instead of the old peasant cocoa farms in this country.

## RESEARCH ON FOOD CROPS IN NIGERIA

Research on food crops is the concern of the Federal Department of Agricultural Research, the Regional agricultural research organizations and the agricultural research departments of the universities. The result of the research on rice at the Federal Rice Research Station, Badeggi has led to the widespread introduction of rice varieties. It will be recalled that even before the last war, most of the rice consumed in this country was imported from Burma and India. This is not so today. Now many swamp and upland varieties of rice such as BG 79, Agbede, G.E.B. Maliong etc. have been introduced. Nigeria is now producing up to about 250,000 tons of rice annually and it is hoped to produce up to a million tons or more in the near future. Rice is fast becoming a commercial crop in this country and it is now exported to the neighbouring West African countries.

Research on maize has produced some good results: new varieties have been introduced such as Trinidad Bulk, Mexico 5, EAFRO 231, ES1 and ES2. These have been grown under Nigerian conditions and some have given yields as much as 50 per cent more than the local varieties. They are now released for distribution to farmers for planting in different parts of the country.

High yielding varieties of cassava which can yield up to 15 tons per acre compared with the national average of about 5 tons per acre have been obtained by hybridisation. Research on yam pests has produced very satisfactory results: farmers can now ensure protection of their crop from attack by yam beetles by rolling the planting setts in "Aldrin" dust, a recommendation based on the research of the entomologists of the Federal Department of Agricultural Research.

In the past the raising of cattle, except the Muturu, was a great problem in southern Nigeria owing to the prevalence of the tsetse fly. Recent researches with drugs and the introduction of exotic types of cattle have produced some promising results. In poultry development, success has been achieved with the introduction of Rhode Island Red, Leghorn and Sussex breeds. Today these birds have been raised or imported in large numbers for poultry keepers and the market is well served with table birds and eggs.

## THE VALUE OF RESEARCH TO AGRICULTURAL DEVELOPMENT

The value of research to agricultural development cannot be over-estimated. Research is the light to guide the feet of agricultural development.

Research helps to minimise unnecessary waste of funds by showing what can and what cannot be done. Without research any agricultural development plan executed is like taking a plunge in the dark which may land one in disaster! I refer here to two classical examples of this type of venture within living memory; the East African Groundnut Scheme in which the British Government sank £30 million into the scheme which proved a total failure and, nearer home, the Poultry Scheme in the Gambia, again operated by the British Government which also proved a failure. (Worthington, 1958). Had these two agricultural schemes been preceded by careful experimentation, only a small fraction of the money wasted on them need have been spent.

Compared with the experience to be gained from long practice which may run to several generations, a few years of research may bring to light useful practical results, applicable to agricultural development. It is quite possible that the results obtained from long experience may not be the best as they may be based on too few comparisons. A well designed experiment usually takes all the necessary factors into consideration and the result can be relied upon.

Research provides basic data for development plans which are now regular features in the developing countries.

## UTILISING RESEARCH RESULTS

The application of research findings has become the chief agent of advancement in the modern world. The difference between developed and underdeveloped countries lies in the application of the results of research to industries and agriculture: this difference will be accentuated if research remains the privilege of the developed countries and is further neglected in the underdeveloped country. Although the research findings in one place can be applied in another the transposition of such results is not an easy business; in certain fields this can be done rapidly; in agriculture it requires long and costly experimentation.

In order to carry the results of research to the farms it is necessary to have the confidence of the farmers. Moreover the research worker should not lose sight of the needs of the community where the results of his investigations are to be applied and he must bear in mind the social and economic consequences of the adoption of the method. It is therefore necessary to conduct some socio-economic enquiries before the findings can be adopted. This should be preceded by repeated tests carried out in the places concerned.

The implementation of research programmes requires a continuity of action; it requires the constant attention of qualified personnel. The condition under which research is carried out calls for material resources, funds and specialisation of men. These are in very short supply in Nigeria.

The spreading of research results to a given area often comes up against a number of obstacles (Mason, 1963). The farmer is often suspicious of the research worker. The farmer's methods are the results of slow development worked out through the generations. He knows in advance from his experience the results of his actions and therefore distrusts new methods as slight modification to his crop patterns endangers the precarious balance of his holding. He knows also that the novel technique on the new crop which has succeeded elsewhere may turn out to be harmful to his farm where ecological, economic, and family conditions are not the same.

Sometimes there may be misunderstanding of the farmer's problem on the part of the research worker. As research calls for specialisation, the worker may be so engrossed in his own field of specialisation as to be quite unable to locate the farmer's problem. This is why there should be an intermediary between the two sets of bodies. Here the extension worker fulfils this role. His work is quite important as it is he who should interpret the results of research to the farmers.

## CONCLUSION

This paper will be concluded by a statement which has been credited to Dr Harrar, Director of Rockefeller Foundation of New York:

> "The first consideration in overcoming world food problems, was the elimination of the traditional, nostalgic and totally unrealistic concept of farming as 'a way of life'. From the beginning it had been a way of life by imposition rather than by choice. It must be recognized as a business enterprise if the world pattern of food production was to meet human need."

Dr Harrar called for co-operation between biochemists, geneticists, soil scientists, economic botanists, zoologists, food technologists, and medical scientists. This, he said, could make it possible to select plants and animal stocks of superior quality and thus "tailor" genetically varieties which had higher yield potentials and nutrient content.

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Dr. B. Hopkins (*Agricultural Biology Department, University of Ibadan*)

# Biological productivity in Nigeria.

SUMMARY

Solar radiation, the ultimate source of all biological energy, can be used only by green plants. This process of photosynthesis is primary production and results in the formation of plant material which is largely carbohydrate. Secondary production is the conversion of this by herbivores into animal material which is largely protein. Tertiary and higher degrees of production by carnivores does not result in a predominantly new type of chemical compound.

The factors limiting primary production are considered in relation to Nigerian conditions. Solar radiation is climatically determined and some tentative data are presented. Biologically, the process depends upon the leaf area exposed, the rate of photosynthesis and the efficiency of utilization of solar radiation. The first two may be considered as *capital* and *interest* respectively. The amounts of primary production for natural vegetation and agricultural crops are considered with reference to the factors limiting these two aspects.

Secondary and tertiary productivity is considered briefly and production by domesticated and wild animals is mentioned.

Biological production is a very inefficient process: the efficiency of photosynthesis is about 1% whilst that of herbivores and carnivores is only about 5-20%.

Methods for increasing biological productivity and agricultural yields in Nigeria are considered. It is essential for increases to be maintained. Management must be such as to take the maximum harvest or crop without causing habitat deterioration so that the biological resources are conserved at the highest possible level.

## INTRODUCTION

In both natural and artificial communities living organisms are dependent upon one another. Different communities interact and intergrade. However, the scope of this paper will be limited to terrestial communities and within these emphasis will be placed on the vegetation.

Productivity may be defined as the amount produced per unit area per unit time. Thus biological productivity is the amount of biological material in terms of either complete plants or animals or of increase in the size of complete plants or animals produced per unit area per unit time. This emphasis on complete organisms is important, for biological productivity is total productivity in contrast with agricultural yield where the production of the economically important organ or organs only is considered.

Before considering the various levels of production and the factors affecting them it will be useful to present a brief overall picture of the subject. This can be done in terms of energy.

Living organisms not only use energy to maintain their vital functions, they also store or conserve it. Most animals, fungi and bacteria are heterotrophic in that their food and energy come partly from organic sources—that is from living and dead organisms. Most green plants, on the other hand, are autotrophic in that they can synthesise their own organic material from inorganic sources and can utilize non-organic energy sources. Some bacteria obtain energy by chemical oxidation of inorganic substances, but almost all the energy entering the biological system does so through the green plant. Thus green plants are fundamental to all living organisms as the primary producers.

Green plants owe their colour to chlorophyll, a complex of pigments which is able to trap the energy contained in light so that the plant can convert it into the energy contained in sugars and other organic materials. This process of energy transfer from sunlight to the plant is known as photosynthesis. Thus biological energy ultimately depends on sunlight which is utilized in the photosynthesis of simple carbohydrates. Some of the carbohydrate is subsequently further synthesised by the plant into more complex carbohydrates, proteins, fats and other organic substances; but the bulk of plant material is carbohydrate.

Herbivorous animals eat plants and in so doing convert the plant material into animals material, which is largely protein. This is secondary production. Tertiary production occurs when herbivores are eaten by carnivores. Higher degrees of production occur in longer and more complex food chains and food webs. Man, in this context, may be regarded as both a secondary and tertiary producer—a matter which will be reverted to later.

## SOLAR RADIATION

Almost all the radiation reaching the earth's atmosphere comes from the sun. Only about half this reaches the ground due to reflection and absorption especially by water vapour and dust particles. The radiation reaching the ground varies in wave-length from about 300 to 2,000 m$\mu$ and about one half of this spectrum (from about 400 to 700 m$\mu$) is useful for photosynthesis.

In order to study adequately the utilization of this radiant energy in primary production, it is necessary to measure accurately the quantity reaching the plants. Solar radiation is measured by solarimeters to which complex expensive electrical recording instruments are attached: there are few of these in operation in tropical regions. There is only one set of data for Nigeria. These are from Benin (West African Institute for Oil Palm Research) and cover the period 1959-62 (Director of Meteorological Service, personal communication).

An alternative method of measuring solar radiation is by a Gunn-Bellani radiation integrator. This is a much simpler and cheaper instrument which records total radiation: readings are normally taken daily when the instrument is re-set. There are 17 of these in Nigeria (Meteorological Service, 1962). These instruments have to be calibrated against a standard instrument and this has not been done for the Nigerian instruments: thus the data for these stations may require slight modification after calibration.

Various methods have been suggested for calculating an estimate of solar radiation using other climatic data, particularly illumination and sunshine or cloud data (Black, 1960; Davies, unpublished). These are useful approximations but must be used with caution especially in areas like Northern Nigeria where a sunshine record is obtained despite a considerable reduction in radiation due to harmattan haze.

Davies (unpublished) has produced maps showing the mean monthly values of solar radiation over Nigeria. With the exception of the Jos Plateau, these show contours roughly parallel with latitude and with the amount of solar radiation increasing with latitude. In general the solar radiation range in Nigeria is from a wet season minimum of 230-450 cal/cm$^2$/day to a dry season maximum of 400-600 cal/cm$^2$/day, though there is a distinct mid dry season trough due to harmattan haze (Director of Meteorological Service and Davies, personal communications).

## VEGETATION CAPITAL

Areas of the world receiving high values of solar radiation do not necessarily have high rates of biological production. Indeed the maximum recorded values of solar radiation occur in desert areas (Black, 1956). Vegetation is necessary and, within limits, the more the vegetation the more will be the production.

Vegetation can thus be regarded as *capital* and the increase in vegetation, or its productivity, as the *interest* received. As long ago as 1919, Blackman (1919) pointed out that plant growth is a continuous process so that it is compound interest which is received. This interest, which measures the overall rate of increase of plant material depends on three factors: the amount of vegetation capital originally present, the rate of photosynthesis of the green parts of the plant, and the efficiency with which these green parts convert light energy into chemical energy. These three factors will now be discussed briefly.

First, the amount of vegetation or vegetation capital per unit area will be considered. The total weight of all the components may be determined. In this case the material has first to be dried for plants contain such varying amounts of water as to make fresh weight data unreliable. It is perhaps not surprising that little data of this type exist except for some herbaceous communities. It has been estimated that the dry weight of vegetation in mature African forests is in the order of 700–1,100 t/ha* (Phillips, 1959; p.161) and about 67 t/ha for a 20-year-old savanna woodland in Ghana (Nye and Greenland, 1960; tab. 2).

Weight is not a particularly good measure for although it is related to the energy store of the vegetation (and it must be realised that the bulk of a tree consists of dead wood) it is not necessarily so closely related to vegetation production for this depends upon green leaves. The functioning of the leaves depends on the chlorophyll they contain.

Hence attempts have been made to measure the cholorophyll content of vegetation. These have mainly been used for aquatic vegetation, particularly phytoplankton. For the terrestial communities which have been analysed, and these include a series of 19 from Minnesota, U.S.A. (Bray, 1960), the chlorophyll content ranged from 0.2 to 6.0 g./sq.m. of ground with most values lying between 0.5–3.0 g./$m^2$ (Newbould, 1963).

Leaf area, leaf protein and leaf nitrogen have all been considered as possible measures of the photosynthetic part of the plant. With regard to leaf area, Watson (1947) stated that "the measure of leaf area which is relevant . . . is the leaf area per unit-area of land, which it is proposed to call the Leaf Area Index (L.A.I.)". He studied the seasonal change in L.A.I. for several temperate herbaceous crops and found that the L.A.I. commenced from zero and rose to a sharp peak after which it again fell. Different herbaceous crops had the same pattern but some, such as sugar beet, had a longer period of high L.A.I. values. Potatoes, for example, had a L.A.I. of greater unity for only ten to twelve weeks in the year (Watson, 1958). The maximum values for temperate annual crops are in the range of 2.4 to 5.0 (Whyte, 1960; p. 80).

L.A.I. in pastures tends to be higher than in annual crops (Whyte, 1960; p. 80) and pasture production is adversely affected by both low and high L.A.I. values. With a high L.A.I. the lower leaves will be in deep shade and for most of the time may be in a light intensity below the compensation point and hence be 'parasitic'. From experiments in New Zealand, Brougham (1956, 1958, 1960) has suggested that the value of the L.A.I. which intercepts 95% of the incident light at local noon be called *critical value* of the L.A.I. for it is at about this value that pastures show their maximum productivity. The critical value of L.A.I. for the series of pastures on which he worked varied from about 3 to 7.

If this relationship between L.A.I. and pasture production is determined it is possible to devise a management system which makes optimum use of the pasture. The aim is to allow the L.A.I. to fluctuate around this critical value by grazing control.

There are few L.A.I. data for Nigeria. Student determinations on *Cynodon plectostachyus/Centrosema pubescens* pastures at the University of Ibadan gave values varying between about 4 and 10. The L.A.I. of the herbaceous layer in derived savanna woodland at Olokemeji rises to maximum value of 4.6 whilst the L.A.I. for the whole community is about 6 (Hopkins, unpublished). Data for evergreen communities would be particularly valuable for these communities (at least in temperate regions) show the highest rates of production. Ogawa *et al.* (1961) suggest that L.A.I. values for tropical forests may exceed 10.

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* 1 metric ton = 1,000 kg. 1 t/ha = 892 lb./acre. 1,000 lb./acre = 1.121 t/ha.

## PHOTOSYNTHETIC INTEREST

The rate of production in terms of leaf area will now be considered. Reverting to the original analogy, how much *interest* is obtained per amount of leaf area *capital?* The rate of production of dry matter per unit area of leaf is known as the net assimilation rate (N.A.R.) (Gregory, 1926).

In the north temperate region it has been shown that there is a wide seasonal change in N.A.R. with a distinct peak in mid-summer (Watson, 1947). This is not surprising for N.A.R. is mainly governed by climatic factors, especially the light intensity, provided that the two substrates—water and carbon dioxide—are in adequate supply. The importance of this is not only the low values of N.A.R. for most of the year but also that this peak may occur before the peak of L.A.I.; in other words by the time the plants have a high leaf area index their net assimilation rate has seriously declined. Maximum values of N.A.R. for Britain are in the order of 0.65 to 0.75 g./dm$^2$/week (Heath and Gregory, 1938, Blackman and Wilson, 1951).

N.A.R. data for ten species growing in Nigeria were presented by Njoku (1959) who showed that on the whole these values were equal to or slightly higher than maximum values obtained in temperate regions; seven of these species showed maximum N.A.R. values greater than 0.8. Njoku's results strongly suggest that there are seasonal changes in N.A.R. with maxima under the dry season conditions of bright sunshine and high temperatures provided, of course, that the plants are adequately watered. In a later paper, Njoku (1960) showed that there was a logarithmic relationship between N.A.R. and light intensity in some of these species.

## EFFICIENCY

The efficiency of any stage may be regarded as the energy value of the products as a proportion of the input energy.

For primary production, the efficiency is the energy value of the products of photosynthesis compared with the energy value of the light received. As has been previously pointed out, half the energy value is of wave lengths unsuitable for photosynthesis. Even during the growing season and with a complete cover of vegetation, most light is reflected or transmitted. It is, therefore, not surprising that photosynthesis is an inefficient process.

Under laboratory conditions, using actively growing material with light intensity limiting, efficiencies of 30% have been obtained (Wassink, 1959). For field crops an annual efficiency of 1-2% has been recorded in Holland (Wassink, 1959). As might be expected from their high L.A.I. values, low albedo due to dark foliage, and ability to photosynthesise during the whole year, the highest annual efficiencies have been recorded for evergreen woodlands. Values of up to 3% are not uncommon for temperate conifers (Ovington, 1962). Similar values have been obtained by Ogawa *et al.* (1961) for tropical forests in Thailand. On the whole, photosynthetic efficiency is very low: total world terrestial production is estimated at 4-6 x $10^{10}$ t/yr. with a mean efficiency of about 0.1% or 0.2% according to the wave length criteria used (Newbould, 1963; Pearsall, 1959).

## PRIMARY PRODUCTIVITY

Production ecology has been studied only during the last two decades so that there are few precise data available especially for tropical regions. Data for Nigeria, together with some other relevant results, are presented in the following table. When comparing the productivity of crops with natural vegetation it must be remembered that the former receive fertilizer treatment.

Productivity Data for Some Nigerian Plant Communities

| *Vegetation Type* | *Locality* | *Remarks* | *Productivity t/ha/yr** | *Source* |
|---|---|---|---|---|
| mature secondary forest | Omo F. R. | leaf fall only | 7.2 | Hopkins (unpublished) |
| mature secondary forest | Olokemeji F. R. | leaf fall only | 4.8 | Hopkins (unpublished) |
| derived savanna woodland | Olokemeji F. R. | leaf fall only | 0.9 | Hopkins (unpublished) |
| derived savanna woodland | Olokemeji F. R. | herbs only | 6.2 | Hopkins (unpublished) |
| grass savanna range plots | Shika | | 3.4 | Rains (personal communication) |
| *Panicum maximum* plots | Ibadan (University) | | 23 | Oyenuga (1960) |
| *Pennisetum purpureum* plots | Ibadan (University) | | 34 | Oyenuga (1959) |
| *Digitaria decumbens/Centrosema pubescens* pasture | Ibadan (Moor Plantation) | | 17 | Anonymous (1962) |
| *Andropogon gayanus/Centrosema pubescens* pasture | Ibadan (Moor Plantation) | | 20 | Anonymous (1962) |
| *Cynodon plectostachyus/ Centrosema pubescens* pasture | Ibadan (Moor Plantation) | | 20 | Anonymous (1962) |
| *Panicum maximum/Centrosema pubescens* pasture | Ibadan (Moor Plantation) | | 20 | Anonymous (1962) |
| *Pennisetum purpureum/ Centrosema pubescens* pasture | Ibadan (Moor Plantation) | | 35 | Anonymous (1962) |
| mature oil palm plantation | Benin (W.A.I.F.O.R.) | | 20 | Rees (1962) |
| 40-year secondary forest | Ghana | | 24.4 | Nye (1961) |
| savanna forest (=savanna woodland) | Thailand | | 7.9 | Ogawa *et al.* (1961) |
| sugar cane | Hawaii | | 72 | Burr *et al.* (1957) |

* one metric ton per hectare equals 892 pounds per acre.

There are no complete data for natural (or semi-natural) communities in Nigeria, though data for forest and savanna elsewhere are given, but there are some data for leaf fall which is related to total productivity. It will be seen that the Omo forest (with a mean annual rainfall of *c.* 2000 mm.) produced about one and a half times as much leaf fall as the drier forest at Olokemeji (with a mean annual rainfall of *c.* 1230 mm.) and that this latter type produced about five times as much as derived savanna in the same locality: this suggests the forest is about five times as productive as savanna.

The only other series of data from one place is the pasture data from Ibadan which show that a *Pennisetum purpureum/Centrosema pubescens* pasture is the most productive. Many more data of this type need to be obtained.

The productivity of 72 t/ha/yr for sugar cane in Hawaii (Burr *et al.*, 1957) is one of the highest values ever recorded.

Westlake (1963), in a recent review estimates the probable mean productivity on fertile tropical soils as 50 t/ha/yr for rain forest, 30 t/ha/yr for annual crops and 75 t/ha/yr for perrenial crops.

## SECONDARY AND HIGHER PRODUCTION

The green plant is the first step in the biological circulation of energy. The second stage is the conversion of the plant material into animal material. The animals which carry out this process are known as herbivores for they feed on plant food.

The rate at which animals increase depends on various factors, the most important of which are food, predation and disease. From an exhaustive study, Lack (1954) has concluded that it is the food supply which is of overriding importance in that it sets an upper limit to the population size: the other two factors tend to be density dependent and thus to limit the population.

On this basis, the highest biomass of herbivores would be expected where there is most food; that is in the plant community with the highest vegetation capital—in the tropical forest. Unfortunately there are no biomass data for tropical forests. The largest numbers of large herbivores are observed on the savanna lands of East and Central Africa where the live weight mammalian biomass reaches 0.20 to 0.24 t/ha (Huxley, 1962). The figure for the Yankari Game Reserve in Bauchi Province is probably about one-twentieth of this (calculated from the data of Sikes, 1963). This low figure is not due to habitat deterioration as in much of Africa but to overhunting in the past (Petrides, unpublished): with protection this biomass should increase very rapidly. These are, of course capital data. Little is known of the productivity of wild herbivores and it is often assumed that productivity is related to biomass: this is not necessarily so for a high population (through protection in a game reserve for example) can lead to overgrazing, habitat deterioration and a consequent fall in population.

Although there are more data on the productivity of domesticated herbivores, there is very little data on a land area basis. At the University of Ibadan a live weight gain of 0.45 t/ha/yr has been maintained for zebu steers for over a year on a *Cynodon plectostachyus/Centrosema pubescens* pasture (Hill, 1962) whilst N'Dama steers on a similar pasture but with *Stylosanthes gracilis* gained at the rate of 0.34 t/ha/yr (McIlroy, 1962). Assuming that 80% of the live weight is due to water these data are equivalent to about 0.08 t/ha/yr dry matter.

Data on the efficiency of herbivores and carnivores are scarce but both processes appear to be equally efficient with values ranging from 5 to 20% (Slobodkin, 1962).

It cannot, however, be stated that animals are more efficient than plants for the energy intake measurements are quite different in each case. Physical scientists are often appalled at the low efficiency of biological systems compared with machines but it should be remembered, as Odum (1959) has pointed out, that organisms maintain and repair themselves and that the capacity for rapid growth may have more survival value than maximum efficiency.

## INCREASED PRODUCTIVITY

Natural vegetation does not provide all the needs of civilized man. It must therefore be altered to increase the proportion of total production which is of direct use—so that the harvest or crop taken by man may be as large as possible—so that the agricultural yield may more closely approach the biological production.

This can be achieved only by land use and land management. Man has already interfered too far with Nature to allow her to go her own way. Even in strict reserves a management plan has to be devised and operated. In order to obtain high productivity now and in the future the natural resources must be protected by habitat conservation. Much of the tropical forest of Africa has been destroyed for development and attention is now turning to the savanna. The savanna should be conserved immediately whilst a sound system of management based on scientific principles is worked out.

Agricultural communities tend to be simpler than the natural communities they replace for there is an enormous loss of efficiency at each stage of biological production. To take an extreme example, tropical forest with its most complex vegetational structure and organization (Richards, 1952) and its stratified animal communities (Harrison, 1962) is replaced by the simple plot of maize. Whilst this leads to increased yields, there are dangers in such simplifications as pointed out by Elton (1958).

To produce the same amount of human food, animals require about ten times the land area as plants. Thus if man was entirely vegetarian his food could be produced from a smaller land area than is the case. Man is not omniverous from choice: his daily food requirements are in the order of 2,000 calories and 80 g. of protein of which 30 g. should come from animal sources.

In conclusion methods for increasing production will be considered.

Primary production depends upon the integration of leaf area index, net assimilation rate and the efficiency of the energy conversion. Increase in one of these may be accompanied by a decrease in others; for example, efficiency is at a maximum when L.A.I. is so high that light is limiting the N.A.R. of the lower leaves. This is not to say that efficiency is unimportant agriculturally, for light is normally the limiting factor in photosynthesis (Black (1963) has recently investigated the interrelations of solar radiation, L.A.I and production of *Trifolium subterraneum* in Australia). Insufficient is known of the seasonal changes of L A.I. and N.A.R. under Nigerian conditions, but it seems likely that both are not high simultaneously —except possibly for a short period at the end of the wet season. Watson (1952) has shown that for sugar beet early planting gives an earlier L.A.I. maximum which lasts for a longer period and it is during this earlier period that N.A.R. is maximum. Early planting of cotton at Samaru has given considerably increased yields (Lawes, 1961), possibly for this reason.

Much increase in L.A.I. and N.A.R. can result from improved husbandry. Research into the physiology of crop plants is essential and cooperation with plant breeders should produce varieties with higher L.A.I., N.A.R. and efficiencies under Nigerian conditions.

Where productivity data for different communities (both natural and artificial) under the same habitat conditions are available it is possible to devise a rational land use policy. Two examples must suffice. First, for an area of poor soils in England the following productivity data (in t/ha/yr) were obtained (Ovington and Pearsall, 1956):

| | |
|---|---|
| deciduous trees | 4.2 |
| coniferous trees | 8.0 |
| agricultural crops | 4.5 |

These clearly show that soft-woods will give the maximum productivity on this particular area. Secondly, in the Serengeti National Park in Tanganyika "the natural eco-system on the *poorer* part of the area is as biologically productive as the human pastoral system on the *better* regions" (Pearsall, 1962). This is undoubtedly due to the wider vegetation 'spectrum' utilized by the wild animals in contrast to the restricted food preferences of domesticated species (Darling, 1960; Huxley, 1961).

Data of this type are urgently required for Nigeria especially for savanna areas where most future development is likely to occur. The International Biological Programme of the International Union of Biological Sciences (of which the Science Association of Nigeria is a member) will, through its emphasis on productivity, stimulate much of this research.

This is not to say productivity data are to be the sole criteria for land use determinations: they are very important and often overlooked, but man's requirements are many and his agriculture must be diversified.

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Professor A. R. Mathieson (*Chemistry Department, Ahmadu Bello University, Zaria*) **Some aspects of protein structure and reactivity.**


SUMMARY

The structure of proteins can be discussed on three levels: (1) the primary structure, concerned with the covalent linkages, the proportion and sequence of the different amino-acid residues present and the number of polypeptide chains; (2) the secondary structure, dealing with the manner of folding of the polypeptide chains and the links between them (if any are present); and (3) the tertiary structure, determined by the interactions between the side chains of the amino-acid residues.

Three examples have been chosen for discussion, dealing with the structures at each of the three levels, from research currently in progress, which are of some interest to agriculturalists. (1) The nature of the proteins present in grains cultivated in Nigeria, such as sorghum, and the proportion of the different amino-acid residues present in them, are important from a nutritional point of view. (2) The folding of the polypeptide chains and the way in which they are linked together in wool largely determines the properties of that fibre. (3) Interaction of the side chains of the amino-acid residues in proteins with other molecules is necessary for the proper functioning of living tissues; the interaction with vitamin $B_{12}$, which determines the absorption of this vitamin, will be considered here.


## INTRODUCTION

As the theme of the Sixth Annual Conference of the Science Association of Nigeria is "Science and the Agricultural Resources of Nigeria", this paper will give a brief account of three aspects of protein structure and behaviour which are at present being studied in the Department of Chemistry at Zaria, and which have some relevance to agricultural problems. At the same time it is intended to try to show how these investigations are related to the general question of protein structure.

## THE PRIMARY STRUCTURE

Linderstrom-Lang (1962) has discussed the structure of proteins on three levels: the primary, secondary and tertiary structures. The same kind of subdivision will be considered here, although the classification will not be quite the same. The primary structure is concerned with the covalent chemical bonds which unite the atoms of the protein molecule. Protein molecules consist of one or more long peptide chains, made up of amino-acid residues: the general formula of an amino-acid is $\mathrm{R\text{-}\underset{\displaystyle \overset{|}{NH_2}}{CH}\text{-}COOH}$ where R represents an atomic grouping, characteristic of a particular amino-acid. There are about 24 different amino-acid residues in common occurrence in proteins, differing in the nature of R. Thus R may be an aliphatic hydrocarbon group, as in glycine, alanine, valine, leucine and iso-leucine; an aromatic hydrocarbon as in phenylalanine; or an alcoholic group as in serine and threonine; a thiol as in cysteine; a phenolic group as in tyrosine; a thioether as in methionine; a disulphide as in cystine; a carboxylic acid as in aspartic and glutamic acids; an amide as in asparagine and glutamine; a basic group as in arginine, lysine, ornthine and histidine; or a heterocyclic group as in tryptophan, histidine, proline and hydroxyproline. In proteins the amino acids are united by peptide links through their carboxyl and α-amino groups, generally in a definite sequence, to form long peptide chains, two units of a chain being shown:

$$
\begin{array}{c}
\text{-CO.NH.CH.CO.NH.CH-} \\
\quad\quad | \quad\quad\quad\quad | \\
\quad\quad R_1 \quad\quad\quad R_2
\end{array}
$$

There may be more than one chain in a particular molecule, the different chains being united either at a branch (one chain end joined to a point along the length of another chain) or by cross-linking (two chains united by one or more short atomic sequences).

In determining the primary structure of a protein it is necessary first to obtain that protein pure, separated from other materials and in particular from other proteins which most likely occur with it in the natural state. The protein needs to be characterized, using some or all of the methods of electrophoresis, optical rotation, infra-red spectroscopy, titration and x-ray diffraction. Hydrolysis followed by chromatography is used to determine the number, and the proportions, of the different amino-acid residues present. The molecular weight of the protein, which could be as high as $10^6$ or higher, is determined by light-scattering, sedimentation, osmotic pressure or viscosity; generally a combination of methods being required. This enables the chain length of the molecule to be found. The final step is the determination of the sequence of the amino-acid residues along the chain, involving end-group determination, chain separation, and partial fragmentation of the chains by acid and by enzymic hydrolysis to yield peptides. These are short fragments of the long protein chains which can be identified, and when this information is pieced together the amino-acid sequence can be determined. This final step has been carried through completely so far only for the comparatively simple proteins insulin (Ryle *et al.*, 1955) and ribonuclease (Hirs *et al.*, 1960; Spackman *et al.*, 1960; Smyth *et al.*, 1962; Potts *et al.*, 1962).

## PROTEINS OF SORGHUM

Although sorghum and millet are of first importance in Northern Nigeria and many other tropical countries as basic human and animal foodstuffs, very little is known of the proteins present in the grains. Work has been started here in Zaria on the proteins of sorghum grains.

Values of total protein of sorghum grains have been published for sorghums grown in Africa, India, and America, and are summarized in table 1. The range of variation of these figures is large, and is perhaps due partly to the use of different strains (Bono and Vidal, 1962), but perhaps also to the conditions of growth. It is clearly important to be able to select the strain with the highest yield of protein, and to find the best growing conditions.

TABLE 1

TOTAL PROTEIN OF SORGHUM GRAIN

| *Origin* | *Per cent of dry weight* | *Source* |
|---|---|---|
| Africa | 9.6—15.1 | Adrien, 1954 |
| Africa | 9.1—12.9 | Bono and Vidal, 1962 |
| India | 6.4— 8.5 | Balasubranian *et al.*, 1952 |
| America | 8.9—13.8 | Chamberlain, 1909 |
| America | 12.2—15.2 | Ball and Rothgor, 1915 |
| America | 10.3—12.6 | Winton, 1902 |

A method is being developed here to determine total protein rapidly on very small samples of grain, so that the new strains at present being developed by Curtis at the Institute for Agricultural Research and described in another paper at this conference (pp.109-121), can be screened for their protein content. This method depends in the use of the biuret reagent in a micro-colorimetric analytical procedure adapted from the method of Kingsley (1939) and Gornall *et al.* (1949).

Although sorghum compares reasonably well with other grains with regard to its total protein content, it seems quite possible that the protein is deficient in certain essential amino-acids. It has been stated (Dalziel, 1937) without documentation that the biological value of the protein is low, and that the ash is remarkably deficient in calcium, sodium, potassium, chlorine and iron but very rich in phosphorus. Determination of the amino-acid composition of the protein is evidently very necessary from a nutritional, as well as a chemical point of view, but the few such determinations which have already been made show considerable disagreement (Adrien, 1954; Balasubranian *et al.*, 1952; Block and Bolling, 1947; Jacobs, 1944; Higgon's, 1959); and while this could be due to the use of faulty techniques, it may be to some extent real and perhaps reflect differences due to the use of different strains. Comparison with the reference proteins from whole egg and human red muscle suggests that sorghum grain may be low in the essential amino acids lysine, arginine, isoleucine and perhaps methionine. If it proves to be the case that the amino-acid content of proteins from different strains is different, it will be important to screen new strains for their content of essential amino-acids. Investigation of this problem is just beginning here.

The total protein of sorghum grain is made up of at least two types of protein, the prolamins and the glutelins, and perhaps also traces of albumins and globulins (Brohult and Sandegren, 1954), with the prolamins accounting for more than 60 per cent of the total. Jones and Brewster (1916) have described a protein, kafferine, from the prolamin fraction. We have started to investigate the nature of the individual proteins present in the mixture, using the techniques of chromatography and electrophoresis.

## THE SECONDARY STRUCTURE

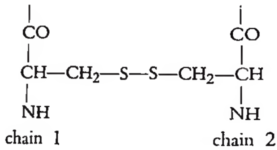
The secondary structure involves the manner of folding of the polypeptide chains, and the linkages which exist between different chains, holding them in a fixed configuration with respect to one another. The folding of the chains has been studied mainly by the method of x-ray diffraction using solid proteins (Zahn and Dietrich, 1960) but optical rotatory dispersion and spectroscopy (Scheraga, 1961) have now started to reveal something of the chain folding in dissolved proteins. Very broadly, we can distinguish three main kinds of chain folding:

(1) the $\alpha$-structure, in which the polypeptide chains are wound in a helical arrangement;
(2) the $\beta$-structure, in which the polypeptide chains are almost straight and parallel to one another, being arranged in a 'pleated sheet' structure;
(3) the random coil, in which the chain has no preferred arrangement.

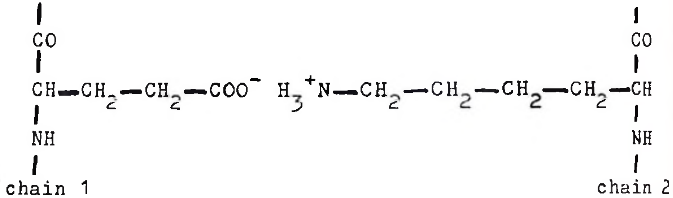
Most fibrous proteins have either the $\alpha$- or $\beta$-structure, though there are exceptions (Cowan and McGavin, 1955). In the globular proteins both $\alpha$-structures and random coils occur, often in the same protein under different conditions, together also with highly specific structures which cannot be classified. When in the dissolved state, these proteins may retain their solid-state structures, or their structures may become modified by intermolecular attractive forces between chemical groups in the protein and the solvent molecules as described under the tertiary structure.

The existence of cross-links between different polypeptide chains must modify the manner of chain folding, and so these are here included in the secondary structure. There are several different types of such cross-links, including:

(1) the disulphide link, a covalent link but one which is relatively easily ruptured by oxidation or reduction. It occurs through the amino-acid cystine, which has two peptide groupings, one of which occurs in each of two chains, united by a disulphide bond:




(2) the 'salt link', or electro-valent link, between side chains carrying charged groups such as ionized carboxyl and amino groups, e.g.



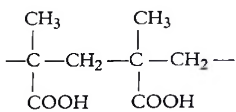

Such a link might be quite specific and give rise to a specific structural arrangement, or it might result only in a generalized attraction between ionized groups when it would properly be regarded as contributing to the tertiary structure.

THE SALT-LINKS IN WOOL

Wool consists of a solid fibrous protein, keratin, in which the polypeptide chains are united both by disulphide cross-links and by salt-links. Study of its electrochemical properties has revealed something of the nature of these salt-links and is beginning to yield information on the secondary structure and the amino-acid sequence as well. The titration of a simple acid by a base obeys the equation

$$pH = pK^{o} - \log\frac{1-\alpha}{\alpha}$$

where $pK^{o}$ is the intrinsic dissociation constant of the acid and $\alpha$ is its degree of dissociation. For a polymeric acid in solution, such as polymethacrylic acid, ionization of the carboxyl



groups produces a high electrostatic potential ($\chi$) on the molecules which causes hydrogen ions to be attracted and inhibits further dissociation. The titration of such an acid follows the equation

$$pH = pK^{o} - \log\frac{1-\alpha}{\alpha} - \frac{0.4343\,\chi F}{RT}$$

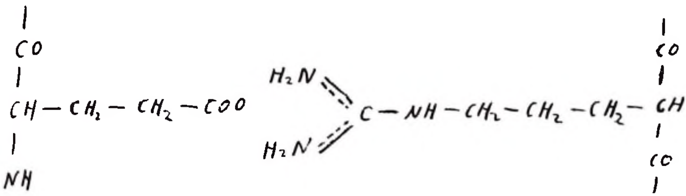
(Katchalsky *et al.*, 1954; Mathieson and McLaren, 1960) where the additional term accounts for this effect, and is known as the electrostatic term; $pK^{o}$ is now the intrinsic dissociation constant of the dissociating group of the acid, F the Faraday of electricity, R the gas constant and T the absolute temperature. $\chi$ has to be calculated from a postulated model for the system.

A solid polymer, such as wool, presents further complexity; first because it is not in solution and in titration is immersed in the liquid whose pH is being measured, the hydrogen ions in this liquid being in equilibrium with those in the solid; and secondly because it contains both acidic and basic groups, as both positively and negatively charged groups occur together on the chains. However, Mathieson and Whewell (1964) have shown that the acid titration of such a material can be represented by

$$pH = pK^{o} - \log\frac{1-\alpha}{\alpha} - \frac{0.4343}{RT}\left[\chi F + \Delta\mu^{o}\right]$$

where the additional term in $\Delta\mu^{o}$ accounts for the attraction of the positively charged sites for the anions of the acid, and may be called the affinity term. Using this expression it was found that for nylon (Mathieson *et al.*, 1964) and crosslinked methacrylic acid (Mathieson and Shet, unpublished) a single intrinsic dissociation constant was operative. Whereas for wool (Mathieson and Whewell, 1964), $pK^{o}$ was found to vary linearly with the degree of dissociation in such a way as to imply that there were two kinds of carboxyl groups present in equal proportions and with quite different intrinsic dissociation constants. At 0°C their values were 4.85 and 3.58. A value of 4.85 is about the normal value to be expected for the dissociation constant of a carboxyl group, but the lower value is abnormal, and is shown by carboxyl groups titrating in close proximity to a group carrying a positive charge, that is by carboxyl groups taking part in salt-links.

This treatment has made it possible to calculate the number of salt-links present and has allowed a better interpretation of some of the mechanical properties of wool fibres to be made (Mathieson and Whewell, unpublished). It has also permitted speculation on the amino-acid sequence of wool. Two amino-acid residues having free carboxyl groups in their side-chains might be concerned, aspartic and glutamic acids, while there are three candidates for the basic member of the salt-link pair, arginine, lysine and histidine. If this salt-link is specific, analytical data show that it must involve glutamic acid and arginine:



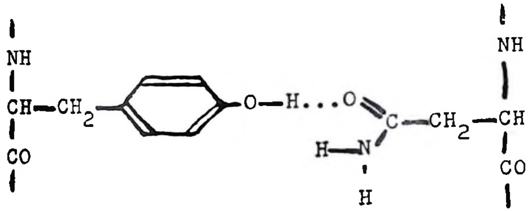
## THE TERTIARY STRUCTURE

Tertiary structure is concerned with interactions of a weaker nature than covalent chemical bonds. Such interactions occur among, and between, side-chain groups and peptide groups of the protein molecules, and with solvent and other molecules and ions in close proximity. In cases where the secondary structure is not rigid, these interactions play a large part in determining the shape of a protein molecule in solution, and how this shape is affected by changes of environments. They are also important in considering the interaction in solution between separate protein molecules and between proteins and other macromolecular constituents of the solution.

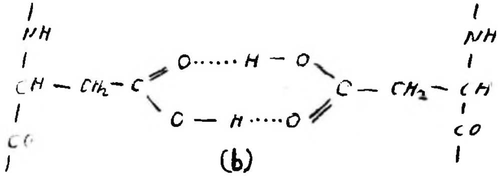
There are three main types of interaction:

(1) Electrostatic interaction of ionized groups. This is the same effect as already encountered in the salt-links of wool, but here a less specific binding occurs. Ionized carboxyl and amino groups can contribute to the overall electrostatic potential of a protein molecule, which thereby will attract or repel simple cations or anions, perhaps derived from a salt, and dipolar molecules such as water. Also, a more specific binding may occur in a dynamic equilibrium, in which ionized groups on the protein may attract salt ions, or each other, but no permanent partnerships are formed, unlike the case of the salt-links. Such binding can be quite firm, as in the attachment of certain divalent metallic cations to proteins by chelation (Gard and Wilcox, 1956).

(2) Hydrogen bonding. This can involve several groups occurring in proteins in various combinations, where oxygen or nitrogen occurs bound to hydrogen. Examples are given of hydrogen bonding between the residues of tyrosine and asparagine (*a*) and two residues of aspartic acid (*b*); these could be in the same, or different, polypeptide chains of one molecule, or in two different molecules:



(a)



(b)

(3) Hydrophobic bonding. The importance of this type of interactions is just becoming recognized (Klotz, 1958, 1960; Kauzmann, 1959; Nemethy and Scheraga, 1962). Here the bond is between two non-polar groups, such as alkyl groups, and occurs because the water in the neighbourhood of such groups is repelled, increasing the contact between the non-polar groups and perhaps conferring on the water a more ordered, ice-like, structure. This kind of bonding, like hydrogen bonding, although very weak

in any individual bond, can provide a strong link between two molecules where it is possible for many such bonds to be formed between them, an extreme case being the union of the twin polynucleotide chains in the helix of desoxyribonucleic acid (Watson and Crick, 1953; Jordan *et al.*, 1956) by hydrogen bonding.

## INTERACTION OF VITAMIN $B_{12}$ WITH PROTEINS

The absorption of vitamin $B_{12}$ into the body takes place by its strong interaction with a protein known as the 'intrinsic factor'. Unless this factor is present and is effective in binding the vitamin, absorption will not take place, and deficiency symptoms will appear, perhaps as pernicious anaemia or sprue (both prevalent in Nigeria), in spite of a sufficient intake of the vitamin by the patient. It is clearly important to discover the nature of this binding, particularly since the intrinsic factor has proved hard to isolate in a pure state. The intrinsic factor is found in gastric juices, and in the stomach wall of several species.

Treatment of megaloblastic anaemias due to vitamin $B_{12}$ deficiency is nowadays made mainly by intramuscular injection of the vitamin, and where the patient does not secrete the intrinsic factor this can be supplied as a purified concentrate of dried hog stomach. There have however been reports of relapses after continued treatment, which could be due to species specificity or to the presence of other substances binding the vitamin and inhibiting its normal interaction with the intrinsic factor (Smith, 1960).

The intrinsic factor appears to be a mucoprotein of high molecular weight, containing amino-acid residues and hexosamine, mannose, galacotose and fructose residues (Latner *et al.*, 1956; Holdsworth and Otteson, 1955). It is not however by any means the only natural substance that will bind vitamin $B_{12}$, and it has been shown that a wide range of different proteins will all bind the vitamin, with different binding strengths (Bird and Hoevet,1951). However, few attempts to locate the site of binding on the vitamin molecule have so far been made. The structure of vitamin $B_{12}$ (cobalamin) has been elucidated (Hodgkin *et al.*, 1955) and is shown in figure 1. The central cobalt atom is linked to four reduced pyrrol rings to form a macro-ring. This carries an amide link to a nucleotide whose sugar is ribose, and whose base is 5:6-dimethylbenziminazole. This base is linked to the cobalt atom by coordination of one of its nitrogen atoms, and the cobalt atom also carried a —CN group.

It is possible that cobalamin could link to protein through the cobalt atom either by removal of the —CN group, or by breaking the linkage to the benziminazole residue, of which the latter seems the more likely (Rosenblum *et al.*, 1956). The benziminazole residue could then also participate in binding to charged groups on the protein. Electrochemical methods can be used to study the binding of benziminazole, both free and combined in cobalamin, to proteins and selected amino acids, while spectroscopic methods seem suitable for studying binding at the cobalt atom. This work is just beginning.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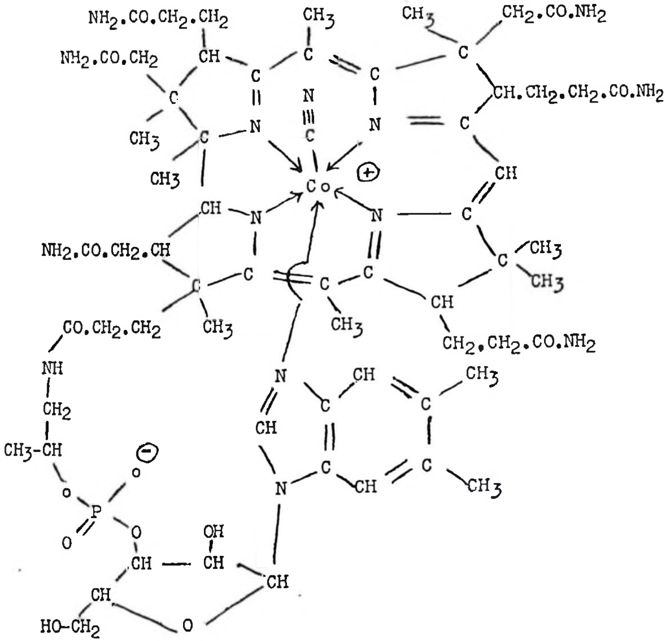


Vitamin $B_{12}$ (Cobalamin)

*Fig. 1*

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Mr. A. C. Zeven (*West African Institute for Oil Palm Research, Benin*) **The development, retrogression and rehabilitation of oil palm groves.**

SUMMARY

The main part of Nigeria's export of palm produce comes from the wild palms and especially from the palm groves in Eastern Nigeria. Up to 1960 the export from Nigeria was about 185,000 tons of oil and 440,000 tons of kernels, accounting for about 24 per cent of the value of the total exports. Since 1960 the export of palm produce has dropped considerably; it is believed that this decline is caused by the price policy of the Marketing Boards. The local consumption of palm oil is estimated at 250,000 tons.

The number of wild palms and the area covered are unknown. Densities vary from 1 to 140 stemmed palms per acre. Dense groves yield about one ton of fruit bunches per acre, giving about two hundredweight each of palm oil and kernels. The output of a grove can be raised by improving or replanting the palm grove and improving the extraction methods.

Palm groves arise from abandoned compounds, and are thus associated with shifting cultivation. With the development of the country, permanent settling is increasing and the cycle of regeneration of the palm groves is broken. For that reason it is necessary to plant palms.

Since 1926 several schemes to improve the oil palm industry in Nigeria have been started; up to now the establishment of the palm produce inspection and the introduction of hand screw presses were the only successes. At the moment the palm grove rehabilitation subsidy scheme in Eastern Nigeria is in operation coupled with the introduction of more efficient hand hydraulic presses.

## INTRODUCTION

The present habitat of the oil palm (*Elaeis guineensis* Jacq.) is the man-made clearings in the forest. The natural habitat is believed to be the sources and banks of water courses, valleys (especially in the forest-savanna transition zone), banks of lakes, swamps, alluvial plains and low-lying islands (Zeven, 1965), from where it has spread to its present habitat and now occurs in great numbers. Depending on the population pressure four main grove types can be recognised:

(1) secondary forest with oil palms
(2) palm bush
(3) dense grove/farmland with oil palms
(4) village grove.

In the first three types, the oil palm is only partly domesticated, growing spontaneously without cultivation in a semi-wild environment (Cook, 1910).

Fossil pollen identical to that of the oil palm has been found in the Niger Delta in sediments from Miocene to the present time (Zeven, 1964). The oil palm in Nigeria is mainly distributed in disturbed areas in the forest, between the 45 inches isohyet and a line running behind the mangrove swamps at the coast (Waterston, 1953).

## DEVELOPMENT AND RETROGRESSION

When man entered the forest he probably took fruits of the oil palm with him. The fruits were eaten and the nuts thrown away, a small number of which germinated to give adult palms. In small clearings it is doubtful if such palms fruited and regenerated, but at a later stage when the clearings were larger and more prolonged, adult palms could come to maturity. These palms were harvested and fruits were carried to new compounds and clearings, where in turn, nuts were discarded.

In areas where the oil palm is abundant, it is not encouraged as a compound plant. Seedlings are destroyed in the process of cultivating the compounds, but as soon as the compound is abandoned, seedlings spring up and develop into a dense grove. One of the conditions necessary for the formation of dense groves, was shifting cultivation and the bush fallow rotation. Oil palms may grow up in farmland, especially when it is cultivated for several years, in the more fertile areas, but these palms do not form a dense grove. Under high population pressure, larger areas of land are under compounds or farmed, giving greater opportunity for palm groves to develop. A relationship exists between population pressure and density and distribution of oil palms but this relationship breaks down where the population pressure is too great and the fallow period becomes shortened giving rise to exhausted soils, grass savanna and erosion. In the Udi "Bad Lands" and their southern fringes the ratio of population density to usable farmland is so high that settlements are permanently sited. Under these conditions palms are planted in the compounds in an irregular way giving rise to village groves and the establishment of the oil palm as a compound crop. In the village groves selection of planting material for high oil, kernel or wine yield is possible and methods employed by the peasant farmer are reported by Zeven (1965).

Jones (1943) observed the relationship between population density, agricultural system and types of oil palm grove, but did not conduct a detailed study into the grove types. Waterston (1953) set up a tentative classification of the main grove types, their subdivisions and their development, but did not observe the relationship of the main type with population pressure. In Table 2 an attempt is made to establish a relationship between population pressure, agricultural system, palm grove type and ownership of land and oil palms in Eastern Nigeria.

The decline in number of oil palms in any given area may be caused by several factors: the natural death of the oil palm; the regeneration of high-forest when clearings are long abandoned; *Ganoderma* trunk rot, a serious fungal disease in some areas; and by the clearing of palm groves to enlarge the area of farmland or to plant other cash crops. In some areas the change from shifting to more settled communities without the establishment of village groves is a major factor. In other areas shortage of climbers does not allow full utilisation of the existing palms and the widespread tapping of the palm for wine considerably reduces the production of fruit.

## REHABILITATION

The average potential annual output of a dense palm grove is about 400 lbs. of oil and 200 lbs. of kernels per acre. The actual output of oil from such groves depends on the method of exploitation and extraction, up to 200 lbs. per acre for traditional methods, 260 lbs. per acre for the screw hand press and 340 lbs. per acre for the hydraulic hand press. The output of a plantation planted with *dura* x *pisifera* material and processing with a mill, should be about 1,700 lbs. of oil and 480 lbs. of kernels per acre. Assuming a price of £40 per ton of oil and £23 per ton of kernels the annual gross income per acre of a plantation would be by about £28 greater than that from a dense grove, where a screw hand press is commonly used. From this amount the cost of establishment, fertilizers, maintenance, harvesting and the processing of the extra yield, have to be deducted. It is estimated that the net income of a plantation would be about £20 per acre per annum, about £13 more than from a grove. Any increase of the price of palm produce would of course favour the difference between the plantation and a grove.

There are several ways in which the grove can be rehabilitated:

(1) complete felling of old stand, complete replanting;
(2) partial felling of old stand, complete replanting;
(3) complete felling of old stand, partial replanting;
(4) partial felling of old stand, partial replanting.

Partial felling is only recommended in cases where the farmer needs some the first years of his plantation. It is recommended that not more than 15 old are left and that these palms are felled before June of the fourth year of pla replanting is recommended to farmers who wish to grow arable crops in additi palms. These crops can be cultivated on a rotational base in avenues left in the inte palm plantation. Intercropping can be done during the first two years and it e development of the oil palm seedlings as long as the food crops do not shade (Sparnaaij, 1957).

The Government of Eastern Nigeria has implemented a scheme to rehabilitate groves. To assist the farmers carry out this rehabilitation, a subsidy of £18 will be p four and a half years. Two earlier rehabilitation schemes preceeded this scheme. T started in 1928 and covered Southern Nigeria, while the second was started in 19 concerned only Eastern Nigeria. It was felt that both schemes failed due to difficul mplementation, the agronomic practices employed and economic stresses (Zeven, he palm grove rehabilitation scheme involves a high capital investment as the actual r acre rehabilitated includes both a subsidy to the farmer and the high cost of organisat interim cheaper way to increase the output of an area is by palm grove improvem ere the palm grove is thinned, leaving about 60 good yielding palms per acre. The remai palms are known to increase their yield considerably and may even produce more bunc ht per acre than before thinning. Table I represents the results from a rehabilitation ovement trial at Obio Akpa near Abak (W.A.I.F.O.R. Experiment 505-2). The average of stemmed palms was 110 per acre before improvement and 41 afterwards, the latter ub-optimal. Some plots thinned to 50-60 old palms per acre produced up to 7,500 lbs. hes per acre. It must be borne in mind that the oil to bunch ratio of these bunches is ferior to that of W.A.I.F.O.R.'s extension work seed material. The advantage of provement is that it is cheap, can be easily carried out and gives the first return after rs; but it must be emphasised that improvement is only temporary and should not ll rehabilitation. It is hoped that the present low price for palm produce will not verse effect on the rehabilitation scheme now so enthusiastically undertaken.

TABLE I

A GROVE BEFORE AND AFTER IMPROVEMENT CARRIED OUT IN 1953

| Yield per acre | | Average bunch weight | Yield per palm | |
|---|---|---|---|---|
| -er of | Weight of bunches (lb.) | | Number of bunches | Weight of bunches (lb.) |
| | 3,208 | 23.6 | 1.2 | 29.2 |
| | 3,588 | 28.9 | 3.0 | 87.5 |
| | 5,483 | 31.9 | 4.2 | 133.7 |

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Table 2. The Relationship Between Population Pressure, Agricultural Systems And Palm Grove Types And Their Development And Retr...

| Population density per square mile | Agricultural System | Types and Development of Palm Grove | Description of ... |
|---|---|---|---|
| Less than 15 | O. HUNTERS AND FOOD GATHERERS* <br> Land and valuable trees are not strictly owned, but attempts will be made to prevent other groups from entering the territory, hunting game and collecting vegetable food stuff; invention or introduction of agriculture. | PRIMARY FOREST; OIL PALMS FROM NATURAL HABITATS | Fruits of the oil ... habitats may have ... in the rain-forest ... |
| Less than 50 | I. SHIFTING CULTIVATION <br> Land is still free; farmers prefer felling a 20 to 30 years' old secondary forest as it is easier than an older forest and this period is long enough to restore the soil fertility; land is UNDER-FARMED for a short period. | SECONDARY FOREST WITH OIL PALMS ⇄ OLD SECONDARY FOREST WITHOUT OIL PALMS | Palms grow up in clea... thinly populated seco... period extends more th... disappear from the veg... period is shorter, oil... felling, new seedlings... The number of palms per... stemmed palms; palms ar... |
| 35-225 | II. TRANSITION BETWEEN I AND III <br> Land is owned by the community; land is farmed continuously for several years; the period of fallow is about 8 to 25 years; land is UNDER-FARMED to MODERATELY FARMED. | OIL PALM BUSH | A great part of the land ... onetime; the fallow peri... rise to about 10 stemmed ... palms are owned by the com... tapped for wine, then they ... |
| 200-525 | III. BUSH FALLOW ROTATION <br> Land owned by the whole village or village quarter; gradual change to individual ownership; period of farming about 1½ years and a fallow period of 5 to 10 years; fallow period too short to restore soil fertility to original level, but soil fertility still sufficiently high to give a reasonable crop; farmland is MODERATELY to HEAVILY FARMED; many land disputes. | DENSE GROVES ⇄ FARMLAND SHRUBS WITH(OUT) PALMS | All land is in use: oil pal... deserted compounds from a de... of time palms die, giving fi... and then a farmland with or w... new compounds are erected; d... averaging 50 to 60 (-140) palm... dense groves and farmland comm... on compounds individually owned... swamps free. |
| 500-850 | IV. BUSH AND GRASS ROTATION <br> Individualization of ownership of land continued, plots are scattered; period of farming in about 1½ years, followed by a 3 to 8 years bush fallow or in drier areas grass fallow; fallow period too short to restore soil fertility; soil fertility too low to give a reasonable yield; compound more or less permanently sited; land HEAVILY and OVERFARMED; danger of erosion; concentration of nutrients from farmland via crops on compound land; many land disputes, tendency to emigrate to new land. | THINNED GROVES | With further increase of the pop... the need arises to "reclaim" pal... land, hence felling of palms, new... erected in thin or thinned grove; ... settle in walled-in or fenced comp... tendency to plant palms in gaps in... or on compounds. |
| Over 750 | V. PERMANENT PALM GARDENS AND GRASS ROTATION IN DERIVED SAVANNA. <br> Farmland has a very low level of soil fertility, annual grass fires, soil erosion; village groves lie as green islands in this Derived Savanna, main crop comes from intercropped palm gardens, where soil fertility is maintained; palm produce provides cash and food; emigration to new land and nowadays migratory labour and cottage industry coming into being. | VILLAGE GROVE | Planting of palms on compounds, some ... seedlings protected; compounds perman... and compound areas permanently covered ... and other trees giving a good protectio... erosion; palms individually owned; dens... in farmland from nought to a few and on... up to 40 per acre. |

* Although "Hunters and food gatherers" is not an agricultural system, these means of support have been added to complete the picture.

At any time the vegetation types - Primary and Secondary Forest, Palm Bush, Dense, Thin and Thinned Groves and Farmland - can be converted into a plantation. The success of the plantation depends on the cultural methods applied. The same holds true for the improvement of the Secondary Forest with Oil Palm, Oil Palm Bush and Dense Grove.

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Mr. D. G. Coursey (*Federal Institute of Industrial Research, Oshodi*) **Microbiological factors in the storage of agricultural products.**


SUMMARY

The importance of research work on the storage of agricultural products is discussed, with particular reference to microbiological factors. These factors are examined in relation to other forms of storage deterioration due to physical losses, rodent or insect attack and autolytic processes occurring in the produce.

After a general discussion of the ecological relationships involving the biodeteriorative microorganisms and the stored crops which form the substrates for their growth, some examples of West African crops, whose storage is affected by microbiological factors, are considered.


## INTRODUCTION

It has been estimated (Prevett, 1962) that between 5 per cent and 10 per cent of all the food crops harvested throughout the world are lost to mankind on account of destruction or deterioration in storage. In the less developed countries of the tropics, where high temperatures and humidities are favourable to most of the processes responsible for deterioration of stored produce, and where indifferent or poor storage techniques are often practised, the losses may be substantially higher. In Nigeria, foodstuff to the value of tens of millions of pounds sterling is wasted annually through loss or deterioration in storage. In the case of a single crop alone, the yam, Coursey (1961) has estimated that the annual storage losses in Nigeria are at least £2½ million. To give another example, the storage losses in dried fish in the Lake Chad area alone have been estimated by Rollings and Hayward (1962) as about £½ million per annum.

Storage losses in agricultural produce arise from the operation of five main factors, whose relative importance will vary according to the type of produce and the conditions of storage:-

Physical losses including spillage arising from faulty containers, crushing such as may occur when crops such as soft fruits are badly handled, and other types of purely mechanical damage.

Rodent attack is too well-known to need description. It is worth mentioning, however, that one of the most serious effects of rodent attack frequently lies in greatly increased spillage losses, resulting from damage to storage containers, and the contamination of the foodstuff by filth.

The results of insect attack (and, to much lesser extent attack by other arthropods such as mites) on stored produce are also extremely well known, and have been the subject of most of the research work in the stored products field. Insect attack causes both actual destruction of food material, and also reduction in the quality of that fraction which is not destroyed. It is probably the most important single factor bringing about losses in stored agricultural produce.

Autolytic processes include chemical and biochemical changes which take place spontaneously within the stored produce, usually, though not necessarily, under the influence of enzymes naturally present in the material, without the intervention of external vectors. These autolytic changes may result in actual destruction of a part of the stored material, as in the case of respiratory losses in yams (Coursey, 1961) or other dormant tubers, or merely in a deterioration of quality, where may be instanced the chemical hydrolysis of palm oil, described by Loncin (1952), and the development of rancidity (Lea, 1929; Holman, 1954) in oleaginous materials in general.

Microbiological factors causing the deterioration of stored agricultural produce have, to date, received less attention from research workers than other aspects of stored products research. It is this subject that provides the theme of this paper.

## GENERAL CONSIDERATIONS

The comparative neglect of the microbiological aspects of stored products research may be due, in part, to the fact that microbiological attack of stored produce rarely results in total destruction of the produce, but rather in a reduction of quality—which may, however, be so great that the produce becomes totally unacceptable as a source of human food. Probably more significant is the historical accident that research on stored products evolved largely from the study of economically urgent problems of pest control. The control of insect and rodent attack on the large grain reserves held by the Ministry of Food and Agriculture in the United Kingdom during World War II, or the heavy *Trogoderma* infestations in groundnuts in the Kano area during the late 1940's may be taken as examples. As a result the greater part of the research work undertaken in the stored products field has been conducted by entomologists, or by chemists directly concerned with insecticide or other entomological problems, and has therefore had a strong bias towards consideration of entomological vectors. Had stored products research evolved, as might appear more logical, as a branch of food technology (where the importance of spoilage microorganisms has long been recognized) the position would probably have been different.

Attention has recently been focused on the importance of microbiological factors in the storage of agricultural produce as a result of the discovery that the growth of certain strains of the fungus *Aspergillus flavus* on groundnuts is associated with the development of a serious degree of toxicity in the groundnuts (Sargeant *et al.*, 1961; Austwick and Ayerst, 1963). Although the production of toxins in foodstuff as a result of microbial activity is a phenomenon well-known to the food technologist, especially where high-protein foods such as fish and meat are concerned, the discovery of aflatoxin in stored groundnuts was, perhaps, the first time that a problem of such a type and magnitude had been brought to the attention of research workers in the stored products field. The deterioration of quality of stored produce as a result of the activity of microorganisms, or biodeterioration, is nevertheless much more widespread, and of greater economic importance, than is commonly realised.

## ECOLOGICAL ASPECTS

In considering whether the quality of a particular product, stored under given conditions, :being affected by such biodeteriorative processes it is necessary to study the ecological relationships of the system as a whole. The observation that a particular microorganism has been isolated under specific conditions does not necessarily imply that biodeteriorative processes associated with that species are occurring. In fact, the value of much research work in this field has been largely vitiated when workers have concentrated merely on compiling lists of species of fungi or bacteria isolated from various types of produce, although such work has often provided a useful basis for further studies. In order to obtain a true picture of the situation it is necessary to consider the ecology of the situation as a whole. This must be done especially from two points of view. Firstly, the organism/substrate relationship must be examined. It must be established whether or not the organisms isolated from the produce in question are capable of bringing about the observed changes in the produce. For example, if an oilseed crop such as groundnut is under consideration, one of the first facts to be determined is whether the organisms isolated are, in fact, lipolytic (i.e. fat-splitting) in nature. Secondly, the ambient conditions under which the produce is stored need to be examined. The most important conditions to be considered in this context will usually be ambient temperature and humidity. Many of the microorganisms capable of affecting stored produce are extremely ubiquitous, and isolations may be made from a wide variety of situations. If, however, the ambient conditions are such as to be unfavourable for growth then the organisms can hardly be held responsible for changes that may be taking place. Again an example may be given from groundnut storage in Nigeria. Little if any microbiological attack will occur while the produce is stored under the low humidity conditions prevailing in Northern Nigeria for the greater part of the year. When it is shipped southward to the ports uptake of moisture will occur. If it is stored long enough under these high humidity conditions, some degree of microbiological spoilage is likely.

It must always be borne in mind that the microclimate prevailing within large stacks of produce may be appreciably different from that indicated by normal meteorological observations made outside the stack. The majority of biodeteriorative microorganisms grow most readily at temperatures around the tropical ambients, e.g. 25°C, and are inactivated by temperature appreciably above 40°C. However, certain strains have adapted themselves to more adverse conditions and can cause spoilage even at cold storage temperatures, while others, which are perhaps of greater importance in connection with the storage of agricultural produce, can grow even at temperatures as high as 60°C (e.g. certain thermophilic *Thermomyces* and *Chaetomium* spp.). A stylised representation of the variation of the growth rates of different types of microorganism with temperature is given in Figure 1.

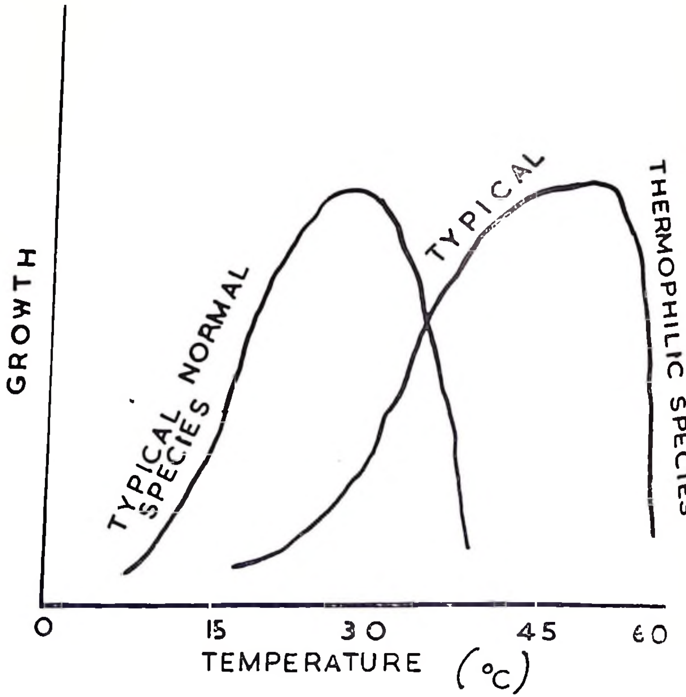


*Fig. 1*

As the temperature of stored produce does not normally vary very far from the ambient temperature while humidity, and hence the moisture content of the produce, can vary over a much wider range, the latter is a more important ecological factor from a practical standpoint. It has generally been supposed, until recently, that the higher the humidity the more favourable are the conditions for the growth of microorganisms: the relationship between growth rate and relative humidity approximating to the ogive form, as shown by the broken curve in Figure 2. Recent work has shown, however, that at relative humidities approaching 100 percent, the growth of biodeteriorative fungi, on at least some type of produce, is inhibited. It has been suggested that this effect is due to the fact that at these extremely high humidities the cell tissues of the produce become turgid and thus it is difficult for the fungal mycelium to penetrate. The continuous curve in Figure 2 indicates the growth/humidity relationship, as it is now understood. The inhibition of microbiological activity at very high humidities was first observed in shipments of Brazil nuts (Ayerst & Budd, 1960) and has also been confirmed in experiments on groundnuts (Austwick & Ayerst, 1963). The storage of damp grain, which is now known to be practicable under certain conditions, also probaly depends on this humidity effect.

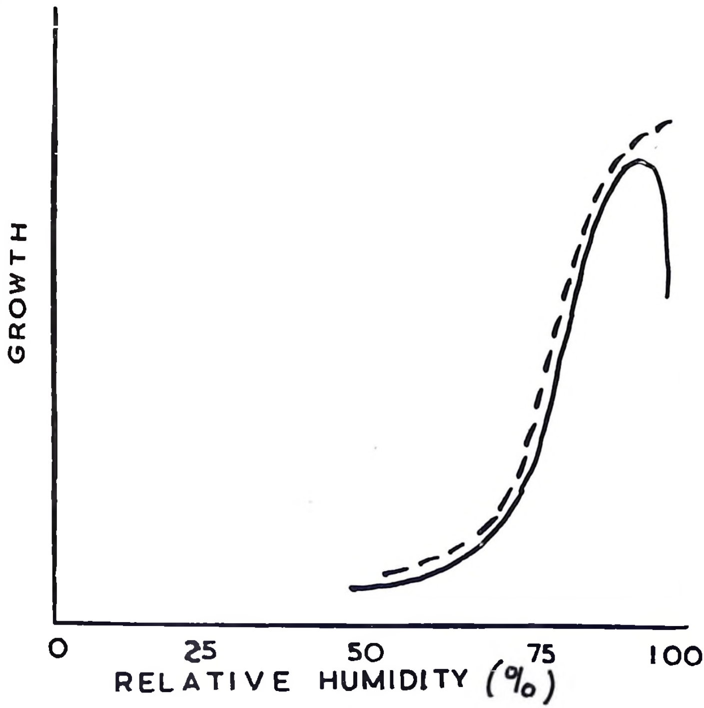


*Fig. 2*

Another ecological factor which is not, currently, of practical importance is the presence of fungicidal or fungistatic substances which destroy or inhibt microbiological development. Although, to date, it has not been feasible to apply such treatments to produce in storage, it is possible that, in the future, fumigation with vapour-phase fungicides, to prevent storage deterioration, may become a practicable proposition.

## SOME APPLICATIONS TO NIGERIAN CROPS

Nigeria's main export crops are oilseeds or vegetable oils, while very large quantities of grains and starchy tubers are grown for consumption within the country.

Little research work has been conducted on microbiological aspects of grain storage in West Africa, although the subject has been fairly well-studied in the major grain-producing countries of the temperate zone. It is generally accepted (Oxley, 1948; Milner *et al.*, 1947) that deterioration of grain as a result of fungal activity becomes serious at moisture contents of above 14 per cent. As a large proportion of the grain crops (principally maize, sorghum and millets) produced in Nigeria are grown in the drier parts of the country, and, furthermore, are mainly harvested during the dry season, losses from these factors are not likely to be of very great importance.

Tuber crops, produced mainly in the southern parts of the country and with natural moisture contents of over 50 per cent, are very susceptible to microbiological attack. Rotting of yam tubers during storage is common, although it comes most serious when associated with physical damage caused by bruising, cutting or pre-harvest nematode or insect attack. It is well known that cassava, unless processed in some way, cannot be stored at all for more than a few days after harvest, owing to bacterial and fungal attack.

Many of Nigeria's most important products, especially those which form the basis of the export economy, are oilseeds. The study of a large number of oilseeds has shown that the "safe" limiting moisture content for storage, i.e. the value above which rapid microbiological attack is liable to occur is inversely related to the oil content of the product. A mathematical relationship has been developed by Bartoszac (1952):–

$$H = \frac{14(100-c)}{c} \times 100$$

where $H$ is the "safe" storage moisture content and $c$ is the oil content of the produce.

Groundnuts, one of the main oilseed crops produced in Nigeria, are grown mainly in the North and harvested and stored under dry season conditions. Microbiological damage is thus a comparatively rare occurrence, except in occasional batches which have been inadequately dried or stored for protracted periods under high humidity conditions e.g. at the port of shipment or in river-side stores. The development of toxin as a result of fungal activity is generally of greater significance than actual deterioration.

Palm kernels, which are produced mainly in the southern parts of Nigeria, can deteriorate rapidly in storage. Considerable increases take place in the free fatty acid content of the oil. The effect is particularly marked with broken or damaged kernels (Coursey, Simmons & Sheridan, 1963) and appears to be associated with the development of mould growth on the kernels.

Copra, the dried flesh of coconuts (which has the very high oil content of about 66 per cent), is very susceptible to fungal and bacterial attack when stored under adverse conditions. The fungal growth is often of a superficial nature and appears to do little damage (Bagot & Servant, 1961), while bacterial attack can have more serious effects (Ward, 1937).

Palm oil, either before or after extraction from the fruit, is readily attacked by several lipolytic fungi whose activity results in a substantial lowering of the quality of the oil, as a result of increased free fatty acid content and impaired bleachability (Coursey, 1963).

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Dr. (Mrs.) E. R. Sansome (*Botany Department, Ahmadu Bello University, Zaria*) **Cytological observations on *Sclerospora sorghi* in relation to the life history of the Oomycetes.**

SUMMARY

Previous observations on *Pythium debaryanum* and on *Phytophthora cactorum* and *Achlya* sp. have shown that these organisms are not haploid, as had been generally supposed, but are diploid with meiosis occurring immediately before gamete formation as in the higher animals. Divisions in the oospore which had been previously assumed to be meiotic divisions had been difficult to obtain in these species because there is a long resting stage before the nucleus divides.

Divisions which were thought might be meiotic in the oospore of *Sclerospora graminicola* were reported but the description and drawings did not support this interpretation.

Present observations on *Sclerospora sorghi* confirm those on *S. graminicola* in showing that two nuclear divisions occur in the oogonia and antheridia. Fourteen to sixteen chromosome configurations believed to be bivalents are observed at the first division and the nuclei after the second division are smaller than the nuclei in the vegetative hyphae. One oospore had two dividing nuclei and in one of them, at least 28 rod- or dot-shaped chromosomes could be counted. Thus meiosis does not occur in the first two divisions of the oospore, since the nucleus counted had approximately double the number of chromosome configurations observed in the oogonial and antheridial nuclei.

It is believed that meiosis occurs in the antheridia and oogonia as in *Pythium*, *Phytophthora* and *Achlya*, and that this is characteristic of the class Oomycetes which are therefore diploid throughout their life history and not haploid as previously assumed.

The Oomycetes are a group of fungi which includes the organisms causing many important diseases of plants.

Sexual reproduction is very similar throughout the group. The female sex organ is an oogonium in which one or several oospheres are produced. The male sex organs is an antheridium which comes into contact with the oogonium, a fertilization tube is produced and one or more nuclei from the antheridium enter the oogonium. These nuclei are the male gametes and one fuses with each oosphere nucleus. The zygote or zygotes so produced develop a thick wall and become oospores. The oospore usually provides a resting stage in the life history of the organism. The fusion of the male and female nuclei in the oospore results in the production of a diploid nucleus which has two sets of chromosomes and two sets of genes. To counterbalance the process of nuclear fusion there is, in the life history of any sexually reproducing organism, a special division of the nucleus in which the homologous or corresponding chromosomes are segregated into different nuclei to give the haploid condition. This reduction in chromosome number is brought about by a special process called meiosis in which two divisions of the nucleus occur with only one division of the chromosomes. Meiosis therefore often results in a tetrad of haploid nuclei being produced from each diploid nucleus.

The stage at which meiosis occurs in the life history determines whether the organism is haploid or diploid throughout the vegetative phase or whether it shows an alternation of haploid and diploid generations.

In the case of many fungi, such as the mushroom, meiosis occurs immediately after nuclear fusion so that the organism is haploid throughout its life history. It was very generally assumed that this was the case also in the Oomycetes, where it was thought that meiosis occurred in the first divisions of the oospore or at an early stage in oospore development, although this had not been actually demonstrated either cytologically or genetically. Fungal nuclei are usually very small, and as has become clear in recent years, the chromosome threads do not normally condense and so become clearly countable during the process of nuclear division as they do in higher organisms. It seems to be only under special conditions such as during meiosis or during divisions immediately following meiosis that the chromosome condense sufficiently to be clearly countable in the fungi.

A few years ago, while slides of sexual reproduction in *Pythium debaryanum* were being prepared for class use, metaphase stages in which chromosomes were visible in nuclear divisions in the oogonia were noticed. Further preparations were made with a view to studying the cytology of this organism. Because of the prevailing impression that the organism was haploid, it was assumed at first that these divisions were mitotic. However, certain peculiarities of the chromosomes, such as their shape and the fact that there was rather more spread in the separation of the chromosomes than one would expect in mitosis, resembled meiosis rather than mitosis. The literature contained no critical evidence, either genetical or cytological, in favour of the organisms being haploid. The small amount of genetical evidence available, though not critical, was in favour of the organisms being diploid rather than haploid.

In some cytological papers it was claimed that meiosis occurred in the oospore, but the illustrations given indicated that this claim was based on preconceived ideas rather than concrete evidence.

Metaphases in the vegetative hyphae or in sporangia were looked for, since, if the oogonial and antheridial divisions were meiotic, the chromosome configurations there would be pairs of chromosomes and during mitotic divisions twice as many chromosomes would be seen. However, it was not possible to obtain metaphases in which chromosomes could be counted, either in the vegetative hyphae or in sporangia even after treatment with chemicals which normally increase the chances of obtaining metaphases. This in itself indicated that there was something unusual about the divisions in the oogonia and antheridia. Investigations on the number of nuclei present at different stages showed that two divisions of the nuclei occurred. Also the nuclei at the end of the second division were found to be approximately half the size of the nuclei at the end of the first division and of the nuclei in the vegetative hyphae. This is, of course, characteristic of meiosis. These observations are all in accordance with the view that the divisions in the oogonia and antheridia constitute meiosis and I was prepared to suggest that the group might be diploid with meiosis occurring immediately before gamete formation on the basis of this evidence.

However, in the course of the examination of a large number of metaphases in an attempt to determine the exact chromosome number, a few nuclei in which an association of four chromosomes could be seen were found. Such an association occurs when chromosomes pair at meiosis and change partner during this pairing. This may occur in polyploids where more than two homologous chromosomes are present, or in plants which are hybrid for structurally changed chromosomes. If we represent two chromosomes as AB CD it is possible by reciprocal translocation to get chromosomes AC BD, a hybrid would have chromosomes AB BD CD AC and when homologous parts pairs at meiosis a ring would be formed. The associations found in *Pythium* could be quadrivalents or interchange rings. Such associations since they are brought about by change of partner during pairing only occur in the division in which pairing occurs, that is, meiosis.

The observation of multiple configurations in the divisions occurring in the oogonia and antheridia was therefore held to be critical cytological evidence that these divisions are meiotic divisions and therefore that the organism is diploid, contrary to the general belief.

Since sexual reproduction is very similar throughout the Oomycetes, it was thought extremely unlikely that the life history of *Pythium* would prove to be different from that of other members of the group and it was therefore suggested that the group as a whole is diploid with meiosis occurring just before gamete formation as in the higher animals (Sansome, 1961, 1963).

Confirmatory evidence has so far been obtained in *Phytophthora cactorum* (Sansome and Harris, 1962), in the same family as *Pythium*, and in an *Achlya* sp. which belongs to another order of the Oomycetes. In these species, polyploid oogonia and antheridia were obtained as a result of treatment with natural camphor and multivalent configurations were observed in the metaphases in the sex organs. In *Phytophthora cactorum* a chromosome bridge and a fragment were observed in a number of divisions in untreated material. Such a configuration results from pairing and crossing over in an inverted region of a chromosome and is therefore further evidence that these divisions are meiotic.

It was thought that perhaps chromosomes would condense to a countable condition during the early division of the oospore. Moreover, the oospore divisions in some of the Saprolegniales had been reported to be meiotic, although on very inadequate evidence judging from the illustrations given.

In the case of *Pythium* and *Phytophthora* the fusion nucleus does not divide before the nucleus enters the resting stage, and they are therefore unfavourable material for the study of divisions in the oospore, since it is not easy to catch the oospores at the right stage as they begin to divide. Divisions in the oospore of *Sclerspora graminicola* had been reported by McDonough (1937) who gave very good illustrations of divisions in the oogonia and antheridia and also of divisions in the oospore. McDonough expected to find meiosis in the oospore but he found twice as many chromosomes as in the oogonial divisions. He tried to explain this by saying that the chromosomes were in pairs and perhaps half went to one nucleus and half to the other. Other workers observing twice the haploid number of chromosomes in the first divisions of the oospore nucleus had suggested that meiosis occurred in the oospore, but that reduction occurred in the second division, not the first. Such a suggestion indicates a total misconception of the process of meiosis.

Since *Sclerospora* seemed to be favourable material for cytological observation, it was thought worthwhile to make a cytological investigation of it, particularly with a view to obtaining oospore divisions if possible.

The development of the oogonia and antheridia was found to be as described by McDonough and very similar to that of *Pythium* and *Phytophthora*. In the early stages of development the oogonium has a considerable number of nuclei – 6 oogonia had an average of 57 nuclei. Many of these abort, and the remainder grow and enter into division. The average number of nuclei undergoing the first division, based on counts of 20 oogonia was 18.3. Metaphases were obtained and in these the chromosomes were less condensed than usual for metaphase of the first meiotic division. Fourteen to sixteen bivalents were counted as reported for *Sclerospora graminicola* by McDonough. It is difficult to make an exact count because the chromosome configurations are looped and so it is sometimes difficult to determine whether a configuration represents one or two bivalents.

After the first division the nuclei undergo a second division as evidenced by the numbers of nuclei present in the periplasm at later stages. Thirty-seven oogonia recorded at this stage had an average of 70.3 nuclei. This is very close to four times the average number of nuclei undergoing first division (18.3). The nuclei at the end of the second division are about half the size of the nuclei at the end of the first division and of the nuclei in the vegetative hyphae. The first division is usually simultaneous for all the nuclei in an oogonium or antheridium, but the second division is not always so, and consequently oogonia can be seen with a mixture of nuclei of different sizes.

The oosphere or egg is delimited when most of the nuclei have undergone the second division and the antheridial nucleus enters soon after. In early stages of oospore formation the nuclei or nucleus in the oospore do not stain readily, possibly because of the thick oospore wall, or because the chromatin enters a relaxed phase.

Later a fusion nucleus with definite chromatin threads can be seen. These reach a stage of contraction greater than in the nuclei of the vegetative hyphae and resemble mitotic metaphase chromosomes. In one oospore at the second division of the zygote nucleus, such condensed chromosomes were roughly countable. Twenty-eight chromosomes were counted. Since very small chromosomes might have been missed, 28 is probably the least possible number of chromosomes present. Since the haploid number of chromosomes is 14-16, it is clear that the diploid number is present at the second division of the zygote nucleus and that meiosis does not occur in the first two divisions of the zygote nucleus as has been widely believed. This is in accordance with the view that the divisions in the oogonia and antheridia are meiotic divisions, as has been demonstrated for *Pythium*, *Phytophthora* and *Achlya*.

The divisions in the oogonia and antheridia certainly resemble meiosis more than those in the oospore. The nuclei and chromosomes are larger at the first division and the chromosome configurations have a looped appearance characteristic of bivalents with interstitial chiasmata.

The evidence, then, is in favour of *Sclerospora* having the same life history as *Pythium*, *Phytophthora* and *Achlya*. Thus a similar life history in two families of the Peronosporales and one member of the Saprolegniales is found. Further work will, no doubt, show that the whole class of Oomycetes has the same life history; that is, the organisms are diploid with the reduction in chromosome number occurring immediately before gamete formation and not immediately after nuclear fusion as previously supposed. It has been clearly established for a long time that the Ascomycetes with a few exceptions are haploid and similarly that the Basidiomycetes are haploid. The present observations serve to emphasise the differences between the Oomycetes and the other two groups. They also indicate the desirability of re-investigating the life histories of some other groups of fungi.

The fact that these organisms are diploid rather than haploid has very important genetical implications, and when it is more widely realised, genetical work on this group should go ahead more rapidly. It is important to have genetical confirmation of these cytological observations and an experiment designed to demonstrate genetic segregation during oospore formation of which there are some indications in some of these organisms is being planned.

Genetical work in the literature is scanty—partly because of the difficulty of oospore germination. The most extensive work on germinating oospores so far reported seems to be that of Couch (1926) on *Dictyuchus*. Couch germinated eggs from crosses between different compatible strains and obtained single oospore cultures from these. When these were tested for mating reaction, some reacted as males, some as females, some were neutral and some gave both male and female reactions. This behaviour is contrary to that shown by Ascomycetes and Basidiomycetes, in which segregation for mating type factors when it occurs, is clean-cut.

The behaviour of four eggs from a self-fertile strain of *Dictyuchus* is of particular interest. On the assumption that the organism is haploid, self-fertilization should produce a homozygous diploid and there should be no segregation. However, the cultures from these four eggs were not all alike in their mating reactions with other strains. Raper (1960) suggested that the results obtained in studies of sexuality in these fungi as well as Couch's results could be explained on the assumption of duplicate factors or polyploidy. They are very easy to explain on the view that the organisms are diploid, if we assume that the self-fertile lines segregating into male and female strains are heterozygous for sex factors.

As stated previously, the generally accepted view is that these organisms are haploid and this view has prevailed for over 50 years. However, some of the earlier workers on the cytology of this group, Stevens (1899) in the United States and Trow (1904) in England, expressed the opinion that the divisions in the oogonia and antheridia were meiotic divisions. Trow's actual words were "such a division is to be regarded as a reducing division, a reduction in the number of chromosomes takes place in gametogenesis in this plant, as in most animals and not in sporogenesis as in most plants". The view was contradicted, and the opposite view that meiosis occurs soon after zygote formation was generally adopted in the absence of any critical evidence. Why this should have happened is puzzling. Perhaps workers were influenced by the fact that the Ascomycetes and Basidiomycetes are undoubtedly haploid. There was for a time a tendency to associate diploidy with differentiation, and if fungi are lowly organisms, then the Oomycetes might be considered to be especially lowly, since they are often called lower fungi as opposed to the Ascomycetes and Basidiomycetes. The two latter groups are considered to be more advanced because they develop fruit bodies of varying size and complexity—thus if the so-called higher fungi were undoubtedly haploid, and if differentiation were associated with diploidy, then the lower fungi might be expected to be haploid. The fallacy was in assuming that diploidy is always associated with differentiation.

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Mr. M. A. Choyce (*Institute for Agricultural Research, Ahmadu Bello University, Zaria*) **Pest and disease control of cotton in Northern Nigeria.**


SUMMARY

Cotton production forms an important part of the economy of Northern Nigeria. The average annual production in the five-year period ending in 1962 was 213,000 bales of 400 pounds, and an increase to 500,00 bales per year during the present decade is planned.

This realistic target can be achieved by the extension of cotton growing into those areas of Bauchi, Bornu and Adamawa Provinces where road and rail communications are being developed. At the same time, yields per unit area in the main cotton growing zone can be increased by the issue of improved selections of seeds, by the adoption of better methods of cultivation, and by the chemical control of pests and diseases.

The only important disease of cotton in Northern Nigeria is bacterial blight. Seed transmission of this disease can be reduced by the use of seed dressings. Because of the ease and relative cheapness of application, this method of control has already been introduced. By 1964 it is expected that three-quarters of a total seed issue of 19,000 tons will be dressed with a mercurial dust before distribution.

The main pests of cotton are bollworms and stainers, and these must be controlled by insecticides applied directly to the growing crop. The response of the crop to insecticides is markedly dependent on its condition: the highest yield increases are obtained from well grown cotton sown early on fertile soil. In the major cotton producing areas yields might be doubled by the use of insecticides on well grown crops.

The introduction of such a radical change in the farming system poses many problems. Insecticides and sprayers are expensive and the farmers' labour requirements are increased both in growing and in spraying his crop. It is probable that insecticide treatment would only be economically justified for those progressive farmers willing to apply the best cotton growing methods.


The cotton industry of Nigeria constitutes an important part of the economy of the country. In 1961, for example, following a favourable season, exports of cotton lint and cotton seed exceeded £13m. in value. The greater part of this cotton is grown by peasant farmers in Northern Nigeria, where it ranks second only to groundnuts as a cash crop. Average annual production during the five-year period 1958 to 1962, excluding cotton retained by farmers for home spinning and weaving, was 213,000 bales of 400 pounds. It is hoped that this will be increased to half a million bales during the present decade. If this target is achieved it will enable exports to be increased, for there should be no difficulty in selling Nigerian cotton overseas if the existing quality and standards of grading are maintained. It will also make available adequate quantities of raw material for processing within Nigeria. Already a significant proportion of the crop is used by textile mills in Kaduna to produce an excellent baft, and other factories for spinning, weaving and the preparation of cotton seed oil and cake are planned.

An increase in production can be achieved in several ways; of these the one most likely to have an immediate effect is the spread of cotton growing to new areas. An efficient cotton industry depends on good communications, and it is probable that cotton growing will increase in parts of Bauchi, Bornu and Adamawa provinces when the railway extension to Maiduguri is completed. This expansion into new areas will eventually be restricted by the amount of suitable land available. In time increased production will depend on increased yield per unit area, and it is in showing how this may be achieved that scientific research has so much to offer.

Yield is partly a function of the variety of cotton grown. Throughout Nigeria there is a single variety issued to farmers, Samaru 26J, which is a selection from Nigerian Allen cotton. A comprehensive multiplication scheme, centred in Southern Katsina and in Gombe Division of Bauchi Province, facilitates the introduction of any new strains produced at Samaru. It is expected that the cotton breeding programme will continue to give increases in the yield potential of the cotton as well as improvement in the quality of the lint.

Of greater potential value are yield increases made possible by improved methods of cultivation, especially by a wider adoption of early sowing combined with the application of fertilizers and insecticides. The average yield throughout the country in a very good season has been estimated at no more than 90 pounds of lint per acre, which is rather lower than that obtained from raingrown cotton in other African countries. Twice this yield can be expected on government agricultural stations, with timely sowing and a good standard of cultivation. Under more carefully controlled conditions at the Institute for Agricultural Research, yields of over 350 pounds of lint per acre are common, and the highest yield over a number of years has exceeded twice this amount.

Cotton which is sown early and properly cultivated is likely to suffer a heavier pest attack than poorly grown cotton, but the higher fruiting capacity of the crop normally leads to a much higher yield. Trials at different stations in the main cotton growing zone over many years have shown that, on the average, cotton sown in early July will yield twice as much as cotton sown under similar conditions in August. Nevertheless, pests impose an upper limit on yield, particularly if the cotton is grown on very fertile soil, and a further advance in yield depends on some form of pest control. A valuable primary defence against pests, the cotton close season, is legally enforceable in the major cotton growing provinces, but full protection can only be given by the direct application of chemicals. It is difficult to give any precise estimate of the total yield loss following pest attack, because of the wide variation in extent of damage induced by the state of growth of the crop. In the more northerly provinces, where most of the crop is grown, it is probable that the yield of good cotton could be doubled by a moderate degree of pest control. Under experimental conditions at Samaru, it has been estimated that a crop yielding 700 pounds of lint when sprayed, will only give half this amount if insecticides are not used.

The major pests of cotton in Northern Nigeria are bollworms and stainers. The cotton stainer, *Dysdercus superstitiosus* (F.) enters June-sown cotton from millet and other hosts soon after flowering begins in late August. Breeding takes place within the crop and the numbers of nymphs and adults rapidly increase as the bolls split in October and November.

The most damaging bollworm is *Diparopsis watersi* (Roths.). This is the notorious red bollworm which passes the dry season as a diapausing pupa in the surface layers of the soil. Moths emerge from these pupae in small numbers up to September; populations then rapidly increase, reaching a maximum in early October. Other pests, normally of minor importance, but which can become locally abundant, include spiny bollworms (*Earias* spp.), pink bollworms (*Pectinophora gossypiella* (Saund)), mirids (*Campylomma* spp.), and leaf rollers (*Sylepta derogata* (F.). The jassid, *Empoasca facialis* (J.) is controlled by the selection of sufficiently hairy strains of cotton for commercial use.

The principal disease of cotton is bacterial blight, caused by the bacterium *Xanthomonas malvacearum* (E. F. Sm.) Dowson. This occurs in its various manifestations of vein blight, angular leaf spot, black arm and boll blight. It can affect more than fifty per cent of seedlings grown from untreated seed, and secondary spread to all plants within a field of cotton occurs up to eight weeks after germination.

The biology of bacterial blight disease and of the insect pests of cotton is such that the methods of control differ not only in cost and method of application, but also in the degree of co-operation required from the farmer. The transmission of bacterial blight can be reduced by treatment of the seed with a mercurial dressing, the number of infected seedlings in a crop grown from this being only about one per cent of the total. The application of this method of control in Northern Nigeria has been facilitated by the unified control of ginning and seed distribution within the country. For the 1963 season, 10,200 tons of seed out of a total issue of 19,500 tons were dressed at Funtua ginnery before distribution; next year a new plant at Kumo ginnery in Gombe Division of Bauchi Province will dress a further 4,000 tons of seed. The toxic hazards associated with the use of mercury compounds on a commercial scale have been carefully evaluated so that suitable precautions can be taken during processing, distribution and storage of the seed.

The control of bacterial blight is therefore not in the hands of the farmer; he has merely to be warned of the possible dangers that might arise from misuse of dressed seed. The whole cost of the treatment, which is paid for indirectly by the farmer through the Northern Nigerian Marketing Board, is easily covered by a yield increase of a few pounds of seed cotton per acre. This is in marked contrast to the cash investment and effort required by the farmer for the direct control of insect pests, when it is necessary for him to mix and carefully apply an insecticide a number of times to a growing crop. At present, it is recommended that a series of six sprays of either a DDT/BHC mixture or Sevin be applied at weekly intervals during the flowering period of the crop. If these insecticides are applied efficiently, there is good control of the more exposed pests of cotton: stainers, mirids, leaf-rollers. Some control of bollworms is also achieved, though really effective control of these pests requires a higher concentration of insecticide and a better coverage of the crop.

Not only is the application of a series of sprays of this kind comparatively expensive and time-consuming, but the maximum return in the form of increased yields is desirable to cover the cost and ensure that a reasonable profit is realised. The farmer must therefore pay much more attention to the way he grows his cotton. If the correct insecticides are efficiently applied, the extent of the yield increase they produce will depend on the potential yield of the crop, and the biggest responses will come from well-grown cotton with a high yield potential. A crop capable of giving economic returns must be early sown on fertile soil; it must be thinned, weeded and cultivated at the right time; and full use must be made of available rainfall by early land preparation and the appropriate use of cross-ties between the ridges on which it is grown. Neglect of any of these factors can limit the yield in spite of the most effective pest control measures. It is only necessary here to refer in detail to the effect on yield of sowing date and soil fertility.

The effect of sowing date on the yield of unsprayed cotton in Northern Nigeria has already been mentioned. The recommended date for sowing the commercial crop is during the first week of July. In some seasons this is a week or two after the optimum sowing date, but it was adopted because cotton is a cash crop which has to fit into a farming system where food crops must receive priority. In practice, a variable and sometimes considerable proportion of the crop is sown after the beginning of July, sowing often continuing into August and early September. This late sowing is most marked in those years in which unsatisfactory early rains delay the establishment of food crops. The progressive fall in yield with later sowing is more marked with sprayed than with unsprayed cotton. At Samaru in 1960, for example, there was an almost linear fall in yield of 60 pounds of lint per acre per week from the first sowing at the beginning of June, when the yield was 680 pounds per acre. Because of his investment in labour and materials, the farmer who intends to spray his cotton cannot afford to sow late, and suffer the loss in yield that this entails.

Although cotton can tolerate a wide range of soil conditions, a well-drained fertile soil is necessary for the growth of a high yielding crop. In the absence of organic manures, which are normally used by the farmer on food crops near his compound, artificial fertilizers must be brought in to improve the productivitiy of the soil. In the provisional recommendations for the use of fertilizers on cotton it is suggested that a worth-while increase in yield from unsprayed cotton can often be obtained following the application of fifty to one hundred pounds of single superphosphate to the crop at sowing time. The further addition of a nitrogenous fertilizer can lead to a reduction in yield of seed cotton if the more luxuriant plant growth enhances the attractiveness of the crop to pest attack. The true response of cotton to a combination of phosphate and nitrogenous fertilizers is only apparent when pest damage is reduced by the use of insecticides. In these circumstances significant increases in yield can result from relatively heavy dressing of both types of fertilizer. For the restricted control of pests given by six sprays, it is recommended that one cwt. each of single superphosphate and sulphate of ammonia be applied per acre of soil if it is not very fertile.

There is therefore a definite progression of events in cotton growing, beginning with early sowing on fertile soil, and ending with the application of insecticides, which gives the best chance of securing a high yield. It is this order which must be followed by the farmer, for fertilizers and insecticides cannot be used to compensate for late sowing, lack of weeding, or inadequate cultivation. The problems that confront the agricultural extention services, first in demonstrating that higher yields of cotton are possible, and, secondly, in persuading farmers to use the methods by which these yields may be obtained, are of considerable magnitude. There is the need of credit facilities for the farmer at the beginning of the season to enable him to purchase his fertilizers and insecticides. There is the problem of land tenure; a farmer wants to be sure that he will benefit in future years from any investment he makes in the soil of his farm now. Most of all the farmer is interested in the cash returns which he will get from his cotton spraying.

The world price of a number of primary products has fallen in recent years, and this has of necessity been reflected in the amount paid to a farmer for his crop. A few years ago the minimum producer price for Grade I cotton in Northern Nigeria was 6d per pound; for the past two seasons this has fallen to about 4s. 8d. per pound. It is very difficult for a farmer to obtain an immediate yield increase which will compensate him for this drop in price. It is more important now for him to take advantage of improved methods of growing his crops so that his former standards can be maintained.

If it is assumed that fifty pounds of cotton can be sold for £1, and that a good farmer gets a yield of 350 pounds per acre from his crop, he will be paid £7. The cost of spraying, including insecticides, fertilizers at the subsidised price, and depreciation on his sprayer, is roughly £5. A reasonable yield expectation from sprayed cotton is 850 pounds per acre, which can be sold for £17. The increased profit to the farmer of £5 must be balanced against his extra labours in the crop: his better cultivations and the time and trouble of spraying. These figures are quoted with considerable reserve because yields from sprayed plots away from the close control of experimental stations vary so widely. Frequently much higher yields are obtained from sprayed cotton, and a commercially-minded progressive farmer could easily be very satisfied with his returns.

The economics of cotton spraying are to a large extent bound up with the amount of cotton which is to be sprayed. A farmer growing one or two acres of cotton can only afford a cheap hand sprayer. A co-operative enterprise in which the cotton from a number of farmers was grown in a single block could use motorised or tractor-mounted sprayers. The detailed economics of these various ways of applying insecticides to cotton requires careful investigation.

The direct control of cotton pests by insecticides introduces a new element into the farming system of Northern Nigeria. It is a method of increasing yields which can only be justified for those progressive farmers who are willing to adopt the best methods of cotton growing. It is probable that at first the number of suitable farmers will be small, but in time the spread of cotton spraying could have a markedly beneficial effect on the economy of the country.

Dr. J. C. Ene (*Zoology Department, University of Ibadan*) **The distribution and bionomics of the *Anaphe* silk moths of Nigeria.**

SUMMARY

In addition to being a review of the literature on the wild silks and silk-moths of Nigeria, this paper attempts to collate records of their commercial history, particularly with a view to assessing why the various efforts at exploitation were all eventually abandoned. Their role as raw material for an indigenous cottage industry, as well as their future economic possibilities are discussed.

Some contribution is made to the knowledge of their biology and geographical distribution. The distribution of the different species in Nigeria is mapped out, and the location of all the towns from which they have so far been reported, shown. The properties and possible uses of the silk are summarised. The names of the communal nests and the food plants of the caterpillars producing them are given in some principal Nigerian languages. This is likely to facilitate further enquiries about them from farmers in the countryside.

## INTRODUCTION

A recent UNESCO publication (Jepson, 1960) said that silk was not woven in Africa: "The African continent can make no serious claim to the production of silk .... The African may not in the past have possessed the patience and dexterity which the Asiatic through the ages has devoted to sericulture."

The fact is that for centuries past, silk yarn has been spun and woven into cloth in parts of Nigeria. Nigerian silks are made largely from cocoons spun by the caterpillars of moths belonging to the family Notodontidae (plate I), notably *Anaphe* spp. The glossy yellow silk of the moth, *Gastroplakaeis rufescens* (family Lasiocampidae) is also used for fancy embroidery work in parts of the country (Golding, 1944). These silks are referred to in the text as *anaphe* silks in keeping with the terminology: *bombyx*, *tussah* and *eri* silks of the Orient.

The following moths yield usable silks in Nigeria:

Family Notodontidae:

*Anaphe infracta*, Walsingham, 1885. [Syn: *A. infractor*, Druce (1887).]

*Anaphe venata* Butler, 1878. [var. *nyansae*, Strand (1910); *sericea*, Karsch (1895); *etiennei*, Michel & Schouteden (1912).]

*Anaphe reticulata* Walker, 1885. [Syn: *A. ambrizia*, Butler (1877); *Actiomorpha euprepiaeformis*, Schaffer (1850–1858).]

*Anaphe (Epanaphe) carteri* Wals. Walsingham, 1885. [Syn: *Epanaphe carteri*, Aurivillius (1904); *Anaphe clara*, Holland (1893).]

*Anaphe (Epanaphe) moloneyi* Druce, 1887. [Syn: *Epanaphe moloneyi*, Aurivillius (1904); *Eupterotidae moloneyi*, Hampson (1909).]

*Anaphe (Epanaphe) vuilletii* de Joann. [Syn: *Hypsoides vuilletii*, de Joann. *Anaphe vuilletii*, Golding (1942b).]

Family Lasiocampidae:

*Gastroplakaeis rufescens* Aurivillius 1904.

Family Saturniidae:

*Epiphora bauhiniae* Guer. 1892. [Syn: *Saturnia bauhiniae*, Guer., 1829; *Attacus baumhiria*, Walk. (1855).]

*Anaphe* caterpillars are gregarious and possess the remarkable habit of congregating to spin large communal nests before pupation. Inside these communal nests they further encase themselves in individual silken cocoons. Hundreds of caterpillars might be involved in the spinning of one of these nests. In one species, *Anaphe moloneyi*, the unusual length of half a metre has been reported (Michel, 1911). Such a nest must have contained over 1,000 caterpillars. After the completion of the communal nest, the caterpillars rest for a period varying from two weeks to three months before pupation. *Anaphe vuilletii* caterpillars are also gregarious in their feeding, processing and resting behaviour. They pile up on top of one another when they are ready to pupate, but only tenuous silken threads bind the individual pupal cocoons together, and there is no communal nest as such.

Like many other natural products used in tropical Africa before the advent of modern culture and the widespread adoption of money economy, the silken nests are collected from the wild, and the food plants of the caterpillars are not cultivated in any way. The collection depends entirely on chance. If a farmer or hunter happens to see a nest while walking through the bush or while clearing farmland, he will take it to the nearest market and sell it. The price varies in different parts of the country, and according to the type, size and age of the nest. In Western Nigeria, where the local demand for anaphe silk is highest, a 'live' nest (usually of *A. infracta*) taken off a tree, costs about six pence or between four shillings and six shillings a pound weight. A previous season's nest, which might have been picked off the ground or singed by bush fires, would be half price. In Northern Nigeria, where the peasants are less affluent, the commonest type, *A. moloneyi*. would now cost about three pence a nest or between two shillings and three shilllings a pound. A nest which contains resting larvae, as distinct from the chrysalids or pupae, would cost a penny extra, as the contents are regarded as good food. To distinguish between nests containing larvae and those in which pupation has occured, they are shaken close to the ear. Those with pupae rattle audibly while those containing larvae do not.

*Anaphe* moths also occur in Eastern and Midwestern Nigeria, but their silks are not used, although the caterpillars may be eaten. When the peasants in these areas were made aware that money could be made from the nests, they were forthcoming: two pence a nest was the price in Agbor market (Midwestern Nigeria) some years ago.

## TRADITIONAL METHODS OF SERICULTURE

### *Yoruba methods*

Among the Yorubas of southern Nigeria, the brown silks of *Anaphe infracta*, and *A. reticulata* are still widely used in the manufacture of princely robes and expensive wrapper cloths. Only *A. infracta*, is really plentiful and widely used in forest areas. *A. venata* nests, although also plentiful, are not used. The caterpillars are not eaten either. Although laboratory and factory tests show that the silk is as good as that of *A. infracta*, and even better than that of *A. moloneyi* (Lehman, 1913), yet it is much more resistant to the action of mild alkalis during the degumming process. It may be that the traditional Yoruba process of degumming cannot cope with *A. venata* silk.

The communal nests are known as *ekuku* or *apo-eruku* and the cloth woven from them as *sanyan*. Traditionally, *sanyan* silk is woven as a narrow band, only 10 cm. to 12 cm. wide, and 60 to 70 metres long. It is then cut up into three-metre lengths and sewn together side by side. Although the colour blue is such a favourite among the Yorubas, blue *sanyan* has not been observed, and the material seems never to be bleached or dyed. The natural brown or greyish brown colour is retained, the only decoration being one or rarely two longitudinal white stripes. Occasionally, green or red stripes are encountered, especially in silks designed for women or for men's caps. Unless specially commissioned, the cross-weaves as well as the stripes are always made of cotton threads. As the individual cocoons of *A. moloneyi* chrysalids are naturally white, they might have been used for the decorative white stripes in the past. Despite the cotton threads, *sanyan* silk cloth of Nigeria is one of the toughest and most durable materials known.

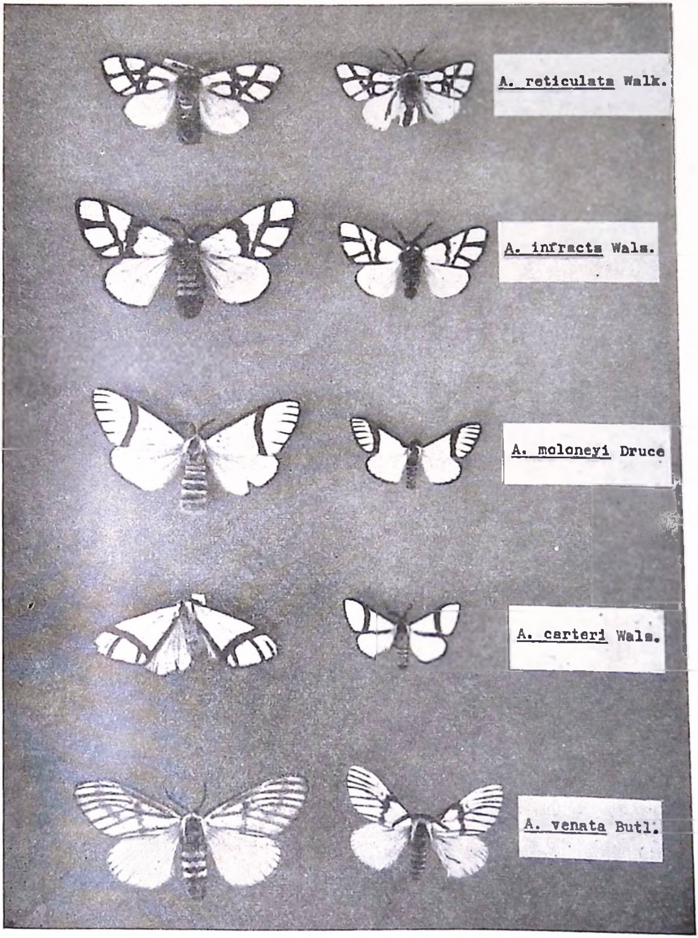
A. reticulata Walk.
A. infracta Wals.
A. moloneyi Druce
A. carteri Wals.
A. venata Butl.

*Plate I*

A special mixture of wood ashes, known as *labulabu*, is used to remove the gum binding the silken threads together. The process is called degumming. The mixture seems to contain the ashes of certain specific but as yet unidentified plants. They are sieved free from debris, mixed with water into a paste and moulded into lumps. These are first dried in the sun and then baked in a hot oven.

When silk is to be degummed, *labulabu* is stirred up in hot water and allowed to settle. The mother liquor, which is alkaline, is decanted off and used as the degumming fluid. A little caustic soda or potash may be added. The caterpillars and chrysalids are first removed, and the outer casings only boiled overnight in the alkaline fluid, which has the effect of removing the gummy substances binding the silk fibres together. The silk casings are considered fully degummed when they float. The degummed silk is washed clean with several changes of water, dried in the sun, and spun by hand into a coarse thread.

The weavers in Yorubaland are mostly men and they work in guilds or family groups. The degumming and spinning, on the other hand, are undertaken by women who are often the weavers' wives or who may do this as a full- or part-time occupation. They visit local markets far and near buying up the silk casings.

Certain taboos are associated with the degumming process. In the Ondo area, a woman "cooking" silk must not sleep with a man that night. Visiting adult males are not allowed near the pot, as they might have had sexual intercourse, which must not be associated with the process in any way.

The major weaving centres in Yorubaland are Iseyin, Oyo, and Ondo, although one comes across silk casings, degummed silk fibres, and the spun threads in many markets in and around the big towns such as Ife, Ibadan and Ijebu-Ode. On-the-spot flame tests show that the average *sanyan* in Ondo market seems to contain a higher proportion of cotton fibres, and is consequently paler in colour than the Iseyin ones. In Ondo, however, the purest *sanyan* silks known to the author were found, being produced by an old, proud and contented man who comes from a long line of silks weavers.

*Hausa methods*

The Hausas of Northern Nigeria make use of silk produced by *A. moloneyi* (common all over the savanna regions of West Africa), *A. vuilletii* and *Gastroplakaeis rufescens*. The silk of the last named moth is yellow, lustrous and exceptionally strong. It is the most expensive in the country. The caterpillars do not spin communal nests, and have been reported only from the Zaria area (fig. 1). *A. moloneyi* nests, although so plentiful, are considered inferior and used rarely only. Northern Nigerian silks are used mostly in the embroidering of 'rigas' and courtly robes. They were probably also woven into cloth centuries ago before the advent of cotton. Old records of the trans-Saharan trade between Kano and North Africa make references to 'Kano silk'.

Cotton was introduced as a cash crop only during the later half of the last century. Being far more abundant and so much cheaper, it would have tended to displace the silk as it grew to become one of the region's principal products. A survey in December 1963 showed that imported artificial silk was being used for almost all the embroidery work taking place in Zaria market place. The craftsmen were emphatic though that the really expensive 'rigas' made for princes and nobles would still be embroidered by hand-spun locals silks. The silk of *A. reticulata* is not used, although the moth is fairly common (fig. 1). Like *A. venata* of the southern forest regions, it is resistant to degumming. Laboratory tests during the World War II again showed its silk to be as good as the others.

Nigerian silk is known in the Hausa language as *tsamiya*. Each type is distinguished by the addition of the name of the plant on which the capterpillars that spin it feed. Thus *A. moloneyi*, which is found on doka trees, is called *tsamiyan-doka*. Similarly there is *tsamiyan-tsamia* on tamarind, *tsamiyan-makarfo* and others, see table.

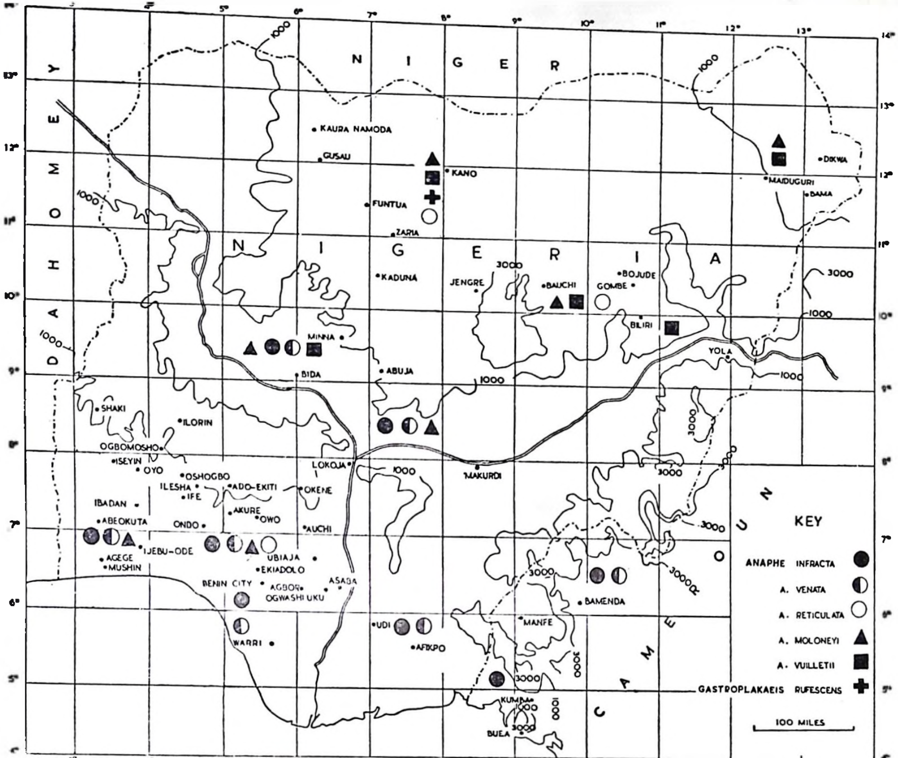
N I G E R
N I G E R I A
D A H O M E Y
C A M E R O U N
KAURA NAMODA
GUSAU
KANO
FUNTUA
ZARIA
KADUNA
JENGRE
BAUCHI
GOMBE
BOJUDE
BILIRI
YOLA
MAIDUGURI
DIKWA
BAMA
MINNA
BIDA
ABUJA
SHAKI
ILORIN
OGBOMOSHO
ISEYIN
OYO
OSHOGBO
ILESHA
IFE
ADO-EKITI
OKENE
LOKOJA
MAKURDI
IBADAN
ABEOKUTA
ONDO
AKURE
OWO
AUCHI
IJEBU-ODE
AGEGE
MUSHIN
UBIAJA
EKIADOLO
BENIN CITY
AGBOR
OGWASHI UKU
ASABA
WARRI
UDI
AFIKPO
BAMENDA
MANFE
KUMBA
BUEA
1000
3000
KEY
ANAPHE INFRACTA
A. VENATA
A. RETICULATA
A. MOLONEYI
A. VUILLETII
GASTROPLAKAEIS RUFESCENS
100 MILES

Fig. 1

*Local names of Nigerian wild silks and the food plants of the caterpillars which produce them*

| Silk Moth | Food Plants | Hausa Names | Yoruba Names | Ibo Names |
|---|---|---|---|---|
| *Anaphe infracta* Wals. | — | Tsamiya | Apo-eruku; Ewuku; Ekuku | Akpa obubu |
| | **Bridelia micrantha* | — | Asha | Aga ofia |
| | *Albizzia zygia* | Madobiyar rafi | Ayinreta | Avu |
| | *Ficus exasperata* | - | Ipin | Asisa; Anwi-linwa |
| *Anaphe moloneyi* Druce | — | Tsamiyan doka | Apo-eruku; Ewuku; Ekuku | Akpa obubu |
| | **Isoberlina doka* | Doka | — | — |
| | *Cordia millenii* | — | Omo | — |
| | *Albizzia adianthifolia* | — | Ayinre | Avu |
| | *Albizzia zygia* | — | Ayinreta | Avu |
| | *Afrormosia laxiflora* | Makarfo | Shedun | Abua ocha |
| | *Ficus gnaphalocarpa* | Baure | — | Ogbu |
| | *Ficus glumosa* | Kawuri | — | Ogbu |
| *Anaphe venata* Butl. | — | Tsamiya | Apo-eruku; Ewuku; Ekuku | Akpa obubu |
| | **Triplochiton scleroxylon* | — | Arere | Okpo |
| | *Bridelia micrantha* | — | Asha | Aga ofia |
| | *Cola gigantea* | Bokoko | Ogugu | Ebenebe |
| *Anaphe reticulata* Walk. | — | Tsamiyan makarfo (baushe) | Apo-eruku; Ekuku; Ewuku | Akpa obubu |
| | *Afromosia laxiflora* | Makarfo(Fulani: Damdam) | Shedun | Abua ocha |
| | *Terminalia avicennioides* | Baushe | — | — |
| | *Bridelia ferruginea* | Kirni or Kisni | Ira-odan | Aga ofia |
| *Anaphe vuilletii* de Joann. | — | Tsamiyan tsamia (gamji) | — | — |
| | *Uapaca guineensis* | Ka-fafago | Ajegbe or abo-emido | Ubia |
| | *Tamarindus indica* | Tsamia | Ajagbon | Icheku |
| | *Ficus platyphylla* | Gamji | Opopo | Ogbu |
| *Gastroplakaeis rufescens* Aur. | — | Tsamiyan doka maikaikai | — | — |
| | *Isoberlina doka* (young trees only) | Doka | — | — |

* Indicates principal food plants.

The degumming agent used in Northern Nigeria is a special wood ash known as *garin-toka*. This is boiled in water. The nests are then immersed and stirred thoroughly with a stick. They are allowed to stand for an hour, washed out, dried, and teased open by hand into silk wool, or combed into single fibres.

## WHY ANAPHE SILK REMAINED VIRTUALLY UNKNOWN

The error in the UNESCO publication mentioned in the first paragraph of this paper is perhaps excusable. The vast majority of educated people living in Nigeria at present, including those who have lived here all their lives, have never heard of the existence of indigenous silk yarn. Knowledge of traditional things vanish pretty quickly in societies whose languages are either not written at all or possess only microcosmic accumulations of indigenous literature. It is particularly so when such societies are subjected to rapid social and economic changes as is the case in West Africa at present.

The suprising thing is that the art of sericulture should have survived the influx and competition of cheap cotton goods and modern dressing habits during the past century. Rather curiously, it has escaped much notice. One major factor probably explains this more or less contradictory state of affairs. The factor is secrecy. Until recently, Nigerian silk cloth was a royal prerogative, and was worn by princes and a few dignitaries only. Silk weaving was practised only within the precincts of palaces, and the art was kept rigidly secret. A secret matter in old Africa was not even discussed, and many such things must have escaped the attention of the 18th and 19th century explorers, missionaries and other anthropological writers. Furthermore, British and German commercial firms, which attempted to exploit anaphe silk earlier in this century, naturally tended to regard at least some of the information they had as trade secrets. Finally, secrecy was clamped on the silk by the British war office and the Nigerian government during the second world war when it was discovered to be an excellent substitute for oriental silk, the supplies of which were cut off early in the war by the Japanese. These will be discussed more fully later on.

Photographs and paintings of Nigerian potentates of the last century show some of them wearing silk robes looking almost exactly as they do today. That this had not been taken much notice of was because the material was invariably mistaken for cotton. Degummed in the traditional manner, it tends to loose the lustre that has come to be regarded as one of the prime qualities of silk. Again the yarn is spun by hand from jumbled silk wool and never unwound as single denier filaments. It is therefore rather lumpy, and yields a coarse cloth, very unlike the popular modern concept of silk.

## REVIEW OF THE LITERATURE

The genus *Anaphe* was first described by Walker (1885) and *Hypsoides* (generic synonym for *Anaphe*) by Butler (1882). Michel (1911, 1912, 1928) published several taxonomic surveys in which he described the adult moths, the caterpillars and the food plants of silk-producing Lepidoptera of tropical Africa, including *Anaphe* spp. Under the auspices of Afrikanische Seidengesellschaft (later to become the African Silk Corporation), five pamphlets were published between 1910 and 1914 on various aspects of the economic exploitation of African wild silks. The first (Afrikanische Seidengesellschaft, 1910) was a simple handbook for farmers suggesting methods for the collection, cleaning, baleing, and exportation of silk cocoons. Schultze (1913) wrote a treatise on the systematic position of the principal silk producing moths; Lehman (1913) discussed the structure of the silks and their possible commercial value; and Kuller (1913, 1914) their known distribution, and the results of large-scale cultivation experiments undertaken by the Corporation in what are now Tanganyika and Uganda.

A number of important publications on the silk, some of which contained biological data, appeared during a brief revival period after the first world war: Kuller (1930) considered their economic importance; Pomeroy (1921, 1923) discussed their possible commercial value and made a study of the life-history of *A. infracta;* Michel (1928) surveyed their distribution and that of their food plants in the Congo; Golding (1942) reviewed the commercial history of the silk and made very brief and unillustrated descriptions of the cocoons and the wings of the adults.

## COMMERCIAL HISTORY

Between 1908 and 1914, the German firm, Afrikanische Seidengesellschaft attempted to produce regular supplies of the silk from plantations of *Bridelia micrantha* (Hochst.) Baill. and other food plants of the caterpillars at Bukoba on the West shores of Lake Victoria. The plants were planted in long parallel hedges, 10 feet apart. Because of a tremendous increase in the number of parasites and avian predators around the large plantations, the experiments were not altogether a success. Smaller plantations, below one and half acres and surrounded by bush and farmland, were however more successful. The firm was thus able, with the help of supplementary collections from the wild in East Africa and in the then German Kameroons, to export hundreds of tons of silk annually to their mills in Germany. The first world war brought a halt to their activities, and the British and French, who took over these territories did not continue the sericulture experiments.

During the early 1930s, repeated efforts were made to revive the industry; this time in Nigeria and the Cameroons. All the attempts were eventually abandoned. A study of records in the archives of the Nigerian Federal Departments of Agricultural and of Forest Research, the Federal Institute of Industrial Research and elsewhere reveal that there were two or three principal causes of the failures. The most important was the trade depression which followed the first world war. Another was the singularly inadequate investigation of the silkworm and its biology, or alternatively the then available literature, before the attempts at exploitation. A third was the discovery, soon after the war started, of how to synthesize nylon—a silk substitute with many similar qualities—from amino-acids. It seems significant that the laboratories of one of the firms which processed anaphe silk for Britain during the war, had described it as consisting of a simple combination of amino-acids. Ycas and Vincent (1960) found them to consist of a fibroin composed, virtually, of alanine and glycine in equimolar amounts.

The following are the most notable attempts to revive the anaphe silk industry in Nigeria since the first world war.

### *Dorman-Smith and Co.*

Negotiations for buying and manufacturing concessions in Nigeria were conducted, under confidential cover, between different commercial interests and the Nigerian Government. On the application of a British industrialist, Mr. R. H. Dorman-Smith, a licence was prepared (Nigerian Government, 1930), granting his firm monopoly rights for ten years, provided they built factories for the degumming of anaphe silk and began to develop the industry within six months. A validating bill was also drafted ready to be passed in the Legislative Council. Mr. Dorman-Smith failed to sign the agreement papers at the last minute because:

> "Our main difficulty is that owing to the depression in trade in this country, we are unable to find sufficient financial support for the development of a new trade, which must be started on an experimental basis.... Therefore we consider that it would not be fair on our part to sign the agreement, especially as we understand that there are others interested in the development of the anaphe silk industry in Nigeria, who might be in a better position to get that industry established" (Dorman-Smith, 1930).

### *The African Silk Corporation*

The 'others' referred to in the above letter obviously included the African Silk Corporation, a German firm mentioned earlier (p. 62). The firm's excellent pioneering work and budding business in East Africa and the Cameroons having been brought to an abrupt end by the first world war: it had been resuscitated and expanded afterwards to include British and Belgian interests. Operations were resumed in the later twenties. Their representatives in the Southern Cameroons induced local farmers in Mamfe, Buea and Bamenda Districts to plant or permit the firm to plant hundreds of thousands of *Bridelia* bushes, the favourite food plant of the commonest tropical forest silk worm, *Anaphe infracta*. They were planted either as hedges round the villages, or scattered on farmland. This technique was calculated to lead to a greatly increased production of wild nests, without bringing in the increase in predators and parasites attendant on the concentration of food plants in large plantations, and without involving the firm in the ownership of land. They had also been attempting for some time to acequire a Government licence to operate in Nigeria.

The Government opened negotiations with them when Dorman-Smith failed to take up his concessions. Once more, a licence and a validating ordinance: The Anaphe Silk Industry Promoting Ordinance (Nigerian Government, 1932) were drafted. Again, the licencees failed to sign at the last moment:

> "The persistence of the World crises and the depreciation of prices generally makes it impossible for us to find necessary capital with which to carry on and it is for this reason we have been unable to give effect to the scheme of which we had the privilege of acquainting you. Having exhausted all our efforts to find sufficient funds to carry on we have now to consider the question of liquidation of our company in the near future". (African Silk Corporation, 1932.)

### *War production drive*

Until the commencement of the World War II, both the Colonial Office and the Nigerian Government had been a bit tardy with regard to the encouragement of, or official participation in the exploitation of anaphe silk. Bombyx silk supplies from the Far East were cut off with the Japanese victories in Asia. Natural silk was needed urgently for the manufacture of aeroplane fabrics, parachutes, lightweight cords with great tensile strength, ammunition bags, and other unspecified war purposes. The anaphe silk of tropical Africa was the obvious solution. A wild-silk collection drive was launched in Nigeria, and met with immediate success. A tentative attempt was also made in East Africa but was soon abandoned. According to Mackay (1942), "the first intimation that the silk was needed came in September 1941. By December, hundreds of tons had been bought up from around Zaria and Gombe in Northern Nigeria. The United Africa Co. was also expected to purchase up to 200 tons that season". Altogether, thousands of tons must have been exported annually to Britian during the later years of World War II.

It was hoped by the Nigerian authorities that this new export trade would continue and expand after the war, but it did not. The wild sources were quickly exhausted, as the exploitation was as ruthless as the requirements were urgent. Further, almost every nest exported during the war was of *A. moloneyi* from Northern Nigeria. This species is considered so inferior that it is only rarely used by Nigerian weavers: Lehman (1913) also declared it to be "the lowest grade African Wild Silk". Although it was found suitable for parachutes and ammunition bags, it could not really compete with the Asiatic silks in normal industrial circumstances after the war. Opinions about its grade therefore adversely affected the other anaphe silks, which were superior to it.

*Post-war efforts*

As recently as the early 1950s, enquiries were still being made by British firms about the possibility of reviving interest in a Nigerian silk industry. One such was from Messers Anthony Ward and Co., who, in a letter to the Nigerian Trade Commissioner in London, referred to a report on the silk industry, the *leit motif* of which was "the sad dimunition of raw silk supplies". The firm argued that the only hope for the industry, at least in Britain, was the building up of raw silk supplies from countries with predominantly peasant economies, where the sometimes meagre returns may still be considered attractive. They drew attention to the success of *Bombyx mori* silk cultivation on mulberry trees in the Congo and tried to encourage a similar venture in Nigeria, at least as a supplement to wild anaphe silk exports.

As a result of the prodding by commercial firms, the Nigerian Agricultural and Forest Departments began to investigate the growth of the oriental silkworm's food plant (*Morus alba* Linn.) in different areas in the country, with a view to repeating the successful experiments in the Congo. Seeds and cuttings from Cyprus were sent to Eastern and Northern Nigeria in October 1951, and there the matter rests officially at the moment.

*Unofficial Private Efforts*

Unofficially, individuals have at various times experimented with silkworm culture in Nigeria. Mr. B. Jemi Alade actually established a private anaphe silkworm farm of 10 acres in Mushin near Lagos in 1942. He sought advice from the Agricultural Department and planted cuttings and seedlings of silkworm food plants in parallel hedges. Although this was during the war when *Anaphe* spp. nests sold readily, he was sure the local cottage-industry would absorb all he could produce. As recently as 1963, an official of the Veterinary Tsetse Research Unit in Northern Nigeria, Mr. L. C. Cronje, imported some *Bombyx mori* cocoons, and is currently experimenting with raising them on mulberry trees which he also introduced.

## PROPERTIES AND USES OF ANAPHE SILK

Beautifully-dyed damask made with anaphe silk was exhibited in the Wembley fair of 1923 in London. Sample velvets, velveteens, and other silk fabrics were also woven and dyed in different colours in order to test the properties, processing, weaving methods and dyeing qualities of the silk. These tests were performed at different times by various European Continental and British Research Institutes and textile firms. Notable among these were L'Ecole Royale de Filature et de Tissage, Crefeld; Afrikanische Seidengesellschaft, Berlin; Imperial Institute, London; British Cotton Industry Research Association, London; and a number of British textile firms, including Hurlingham Dyeing and Finishing Co. Ltd., Murray Bull and Spencer Ltd., Coastals Ltd., and Gaddum Ltd. Later in 1957, Dr. M. Ycas, from the State University of New York, spent some months in Ibadan and Zaria investigating the amino acids from the silk glands of *Anaphe* spp. caterpillars.

A succinct resumé of the properties and uses of the silk is made from the reports and other publications of these investigations. All the following statements are either direct quotations or translations from German or French texts:—

Simple molecular structure . . . exceedingly simple amino-acid composition.

Composed, virtually, of alanine and glycine in *equimolar* amounts.

Clean and even thread.

Low extension factor but good strength.

Extraordinary firmness and elasticity . . . considerably greater than that of ordinary bombyx silk.

The twisted African *schappe* is an excellent sewing silk. Its strength, greatly exceeding that of other silks, renders it highly appropriate for this particular purpose.

Has the merit of having a fine denier filament.

Good weaving properties but liable to crease.

Suitable yarn for the manufacture of damask and other silk products, with excellent dyeing qualities.

Particularly suitable for the manufacture of velvet. The extreme fineness of the individual fibres imparts a beautiful surface to the velvet and produces an excellent pile.

Suitable for umbrella and necktie material.

Found to be excellent for the manufacture of parachute cloth and cords, aeroplane fabrics, cartridge bags, and other war purposes.

For making baloons and aeroplane fabrics, it supercceds all other materials on account of its strength. A still more important quality qualifies it for this particular purpose, and that is its unusually low specific gravity, which is more than 20% less than that of *Bombyx mori*.

The structure of the anaphe fibres gives them a particular adhesive force which renders them highly suitable for mixing with other fibres. Anaphe and wool mixtures yield threads of such fineness as would be impossible if composed of wool alone.

A number of disadvantageous features also came to light during attempts to work anaphe silk. Briefly they are:

urtication,

the presence of sticks and other debris,

the shortness and weakness of fibres in some samples,

comparatively low yield after degumming and combing,

comparative lack of silken lustre, and

the fact that, being the product of many individuals, the fibres are jumbled up and can never be unwound like classical silk, but must of a necessity be spun like wool or cotton.

The hands, faces and nasal passages of workers baleing the silk casings or handling the undegummed silk in factories suffer from some irritation which sometimes leads to inflamation. This is caused by hair-like scales from the tips of the abdomens of female moths. These scales are normally deposited on newly laid eggs as protective coats. Some become detached and are left behind in the nest casings during emergence of the moths (Pomeroy, 1921). Wetting the casings during baleing operations temporarily stops the urticating properties of the scales (Anon., 1920). Immersion in 1 per cent ammonia solution for twenty-four hours or boiling for two hours with 1 per cent sodium carbonate solution, and afterwards washing and drying, permanently destroys the scales and stops urtication (Anon., 1932). As treatment with dilute alkali is normal during the degumming of silks, they are not damaged in any way. The treatment further leads to a reduction of about 33 per cent of the original weight of the silk casing, as it effectively removes the dead silk worms and pupal remains, leaves, sticks, sand (acquired from flood waters when detached from trees and picked from the ground), and other debris.

After brief tests, one or two British investigators reported adversely on the strength and average length of anaphe silk fibres. The Imperial Institute (1942) advisory committee on silk production also investigated and reported adversely on the silk. After carding or combing, they obtained a yield of dry "top" silk of only 7.55 per cent, and "noils" of as much as 46.9 per cent. The silk was also pronounced "weak, lacking in lustre and uneven in spinning". In contrast with these reports, the African Silk Corporation, which must have had more data than any other organisation after twenty-two years of experimentation and scientific study, found that the yields as well as the gloss of the silk varied greatly with the pre-degumming treatments, the degumming methods and the chemicals used. They obtained yields, after carding, of between 25 per cent and 40 per cent from *A. moloneyi* samples (Kuller, 1930). They produced data (Lehman, 1913) to prove conclusively that threads spun from *A. moloneyi* fibres, although the weakest of the anaphe silks, had greater tensile strength and greater elasticity than those of bombyx silk at every thickness of thread tested (figs. 2 & 3). Kuller (1930) concluded that the "sole disadvantage of African silk is that its lustre is somewhat less than that of ordinary silk", and was sure even then that methods of overcoming this would be found in time.

Because of the anomalies between the British investigations and the German ones, an attempt was made to trace the sources and details of the yarns tested in Britain. It turned out that some samples were sent from the Nigerian Department of Agriculture in Ibadan, and consisted of "old season" nests of *A. moloneyi*, or of fibres already degummed by local methods. As had been mentioned earlier, this is considered much inferior to other species, and being old season, might well have been lying on the ground in the bush for years before being picked up. Local methods of degumming include boiling for unspecified durations in alkali mixtures of variable strengths.

The largest sample tested in Britain before World War II consisted of eight tons of *A. moloneyi* nests held in store for years in Hamburg before being purchased at 5d. per pound c.i.f. London. The sample was admittedly "in bad condition, having been stored for a long time and being entirely devoid of any outer coverings" (Dorman-Smith, 1930).

## ECONOMIC POSSIBILITIES

Practically all known publications on *Anaphe* spp. were made by industrial and agricultural research workers, who were naturally more interested in the silks and how to exploit them than in the insects producing them. It is immediately obvious, from the literature, that the authors all believed in the viability of a sericulture industrv based on the African wild silks. This unanimous opinion is summarised by the closing paragraph of Kuller's (1913) pamphlet: "finally, the writer would express as his confession of faith that the economic importance of a high grade textile fibre cannot be overrated. Just as the silk of Asia, the wool of Australia, the cotton of America have given their continents a certain stamp, so too does Africa possess in her wild silks the foundation of a speedy economic development and the accumulation of great wealth, not only for its profit, but of the highest importance for the world's economic condition of the future."

It is true that for real utilisation purposes, natural silk is being largely replaced by such synthetic fabrics as nylon and terylene which possess closely similar qualities, yet in the fields of fashion and sentiment, silk still commands a ready market. Its value in the world market in 1945 was $425 million. Sericulture remains an important industry in China, Japan, Italy, Spain, and Southern France, and was more recently introduced into Brazil and Congo (Ituri and Mount Hawa). In fact the limiting factor to production is "the sad diminution of raw silk supplies" as one British textile firm put it.

The raw silk produced in China and Korea are just about enough for their domestic needs and the Indian ones do not even suffice to raise sericulture above the cottage industry level. Only Japan produces enough to export raw silk, which all goes to United States mills, and they could process more. Southern Europe has ceased to be a reliable source because of the greatly increased standard of living of peasants since World War II. The hard work and comparatively meagre profits no longer attract the peasants of Italy and Provence in Southern France. It would be easier to build up an export industry based on these wild silks in Nigeria than in any other country. Although widespread all over tropical Africa, the moths are found in greatest abundance in Nigeria, where the food plants of their caterpillars

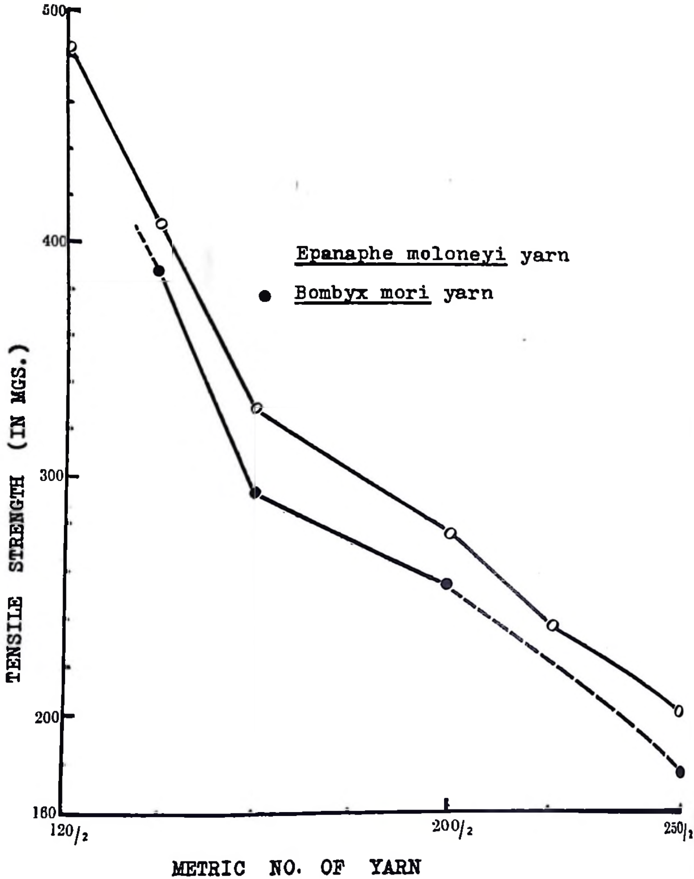
Epanaphe moloneyi yarn
Bombyx mori yarn
TENSILE STRENGTH (IN MGS.)
500
400
300
200
160
120/2
200/2
250/2
METRIC NO. OF YARN

*Fig. 2*

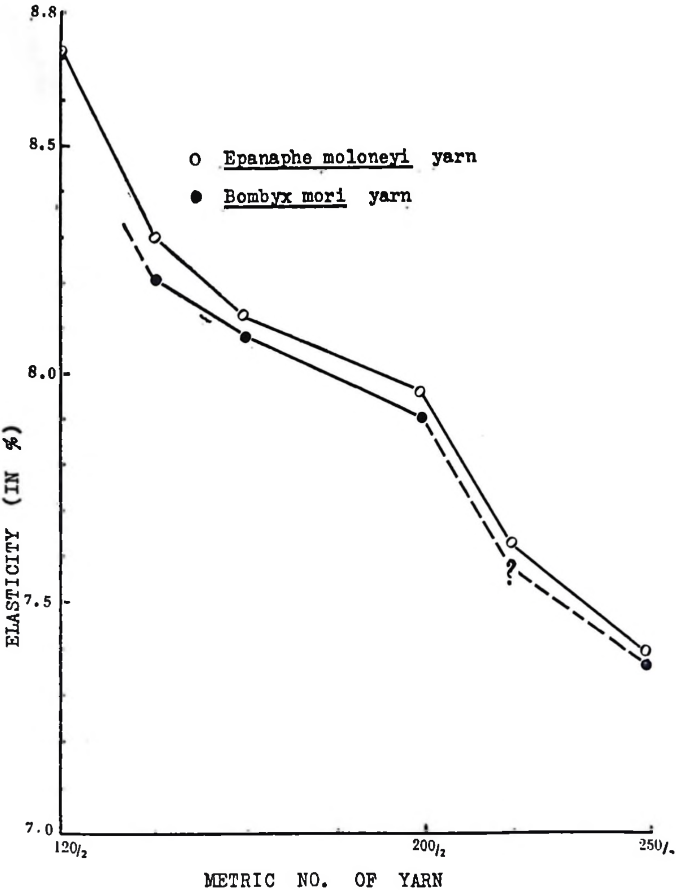
8.8
8.5
8.0
7.5
7.0
ELASTICITY (IN %)
o Epanaphe moloneyi yarn
● Bombyx mori yarn
?
120/2
200/2
250/2
METRIC NO. OF YARN

*Fig. 3*

abound naturally. Many Nigerian peasants already know the different types of silk nests, their differing qualities and market values, the caterpillars producing them, their food plants and breeding seasons.

Examined from the biological, ecological, cultural and economic points of view, there is no reason why the anaphe silks of Nigeria should not eventually succeed in the world market. In Britain, Germany and the rest of Northern Europe, it would now be immediately acceptable, and would probably also sell readily in U.S.A. and Eastern Europe.

Compared with the better known *bombyx*, *tussah* and *eri* silks of the Orient whose caterpillars spin individual cocoons, there are obvious advantages in the large communal nests of anaphe silk caterpillars. Apart from yielding a superior silk which is stronger, more elastic, lighter in weight, and as fine as any, the collection of the nests from the host plants should be infinitely easier and cheaper. Much of the filature (i.e. cleaning, baleing, degumming, combing and other pre-spinning treatments) ought to be equally facilitated.

Major precautions to be taken to ensure successful and steady output can be readily drawn up, based on the experiences of the African Silk Corporation and the findings of research workers in Nigeria and elsewhere.

An export industry based solely on the uncontrolled collection of raw wild materials cannot have any future especially when, as in the case with silkworms, there is a real danger of extermination. It would be essential therefore for some degree of semi-cultivation of the silkworms and their food plants to be practised. It would also be necessary for some form of closed season control of the silk collection to be imposed by legislation, in order to permit the adult moths to escape and prevent their eventual extermination.

In order to avoid the excessive attack of parasites and predators, scattered planting of the food trees among farmland would be better than the establishment of large plantations. At least the preliminary stages of degumming should be carried out in Nigeria before baleing the silk for export. This would permanently eliminate urtication, cut out the 33 per cent dead weight due to extraneous matter and thus avoid the low-yield complaints, standardise the size and weight of bales, ensure uniform quality, and provide opportunity for official grading and fixing of prices. To do this properly and set the industry firmly on its feet, monopoly rights might have to be granted, for a period, to a company having Nigerian Government or private investments, as well as investments from one or more textile manufacturing firms. The company would then naturally be invited to establish silk weaving mills in the country when sufficient raw materials exist to provide for the home as well as export markets.

For the successful establishment of a sericulture industry in Nigeria, it might be necessary to supplement the anaphe silks with bombyx silk. The food plant, *Morus alba* var. *latifolia*, has been well established in the Mount Hawa region in Congo Republic, and in the Cameroun Republic near Adamawa, for the past twenty years. It should grow readily in the Udi and Okigwi hills and the Obudu Plateau of Eastern Nigeria and on the Jos Plateau. A species of mulberry, *Morus mesozygia* Stapf. is indigenous and widespread in certain parts of Nigeria, and it would be necessary to experiment with it as a food plant for *Bombyx mori*. Other species, such as *Morus nigra* Linn. and *M. indica* Linn. could also be introduced and tried.

Some preliminary biological research would also need to be carried out to ensure success. Only one or two species of *Anaphe* moths have had their life histories investigated. The physiology of the caterpillars, and the intricate ecological and pathological interrelationships with pests, predators and parasites are virtually unknown. The loss of silken lustre must also be overcome if they are to appeal to the markets of fashion and sentiment.

The best method of approach might therefore be to establish a sericulture research organisation or corporation which will begin by collating all available information on the subject and planning the venture anew on scientific lines.

## ACKNOWLEDGEMENTS

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My thanks are also due to Tony Youdeowei for his help with enquiries in Ondo area; the Directors of the Nigerian Federal Departments of Agricultural and Forest Research for allowing me access to their archives; and to Mr. D. P. Stanfield for the identification of food plants.

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Dr. T. A. Taylor (*Agricultural Biology Department, University of Ibadan*)

**The bionomics and control of Nigerian yam beetle species.***

SUMMARY

Many years of research have produced some useful information on the biology and control of yam beetle species in Nigeria. The picture is by no means complete and it is hoped that further investigation will fill in the gaps in our knowledge about the biology and ecology of these species.

Four main species of yam beetles occur in the Nigerian fauna: these are *Heteroligus meles, H. appius, Prionoryctes canaliculus* and *P. rufopiceus*. Of these the commonest and most important, economically, is *Heteroligus meles*. *H. meles* is distributed throughout the main vegetation zones in southern Nigeria including the guinea savanna zone which spreads into Northern Nigeria. The other species appear to be restricted to the forest zone and have never been reported outside it. The distribution of the species and areas of infestation follows the courses of the Rivers Niger, Benue and some other all-season rivers along which the 'Major' and 'Minor' breeding areas are situated. Some aspects of the ecology of the breeding areas have been described.

The biology of *H. meles* and *H. appius* differ substantially. *H. meles* oviposits in the breeding areas from November to December; the eggs, larvae and pupae develop in the breeding areas and the adults migrate into the yam plots and attack yam setts or new yams from April to June. They migrate back to their breeding areas in November and December. On the other hand, adults of *H. appius*, just out of hibernation, migrate into yam plots at the same time as *H. meles*. Oviposition and larval development take place in the yam heaps and the resultant generation of adults migrates back to, presumably, the same breeding areas as *H. meles* at about the same time for a period of hibernation. In the yam heaps both yam setts and the root system are extensively damaged by the larvae and adults. Successful laboratory rearing of the two species has been undertaken and the duration and character of the developmental stages studied.

Beetle migration has been studied by the use of mercury vapour lamps in Robinson's light traps during the periods of migration. It is now known that yam beetles migrate twice in a calendar year in the forest zone as follows: the 'feeding migration' in *H. meles* (feeding–breeding migration in *H. appius*) occurs about 4-6 weeks after the beginning of the rains, from April to June, and the breeding migration in *H. meles* ('hibernation migration' in *H. appius*) from late October or November to December. In the guinea savanna zone the period between the two migrations is extremely short due to the fact that the 'feeding migration' does not begin until early June and may continue into September, and the breeding migration commences in October. Rainfall, temperature, and probably condition of gonads, affect migratory behaviour. Other aspects of beetle migration are still under investigation.

The most effective control measure against yam beetle damage is by insecticidal treatment of yam setts or the soil around the setts with 2.5 per cent Aldrin dust at planting. This measure is not very satisfactory with early planted (November) yams, and some other more persistent insecticides, as well as other methods of application, are under investigation to remedy this.

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Professor H. A. Oluwasanmi (*Agricultural Organisation Department, University of Ibadan*) **Peasant farming and technical change.**

Dr. I. S. Dema (*Institute of Child Health, University of Ibadan*) **A review of recent nutritional surveys in Nigeria as a guide to social action in the country.**

SUMMARY

The question of the proper feeding of Nigeria's expanding population, evidenced by high fertility and declining mortality rates in localities that are served by maternity and child welfare centres, is increasingly exciting much social interest in view of the widespread incidence of caloric-protein deficiencies in the local diets. The most marked effects of these unsatisfactory diets are:

poor lactation performance,
retarded physical development in early childhood,
low serum albumen levels,
high child mortality rates,
and diminished working capacity in adults.

Without invoking the pessimism of the Malthusian Theory the purpose of this contribution is to apply research data to stimulate discussion on ways of feeding adequately the growing population of Nigeria.

Recent ecological studies of the nutritional status of samples of Nigerian communities have shown that while parasitic infections are universal the unsatisfatory food supplies are related to:

decreasing rural labour force due to withdrawal of young active workers into urban centres,
large numbers of dependents per active workers,
shortage of arable land due to population pressure, loss of fertile lands through erosion, and indiscriminate cash cropping,
pest infestation and poor transport and processing facilities, all of which tend to reduce the amount of food available to the family,
and low educational standards which restrict earning capacity, and also prevent the individual from taking full advantage of available resources.

Therefore, in order to provide the resources needed for a widespread rise in the living standards of the population the nation should adopt the following programmes:

Industrialisation to absorb the surplus population as well as create markets for some of the agricultural products. Manufacturing industries will help agriculture by trying to compensate for the withdrawal of much of the manual farm labour. This it will do by making machinery that can cope with some of the more difficult farm operations, the development of fertilizers and pest control agents for greater yields, and the establishment of agricultural demonstration, advisory and sales services to encourage farmers to adopt improved methods.

Rural development to make agriculture and village crafts more profitable, and to create such social services which would try to abolish some of the material differences between town and country habitations. Improvement of small farms, not by major amalgamation since farmers are unwilling to surrender their individual land rights, but by co-operatives, etc., to improve the technical and commercial aspects of their agriculture.

Education in nutrition which should include good husbandary and practical housewifery.

Integrated community development needed for working a balanced economy. Guided self-help linking economic development and agriculture with health education through food and nutrition.

## DIETARY PROTEIN-CALORIE DEFICIENCIES IN NIGERIA

The question of the proper feeding of Nigeria's expanding population is increasingly exciting much social interest in view of the widespread incidence of caloric-protein deficiencies in the local diets.

Estimates made from measurements of food intakes show that up to about 75 per cent of the sample households studied in various parts of Nigeria (Collis, Dema & Omololu, 1962) do not have enough calories by FAO (1957a) standards. In addition, dietary protein requirements are hardly met, but there are some households where per caput protein intakes appear to be adequate by FAO (1957b) standards yet clinical signs of malnutrition occur in the children (Nicol, 1959). This situation could arise from the failure to recognise and apply the fact that the nutritional requirements of infants, and pregnant and lactating women are higher than those of the ordinary adults who often get the best and largest part of the family meal (Dema, 1962).

The occurrence of malnutrition despite adequate food intakes can also be due to parasitic infections such as malaria (Dema, Miller & Platt, 1959) or to toxic agents which might impair the utilization of ingested foods. By drawing certain contrasts between the patterns of protein malnutrition in Bantu children in South African and those seen in Western Nigeria, Hendrickse (1963) has advanced the suggestion that toxic principles such as alkaloids, tannins and cyanogenetic glycosides in herbal preparations and incompletely processed foods, and possibly aflotoxin from grain contaminated by *Aspergillus flavus*, might contribute to the graver pictures of liver damage which this disease presents in our communities.

The most marked effects of these unsatisfactory diets may be summed up as follows:

poor lactation performance,
retarded physical development in early childhood,
low serum protein levels,
high child mortality rates,
and diminished working capacity in adults.

## LACTATION PERFORMANCE

Jelliffe (1952) and Bassir (1956) in Nigeria, and Walker *et al.* (1954) in South Africa have shown that, at least as regards protein concentration, there is no difference in the chemical composition of milks from African and European nursing mothers. Furthermore, work in the Congo (Close & de Walle, 1957) has shown that there is no alteration in the amino-acid patterns of milk samples from mothers of malnourished children. The curd:whey fractions are, however, altered in the milks of such women, and since these protein fractions are digested at different rates the utilization of the milk may be impaired (Lutz & Platt, 1958). This hypothesis has not been tested in human infants, nevertheless it seems probable that the most important factor for child nutrition is the amount of breast milk secreted by the mother.

As a contribution to a combined sociological and medical study of child development, the Institute of Child Health, University of Ibadan, has for the past year been carrying out in the Oje native community of Ibadan cross-sectional studies of the quantitative food intakes of breast-fed babies. Evaluation of the food intakes of individual persons in sample households in this community brought to light the fact that their pregnant and lactating women are actually underfed (UNICEF Fellows, 1963).

Probably because of this state of maternal malnutrition the daily milk out-put as recorded by test-weighing of the breast-fed babies (see figure 1a) (drops quite suddenly from about

20 oz. in the first month to 12 oz. in the third month, 9 oz. in the sixth month, then it falls steadily to 6 oz. in the twelfth month, and finally it fluctuates between 5 and 4 oz. in the second year of lactation until complete withdrawal of the child from the breast any time after 18 months of age. Additional foods, largely in the form of maize pap, are given by forced-feeding from the time the infant is six months of age.

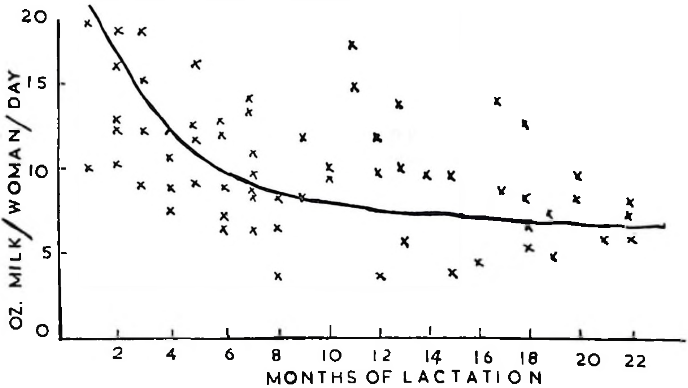


*Fig. 1a Breast milk output by Oje women*

Mother's milk alone appears to provide enough calories for the suckling baby during the first month of life, but thereafter, the falling milk out-put and the lack of enough of the right kinds of supplementary feeds make it difficult to satisfy the energy needs of the growing child (figure 1b). It is only when the child is completely off the breast that energy requirements appear to be met through the greater intake of adult-type foods. But these are largely starchy foods so that this period marks the onset of protein malnutrition associated with excessive dietary calories without adequate protein intake.

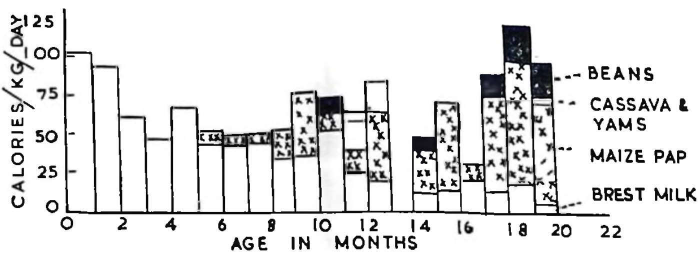


*Fig. 1b Food intake of Oje babies*

## PHYSICAL DEVELOPMENT

Measurements of the body weights of the Oje children show that for the first three months of life physical development follows that of their well-fed English counterparts (see figure 2). Beyond this stage their development begins to be retarded because of the inadequate breast milk and the relative absence of real supplementary infant feeds. In support of this view, it has been found in studies with older Nigerian children that the physique of those from well-to-do families is as good as that of well brought-up English children. The difference is so marked that at 4½ years of age Nigerian children from well-to-do families in Ibadan have been found to be 6 inches taller and 9 lbs heavier than their counterparts from the Ilesha rural areas (Collis, Dema & Omololu, 1962). By further comparisons of Nigerian children from various agricultural areas, as shown in figure 3, it has been noticed that the more and better the food supplies the closer their physique approaches that of the optimum Nigerian group (Collis, Dema & Losi, 1962; Dema, 1963a).

## LOW SERUM ALBUMEN LEVELS

The lowering of serum albumen levels is one of the recognised effects of protein malnutrition. Mean serum albumen levels for Nigerian children have been reported to be in the range of 5.2 to 5.4 gm/100 ml in normal subjects, and down to 2.5 gm/100 ml in the kwashiorkor type of protein malnutrition. Therefore, values between 2.5 and 3.2 gm/100 ml in apparently healthy looking subjects indicate sub-clinical protein deficiency (Edozien, 1960).

Recent comparative studies of serum albumen concentrations in rural Nigerian children under 12 years of age show differences which range from mean values of 3.6 gm/100 ml in the well-fed Pankshin children down to 2.98 gm/100 ml in the poorer-fed Ilesha children.

## CHILD MORTALITY

Results obtained by questioning and the examination of the age composition of the community show that about half the children born in Nigerian villages die before their fifth birthday. Careful statistics kept by Morley (1959) in Ilesha also show that about 12 per cent of these deaths are caused by malnutrition, including undernutrition. Together, malnutrition, diarrhoea and other disease conditions which may, at least in part, be connected with nutritional factors account for about 54 per cent of these deaths. Malnutrition is therefore regarded as the real killer in most cases, and Bengoa *et al.* (1959) have established from survey data that a high mortality rate among children under five years of age is indicative of widespread malnutrition.

## NUTRITION AND WORKING EFFICIENCY

There are as yet no measurements of working efficiency in chronically underfed populations. However, available data from starvation experiments performed in the United States of America (Keys *et al.*, 1950) indicate that emaciation, and the loss of muscle strength and endurance at work were evidenced.

It has been observed in southern Nigeria that food intakes may be so low in the planting season that they supply only about two-thirds of the energy requirements, (Dema, 1963a). In attempts to exert maximum physical effort the farmers work under considerable energy debt which is paid from their own muscles as evidenced by marked losses in body weight. Similar findings have been reported from the Gambia (Fox, 1955) and the general impression is that the resulting emaciation and the often associated impaired drive could lower agricultural productivity. It is true that training and enthusiasm can make certain underfed communities work harder than some better fed people elsewhere, but in the long run the same man can raise his level of economic activity by improved feeding.

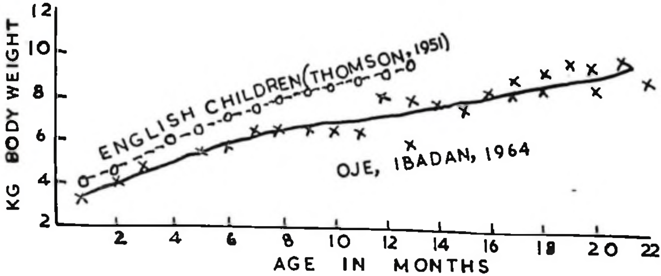


*Fig. 2 Body weights of Oje children*

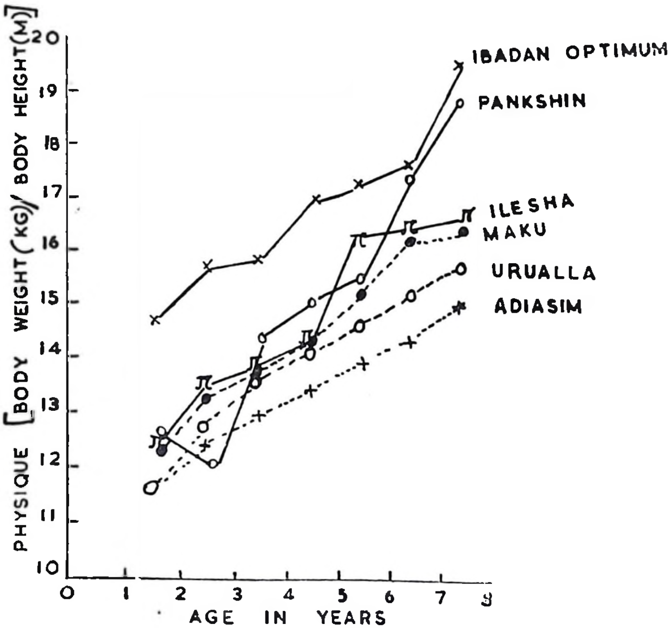


*Fig. 3 Weight-height changes in Nigerian children*

## ENVIRONMENTAL AND CULTURAL FACTORS

Having presented the facts about the effects of protein-caloric deficiencies in Nigerian communities, an attempt will be made to examine the associated ecological factors so as to provide basic information for planning ways of adequately feeding the growing population. Recent combined studies of health in relation to diet and agricultural factors in samples of Nigerian communities show that whereas parasite rates are about the same in all the villages examined, the nutritional states of the people can be related to:

the size and composition of the family unit, i.e. people eating out of the same pot,

the extent and nature of cropping,

food wastage through pest infestation, and inefficient storage, transportation and processing,

and low educational standards which restrict earning capacity, and also prevent the individual from taking full advantage of available resources.

## SIZE AND COMPOSITION OF THE FAMILY UNIT

Examination of the age structure of samples of rural Nigerian communities (figure 4) has shown that the economically dependent members of the village comprise of about 49 per cent young persons aged under 15 years, and of about 3 per cent very old people of over 65 years of age. Therefore, the economically active workers (aged 15–65 years) in the villages cater for relatively more dependents (48:52) than their counterparts in the industrially developed countries such as the United Kingodom (68:32). The situation is worsened by the farm labour force being reduced because the younger active workers (aged 15–21 years) increasingly leave the villages in search of economically more rewarding occupations in the urban centres which also have better facilities for recreation and social enjoyment. This urban drift of young persons therefore makes the populations in the newly developing Nigerian towns relatively younger than in the rural communities.

Because of the preponderance of dependants over active workers there is not always enough food to go round, especially in the larger families, as illustrated in figure 5, which has been drawn from data obtained in Eastern Nigeria. A comparison of actual dietary intakes (figure 6) measured in wage earning families in Lagos (Oshodi, 1961) showed that per caput food intakes increased with the rise in income from £200 to £400 per annum. Beyond this point and up to £600 per annum the per caput food intakes tended to drop, probably because of the increasing number of dependents which were unfortunately omitted from the original report and therefore made it difficult to calculate nutrition intakes in relation to actual requirements. This point is being clarified with more recent data collected in Port Harcourt (Dema, 1963b).

## EXTENT AND NATURE OF CROPPING

By considering together the growth curves (figure 3) and the agricultural and dietary records of the areas surveyed (figure 7) it can be seen that the food intakes and physical states of the people depend on the size and nature of the local cropping. Poor transport facilities and rigid food preferences make the people rely almost entirely on what they can produce from their own farms.

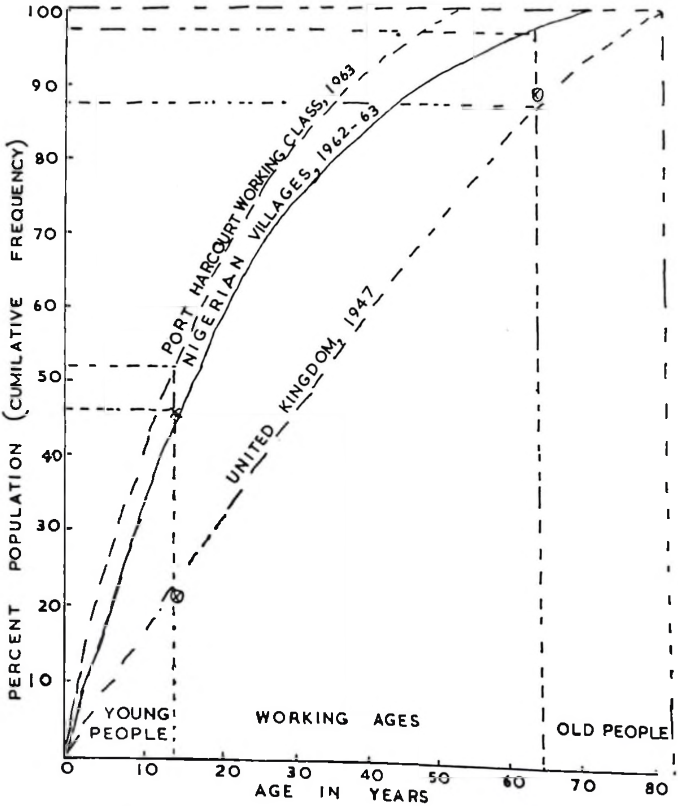


*Fig. 4 Age composition of samples of Nigerian rural and urban families*

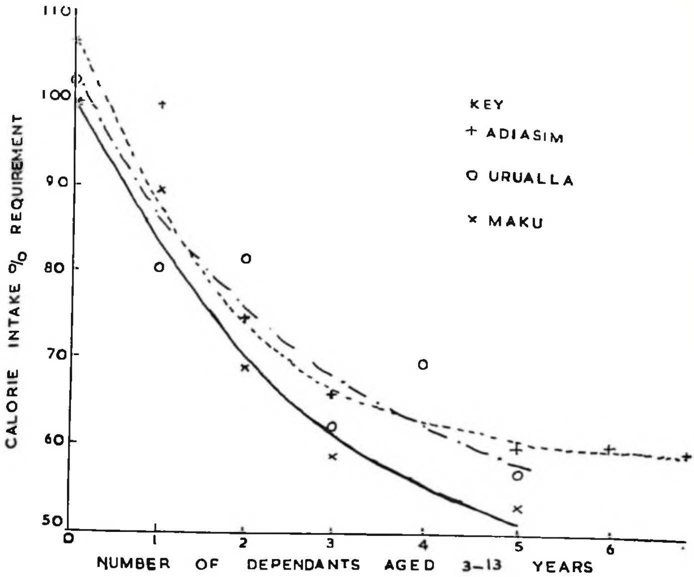


*Fig. 5 Caloric intakes in relation to family size in parts of Nigeria*

Full and adequate diets are not always obtained where the per caput food crop area is small due to population pressure, difficult terrain coupled with the loss of cultivateable lands through erosion (e.g. Awgu in Eastern Nigeria) or the indiscriminate planting of cash crops (e.g. cocoa in Ilesha, and oil palms in south east Nigeria). Because of the people's feeling of urgency for needs other than food, namely, school fees, building materials, clothing, and a variety of religious and social celebrations, the increased earning from the cash crops is not used to improve the diet of the family.

In order to add to the meagre incomes from their small farm holdings the adult males from some of the land-hungry parts of Eastern Nigeria migrate seasonally to work as farm labourers in the timber, cocoa, rubber and denser oil palm areas of the country. There is, on the other hand, no shortage of arable land in Northern Nigeria where cash crops such as groundnuts, cotton and beniseed are grown in rotation with food crops.

## FOOD WASTAGE

Food wastes through pest infestation of growing crops and stored foods, and the effects of inefficient handling and processing, can cause considerable reductions in the quantity of food and nutrients available to the family. The low yields and occasional failures experienced in native cropping are quite often due to pest infestation. For example, Taylor's (1963)

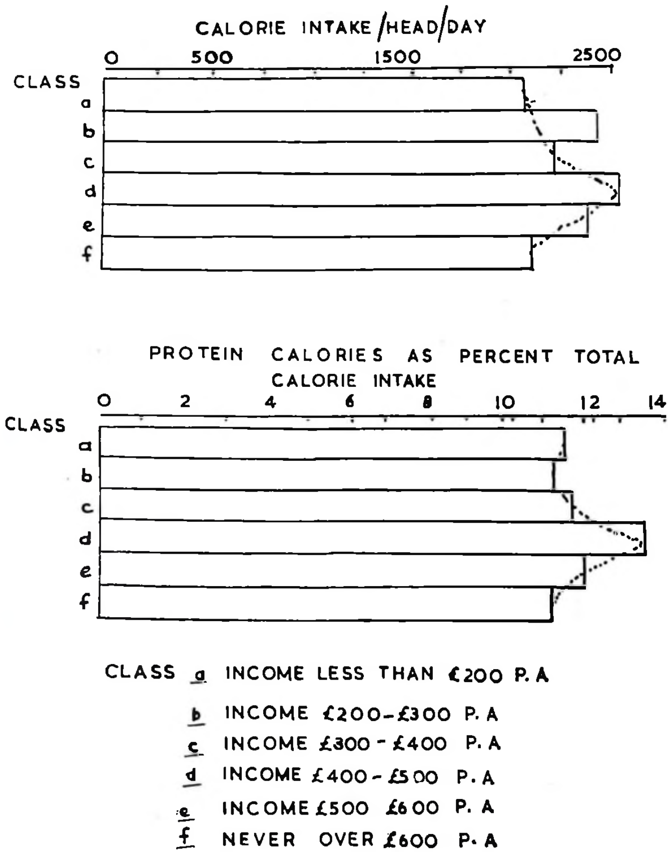


*Fig. 6 Food intake in relation to incomes in Lagos (Oshodi, 1961)*

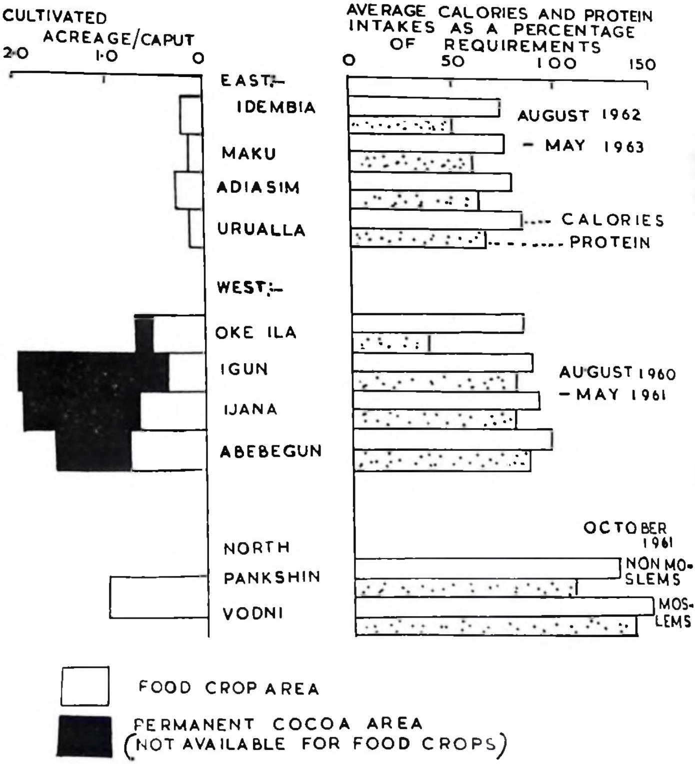


*Fig. 7 Food intakes and crop areas in various parts of Nigeria*

calculations which are based on the count of the number of seeds in insect-damaged cowpea pods indicate that the current yields are between one-sixth and one-third of the potential yield of the crop, and that this discrepancy can be removed by chemical pest control as demonstrated in Samaru (Booker, 1962). Lack of efficient storage facilities also accounts for considerable loss of stored grains.

Turning next to the problems of food processing, quick reference will be made to nutrient losses in preparing corn meals. The traditional corn grinding processes of pounding, winnowing and sieving tend to give highly refined products with concomitant losses of important nutrients in the bran and grits as reported by Carr (1961) in Southern Rhodesia. Another factor which accounts for the protein shortage in the traditional Yoruba dietaries is that maize, which is the third important staple, is eaten mainly as a highly refined meal obtained by wet milling and several rinses with large quantities of water. Recent analysis of samples of the meal prepared in this way show that the resulting product retains only one-fifth to one-third the crude protein of the starting material, the amount of nitrogen lost also being dependent on the degree of deterioration of the grain, since smaller losses were obtained with more recently harvested maize. Corn milling in Northern Nigerian communities seems to involve smaller nutrient losses; the grain is soaked, then dried, before grinding and sieving, and the remnants, if not fed to livestock, are reground into a finer form for incorporating into the meal.

## WAGE-EARNING CAPACITY

The importance of education in raising earning capacity and living standards hardly needs to be argued but some specific evidence of this relationship will be presented to help to stimulate thinking along these lines. Comparison of the diets and health of the village and town communities of the same ethnic origins in Ilesha (Yourba) and Port Harcourt (Ibo) revealed better nutritional states in the urban groups. Probably as a result of their education and higher purchasing powers the urban families kept to the traditional staples but also ate more meat and grain legumes than the villages could afford.

## COMMUNITY DEVELOPMENT AND BETTER NUTRITION

In order to provide the resources needed for a widespread rise in the living standards of the expanding population the following programmes are recommended:

*Industrialization* to absorb the surplus rural population as well as create markets for some of the agricultural produce. Manufacturing industries will try to compensate for the withdrawal of much of the farm labour by:

making simple machinery that can cope with the more tedious farm operations, including bulk food processing,

the development of cheap fetilizers and pest control agents for increased crop yields,

and the establishment of agricultural demonstration, advisory and sales services to encourage farmers to adopt improved methods.

It is by making products which are usable on the farm that the mass diversion of rural labour to manufacturing and other projects will prevent the food shortage of subsequent years (Clark, 1962).

*Rural development* to make agriculture more profitable, and to create such social services as would abolish some of the material differences between urban and rural habitations. Until this is done, one cannot stop the drain of workers to Fernando Po to work on farm projects which could equally be operated in Nigeria.

Village crafts should be introduced to remove the burden of unemployment in the waiting period between the sowing and harvest of the main crop. It will increase earning and therefore avoid the temptation to over-sell staple foods in order to obtain badly needed cash. Improvements should be brought into the small farms, not by major amalgamation since farmers are unwilling to surrender their individual land rights, but through co-operative organizations to improve the technical and commercial aspects of their agriculture.

*Rural education* should include good husbandry on the farm and home management (i.e. home economics extension). This knowledge will equip and encourage the people to make the best use of available resources. Suitable village organisations through which rural education can be taught are adult literacy classess, young farmers clubs and the welfare centres.

*Integrated community development* in which agricultural and economic advancements are linked with health education through food and nutrition, for there is no sense in saving the people from infectious diseases only to let them die later of food shortage. The studies made so far have brought out the inter-relationship between nutritional states and environmental factors (see figure 8) thus under-lining the combined yet simple approach to village development. The Institute of Child Health, University of Ibadan, in collaboration with the respective Western Regional Government Ministries concerned with agricultural extension, rural health, home economics and community development, has initiated a programme of integrated rural development in two pilot villages in Ilesha Division. Plans are also under way to have similar integrated villages development carried out in parts of Eastern Nigeria on the basis of demographic, agricultural, dietary and medical data already collected there with the active co-operation of the Regional Government.

## CONCLUSION

Nutritional data have been applied in bringing into relief the basic problems of the country. It is in the science of nutrition that are seen human needs and human obligations in their proper perspectives (Cuthbertson, 1963). Therefore, taking food and nutrition as the links with the other needs of our community, local co-ordination of the field services would lead to organised planning for a balanced economy in which rural education and agricultural productivity keep pace with urbanisation and the manufacturing industries. Only such a balanced economy in a balanced society can fully provide the basic needs for maintaining decent standards of living for our rapidly expanding population.

## ACKNOWLEDGEMENTS

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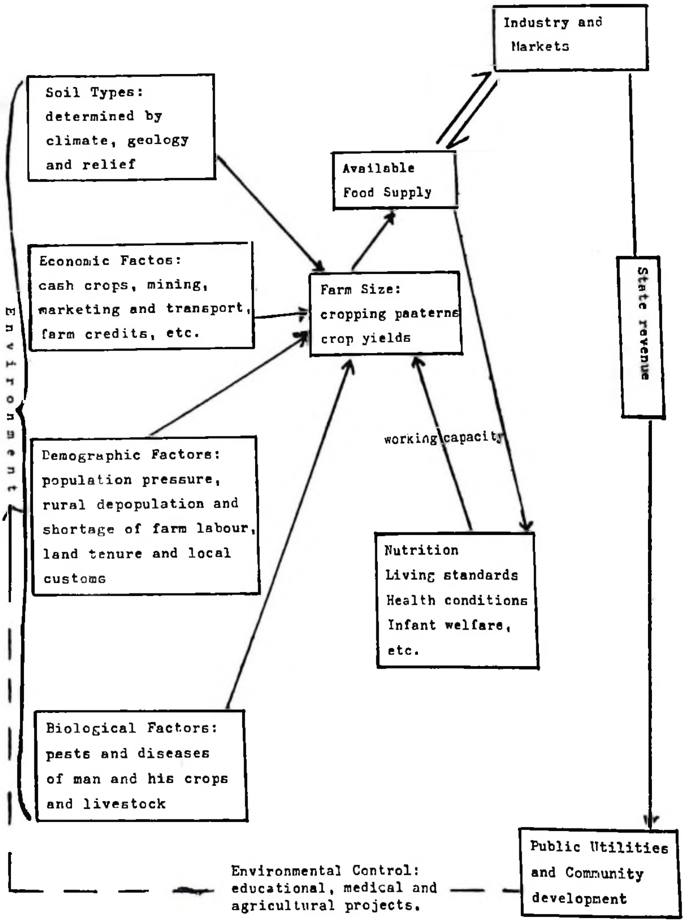
Industry and Markets
Soil Types: determined by climate, geology and relief
Available Food Supply
Economic Factos: cash crops, mining, marketing and transport, farm credits, etc.
Farm Size: cropping paaterns crop yields
State revenue
Environment
working capacity
Demographic Factors: population pressure, rural depopulation and shortage of farm labour, land tenure and local customs
Nutrition Living standards Health conditions Infant welfare, etc.
Biological Factors: pests and diseases of man and his crops and livestock
Public Utilities and Community development
Environmental Control: educational, medical and agricultural projects.

*Fig. 8*

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Mr. J. M. Babalola (*Meteorological Service, Lagos*) **The scope of agro-meteorology in Nigeria.**

SUMMARY

The general scope of agro-meteorology is defined. The role of weather as a controlling factor in food production and the need for agriculturists and meteorologists to work together in close cooperation is stressed. Progress in the field of agro-meteorology in other parts of the world is sketched and the expansion programme of the Nigerian Meteorological Service in this new field is briefly discussed.

## INTRODUCTION

The true wealth of a nation depends on its natural resources. Among these natural resources climate and soil are probably the most fundamental. These two factors are in themselves interrelated in the sense that both the soil and the vegetation growing on it depend to a considerable extent on the climate. On the shorter time scale it is the weather which dictates the best period for carrying out various farming operations; on the longer time scale it is the climate which dictates where certain crops can grow. The importance of climate in agricultural production is still more sharply emphasised by the fact that whereas it is possible by means of fertilisers to reduce the effect of the soil factor to a minimum, such artificial modification in climate is at the moment not possible. Added to this is the fact that the climatic elements vary both in space and time thus causing noticeable changes in environment. Even though these facts are obvious, to establish relationship between the agricultural factors and the climatic elements is not an easy task. First, difficulties arise from the multiplicities of the meteorological elements or their combination, whose influence on plants and animal life is neither equal nor in the same direction. Secondly, the variation of climatic factors from day to day, hour to hour or even minute to minute adds another difficulty to the interpretation of crop yield in terms of the effects of such factors on the physiological process of the plant. Thirdly, there is often a time lag between a climatic factor and its resultant effect on the plant.

Agricultural meteorology is concerned with the interaction between meteorological and hydrological factors on the one hand and agriculture in its widest sense on the other. Its object is to discover and define such effects and thus to apply the knowledge of the atmosphere to practical agricultural use especially in the improvement of agricultural products and reduction of production costs and also in the selection of improved varieties of plants and breeds of animals. Agro-meteorology is primarily concerned with the shallow layers of soil in which the deepest plant and tree roots are firmly established, through the air layer near the ground in which crops and woods grow and animals live, to the highest levels of interests to aerobiology.

In addition to natural climate and its local variation, agro-meteorology is also concerned with artificial modifications in environments (as brought about for example by irrigation, windbreaks and shelter-belts and glass-houses); in climatic conditions of storage, whether indoors or in the field, in animal shelters and farm buildings; in the combating of pests and diseases and during the transport of agricultural produce.

The vegetation of Nigeria is primarily determined by climate; in particular by the mean annual rainfall and the severity of the dry season. In the south, forest is the climax vegetation whereas in the drier north the climax vegetation is savanna woodland. The Nigerian climate is generally favourable for quick plant growth. Frost is unknown and temperatures are uniformly high. Atmospheric changes are governed by the two principal air masses which invade the country. Rainfall on the whole is heaviest in the south, averaging about 70 inches a year in the south-west and 120 inches in the south-east. The amount falls off sharply to the north, where it averages between 20 and 30 inches. The annual mean of daily maximum temperature is about 87°F on the coast rising generally to about 94°F in the north. Mean maximum temperatures are highest in February in the south, changing gradually from March in the Middle Belt to April in the extreme north. The annual mean of daily minimum temperature is about 72°F over most of the south but falls to about 66°F in the north. The annual range of temperature in the south is slight but increases sharply to the north. The absolute maximum and minimum temperatures on record from any part of the country are 111°F (Maiduguri: 11 May 1956 and 11 April 1958; Nguru: 12 April 1958) and 37°F (Potiskum: 8 Jan. 1957) respectively. Near the coast at dawn relative humidity is generally between 95 and 100 per cent decreasing to between 70 and 80 per cent in the early afternoon. The seasonal variation is slight, but periods of a few days of very low humidity may occur in January and February. Northward from the coast the relative humidity decreases steadily and changes abruptly with the seasons, according to whether the locality is under the influence of the very moist south-westerly wind current or the very dry north-easterly current.

## THE INFLUENCE OF WEATHER ON AGRICULTURE

The influence of weather on agriculture may be summed up under various heads, but in this discussion it will be considered under the following:

plant growth and crop production,
diseases and pests of crops and animals,
food storage.

The most important meteorological parameters to consider from the agricultural point of view are rainfall, temperature, radiation and humidity or saturation deficit.

## WEATHER IN RELATION TO PLANT GROWTH AND CROP PRODUCTION

Of all climatic parameters, rainfall is clearly the most important single factor that affects plant growth and crop production. Rainfall is important to the plant throughout its various stages of development more especially during its critical periods and also at the sowing time.

It must be mentioned here that it is not necessarily the amount of rainfall that counts but the amount of water available in the soil for the plant. This in turn depends not only on the amount of rain but also on the type of soil, its topography, and also on evaporation and transpiration. Not only does deficient rainfall hinder the healthy growth of plants, excessive rainfall is equally harmful as it causes water logging which prevents atmospheric oxygen from reaching the roots of the plants. In general, rainfall or the water factor both in its intensity and temporal distribution determines to a large extent the quantitative yield of crops.

According to Azzi (1956) "if soil moisture has been below limit compatible with normal development during the critical period of cereals poor harvest results even if conditions have been favourable during the vegetative period. On the other hand, when water is plentiful during the critical period the yield is good even if there has been a relative deficiency throughout the rest of the biological cycle". In like manner Adejuwon (1962) in a survey of the crop-climate relationship for cocoa in Western Nigeria found a significant correlation between "the dry season mean total rainfall and the areal intensity of cocoa production". Areal intensity is defined as the "percentage of cultivated land that is devoted to cocoa production". He also found that over 70 per cent of the areas growing cocoa have a mean annual rainfall of between 50 and 60 inches and also "that the elements of climate are more important than soil characteristics" for cocoa production. In discussions with officials of the Ministry of Agriculture and Natural Resources at Ibadan the writer was informed that the 60 inches isohyet seems to set a minimum "rainfall limit" to the economic cultivation of rubber and also that the cotton plant requires maximum water during its twentieth week (critical period) this time being the period of maximum leaf development.

In this country temperature is in general less important than rainfall and is usually reflected more on the quality than on the quantity of the yield. Temperature becomes a serious problem when the daily maximum temperature becomes so high that it causes shrivelling. This is most likely during a prolonged hot spell, when those factors accentuating transpiration reach such an intensity that the roots, although absorbing water fully from the soil, are unable to compensate for transpiration losses. Under this condition wilting may occur even in soils saturated with water or in soils irrigated with water; indicating that the phenomenon is not necessarily due to lack of water alone.

The ultimate source of energy for sustaining life is the radiant energy of the sun. Plants are sensitive to the total intensity of radiation, its quality and also to the photo period. For some processes such as assimilation, the longer wavelengths of the spectrum are the most important while for others like elongation the shorter wavelengths are the most effective. Solar radiation is primarily an astronomical phenomenon; the amount reaching any point on the earths surface as a whole depends on various factors like its distance from the sun and especially on the type and amount of cloud. In Benin (WAIFOR) for example the monthly mean of daily global radiation varies from a maximum of about 410 gm cal/sq cm/day in April to a minimum of about 290 gm cal/sq cm/day in July. There is also a secondary maximum (390 gm cal/sq cm/day) in October and a secondary minimum (330 gm cal/sq cm/day) in January. The minima are primarily due to predominantly cloudy weather in July and also the harmattan haze in January. The photoperiod as opposed to rainfall and temperature which are extremely variable in space and time has the advantage of remaining constant from year to year although it may vary from season to season. Until recently it was generally assumed that the seasonal differences in daylength in the tropics were too small to affect plant behaviour. It has now been clearly demonstrated that on the contrary tropical plants are extremely sensitive to the photoperiod. Njoku (1958) experimenting with a number of southern Nigerian plants at Ibadan (07° 26'N 03° 54'E) where the daylength varies from 11 hours 40 minutes in December to 12 hours 33 minutes in June, found that for most of the plants tested "the photoperiod is very narrowly defined" and that "a difference of 15 minutes may mean flowering or only vegetative growth". In Lagos (06° 27'N 03° 24'E) the maximum photoperiod is about 12 hours 30 minutes (June) and the minimum 11 hours 45 minutes (December). For Kano (12° 03'N 08° 32'E) the figures are 12 hours 50 minutes (June) and 11 hours 25 minutes (December) respectively.

The humidity of the air is one of the dominant factors in plant growth and crop yield. Its influence becomes the more important during the ripening stage when the water need is very low and also during harvesting. Modern harvesting techniques aim at ensuring minimum loss of yield; the harvesting time being determined by the maturity of the grains or fruits which in turn depends on the environmental temperature and humidity. The rate of ripening is governed by the rate at which moisture is lost by the plant to its environment and, consequently, depends on the air humidity, which in turn may be expressed more conveniently by the saturation vapour pressure deficit. From the agricultural point of view the saturation vapour pressure deficit (which effectively measures the evaporative or drying power of the air) is a more useful parameter than atmospheric humidity. In fact according to Protserov (1962) "a hyperbolic relationship exists between the length of the interval from yellow to complete ripeness [for fruits and grains] and the mean daily vapour pressure deficit". Thus once this relationship has been established it is an easy matter to forecast the date of full maturity.

## WEATHER IN RELATION TO PESTS AND DISEASES OF PLANTS AND ANIMALS

The effect of weather on the pests and diseases of plants and animals is threefold. First, the weather influences the susceptibility of plants and animals to attack by pests and diseases. During this critical period temperature alone is sufficient to trigger off an outburst of infection. Once the thermal threshold has been reached relative humidity becomes the most important factor. Thus, for sugar-cane the condition known as red stripe is particularly virulent only when the relative humidity reaches about 85 per cent and the plant is about 2-3 months old. When the relative humidity is below 85 per cent the effect of an infection is not generally significant.

Secondly, weather enters into the biology of the insects and disease organisms and this affects the nature, numbers and activity of pests and the extent and virulence of diseases. A common example here is the effect of rainfall in accelerating the emergence of insects from quiescent stages. The effects are partly due to the mechanical action of water on the outer covering of pupae (cocoons) or egg shells which can be burst only when softened, while in some cases the effect may be connected with absorption of water necessary for completing the development of the stage or the resumption of physiological activities. Indirect controlling action of rain through vegetation is also important as drought conditions cause destruction of insects through lack of food material or in the cases of the tsetse fly through lack of shade.

Similarly, it is well known that for the occurrence of an epidemic, it is not necessary for the fungus or other pathogen to be present at the outset in overwhelming numbers. It is sufficient if a small amount of the pathogen is present in a resting or latent state; for these, when the weather is favourable, will develop and attack the host plant. Consequent upon this the secondary source of infection (usually spores of some kind) formed by the pathogen when once established on the host plant become distributed naturally, often by winds, to other plants. In this way the area of infection increases and an epidemic develops.

Thirdly, weather factors have an impact on the timing and the effectiveness of control measures and on the amount and toxicity of spray residues on harvested crops. To secure fungicides and insecticides is not enough. The best material may fail if used in the wrong way or at the wrong time. The user should know something about the habits of the pests he wants to get rid of, the physical properties of the insecticides and their effectiveness, and also the influence of weather on the insecticides both during and after application.

Rain, wind, and turbulence are the major factors which may affect the application of insecticides. High temperature may also affect certain types of insecticides and rain may wash off those which are soluble in water. The wind acts in such a way as to decrease fume concentration by dilution. Strong winds may carry away the dust already deposited on the leaves to regions where they are not needed. Normally near the ground the maximum wind speed occurs about mid-day, while at night it diminishes to a minimum. Similarly on a clear sunny day the earth's surface is warmed by the rays of the sun. The air layer next to the ground is in turn warmed by conduction from the ground surface while the upper layers remain relatively cool. An overturning occurs and convection currents are set up which transport the spray upward from the leaves while it is settling. Thermal turbulence increases during the day and part of the insecticide may be transported to regions where it is not needed. On clear nights, owing to surface cooling an inversion is soon formed near the surface of the earth and the atmosphere becomes quite stable. Thus, day time, although the most convenient time for spraying is in fact not the most practical time. Thus the application of dusts or sprays should be made early in the morning or in the evening.

## WEATHER IN RELATION TO FOOD STORAGE

Most agricultural products as they reach maturity become increasingly sensitive to weather condition and once picked these products usually deteriorate. Deterioration results from certain physiological processes caused by enzymes which begin their decomposition. Some products however require these processes to a certain extent to reach their full maturity and flavour. The dominating factors in this case are temperature, rain and humidity. According to Vant Hoff, for every 10°C rise in temperature above 10°C the rate of growth (or deterioration) approximately doubles. Thus if tomatoes keep in good condition for four days at a temperature of 10°, they will only keep for 2 days at a temperature of 20°C and for only 1 day at a temperature of 30°C. At less than 10°C the process of decomposition is reduced to a minimum. Below the ideal temperature, products are damaged by cold and this further complicates the decomposition process. Ideally therefore, agricultural products should be stored at their optimum temperature.

From the forgoing it will be seen that the role of weather and climate in agriculture is a very vital one. Experience from other parts of the world reveals how very disastrous it could be to ignore the effects of weather factors during the planning stages of an agricultural project. Among the most recent in the series of such projects which ended with catastrophic failures could be cited the Groundnut Scheme in Tanganyika, and also the Colonial Development undertakings in Nigeria, Gambia and Bechuanaland. It is a matter for regret therefore that so little attention is being paid to the weather aspect of agriculture by our agriculturists.

## COLLABORATON BETWEEN AGRICULTURISTS AND METEOROLOGISTS

The objectives of agro-meteorology can be fully achieved only if there is close collaboration between agricultural and meteorological interests. On the international level this liaison is secured mainly by co-operation between the World Meteorological Organisation (WMO) and the Food and Agriculture Organisation (FAO) of the United Nations. On the national level WMO (1963) recommends the establishment of national co-operating committees composed of representatives of meteorological, agricultural, animal husbandry, forestry, hydrological and soil science, or alternatively the establishment of satisfactory direct liaison between the meteorological service and the other agencies. Apart from problems of general co-ordination, the following measures were also recommended:-

(*a*) The establishment of national committees composed of both meteorologists and agricultural scientists.
(*b*) The encouragement of personal collaboration between meteorologists and agricultural scientists in research field, experiment, advisory and educational activities.
(*c*) The employment in the national meteorological service of persons well trained in agriculture and/or employment in the agricultural service of persons well trained in meteorology.

The services which the meteorologists can provide for the agriculturist may be briefly summarised as follows:-

(*a*) To co-operate with and seek advice from agricultural services in all matters of common interest. To supply, as far as practicable, any available meteorological data required by agricultural scientists in their research, experimental or advisory work.
(*b*) To advise on the best utilization of weather and climatic data in attaining such objectives as improving agricultural production, introducing new species of plants and animals and increasing the area in efficient farming use.
(*c*) To assist agricultural and allied interests in combating unfavourable weather and climate.

(d) To assist in the fight against agricultural pests and diseases, by consideration both of environmental factors in their life-histories and of the meteorological factors which may influence the effectiveness of protective measures taken against them.
(e) To advise on the protection of agricultural products, in storage and in transit, against damage by weather.

In turn the agriculturists should provide the agro-meteorologist with the following services and information:-

(a) To co-operate with and seek advice from meteorological services in all matters of common interest.
(b) To supply meteorologists with such ecological data on the life-histories of plants and animals, and of the pests and diseases thereof, as may serve as a guide in the preparation of corresponding weather forecasts and in the drawing-up of climatological advices on such matters as the introduction of new plants and animals.
(c) To encourage the institution of continuous and comprehensive national surveys of important agricultural pests and diseases, so that the relationships with weather factors in different regions may be studied further.
(d) To supply, as far as practicable, statistical data on crop yields, adequate for the investigations of reliable crop-weather relationships.
(e) To co-operate with meteorological services in the establishment of standard agrometeorological stations and in the collection of other relevant data.

Working together, the meteorologist and agriculturist should be able to provide among other things, the following services:-

(a) Establish meteorological equivalents for the main crops in the country and also the critical periods for these crops.
(b) Establish agroclimatic indices (i.e. quantitative relation between elements of agricultural production and climate) and also prepare an agroclimatic atlas for the country.

## AGRO-METEOROLOGICAL FORECASTS

One of the most practical ways in which meteorologists could be of service to agriculturists is through a regular weather forecast specifically designed for agriculture. Such weather forecasts can make a very useful impact on a very wide range of agricultural problems and practices. In particular, forecast of the onset of the rainy season will go a long way in helping agriculturists in planning well ahead when to plant their crops. Similarly medium or long range forecasts of rainfall amounts and intensities and of temperature could help greatly in planning cropping, grazing and tilling.

Another type of forecast that can be jointly undertaken by both agriculturist and meteorologists working together is "crop yield forecasts". The value of such a forecast can not be overemphasized in a country like Nigeria where agriculture forms the mainstay of the country's economy. Such a forecast is of vital importance to the Government for purposes of taxation and also for purposes of providing adequate storage sheds for such crops like cocoa or groundnuts which may have to be stored for an unspecified length of time before they are exported. It also acts as a counter against false speculation which if not checked may lead to inflation. Finally for a crop like groundnuts, it is important to know the probable size of crops so that adequate arrangements to convey the crops may be made well in advance.

Before any progress in crop yield forecasts can be made however it is necessary to establish a set of climatic parameters significant to crop yield. It is gratifying to note that work along this direction is in progress in some parts of the country. For example some workers in WAIFOR (1963) have recently found that for the oil palm, a good correlation exists between field bunch yield and the effective sunshine 28 months previously.

The third way in which meteorological forecasts can aid agriculture is in agricultural aviation forecasting. The application of agricultural chemicals by spraying and dusting are largely controlled as has been pointed out above by weather factors. Rain is probably the most significant parameter followed by wind speed. The range of tolerance to be allowed for wind speed varies with the urgency of application, the topography of the area and the toxicity of the chemical since a strong and favourable wind may carry the chemicals over long distances to human habitation. In this case however the meteorologist could only issue a forecast at the express demand of the agriculturist or the pilot.

## THE FUTURE OF AGROMETEOROLOGY IN NIGERIA

The potentialities of an agro-meteorological service in this country are immense. Realising this and following the example of many other countries in the world the Nigerian Meteorological Service has now set up a small unit to cater specifically for agricultural problems. As a first step an expert was invited to this country a few months ago to advice on the establishment of an agro-meteorological service in Nigeria. He has already submitted his provisional report which is now being carefully studied by the various Governments.

At the moment however and owing to acute staff shortage the activities of the Agro-Meteorological Unit are limited to routine advice to agriculturists on meteorological problems and the publication of the monthly Agro-Meteorological Bulletin. This publication which is issued free of charge to all agricultural interests contains items of interest to agriculturists and also climatological data for about 40 Nigerian stations for the preceeding month. Among the special investigations which have been undertaken by the Agro-Meteorological Unit to meet agricultural demands are the calculation of the potential evapotranspiration and also the saturation vapour pressure deficit for all stations for which sufficiently reliable records are available all over the country.

At the moment, the observational network of the Meteorological Service comprises some 27 synoptic, 50 agro-meteorological and 51 climatological stations. The synoptic stations are manned by full-time professional observers maintaining continuous weather watch and making hourly instrumental observations for periods of up to 24 hours daily. Temperature, humidity, pressure, rainfall, sunshine and in some cases wind are recorded autographically. The agro-meteorological stations are manned by part-time observers making twice daily instrumental observations of temperatute, humidity, rainfall, evaporation wind and soil temperatures. Some elements are recorded autographically. Climatological stations are similarly manned by part-time observers making once or twice daily instrumental observations of rainfall, temperature and humidity. In addition to these there are about 1,000 rainfall stations where observation of rainfall are made once every day.

In the near future the number of synoptic stations is to be increased to about 60 whilst that of both agro-meteorological and climatological stations is to be increased correspondingly to give a better coverage of those areas where meteorological data are at present scanty. The strength of the rainfall stations is also to be increased to about 2,500. One major problem mitigating against this expansion programme is the inaccessibility of some parts of the country. Arrangements are however on hand for the establishment of a few all-purpose automatic weather stations. These will be supplemented with a number of totalisators and pluviographs which need only be attended once or twice a year. Plans are also on hand to establish a standard agro-meteorological station at the major agricultural research stations and also a principal field station near the Meteorological Training School at Oshodi.

There has of late been an increasing demand for radiation data all over the country. Because of its high cost and also because of the special skill required to handle these instruments, it has not been possible to establish enough radiation stations to give adequate coverage to the various climatic regimes in the country. With the co-operation of the university authorities plans are now ahead to install radiometers in these institutions and other research centres for both total and diffuse measurements. Arrangements are also being made to provide an agro-meteorologist in each regional capital. In this way the meteorologist can learn at first hand the problems facing the agriculturist. Similarly a group of field inspectors are to be trained and these will be responsible for the regular inspection of the various meteorological stations all over the country.

As is usual in most ventures, the limiting factors are money and personnel. So also in this case, what will govern the rate at which the Agro-Meteorological Service will develop in this country will be largely determined by the availability of funds and trained personnel. Once the initial difficulties are overcome the Agro-Meteorological Service in conjunction with the agricultural agencies will no doubt be able to play a leading role in the scientific and economic development of our country.

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Mr. R. N. Jenkin (*Federal Department of Forest Research, Ibadan*) **The role of soil survey in the development of the forest resources of Nigeria.**

SUMMARY

Nearly 80 per cent of the forest land of Nigeria carries savanna vegetation. In the savanna reserves, even under the most favourable conditions of full fire protection, the vegetation yields only a small amount of firewood and a few poles. The demands of agriculture are threatening much of the land at present occupied by forest; whilst, at the same time, a general raising of the standard of living is ensuring an ever-increasing local consumption of timber. A serious attempt is now being made to alleviate this situation by the establishment of plantations of more valuable exotic species. Satisfactory results can be achieved only by careful planning in which soil survey has an important part to play, as evidenced by the very mixed success of early attempts at plantation establishment where little attention was paid to soil factors.

Two of the basic requirements for the successful establishment of plantations are a knowledge of both the soil preferences of the various tree species grown in plantations and the characteristics of the soils in available plantation sites. If soil surveys are to be of use in the selection of sites for plantations, emphasis must be placed on the production of maps showing the distribution of individual soil properties rather than soil types determined by a variety of factors. The average forest officer, faced with undertaking extensive soil surveys, has neither the time nor special qualifications for this, unless a method is adopted in which most of the field and office work can be left to trained junior staff.

The method of survey advocated is divided into four phases or steps, in which each step provides progressively more information than the previous one and where the number of steps taken will depend upon the amount of detail required. In the first phase, the preliminary reconnaissance survey, aerial photographs are used to map the major vegetation and topographic units, whilst in the subsequent phases, the reconnaissance, semi-detailed and detailed surveys, the soil profile is examined using a soil auger at intervals of 400 feet, 200 feet and 100 feet, respectively. Specially designed forms are used to record the soil profile characteristics to ensure standardisation of observation. Unsuitable areas for development, as they appear during the early phases of the survey, are eliminated and the area surveyed is progressively reduced as the later more detailed survey stages are reached.

A series of maps are prepared from the profile description forms showing the distribution of individual soil properties, such as colour, mottling, texture, consistence, stoniness and depth, thereby obviating the influence of personal interpretation at too early a stage in the survey. These maps, which can be prepared by junior staff, present the information collected in the field in such a form that they are readily interpreted, in the same way that a graph or histogram often illustrates a point more clearly than a column of figures.

## THE VALUE OF SOIL SURVEY

In Nigeria, as in many other developing tropical countries, increasing emphasis is being placed upon the necessity for efficient land use as the pressure on the available land grows. The demands of agriculture are threatening much of the land at present occupied by forest; whilst, at the same time, a general raising of the standard of living is ensuring an ever increasing local consumption of timber. In the high forest areas of the south, and particularly the West and Mid-West Regions, the claims of agriculture are more easily withstood because of the annual revenue accruing from the exploitation of the forests (table 1). On the other hand, in the savanna areas of the Northern Region, where the natural vegetation is too sparse and in many cases unsuitable even to fulfil the requirements of the local population, let alone promote an export trade, agricultural pressure is less easily resisted except on the grounds of soil and water conservation, especially in catchment areas. Also in Nigeria there is a desire to attract industries which can utilise locally produced raw materials; typical of such industries are paper and chipboard manufacture.

Table 1: Income and Expenditure on Forestry by Regional Governments, Native Authorities and Local Councils

Data in pounds sterling from latest available Annual Reports

| REGION | YEAR | INCOME | EXPENDITURE | SURPLUS OR DEFICIT |
|---|---|---|---|---|
| East × | 1961-2 | 55,374 | 118,415 | −63,041 |
| North* | 1961-2 | 54,584 | 325,715 | −271,131 |
| West | 1958-9 | 467,797 | 341,551 | +126,246 |

× Includes Colliery Plantations of Nigerian Coal Corporation.
* Only draft form of Annual Report available.

About a third of Nigeria's 356,669 square miles is forested and of this third nearly eighty per cent carries a savanna vegetation (table 2). Therefore, considered from the point of view of timber production, the effective potential productive area is only 9,328 square miles or 2.6 per cent of the total area of Nigeria. In the savanna reserves, even with full fire protection, which is impractical in most cases, the natural vegetation produces only small amount of firewood and a few poles per acre. Table 2 shows that a large proportion of the area of high forest available has already been reserved so that, even if it were possible, little immediate increase in total production could be achieved by an expansion of the forest estate. The need therefore is to improve the productivity of the land at present devoted to forestry.

Table 2: Area of Forest Land and Forest Reserves in Nigeria. Data, in Square Miles, Taken from Standard Form I in Latest Available Annual Reports

| | | SAVANNA | | HIGH FOREST | | MANGROVE | | TOTAL FOREST | |
|---|---|---|---|---|---|---|---|---|---|
| REGION | YEAR | Forest Reserves | % Savanna | Forest Reserves | % High Forest | Forest Reserves | % Mangrove | Forest Reserves | % Total Area of Region Reserved |
| EAST | 1961-2 | 66 | 2.5 | 2,511 | 95.8 | 45 | 1.7 | 2,622 | 8.9 |
| NORTH | 1960-1 | 23,518 | 97.8 | 521 | 2.2 | 0 | 0.0 | 24,039 | 8.5 |
| WEST | 1958-9 | 3,006 | 41.5 | 4,228 | 58.4 | 10 | 0.0 | 7,244 | 16.0 |
| TOTAL | | 26,590 | 78.4 | 7,260 | 21.4 | 55 | 0.2 | 33,905 | 9.5 |

In the high forest reserves, the standing trees represent a certain capital on which interest is received through the annual increment of each tree. Additions to the list of economic species, as recommended by research departments can increase the capital value of the forest; careful silvicultural tending can increase the interest rate by raising the growth rates of the more valuable timber species. The capital may be increased further by enrichment techniques, such as line planting, in which seedlings of the more important species are planted in areas whose natural vegetation shows a paucity in economic species. In some cases it may be found that the clearing of the natural vegetation and the establishment of plantations of valuable exotic species, such as teak, is more profitable. In such cases, however, it is important to ascertain if the site is suitable for the species to be planted before any drastic action is taken to implement the proposal. Here soil survey must play its part.

In the savanna areas, the capital as represented by the trees is small and the rate of interest, even under the most favourable conditions, is poor. In most cases full fire protection is not possible, so that optimum conditions for growth are seldom achieved. Experiments carried out by the forest departments of Nigeria have shown that where full fire protection is not possible early burning offers a partial solution. Even with early burning the stocking and growth rates are low and many species are of poor form and produce timbers whose characteristics do not commend them to the timber contractor or the user. The solution must be found instead in the establishment of plantations of more valuable exotic species, which means in effect that the "true" capital is represented by the soil rather than the trees at present occupying the site. Therefore with a forest policy bent upon increasing plantation establishment, soil survey becomes of particular importance to the forester; especially so, when the very mixed success of early attempts at plantation establishment are subjected to a critical appraisal.

Two of the basic requirements for the successful establishment of plantations are a knowledge of the soil preferences of the various tree species and a knowledge of the properties of the soils in available plantation sites. The elucidation of the soil requirements of a tree species is a problem more suited to a research department, but the collection of information concerning the soils and their distribution throughout the forest estate must normally remain the work of the forest officers in the field. The method of survey adopted to fulfil the second requirement must be such that full advantage can be taken of the work, now proceeding in the Federal Department of Forest Research, on the correlation of the growth rates of the more important plantation species with the physical and chemical characteristics of the soil. It has been found that emphasis must be placed on the mapping of individual soil properties, such as texture, stoniness, depth, presence of mottling, colour and consistence, rather than on mapping soil series. In the agricultural soil surveys carried out by the Regions, one group of highly trained personnel is responsible for the survey of the whole Region and therefore a unified classification system can be developed. In forestry relatively restricted and widely separated areas are surveyed intensively, each area often being the responsibility of a different group, and the adoption of a single classification into soil series is impractical.

## THE METHOD OF SOIL SURVEY

For a soil survey method to be suitable for forestry purposes, a number of conditions must be satisfied, namely:

(*i*) It should not require the services of a trained soils specialist, being entirely within the scope of a competent forest officer.

(*ii*) It should be possible for the greater part of the work to be performed by unskilled and semi-skilled workers.

(*iii*) The supervision by a senior officer should be reduced to a minimum; it being practical to employ trained junior staff to organise and supervise nearly all of the field work and much of the office work.

(*iv*) It should occupy the minimum of time both in the field and in the office.

(*v*) It should produce factual results that are independent of personal interpretation, especially where relatively inexperienced personnel are involved.

A procedure has been adopted for forest surveys in Nigeria (Jenkin, 1963) in which there are four phases, namely:

I. Preliminary reconnaissance survey
II. Reconnaissance survey
III. Semi-detailed survey
IV. Detailed survey.

The four phases of the soil survey procedure form a series in which each step provides progressively more information than the previous one concerning the classification and description of the soils of an area. The number of steps to be taken will depend upon the object of the survey and the locality.

Where the object is to assess the forestry potential of large areas the preliminary reconnaissance survey (phase I) may provide sufficient information, especially in the drier sahel and sudan savanna zones. However, where the site for a plantation is sought, the degree of detail required before an accurate estimate of the potential plantation can be made, necessitates survey up to the semi-detailed level; whilst in the selection of a site for a species trial or an investigation, it is essential to survey up to the detailed level. Each type of survey has its own particular importance and it is quite wrong, in an attempt to save time, for semi-detailed surveys to be made before preliminary reconnaissance and reconnaissance surveys have been completed. Such action usually results in large areas of wholly unsuitable soils being mapped at the semi-detailed or even detailed level. If the whole procedure is followed step by step, up to the phase which will give the desired amount of information, a reduction in the area to be surveyed at the more detailed levels is usually possible through the elimination of many of the unsuitable sites as they appear during the earlier phases of the survey.

In the preliminary reconnaissance survey (phase I) aerial photographs are used to plot the major vegetation and topographic units. In the sahel and sudan savanna zones, where a reasonable correlation exists between the soil, topography and vegetation, these maps are usually reliable and accurate. By contrast, in the guinea and derived savanna zones, the vegetation, conditioned as it is by fire and cultivation as much as by edaphic factors, is not such a reliable guide to the soil; here the topography provides a sounder basis for the classification and mapping, through the concept of the catena. In the forest zone, the interpretation of aerial photographs is more difficult and less is known of the correlation between the floristic composition and the soil conditions. In the reconnaissance, the semi-detailed and the detailed surveys (phases II, III, and IV) soil sampling is carried out using an auger at regular intervals throughout the area, the intensity of the survey increasing with each ensuing phase. The intervals between auger points for the three phases are 400 feet, 200 feet and 100 feet, representing a sampling density of 1 per 4 acres, 1 per acre and 4 per acre, respectively.

Standardisation of observation is ensured by the use of specially designed description forms on which not only the soil property headings but also the possible descriptive terms are printed (fig. 1). The recorder merely has to place a cross against the appropriate descriptive term. Normally, all auger samples are brought to some central point for description, thus greatly facilitating adequate supervision at this stage.

The data recorded on the description forms is transferred directly on to maps without any attempt being made to interpret the results at this stage. For each horizon a series of maps is produced, each map showing the distribution of one soil profile characteristic. Thus for each horizon there will be five maps, showing colour, mottling, consistence, included material and texture respectively. A scale of 1:12,000 has been found satisfactory because it permits the use of one-tenth inch graph paper for plotting and both phases II and III can be plotted on the same map. For convenience in plotting, a larger scale is used for phase IV.

Though the number of maps produced may seem unduly large, the work of plotting is entirely routine and can be undertaken by junior staff. These maps present the information

SOIL AUGER SAMPLE DESCRIPTION FORM

Survey Area.................... Traverse No.............. Point No............ Date.....................

| HORIZON | | | 0–3 | 3–6 | 6–12 | 12–18 | 18–24 | 24–30 | 30–36 | 36–42 | 42–48 | 48–54 | 54–60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COLOUR | MUNSELL NUMBER | | | | | | | | | | | | |
| | NAME | | | | | | | | | | | | |
| MOTTLING | | *Faint* | | | | | | | | | | | |
| | | *Distinct* | | | | | | | | | | | |
| | | *Prominent* | | | | | | | | | | | |
| CONSISTENCE | | *Loose* | | | | | | | | | | | |
| | | *Hard* | | | | | | | | | | | |
| | | *Very Hard* | | | | | | | | | | | |
| INCLUDED MATERIAL | TYPE | *Iron Stone* | | | | | | | | | | | |
| | | *Rock debris* | | | | | | | | | | | |
| | | *Ca-Carbonate* | | | | | | | | | | | |
| | QUANTITY | *Occasional* | | | | | | | | | | | |
| | | *Many* | | | | | | | | | | | |
| | | *Abundant* | | | | | | | | | | | |
| | SIZE | *Small* | | | | | | | | | | | |
| | | *Medium* | | | | | | | | | | | |
| | | *Large* | | | | | | | | | | | |
| TEXTURE | | *Sand* | | | | | | | | | | | |
| | | *Loamy Sand* | | | | | | | | | | | |
| | | *Sandy Loam* | | | | | | | | | | | |
| | | *Loam* | | | | | | | | | | | |
| | | *Clay Loam* | | | | | | | | | | | |
| | | *Light Clay* | | | | | | | | | | | |
| | | *Heavy Clay* | | | | | | | | | | | |
| WATER TABLE | | | | | | | | | | | | | |

FIGURE I. SOIL AUGER SAMPLE DESCRIPTION FORM.

collected in the field in such a way that, for the senior officer, interpretation is very greatly facilitated. In contrast, when interpretation directly from the description forms is tried, the results are often unreliable and usually incomplete through the classification being limited to one or two characteristics to the exclusion of all other soil profile features described.

From these maps, the extent of the variation of each soil property within the plant community, topographic or catenary unit can be measured, comparisons can be made between the soils of widely separated areas as well as assessments of the soil in terms of its suitability for a particular tree-species.

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Mr. D. W. M. Haynes (*Institute for Agricultural Research, Ahmadu Bello University, Zaria*) **The development of Agricultural Implements in Northern Nigeria.**

Agricultural Engineering covers a wide range of endeavour. If the widely-held, but erroneous, idea that an agricultural engineer is a highly-paid vehicle mechanic is disregarded, the work of our agricultural engineers may be divided into field engineering and farm mechanisation. In Northern Nigeria most Agricultural Engineers are engaged in field engineering, which includes the design, construction and operation of irrigation and soil conservation schemes, land clearing, and other projects to develop and protect the two basic resources, water and soil. The men engaged in such work are often civil engineers and tend to call themselves "irrigation engineers" or "soil conservationists" rather than "agricultural engineers"—a term which is usually reserved for those working directly on farm mechanisation.

In planning a short paper it is tempting to catalogue agricultural engineering successes, such as irrigation schemes, the rice ploughing schemes which are providing an invaluable service at an economic rate, and the successful development of methods for yam cultivation, planting and harvesting (Stokes, 1959). However the theme of the conference suggests challenges rather than achievements and I have chosen as my theme a sphere in which we have made some limited progress but are still groping for the final answer—that is the mechanisation of upland, rain-fed farms.

Farm mechanisation means literally the application of machines to farm work and thus should be applied to the introduction of any device with two or more working parts which will improve the application of power to the task in hand. However, in modern English usage, the word mechanisation implies the use of prime movers and, especially, of systems of farming depending on tractors for power.

In both its common and its wider sense, mechanisation aims at increasing the productivity per man. Workers in other disciplines strive to increase the yield per plant or the yield per unit area of soil but the agricultural engineer tries to increase the yield per unit of labour. In certain cases, it is true, the use of greater power may ameliorate some adverse condition and, by allowing the full potential of the plant or soil to be realised, may increase yields. More commonly, however, mechanisation brings a reduction in yield per acre but a marked increase in the out-put per worker.

In other words, mechanised farming is essentially extensive: machines, which are unable to take decisions, and can rarely be controlled with an accuracy of more than a few inches, find few applications in intensive farming.

Intensive and extensive methods are mingled haphazardly in the farming pattern of Northern Nigeria. Essential food crops often receive fairly intensive treatment, and intercropping with several different plants is common, but extensive methods are usually applied to cash crops. The one factor which is common to subsistence and cash crop farming throughout the country is the low level of productivity.

The vast majority of Northern Nigerian farmers use nothing but simple hand tools for all their tasks. The indigenous tools are similar in design to those in other countries with similar conditions in the Near and Far East: the metal parts, indeed, are probably of better quality than those used by millions of farmers in other parts of the world. Northern Nigeria, however, is somewhat unusual in that the first major step in mechanisation—that is the use of draught animals for primary cultivations—was taken within living memory.

Animals were first used to cultivate Government farms in 1922 but it was not until 1928 that the first two private individuals used draught oxen on their farms: these farms, near Samaru, were the first of the so-called mixed farms. By 1956 there were 15,452 mixed farmers but it is impossible to give accurate figures at the present time. The reason for this is that until 1956 all mixed farmers were established with precisely-recorded Government loans but in recent years thousands of farmers have acquired cattle and ploughs and set themselves up as mixed farmers without any outside help. This is an encouraging development.

Very little data have been published on the productivity and economics of mixed farms, although departmental annual reports hint at many interesting changes. For example, locally-made wooden ridging ploughs were used for thirteen years until Ransome DY steel ploughs were first imported in 1935. Yet there is no readily available information on the effect of this radical change. The DY plough was superseded by the Emcot designed specifically for our conditions and this in its turn, was replaced after the war by Emcot S17. Each plough was superior in technical details to its predecessor, but no details of the effect on productivity have been published.

Gittens (1950) has collected information on similar changes in America and table 1 shows his data on cotton, a crop grown in Nigeria. Unfortunately, Gittens does not record any figure for hand farming, his first reference being to wooden ploughs in 1841. It may be assumed however that the hand labour required in the United States in 1840 was about the same as that needed in Northern Nigeria in 1963—that is, very roughly, 330 man hours per acre.

Table 1: Man-hours to produce cotton by different methods in the U.S.A. (From Gittens, 1950.)

| *Years* | *Method* | *Man-hour per acre* |
|---|---|---|
| 1841 | Wooden mouldboard plough, hand planting, hand hoeing, hand picking | 149 |
| 1895 | Steel plough, hand planting, hand hoeing, hand picking. | 102 |
| 1925 | Steel plough, hand planting, hand hoeing, hand picking. | 96 |
| 1948 | Tractor equipment for all operations. | 21–38 |

These American figures confirm the observation that the first stage of mechanisation—the introduction of very simple animal-drawn implements for cultivation—will more than double the farmer's productivity. Improvements to his implements can bring further gains and with equipment of today it may be confidently expected that this first step in mechanisation will triple the productivity of a farm worker.

A farmer who makes this first step towards mechanisation—and as mentioned above, thousands of Northerners have invested over £70 of their own money to become mixed farmers—may not be able to realise the full potential of his implement since he is dependant still upon hand labour for planting, weeding and harvesting. He can use his plough to reduce the peak of labour demand at the beginning of the rains (and can earn additional income by ploughing others' land) but he can only increase his own acreage if he becomes an employer of labour.

This is the first—and by no means the least—of the social problems of mechanisation. It is a problem which is not always solved. During the period up to 1956, for which records were available, some 33 per cent of new entrants to the scheme failed (Chambers, 1958). Over 23,300 acquired cattle and ploughs but only 15,452 survived as established mixed farmers. Many of the failures were undoubtedly due to unfortunate circumstances, such as cattle diseases: many more were probably due to the inability of the individual to change his role from head of the family farm to "manager" of the mixed farm.

The agricultural engineer can reduce this management problem by providing implements which will reduce each peak in the labour requirements distribution to a common level and three implements have been developed at Samaru for this purpose. All of the implements were designed for local manufacture and are of all-steel construction, because wooden load-carrying members are unsatisfactory in the climate. The frames, brackets, etc., are fabricated by welding from water piping and plate to eliminate the need for forgings and castings. It has not been found possible to use mild steel for the earth-moving parts and shares, etc., have been cut from old plough discs during development work. It is anticipated that it will be necessary for local manufacturers to import tempered shares for their products for many years to come.

The Samaru implements fall into two groups, the single-purpose and the multi-purpose. Single-purpose tools are designed to reduce the labour peaks at weeding and harvesting; the multi-purpose tool-frame is intended to provide the farmer with the means to carry out more operations.

*Single-purpose Implements*

Although weeding is not, of itself, the most labour-consuming job in the farming year, the first weeding of the early crops coincides with the cultivation and planting of late crops, creating major labour shortage. The simple weeder is intended to supplement the farmer's existing plough and has been made as cheaply and simply as possible.

Harvesting of all crops demands more labour than weeding but is spread over several weeks. This is fortunate since there appears to be little hope that simple machines will help with the harvest of sorghum (not, at least, the very tall *fara-fara*) or cotton. An implement has, however, been developed at Samaru to lift groundnuts, an operation that can be troublesome for mixed and hand farmers in areas where the soil dries out rapidly after the end of the rains.

The concept of this groundnut lifter is somewhat different from that of the simple weeder because a very simple, and thus potentially cheap, imported lifter had already been tested and approved for areas with light soils. The Samaru lifter is a rugged implement with excellent penetration and it is fitted with wheels—expensive luxuries—to control depth and to facilitate transport. It is thus suitable for heavy or hard land and for contract work on widely scattered farms. The nuts are lifted to the surface and the time spent in gleaning is reduced by as much as 80 per cent. The penetration of the lifter is so good that it has been found possible to lift cotton stalks during the height of the dry season.

*Multi-purpose Implements*

The third of the new implements is a multi-purpose unit intended for new mixed farmers who have not already purchased ploughs. The frame is fabricated from piping and is offset to one side to improve the clearance for such operations as groundnut and cotton stalk lifting. Provision is made for attaching the body of an Emcot ridging plough. This body is somewhat expensive but has proved very satisfactory, whereas attempts to produce locally-made bodies from mild steel have been dismal failures. The attachments for tie-ridging, dry-season ridge splitting, weeding and lifting can, like the frame, be made locally.

Prototypes of these Samaru implements have been tested in the Provinces. Farmers' reactions have been favourable and the Ministry of Agriculture is at present calling for tenders for the manufacture of initial batches for distributions. Because of this call for tenders, prices cannot yet be quoted. If the new implements are accepted by farmers, they will increase productivity by a factor of four or five and, more important, they will reduce the management problem by reducing the peak demands for hand labour.

With a ridging plough, weeder and lifter, or with a multipurpose tool, the Nigerian farmer will be able to progress to the second stage of mechanisation. With the development of a suitable cart, prototypes of which are now being developed at Samaru, and perhaps a planter, the farmer will be able to use his cattle for all farm operations except grain and cotton harvesting. There will then be few opportunities for introducing radically new animal-drawn machines. It is true that horses were used as a source of power for threshing drums, etc., in the last century, but animal power can no longer compete with the internal combustion engine as a source of power for stationary machines. For example the current cost of the gear needed to transmit the in-line motion of the animal to the rotating machine is greater than that of a mass-produced petrol engines of ten times the power.

## TRACTOR FARMING

The first attempts at tractor farming were made at Samaru in 1948, using a pair of tractors borrowed from an airfield: shortly afterwards large numbers of new machines were imported and three main tractor farms were established in 1949. The work of one of these, the Niger Agricultural Project, has been well documented (Baldwin, 1957) and copious records exist for the others. Space does not permit a detailed description, but it is apparent that in 1953/54 tractor farming was approaching the stage when it would have been a practical and an economic proposition. Ten years later, in 1963/64, there is little doubt that, so far as the machines themselves are concerned, complete tractorised farming is practicable, for all the the crops grown in Northern Nigeria are mechanised in some country and commercial machines exist somewhere for all operations except, perhaps, the harvesting of *fara-fara*.

### *Cost of Tractor Operations*

But if the machinery problems have solved elsewhere, the economics of tractor farming have deteriorated sharply in the past decade. The capital cost of one standard tractor, for example, has risen from £435 to £860. Since it is often suggested that increases in tractor prices are due to the incorporation of technical refinements which are not needed at any early stage of development, it is interesting to note that there has been a proportionally greater increase, from £132 to £330, in the cost of the heavy disc plough that has not been modified in any way during the same period. The increases in capital costs have, of course, been accompanied by similar rises in the prices of spares and the cost of labour and fuel has risen. Published figures show that the cost per tractor hour at Mokwa rose from 5/11d in 1955 to 8/5d in 1957, an increase of about 45 per cent in three years: detailed accounts are no longer kept but it is estimated that the cost today is about 20/- per hour.

While capital and running costs have increased greatly over the past 10 years, the price of the produce has remained fairly constant. Thus, spectacular increases in the productivity of the tractor and/or major increases in crop yields are required if the economic position of 10 years ago is to be regained. In recent years the tractor unit farms have all been closed down and work at Samaru and Mokwa has been concentrated on improving methods of cultivation which, in 1953, accounted for two-thirds of the total cost of production. By 1957 improved techniques had reduced working time by only 5.3 per cent and it was clear that development of the existing system of ploughing could not keep pace with rising costs. From 1958, therefore, attention was concentrated on eliminating ploughing, the most expensive of all cultivations, and by 1962 a reasonably satisfactory system of annual cultivation has been devised. The new system involves:

(*a*) Ripping the ridges during the dry season to encourage percolation of the early rains into the core of the old ridges.

(*b*) Direct splitting of the old ridges, to form a new planting ridge, after the first rain.

During 1962, the Tractor Hiring Units of the Ministry of Agriculture cultivated nearly 2,000 acres using these new methods. The Hiring Units accounts have been recast in table 2 so that the cost per acre can be expressed on roughly the same basis as the published figures for Mokwa. It should be remembered that the 1963 figure refers to work done on widely scattered, badly-cleared fields, whereas at Mokwa the fields were in compact blocks and carefully cleared. Contract work by government involves many special expenses such as mileage and sleeping-out allowances, expatriate supervision etc. During 1962, these amounted to nearly half of the total cost, a fact which was recognized by a 50 per cent Government subsidy. The average payment by farmers was about 28/- per acre.

Table 2. Cost of cultivation with tractors

| *Source* | *Year* | *Cost per acre* (shillings) |
|---|---|---|
| Mokwa | 1953 | 43.75 |
| Mokwa | 1957 | 74.25 |
| Tractor Hiring Units | 1963 | 54.00 |

The new system of cultivation not only reduces the cost of cultivation but increases the area which can be covered by the tractor: the heaviest work is done during the dry season, when the tractor was idle under the old ploughing system, and once the soil has been softened by rain the implement cultivates 12 feet at each pass, as compared with the 3-foot width of a plough. The Ministry's Hiring Unit tractors averaged 250 acres each in 1962 but experience at Samaru and elsewhere shows that it is quite feasible for one 65 h.p. tractor to cultivate at least 300 acres on a commercial farm. One tractor is thus equivalent to at least 12 pairs of oxen although the investment per acre is about 50 per cent higher.

From the technique point of view, tractor farming and mixed farming are at about the same stage of development. Cultivations can be tackled as a matter of routine with either form of power with a marked increase in productivity per worker.

With both forms of power, implements for the tie ridging and weeding have been developed but are not yet in general use and are not available commercially. However, whereas there is little hope of using animal power for harvesting, there is every reason to hope that the groundnut lifters, combines and cotton pickers developed in more industrialized countries would work successfully in Northern Nigeria and both the Institute for Agricultural Research and Ministry of Agriculture are planning to continue investigations into completely mechanised farming.

### *Small Tractors*

In the majority of countries, agriculture has progressed in one step from animal power to medium-powered tractors. This is a vast step involving much more than the development of successful tractor-drawn implements and having effects which are felt far beyond the boundaries of the farm.

Many people consider that the step is too great in countries, such as Northern Nigeria, where industrialisation with its associated technical education, distribution systems and servicing facilities has not progressed very far. As an alternative to the establishment of large power farms it is often suggested that the step from muscle power to engine power can best be achieved by replacing the mixed farmers' cattle with a cheap, small tractor.

Progress along such lines is socially possible and agriculturally desirable, but is prevented by economic and technical factors. To meet the requirements, such a tractor would have to be cheap and small and unfortunately, small tractors are not cheap. The local retail price *per horse power* is as follows:

| | |
|---|---|
| 7 h.p. | £40. 12. 0d |
| 30 h.p. | £24. 10. 0d |
| 50 h.p. | £16. 6. 0d |

Whether the basis of comparison is price per unit power or capital required per acre, the smaller tractor is always more expensive than the larger. This is due in part to the distribution costs which are an essential part of the retail price. Government officials are well aware that tractors can be imported through official agencies at far less than the local retail price, but are aware, also, of the continual stream of complaints from field workers about the inadequacy of after-sales service for tractors. After-sales servicing in all its aspects is essential if tractors, regardless of size, are to be owned by farmers. Yet where a small, cheap tractor fulfils the essential requirement of reliability, the sale of spares alone will not support the cost of these services and the agent has no alternative but to increase the selling price of the tractor itself.

Granted that a small tractor is expensive in proportion to its size, a suitable type may still be possible for the emergent power farmer, as the total capital outlay is less and the owner already owns sufficient land, thus avoiding social upheaval.

In Northern Nigeria, experience with these small tractors is very limited, but there is a wide range of small garden tractors, controlled by a man walking, available from different countries.

The useful power which can be obtained from a wheeled tractor is proportional to its weight, and the pull which can be obtained from two-wheeled types is usually too small to carry out normal cultivations with conventional tools such as ploughs and ridgers. Designers have attempted to overcome this problem by applying the power directly to the soil-working parts and a number of variations of the familiar rotary hoe theme have been produced. One type tested costs about £150, through the Crown Agents, with a range of implements and a trailer. It does not use driving wheels for cultivations, the forward motion being derived from the power driven tools, which include a screw-like blade designed to put up ridges. This machine and two others of similar type, demonstrated in Northern Nigeria by the local agents, are extremely tiring to work. While they may be suitable on very light soils, they do not achieve much useful cultivation on heavier soils and cannot be recommended for general adoption.

An alternative solution to the limiting factor of weight is to add the drivers weight to that of the tractor by letting him ride. This, of course, immediately increases the weight, complexity and cost of the machine, which must have at least three wheels to remain upright. The size of the driving wheels often becomes the limiting factor in the drawbar pull and the designer must make a compromise between efficiency and cost since a set of tyres of quite moderate size can be as expensive as an engine. Again, there are many examples of tractors of this type on the market but the majority, being designed for sports field maintenance and similar light work, have very small driving wheels and develop little pull.

The National Institute of Agricultural Engineering, in the United Kingdom, has designed a three-wheeled riding tractor which they claim is a *basic* tractor with no refinements. A prototype of this machine, which is now manufactured commercially, was tested by N.I.A.E. (in cooperation with the United Kingdom Department of Technical Co-operation) in Northern Nigeria last season. It has a 4-stroke 7 h.p. engine which drives the two-speed-and-reverse gearbox through a flat belt which is slackened to declutch. The drive is through a single 40-inch diameter rear wheel and, with an all-up weight of 1350 lb., the drawbar pull is 550 lb.

The designers are most emphatic that this basic tractor must be considered as a replacement for a pair of oxen and not in any way as an alternative to conventional farm tractors. Certainly, with a pull of only 550 lb. and a working speed of $1\frac{1}{4}$ m.p.h., the rate of work is not much higher than that of a good pair of bulls although, of course, the total output is much higher because the tractor can work much longer hours.

Detailed reports of this season's trails with the prototype are not yet available. Both the Ministry and the Institute propose to test the commercial version next year but it seems fairly certain that the tractor is not entirely suitable in its present form. The tricycle layout is a major disadvantage on ridged land. Ridge splitting is impossible and it is necessary to flatten the soil and then re-ridge. Groundnut and cotton stalk lifting is also impossible unless two rows are lifted, a feat which is beyond the tractor's capabilities on all except the lightest soils.

I have no revolutionary idea on a small tractor to offer you today. Even if I had, it is by no means certain that the tractor could be produced, marketed, and serviced in a way that would suit our farmers. A large international charity recently attempted to introduce a special tractor for peasant farmers but none of the major tractor firms with established distribution, servicing and training networks would accept a contract unless a minimum of 25,000 were ordered (Anon., 1962). Smaller firms are prepared to make special machines but most lack the capital and facilities to provide the sort of services which would be essential. It is interesting to note that the basic tractor designed specifically for peasant farmers in the tropics has been put into production because it met a demand for a small, light machine for weeding crops like sugar beet in the United Kingdom. It is also pertinent to note that the English farmer can buy one for £180 whereas the price quoted in Kaduna is £290.

In this very brief survey of agricultural engineering in Northern Nigeria, I have concentrated on the main theme of mechanised upland farming. The overall picture is of a continual struggle against rising costs and whatever form of mechanisation is adopted, it is apparent that the power farmer will have to be a good farmer if he is to survive. In other words he will need to use every possible means to raise his yields if he is to cover his costs.

The word mechanisation has a special magic in many ears. Pursued as an end in itself, mechanisation is an expensive toy, as many scrap heaps in Africa and Asia show. The target must be mechanised farming—an integrated system of machines to increase productivity of men and good farming methods to increase the return from Northern Nigeria's resources and to conserve these resources for the future.

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Mr. D. L. Curtis (*Institute for Agricultural Research, Ahmadu Bello University, Zaria*) **Recent developments in cereal research in Northern Nigeria with special reference to guinea corn.**

SUMMARY

Sorghum and millets provide the staple diet for peoples living in the savanna zones of West Africa. In Northern Nigeria, sorghum occupies 27 per cent of all land devoted to arable crops but the average yield is only 600 lb. per acre. There is wide variation between Nigerian varieties but most types are characteristically tall, late maturing and low yielding, although they produce a high quality grain. High yields have been obtained from introduced varieties and hybrids but the plants mature too early during the rains and the grain is unacceptable for human consumption. Delayed planting of early maturing sorghums has not yet proved successful.

Selection within local populations has produced improved strains but further progress is likely to be through hybridisation between Nigerian and exotic varieties. At Samaru, new varieties have been bred but they are not yet ready for release. Plant characters, thought to be desirable in future varieties or hybrids, are described in relation to physiological adaptation and consumer preferences. Recent attempts to incorporate some of these characters into sorghums suitable for Northern Nigeria, illustrate the way in which established techniques developed elsewhere may need modifying. For example, cytoplasmic male sterility, a pre-requisite to the utilisation of hybrid vigour in the commercial production of sorghum, cannot be introduced into the major Nigerian varieties by a straightforward back-crossing programme. Other studies in progress include the identification of genotypes with respect to height, maturation and various seed characters.

The paper concludes with a brief report of the work at Kano on *Pennisetum* millets.

## INTRODUCTION

Of the world's major cereal crops, sorghum ranks third behind wheat and rice in the number of people it feeds. Sorghum is the most important cereal in Africa where it provides the staple diet for people living in the savanna zones. In 1957/58 it was estimated that nearly 8 m. acres were grown in Northern Nigeria representing 27 per cent of the land under arable crops. Total production was just over 2 m. tons of grain per annum and the average yield was 600 pounds per acre. The acreage and production have almost certainly risen since this survey was published but it is likely that the average yield has remained the same.

In 1958, a sample survey was carried out by the Institute for Agricultural Research (then the Regional Research Station) in co-operation with field officers of the Ministry of Agriculture. The survey was designed to sample the types of sorghum grown in the region and to collect information on the uses of the grain and stems. The information derived from this survey has influenced the present breeding programme and it is necessary to describe briefly some of the results as a background for the discussion on recent developments.

## RACES OR AGRONOMIC TYPES OF SORGHUM AND THEIR DISTRIBUTION

There is no satisfactory classification of the cultivated sorghums. Most cytogeneticists agree that all varieties belong to a single species which recently has been renamed *Sorghum bicolor*.

Snowden (1936) classified the cultivated sorghums into 31 species using grain and spikelet characters, some of which are known to represent single gene differences. Nevertheless the book is useful as a catalogue, particularly where local varieties are described in detail.

Sorghum breeders, especially those in the United States of America have tended to refer to agronomic types like Durras, Milos, Kafirs, Kaoliangs, and Hegaris. These names refer, not only to sorghums in which certain characters are constantly associated, but often to varieties from the same geographic area. However, as a result of hybridisation, the commercial varieties and more recently the $F_1$ hybrids grown today, may exhibit characters of several agronomic types.

At Samaru, the term *race* has been used to describe varieties distributed throughout the same area and possessing similar morphological characters. On this basis eight races are known to occur in Northern Nigeria, of which four are important. The distribution of these races is shown in fig. 1.

### *The Guinea Race* (Plate I A)

This race is characterized by open, loose and pendulous (often one-sided) panicles. The grain is typically flattened and twisted between lanceolate glumes which gape at maturity. Varieties in this race are cultivated throughout Nigeria but their importance declines north of latitude 11° 30′N. This is typically a race of the guinea savannas of West Africa, apparently adapted to rainfall of more than 40 inches.

### *The Kaura Race* (Plate I B)

Grain in these varieties is large, round, and protrude at maturity from ovate clasping glumes. All varieties in which the endosperm contains carotene appear to belong to this race. It is interesting to note that so far this character has been found only in this race and only in Nigeria. The panicle shape and density is variable but varieties designated as Kaura usually have fairly dense semi-compact heads.

The Kaura race occupies a broad belt across the country at approximately latitude 12°N and this includes areas of major economic importance in Katsina and Kano provinces.

### *The Farafara Race* (Plate I C)

Found within the same area as the Kaura race, and often on poor soils, are varieties in which the grain is slightly flattened and lacks carotene. In many ways these sorghums resemble hybrids between the Guinea and Kaura races which may have been their parents.

### *The Chad Race* (Plate I D)

A distinct race is found in the north-east part of the region. The panicle is compact and the grains are slightly flattened and bent towards the lower glumes. Varieties in this race closely resemble those which have been imported from the republics of the Sudan and Tchad. These sorghums are among the earliest maturity types in Nigeria. Grain quality is poor and many varieties have an undesirable dark testa.

## IMPORTANT DIFFERENCES BETWEEN NIGERIAN AND EXOTIC SORGHUMS

### *Duration of growth*

In most parts of the world, sorghums reach anthesis in approximately 60 days. Nigerian sorghums, which are usually planted at the beginning of the rains, ripen at the end of the season so that, depending on the location, they take from 80 to more than 150 days to reach anthesis. In Zaria, for example, the local sorghums take between 125 to 135 days to reach anthesis. This is twice as long as most American sorghums.

*Height*

Compared with the world's sorghums, particularly those bred for combine harvesting, Nigerian varieties are very tall and may often exceed 20 feet in height. The relationship between height and maturity is discussed later.

*Grain quality*

The popular requirement in Nigeria is for a variety which will yield sweet white flour, even under conditions of heavy rainfall. Most varieties escape the period of heavy rainfall, but there is an indication that some, particularly those with coloured pericarp, are less prone to weathering and other factors which may adversely affect quality.

Some varieties from countries like India, where sorghum is a food crop, possess acceptable grain quality, but where the crop is used for stock feed, the grain is usually unattractive and unpalatable. Grain quality is also affected by the presence of the testa, a thin dark sub-coat beneath the pericarp. This is not removed in the traditional milling processes employed in Nigeria and it remains to colour the flour. Fortunately, most varieties in Nigeria lack this.

The grain characteristics of Nigerian sorghums indicate that, apart from some areas where sorghum may be used for brewing, the main use is in the preparation of such foods as 'Tuwo' (similar to a cold, stiff porridge), cakes and various gruels.

*Grain yield*

The average grain yield of Nigerian sorghums is low. The extent to which this is a result of present agronomic practices is outside the scope of this paper but the following observations strongly suggest that new types of sorghum are necessary:
(*a*) Some exotic sorghums have yielded 5,000 lb. of grain per acre at Samaru. This is much higher than 1,500–2,000 lb. obtained from varieties of the Guinea race and from 2,000 to 3,000 lb. per acre obtained from Kaura varieties. (*b*) Within the local varieties, spectacular yield increases above these levels have not been achieved by seed dressings, earlier planting, closer spacing, fertilization, or spraying against pests and diseases, Moreover, treatments designed to improve soil conditions, like cross-tying ridges and mulching, also failed to produce results similar to those achieved with cotton at Samaru. In fact, apart from recommending the use of seed dressing (mainly against covered smut) and modest applications of fertilizers at economical subsidised prices, it would appear there are few ways in which yields can be raised at present. Hence the importance of avoiding yield losses during storage by treatment with insecticides. (*c*) It should also be borne in mind that the average yield of 600 lb. per acre is a result of intensive not extensive farming. If extensive mechanized farming is envisaged, there is a clear need for varieties of sorghum which can be combine-harvested. For this reason alone, work on producing what will be almost a new crop appears to be justified even at this stage. The present position is that a large acreage is devoted to producing food inefficiently. In a farming system based on annual crops, this also affects cash crops like cotton and groundnuts whose acreage depends on what has already been planted to cereals and whose planting and subsequent cultivation suffer through lack of time, labour and money. Against this background of the crop as it is grown today, the results achieved so far and the recent developments in the plant breeding programme will be discussed.

## SORGHUM RESEARCH PROGRAMME AT SAMARU

*Definition of areas within which the same variety may be grown*

One of the first objectives of the present programme was to find out if it would be necessary to breed a different variety for each village, area, or vegetation zone; or better still

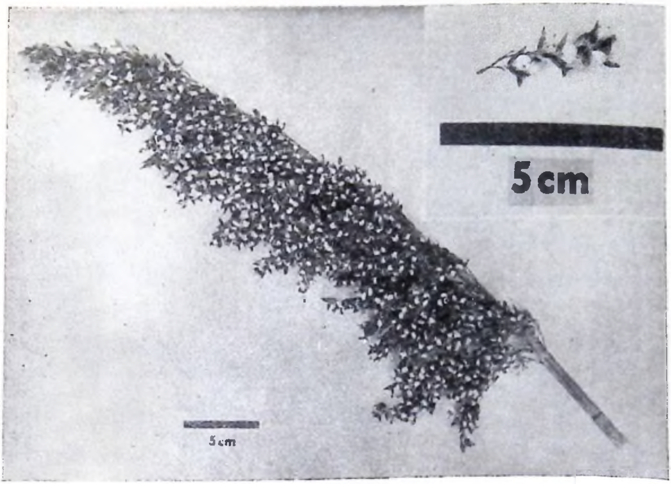


*Plate I A. Guinea Race*

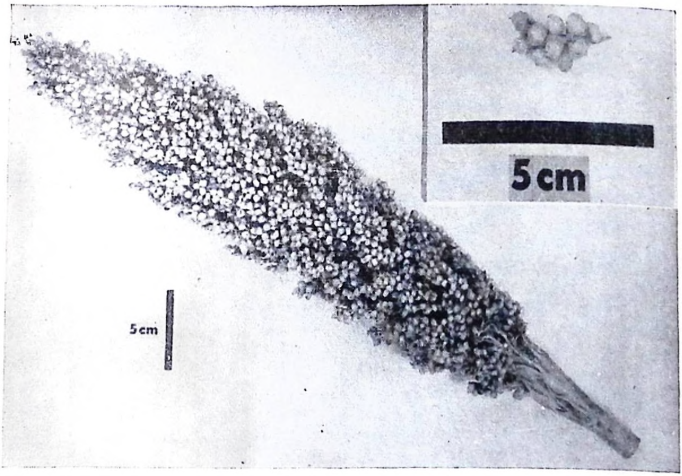


*Plate I B. Kaura Race*

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## SORGHUM RESEARCH PROGRAMME AT SAMARU

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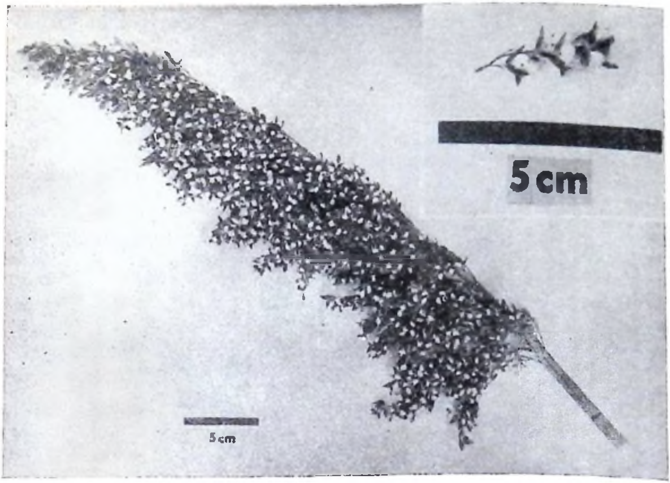



*Plate I A. Guinea Race*

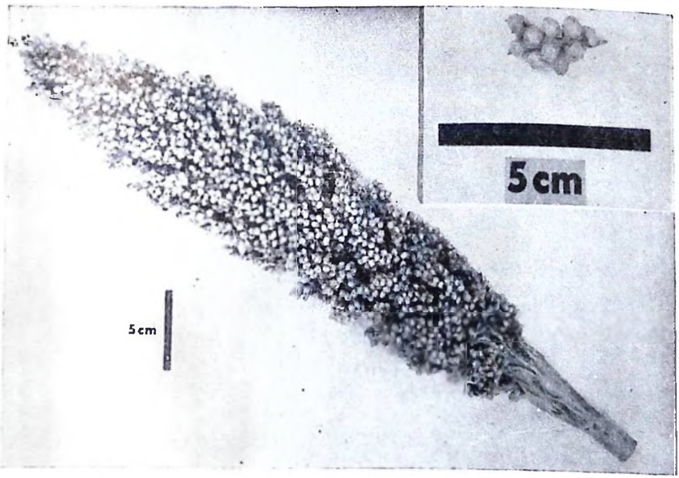



*Plate I B. Kaura Race*


*Plate I C. Farafara Race*

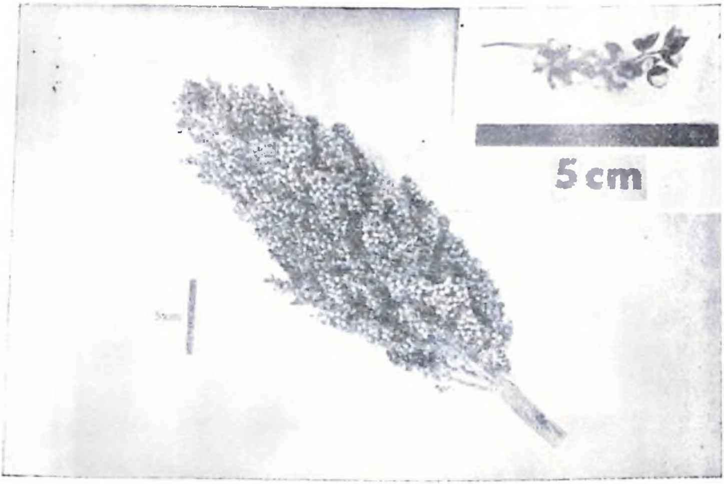



*Plate I D. Chad Race*

whether the whole region could be served by the same type. In order to delimit the areas which could be served by one type, standard sets of local varieties were grown in replicated yield trials throughout the region. The distribution of local varieties and the vegetation zones were used as a guide. The sets of local varieties were different for each zone but common checks overlapped between zones. As yield responses alone are not always reliable, data on flowering, node number, height, etc. were also recorded. As a result of these trials it has been possible to outline areas in which it is likely that one variety would be suitable. These areas are shown in fig. 2.

The information gained from this approach may be used in several ways. The relative economic importance of each area can be assessed and this will influence the choice of centres at which breeding work should be expanded. For example, work on cereals at Kano is to be expanded and the choice of this centre is fully justified by the importance of the area it serves. It has also been possible to regroup variety trials so that the results obtained will have the widest possible application.

*Selection from local varieties*

Apart from defining areas, this series of trials provided information on the type of material likely to be suitable for each area. Although the original varieties used have been largely superseded by selections from a wide range of new material, they served as useful controls and in some cases yielded promising selections. Selection work, which in some races started before the results from the adaptability trials were fully confirmed, has led to the production of several multiline strains. The 1962 results showing the performance of strains recommended to farmers in two areas are shown in tables 1 & 2.

Table 1. The performance in 1962 of the improved multiline strain 'Yar Gunki'

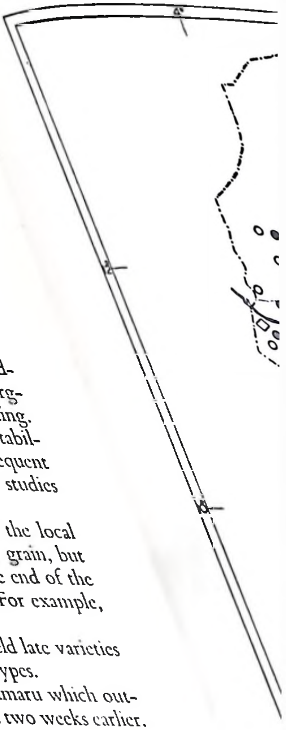
| *Locality* | *Percentage Yield Increase* |
|---|---|
| Gusau | 33 |
| Kafinsoli | 19 |
| Kano | 14 |
| B. Kudu | 19 |
| Azare | 13 |
| Misau | 26 |
| Daya | 36 |

Table 2. The performance in 1962 of the improved multiline strain 'Farafara'

| *Locality* | *Percentage Yield Increase* |
|---|---|
| Zuru | 17 |
| Samaru | 83 |
| Gimi | 14 |
| Bauchi | 11 |
| Darazo | 18 |
| Mubi | —13 |

The selection work at Samaru has sometimes been misunderstood. In view of the statements made earlier in this paper concerning the seemingly low yield potential and other undesirable characters of local sorghums, the obvious approach would appear to be through

al by hybridisation. This is being tried,
leased.
s limited to the assessment of their relative
udy sorghums, and classify them so that the
xotic material. In some ways, selections from
s of the breeding programme. Nevertheless the
to hold back material which is better than that
hoped that something much better is on the way.
sorghums and are adapted to present farming
her varieties of hybrid origin will posses acceptable
ed so far were derived from crosses made between
ain from these lines is similar to that of the Nigerian
n, and the quality of the flour is affected by their sus-



, the characters which make them adapted to Nigerian cond-
t to which the areas delimited by standard sets of local sorg-
ies depends on whether or not the same factors are operating.
ication of characters which are associated with their adaptabil-
ell be important in the selection of parents and in the subsequent
m hybrid populations. Unfortunately, there have been few studies
tors associated with the adaptability of local sorghums.
trials, it was thought that the duration of growth in the local
hether or not the standard checks produced good quality grain, but
ields. Obviously, since most local sorghums flower at the end of the
take longer than the local are likely to fail completely. For example,
uth will not mature in the far north.
bvious is why early varieties should in some cases outyield late varieties
his may occur within the same type and among different types.
f the former is found within unselected Farafara from Samaru which out-
varieties in Benue and Kabba Provinces and flowers about two weeks earlier.
s difference the varieties are indistinguishable. It has been stated as a general-
ithin the same type, yield is proportional to the length of the growing season.
might be assumed that the local varieties from Samaru and Benue are perhaps
pes if it were not for the fact that it remains to be demonstrated that the yield of
riety is always higher when the plant takes a longer time to mature. By planting
possible to extend the growing season by at least 30 days but the yield is not
. However, significant yield decreases have been obtained when the normal grow-
od is shortened by late planting.
increase or decrease in the length of the growing season is mainly a reflection of the
ences in time to floral initiation, i.e. the period during which the number of leaves is
rmined. There is probably a minimum number of leaves necessary, below which the
of the initial is reduced, but once this has been reached, an increase in leaf number does not
pear to be important. The size of the initial is critical because yield in sorghum is largely
ependent on the number of grains per head and not on grain size. This means there is no
real reason why within the same variety or similar varieties the yield should be increased by
a longer growing season unless this is going to lead to a larger head initial.

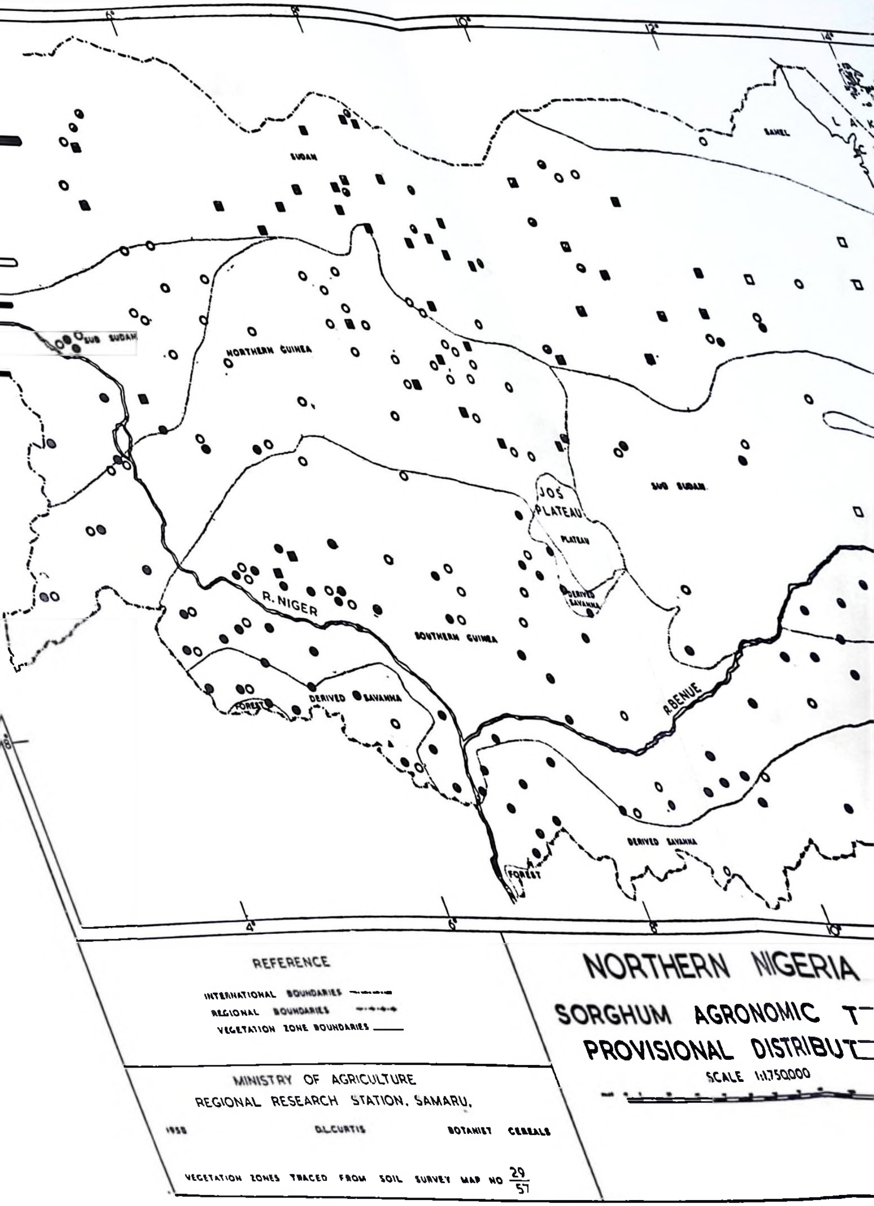



Fig. 1 Map showing the distribution of impo

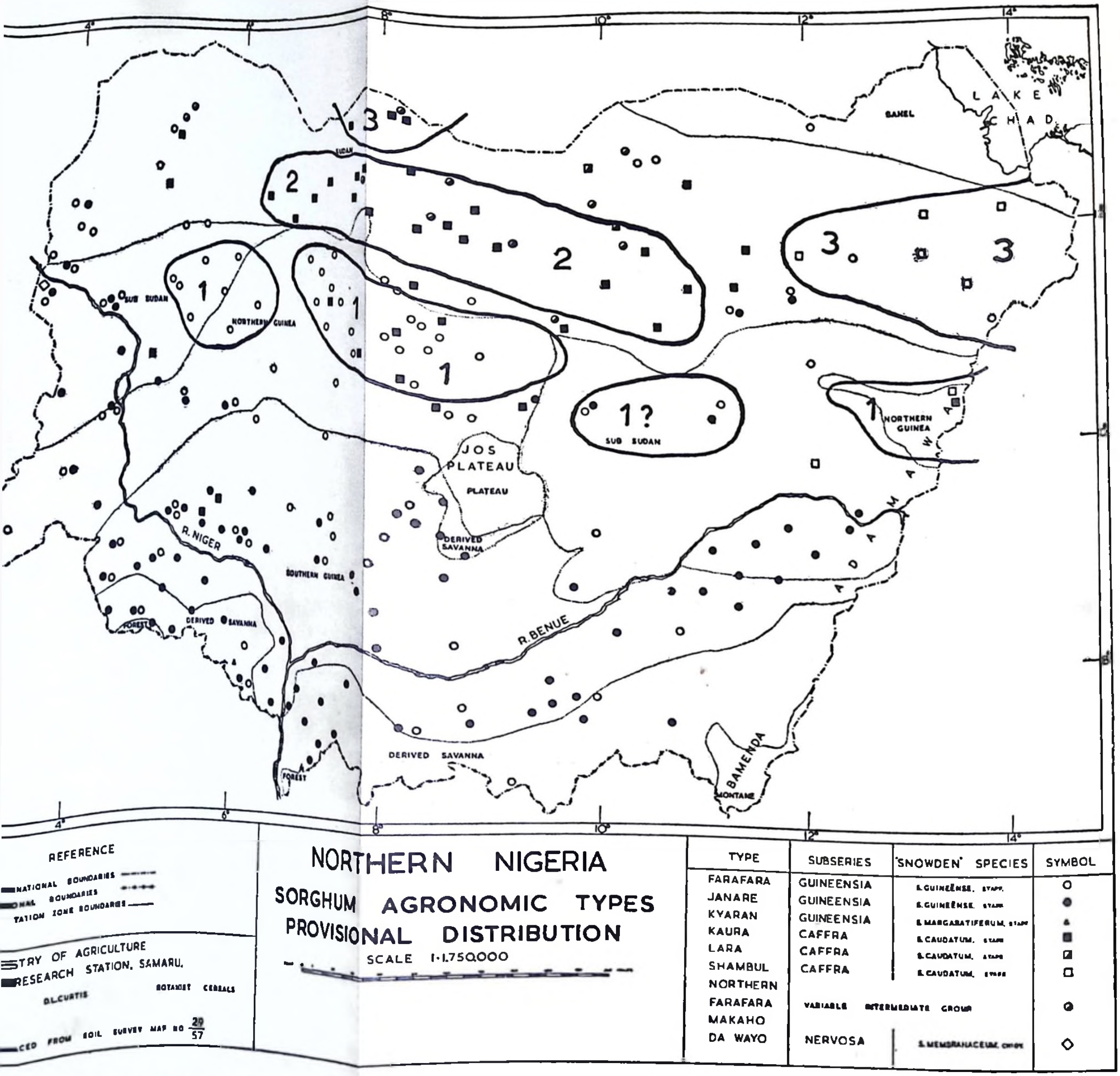



*Fig. 2 Map showing areas in Northern Nigeria where various varieties have been proved suitable.*

Among different types, many hybrids and varieties from the United States of America outyielded the much later maturing local varieties at Samaru. There may be several contributing factors, but the one which is obviously important is their ability to retain a large head at high plant population. Yields of American varieties and hybrids in 1963 are shown in table 3, column 2. Although these earlier maturing types, mainly from the United States, outyielded the local sorghums, unfortunately they mature during the rains and the quality of the grain is seriously affected.

Table. 3. Yield results—U.S.A. hybrids and varieties—Samaru 1963
(lb. threshed grain per acre. 12% moisture)

| *Variety* | *Yield* | | |
|---|---|---|---|
| | *Planted early* | *Planted late* | *Decrease* |
| NK 300 | 4,950 | 1,938 | 2,962 |
| x 1590 De Kalb | 4,923 | 3,545 | 1,378 |
| RS 617 | 4,730 | 2,998 | 1,732 |
| AKS 614 | 4,345 | 2,646 | 1,699 |
| AN 330 | 4,043 | 2,883 | 1,160 |
| TE 88 | 3,823 | 2,665 | 1,158 |
| GA 609 | 3,795 | 2,893 | 902 |
| RS 301 F | 3,768 | 2,291 | 1,477 |
| NK 283 | 3,630 | 1,315 | 2,315 |
| RS 681 | 3,548 | 912 | 2,627 |
| TE 77 | 3,410 | 2,042 | 1,368 |
| RS 608 | 3,328 | 1,223 | 2,105 |
| De Kalb F-63 | 3,245 | 1,564 | 1,681 |
| CK 60 | 3,122 | 2,244 | 878 |
| NK 310 | 2,998 | 1,861 | 1,137 |
| OK 612 | 2,915 | 1,250 | 1,665 |
| RS 601 | 2,860 | 2,354 | 506 |
| NK 210 | 2,750 | 1,528 | 1,222 |
| *SK 60 (Local check)* | *2,730* | — | — |
| RS 501 | 2,668 | 1,654 | 1,014 |
| N 80 | 2,613 | 1,514 | 1,099 |
| KS 603 | 2,558 | 1,267 | 1,291 |
| CK 60 A | 2,530 | 1,814 | 716 |
| *SFF 60 (Local check)* | *2,421* | — | — |
| NB 505 | 2,365 | 1,731 | 634 |
| OK 632 | 2,304 | 1,306 | 998 |
| White Martin | 2,283 | 1,958 | 325 |
| White 7078 | 2,255 | 1,037 | 1,218 |
| NK 125 | 2,063 | 1,162 | 901 |
| White Norghum | 2,008 | not harvested | — |
| SD 451 | 1,705 | " " | — |

Another approach which has been tried is to plant late. Apart from considerable difficulties in establishing the crop, yields are drastically reduced and often lower than those of the local checks planted early. A comparison between early June planting and late August planting is illustrated in table 3.

In these trials, it was observed that the duration of growth was slightly shortened, probably as a photoperiodic response, but it seems unlikely that this could account for the serious reductions in yield.

Introductions of higher yielding varieties which do not mature at the same time as do the local sorghums have so far been unsuccessful and, although it may be possible to overcome the associated problems, our present state of knowledge justifies breeding for the same period of maturity as on local sorghums. At any rate, duration of growth is important and is among the three characters which are discussed in greater detail below. The other two characters in which we are interested are height and cytoplasmic male sterility.

## PLANT CHARACTERS OF SPECIAL IMPORTANCE IN THE BREEDING PROGRAMME

### *Duration of growth*

A study of the duration of growth in Nigerian sorghums has only just begun. Sorghum is termed a short-day species because maturation is hastened in short days, but there are differences between varieties in the degree of sensitivity to day length or photoperiod. From the practical point of view, it is useful to distinguish between those which are relatively insensitive, probably because their thermal requirements have not been met, and those which are sensitive. Quinby and Martin (1954) have shown that sensitivity to photoperiod is inherited as a dominant.

Within groups, varieties differ in their responses to a critical photoperiod and, according to Quinby and Karper (1945, 1947 and 1961), the inheritance of these responses is determined by a series of independent maturation genes, some of which are multiple alleles. Genetic stocks, received from Quinby, have been crossed to the main Nigerian varieties this year. The $F_2$ and backcrosses will be made during this dry season and by the end of next rains it should be possible to determine the genotypes of Nigerian sorghums with respect to maturation. Although genetic studies have not been completed, observations in segregating $F_2$ breeding populations are of interest. For example, in the cross between an American variety CK 60, which takes 60-65 days to head at Samaru, and Shambul, a local Nigerian sorghum in the same race which takes 80-90 days to head, segregation in the $F_2$ appeared to indicate that lateness is due to a single major dominant gene. These results are presented in fig. 3.

Where crosses are made between races, the situation is much more complicated. For example, figure 4 shows the segregation in an $F_2$ population where the parents were the same American variety CK 60 but the local sorghum, Farafara, belongs to a different race. This is only meant to serve as a comparison with the previous figure. There is no point in trying to analyse these data which were taken from populations forming part of the breeding programme and not specially set up for genetic studies.

From other observations, it appears that most Nigerian sorghums are very sensitive to photoperiod. By planting at different times the local Farafara can be induced to head at anything from 60 to 150 days after planting. Part of this variation is almost certainly due to temperature and other factors and for this reason the varieties used in the genetic studies have been sent to Beltsville, Maryland, to see how they react under controlled conditions.

This sensitivity to photoperiod is not in accordance with the views expressed by Quinby (1961), who suggested that most tropical sorghums are relatively insensitive. The fact that this may not be the case is very important. Under Nigerian conditions it is difficult to predict the planting date or length of season, particularly in the far north. It would appear advantageous to retain sensitivity to photoperiod in new varieties, so that they, like local

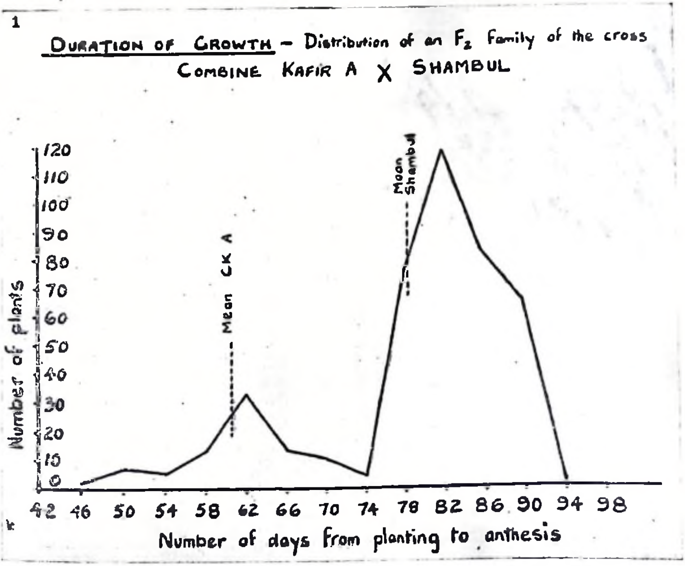



*Fig. 3 Frequency distribution for the number of days to anthesis in an* $F_2$ *population (CK60 X Shambul)*

sorghums, will adjust themselves to late planting by shorting their duration of growth and anthesis will occur at the end of the rains. At least some yield will be obtained even if this is not as high as it might have been with early planting. If the duration of growth is fixed, there might be no yield at all if the crop was planted late and it failed to reach anthesis at end of the rains.

*Height*

Height in sorghum is determined by the number of internodes and their lengths. The number of internodes is related to the duration of growth and is dependent on genes controlling maturation. Length of the internodes has been studied by several American workers, who postulated that it is determined by a series of four independent genes, each with additive effects. Long is dominant to short at each locus and commercial hybrids and varieties are referred to as 4 dwarf, 3 dwarf, etc., depending on the number of recessive alleles.

The approach being used at Samaru is to cross Nigerian varieties with genetic stocks from the United States. Results are not yet available but it is worth mentioning some of the difficulties. First, due to the simultaneous segregation of maturation and height genes, analysis has to be carried out within the same maturation group. Attempts to do this by grouping within heading dates have proved difficult and it will probably be better to group according to the number of leaves. Secondly, large populations are needed. Thirdly, unlike

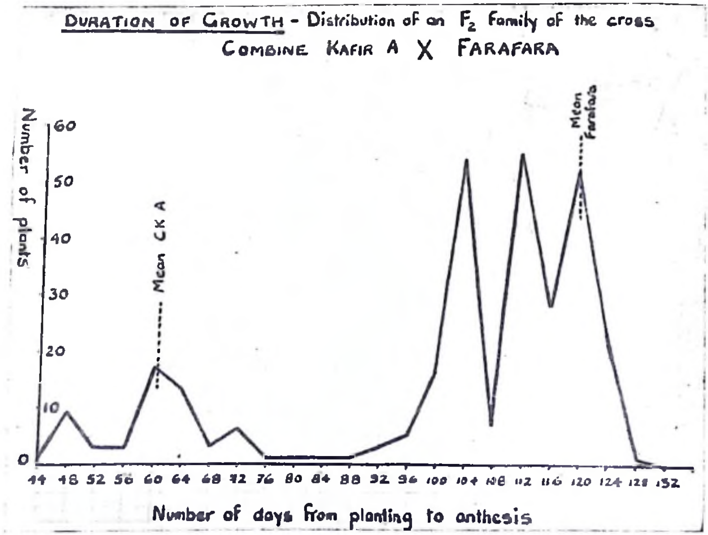



*Fig. 4 Frequency distribution for the number of days to anthesis in an* $F_2$ *population (CK60 X Farafara)*

many other cereals where height differences are measured in inches, the differences in our populations amount to several feet. In segregating $F_2$ populations the shortest plants are etiolated and their mean height is above that of the shorter parent. The frequency distributions in fact resemble those obtained by Leonard *et al.* (1957), for height in barley, where the mode of the short plants in the $F_2$ was higher than that of the shorter parent. This led them to postulate a second gene pair with an effect three times as small as the major gene pair. To overcome this difficulty, the plants in our trials next year will have to be very widely spaced at least 3 x 3 feet.

So far only the difficulties in studying height in our populations have been discussed. From preliminary observation in breeding populations it would appear that most of the height differences between our 15-20 feet sorghums and 3-4 feet, 3-dwarf American sorghums are attributable to maturation factors and that there is segregation for only one height gene at the most. This is confirmed by the fact that Short Kaura, which can grow up to 10 feet when it takes 130 days to head is the same height or even shorter than American 3-dwarf varieties when it takes the same time, about 60 days, as they do to mature. This suggests that we may have difficulty in breeding combine height sorghums which take 130 days from planting to anthesis. Instead of making our crosses to 3-dwarf varieties, it would appear we may need to use 4-dwarf material. The real difficulty is that so long as a 130-day sorghum produces 30 or more leaves there will be a limit to how far we can dwarf it. Already there must be considerable mutual shading in some of the new short lines with which we are working.

*Cytoplasmic male-sterility*

It is necessary to introduce cytoplasmic male-sterility into our material in order to obtain female lines for the commercial production of $F_1$ hybrids. Hybrid seed is obtained by harvesting the male-sterile female line in production fields where the only source of pollen is from the other parent chosen to make the cross.

Although the degree of partial fertility may be determined by several genes, complete male-sterility appears to result from the interaction between the male-sterile *msc* gene and sterile cytoplasm derived from Milos. Either the homozygous dominant *Msc Msc* or heterozygous *Msc msc* restores fertility.

Although cytoplasmic male-sterility was first found in the United States, workers in many other countries including Australia, Israel and India have transferred this character to their own stocks by a simple backcrossing programme. Local sorghums are test-crossed to a male-sterile line and those which possess the sterile gene are used as recurrent parents. The male-sterile **A** line is maintained by crossing to the parent **B** line which is fertile because it has normal cytoplasm.

We have found at Samaru that the major Nigerian varieties do not possess the male-sterile genes. This means we are unable to covert them to male-sterile lines by a simple backcrossing programme. The search is continuing and the $F_1$ hybrids from a further 108 local and exotic varieties will be checked during this dry season. Most of these are likely to prove unsuitable in other respects. This situation is not as bad as it seems. It would not really be worthwhile to convert local 15-20 feet sorghums into male-sterile lines as they could not be used as parents for commercial $F_1$ hybrids. Therefore two other approaches are being used. These approaches may be of interest to other breeders when they need to develop a new range of female parents. As far as I know they have not been developed elsewhere because the necessity has not arisen.

The first is to make the original cross in normal cytoplasm by hand emasculation, choosing a parent known to carry male-sterile genes and other desirable characters like dwarfness. A quarter of the plants segregating in the $F_2$ should be homozygous *msc* recessive which can be determined by test-crossing with a male-sterile line. The desirable plants can then be used as recurrent parents and **A** and **B** lines can be developed simultaneously. A disadvantage of this method is that one can only select in a quarter of the $F_2$ population and it assumes that the $F_2$ plants chosen as potential recurrent parents will not segregate for the characters for which they were chosen. If selection is delayed until later generations, which would be desirable, the chances of recovering homozygous recessives would be seriously limited especially if tall plants were removed from the population each year. A refinement to this approach which is being used at Samaru is to testcross the local parent first and then make the cross ensuring that male-sterile genes are introduced through both parents. Selection can then be made in the $F_4$ and $F_5$ knowing that all plants are potential **A** lines, i.e. male-sterile *msc msc*.

The second approach, which is also being tried at Samaru, is to make the original cross in sterile cytoplasm and to follow an alternate selfing and backcrossing programme. The generation following the selfing segregates into sterile and non-steriles, as it is in sterile cytoplasm and desirable plants are backcrossed to the recurrent parent. The parent donates undesirable dominant genes for fertility and height, but these plants are easily avoided in backcrossing. The serious disadvantage to this method is that one does not develop simultaneously a maintainer **B** line with fertile cytoplasm. This can be overcome by using in later generations, a plant heterogygous for *Msc* and reversing the cross so that a similar plant in fertile cytoplasm can be selected. This is an awkward approach and the main reason for carrying through with it is that it is interesting and involves little work.

Both approaches depend on the behaviour of male-sterile genes in populations involving Nigerian material. The results obtained so far in $F_2$ populations have agreed very closely with the predicted 3 : 1 ratio of fertile to sterile plants, respectively.

## CONCLUSION

Most of the lines of work described here are in their early stages of development with the exception of the selection programme based on local material. The main emphasis now is on producing a new range of varieties from crosses between local sorghums and exotics, mainly from the United States. In this work, attention is being given to the eventual use of the lines produced as potential parents in hybrids combinations.

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Professor H. S. Darling (*Institute for Agricultural Research, Ahmadu Bello University, Zaria*) **Science and agriculture in Nigeria.**

It is my responsibility to give a summary account of the papers presented and to place them in perspective against the agricultural industry of the country.

The introductory papers by Vice-Chancellor Alexander, by the Governor and by our President all referred to the complexity of science in relation to Agriculture and rightly insisted on a team-work approach to research by workers from many disciplines. Insistence was also correctly laid on the need for fundamental research when tackling agricultural problems and this point was driven well home by Professor Wain. His fascinating paper showed with a clarity that none could fail to understand how scientific reasoning in terms of pure chemistry could result in revolutionary advances in field practice.

The need for corresponding advances in Nigeria was emphasised in the opening address by the Governor, and the case was enlarged upon and cogently argued by Mr. Okiy in his paper on the role of research in Nigerian Agriculture.

A natural unity is imposed on agricultural research from which none of us can escape. This was pointed out by Dr. Hopkins in his paper on biological productivity. Agriculture in the widest sense of the word is the only large-scale basic industry which makes deliberate use of sunlight as its direct source of creative energy. The life and prosperity of Nigeria depend upon the efficiency with which our farmers make use of plants and soil (including soil water) to convert sunlight into biological fuel for human energy, into the body-building proteins so ably discussed by Professor Mathieson, and into commodities such as cocoa, cotton, rubber and vegetable oils which provide our essential income from trade and commerce.

Agricultural research is therefore basically involved with meteorology; a truth which those investigating field problems rapidly discover once they begin work. On this account glad mention is made of Mr. Babalola's paper on the scope of agrometeorology in Nigeria. More of such work is obviously needed.

In this connection it should be noted that in many areas of tropical Africa with pronounced division of the year into wet and dry seasons, it is observed that the earlier crops are sown in the rains, the greater is the yield potential. Many factors contribute to this effect, not least being nitrogen loss from the soil through leaching and the build up of the incidence of pests and diseases. When these factors have been allowed for, there still remains an unexplained yield differential in favour of early planting. A possible explanation of this effect may lie in the build up of cloud cover and humidity as the rainy season develops, which reduces the amount of solar radiation reaching the plants. Early sown crops establish themselves under a relatively high incidence of radiation and form vigorous plants with a high yield potential. Later planted seedlings receive less radiation and are often visibly weaker in growth and development. It is hoped that this possibility will be investigated at Samaru.

Sunlight can only be made effective to the farmer through plant life; the study of plants—botany in the widest sense of the word—is therefore as basic to agriculture as is meteorology. Two papers only in this vast field have been presented to the conference, namely one by Mr. Zeven on factors affecting the oil palm industry in the south of the country and one by Mr. Curtis on sorghum and millet breeding in Northern Nigeria.

Under agricultural conditions, plants grow in soil. Soil science is as basic to agriculture as meteorology and botany. Two papers in the field of soil science were to have been presented to the Conference. That by Professor Mitchell-Thome which was not actually given, was intended to deal with the important topic of ground water supplies in Eastern Nigeria. Water is as essential to plant growth as it is to human and animal life. Plants cannot photo-synthesise without transpiring water and the use of solar radiation in this way is inevitably accompanied by the loss of soil water through the plant to the air. Penman's classic work has done much to establish the energy relationships of this process and has provided a rational basis on which the use of soil water by plants can be scientifically investigated. This will prove of fundamental importance in developing irrigation techniques but will make heavy demands on the national meteorological service for relevant data from a wide range of localities.

The second paper on soil sicence was that given by Mr. Jenkin on the use of soil survey in the development of Nigerian forest resources. It provides an inventory of one of the major capital resources of the nation; without this inventory, planned development of agriculture is impossible. Soil survey was once a handmaid of geology but has developed into a specialised branch of research in its own right. Current advances include the use of soil physics to measure water-supplying ability—perhaps the most important property of tropical soils.

It must not be thought that chemical factors are no longer of importance in soil science. The reverse is the case and research on the chemistry of soils has gained new relevance through advances in other branches of the science. In this connection it is of interest to note that chemical fertilizers are being used on an ever-increasing scale in Northern Nigeria.

Insects and plant diseases are of importance in agriculture when they interfere with the economic aspects of crop production and utilization. Such interference is often dramatic in its effects and can attract much attention. This perhaps explains why nearly one-third of the papers given at this Conference have been in the fields of agricultural entomology and plant pathology. Among these papers that by Dr. Ene was markedly different from the others in that it dealt with a group of insects which man has been able to use to his benefit—namely indigenous silkworms of the genus *Anaphe*. Of the other four papers, that by Mr. Choyce summarised the recent advances in pest and disease control in Northern Nigeria, while Dr. Taylor in his contribution discussed the bionomics and control of yam beetles which are a limiting factor in the production of this important crop and for which adequate control measures have yet to be devised. Mr. Coursey drew our attention to the problems that affect the storage of agricultural produce: a most important field of work. The annual loss in store of thousands of tons of food and other valuable commodities is a continuing waste of national resources that should not and need not be accepted as inevitable. Those of you who visited Samaru on Thursday afternoon saw something of what is being done to prolong the storage life of food grains in the North and similar work is in progress throughout the country. In the fifth paper in this field, Dr. Sansome related pure science to agricultural practice in reporting her studies on downy mildew of guineacorn. She has elucidated important details of the reproductive cycle of this disease and so added to the data available for use by those investigating its field importance.

We noted earlier in this paper that agriculture is a basic industry unified by the fact that it invaribaly involves the use of solar radiation through the manipulation of crops and soil by man. We have discussed the radiation, the crops and the soil but what about man? Agriculture indeed involves the study of man himself for he is often the limiting factor in production. Under African conditions he may be limiting in terms of physical energy. It is in this connection that mechanization becomes important and Mr. Haynes, in this paper on agricultural engineering in Northern Nigeria, has drawn our attention to research being carried out in this important field.

It is not only in the field of mechanization that research on man is relevant. There are also the vital matters of preference and necessity in determining human diet which do so much to determine the pattern of agricultural production in any area. This aspect of research has been reviewed for us by Dr. Dema, who related his work on human nutrition to social and economic factors. This economic theme was further enlarged on by Professor Oluwasanmi in his paper on peasant farming and agricultural change. There is no escaping the fact that economic motives, or the lack of them, are of paramount importance in agriculture and must be given priority of consideration in agricultural research. Much economic and social research is needed if we are to see the farmer and his problems in true perspective. Without such research most if not all of other scientific effort in the support of agriculture can be wasted. There is much leeway to be made up in this respect in Nigeria. It is good to know that a start has been made and that research in this field is gaining momentum. The need for such work in the North is fully appreciated and it is hoped it will be commenced in the near future.

Finally, Mr. Okiy in his paper touched on the need for co-ordination in agricultural research throughout the country as a whole.

## OTHER ACTIVITIES

A reception in honour of the Association was given by Ahmadu Bello University following the formal Opening Ceremony. A very successful Conference Dinner was held on the final night of the Conference in the University Dining Hall at which Professor R. L. Wain, F.R.S., proposed the toast to the Association and the President (Professor C. W. L. Bevan) replied.

Excursions were made to Gaskiya Corporation, the Institute for Agricultural Research at Samaru and at Shika, Nigerian Tobacco Co. Ltd. and to Zaria Old City.

On the Thursday evening the following films were presented by the Shell-BP Development Co. Ltd:

*The Revealing Eye*
*A Light in Nature*
*Food or Famine.*

There was a general exhibition of displays by commercial firms and government departments, etc.

## BUSINESS OF THE ASSOCIATION

### *Report of the Hon. Secretary*

*Membership*

The membership of the Association on 1st December 1963 was 312, made up as follows:

| | | |
|---|---|---|
| Ordinary members | 220 | (204) |
| Associate members | 14 | ( 12) |
| Coporate members | 78 | ( 75) |

Figures for 1st December 1962 are shown in brackets.

The geographical distribution of ordinary members has remained unchanged during the year except for a small increase for Zaria due to the fact that most of the new members are from the Ahmadu Bello University including the Institute for Agricultural Research, Samaru.

*Council*

Council held six meetings during the year: four in Ibadan; one each in Lagos and Zaria. Mr. A. M. Oseni was again co-opted to continue as Publicity Officer for the Association. Professor N. Skinner and Mr. R. L. Story joined Council as Chairman and Secretary respectively of the Zaria Local Committee. Professor H. S. Darling was co-opted for the Zaria Council meeting.

*W.A.S.A.*

A conference of the West African Science Association was held in Kumasi, Ghana in March 1963. Twenty delegates attended from Nigeria out of which eleven presented papers. The following amendment to WASA constitution was passed:

> "The management of the Association shall be vested in a Council which shall meet at least yearly and comprise up to 3 members appointed by each affiliated National Society in addition to the Secretary of the Society."

The following were appointed to serve on WASA Council in addition to the Secretary:

Prof. C. W. L. Bevan
Prof. C. A. Onwumechilli
Dr. C. Oyolu.

The *Journal of W.A.S.A.* continues to lag behind schedule; and the last number, Vol. 7, No. 2, although dated February 1963 was for August 1961. This explains why members who have joined the Association since 1962 have not had copies sent to them.

*Proceedings of S.A.N.*

The *Proceedings* continues to flourish under the energetic editorship of Dr. Brian Hopkins and an Editorial Committee. Vol. 5 already distributed to members contains a full account of symposium, "Harnessing the Niger" held during the Lagos Conference. Advertisements also appeared in Vol. 5. Council has decided that for the Vol. 6, covering the Zaria conference, papers presented will be published in full instead of abstracts as in the past.

*Nigerian Journal of Science*

Council has seriously considered the necessity of starting a journal to cater for publications in all the scientific disciplines. A committee is working out the details but the Annual General Meeting will be asked to approve the scheme in principle.

*Directory of Learned Bodies and Research Organisations in Nigeria*

A committee of Council considered the publication of a Directory of Learned Bodies and Research Organisations in Nigeria. Plans are going ahead with the project.

*International Council of Scientific Unions*

The Association has been admitted as member of ICSU as national member for Nigeria. S.A.N. has also joined four of the member unions:—

The International Union of Biological Sciences
The International Union of Geodesy and Geophysics
The International Union of Radio Science
and The International Union of Geological Science.

A National Committee of the second, the IUGG has been formed with headquarters in University of Ibadan and is taking part in the International Year of the Quiet Sun. National Committees of the other Unions remain to be formed.

S.A.N. was invited by the Federal Government to serve on the UNESCO National Commission for Nigeria. This Commission is now taking up the proposals made by S.A.N. in the past three years for a National Council for Science and Technology in Nigeria.

*Local Branches*

A Lagos Branch of S.A.N. was formed during the year. Council is desirous that more active local branches should be formed in the main centres of Nigeria. The Local Committee in Zaria was responsible for the planning of the present conference.

*Seventh Annual Conference*

Council has proposed that the next Conference should be held in the University of Nigeria, Nsukka in December 1964.

There was a slight increase in income during the year, and early in July 1963 a sum of £300 was transferred from current to savings account. This is not indicated in the balance sheet because the transfer took place after the end of the financial year.

Some saving was made on "Secretarial Help" during the year. This was effected by some free provision of facilities by the secretarial staff of the Hon. Treasurer's department and by careful control by both the Hon. Secretary and the Editor.

There was a small deficit in the "Conference Account" for 1962, but there was some improvement, at least on the financial side over the 1961 conference.

For the first time a credit balance was returned when the total sum charged on bank commission had been deducted from interest on "Savings Account". This trend will continue if members remember the simple "Commission to drawer's account" rule.

The Federal Government continues to give us the usual generous subvention of £500 per annum. Out of the credit balance of £307-8s-10d. from this account, payment will be made for the printing of the fifth volume of the Proceedings of the Association. Payment will also be made partly from this vote for the S.A.N. contribution towards publication of the Journal of W.A.S.A. for 1963. We are most grateful to the Federal Government for this firm and steady annual aid.

The UNESCO gave us a subvention for the W.A.S.A. Conference at Kumasi, but as this money was not received before the end of the financial year, it does not appear in the balance sheet. We appreciate this generous help from the UNESCO.

Sale of copies of the *Proceedings* is not yet encouraging, but we are gradually building up a market for this publication, and with the money realised from advertisements, it is hoped that in the near future something substantial will come to the coffers of the Association from this source. It is not hoped however, that the *Proceedings* will be able to pay for its publication for the next few years.

The Auditor this year, Mr. S. O. Owolabi, B.SC., C.I.S., gave some useful advice to the Hon. Treasurer, and worked very hard to check every detail in the accounts of the Association for the year. This was the first time a professionally qualified accountant audited the accounts of the Association.

## *Sixth Annual Business Meeting*

At this meeting the reports of the Hon. Secretary and Hon. Treasurer were received, elections held and the following proposal carried unanimously "That the Association should take all necessary steps to commence the publication of a *Nigerian Journal of Science*".

### *Council Membership for 1963*

| | | |
|---|---|---|
| President | : | Professor C. W. L. Bevan |
| Vice-President | : | Mr. G. E. O. Okiy |
| Hon. Secretary | : | Dr. C. I. O. Olaniyan |
| Hon. Treasurer | : | Mr. T. O. Fayiga |
| *Ordinary Council Members* | : | Professor J. C. Edozien |
| | | Dr. J. C. Ene |
| | | Mr. K. H. Hatherly |
| | | Dr. B. Hopkins |
| | | Professor V. O. Oyenuga |
| | | Dr. B. N. Okigbo |
| | | Dr. M. O. Chijioke |

*Sectional Representatives*

| | | |
|---|---|---|
| Agriculture | : | Mr. G. E. O. Okiy |
| Botany | : | Mr. C. F. A. Onochie |
| Medical Sciences | : | Dr. A. E. Boyo |
| Physical Sciences and Engineering | : | Mr. C. J. Davis |
| Zoology | : | Professor N. Bolwig |

*Co-opted Members:-*

| | | |
|---|---|---|
| Public Relations Officer | : | Mr. A. M. Oseni |
| Chairman Local (Zaria) Committee | : | Professor N. J. Skinner |
| Secretary Local (Zaria) Committee | : | Mr. R. L. Story |

## GENERAL ACCOUNT

| *Income* | £ | s | d | *Expenditure* | £ | s | d |
|---|---|---|---|---|---|---|---|
| Balance from 1962 | 733 | 4 | 1 | Printing and Stationery | 36 | 19 | 4 |
| Annual Subscriptions 1962 | 184 | 15 | 6 | Secretarial Help | 34 | 6 | 3 |
| Annual Subscriptions 1963 | 362 | 15 | 6 | Bank Charges | 7 | 18 | 11 |
| Miscellaneous Receipts | 24 | 9 | 0 | Sundry Debts | 1 | 13 | 0 |
| Overall Profit on Conference Account | 22 | 4 | 7 | W.A.S.A. Journal 1962 Subscription | 300 | 0 | 0 |
| Interests on Savings | 12 | 13 | 6 | Stamps and Postage | 17 | 0 | 4 |
| | | | | Excess Income | 942 | 4 | 4 |
| | 1340 | 2 | 2 | | 1340 | 2 | 2 |

## FEDERAL GOVERNMENT SUBVENTION ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Balance from 1961/62 Account | 188 | 17 | 4 | S.A.N. Proceedings Account | 181 | 6 | 11 |
| Federal Government Subvention for 1962 | 500 | 0 | 0 | Fund for meetings Account | 200 | 1 | 7 |
| | | | | Excess Income | 307 | 8 | 10 |
| | 688 | 17 | 4 | | 688 | 17 | 4 |

## PROCEEDINGS OF THE SCIENCE ASSOCIATION OF NIGERIA ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Federal Government Subvention Account | 181 | 6 | 11 | Printing and Stationery | 173 | 8 | 8 |
| Sales of Copies of the Proceedings | 21 | 8 | 1 | Secretarial Help | 17 | 5 | 0 |
| | 202 | 15 | 0 | Postage | 12 | 1 | 4 |
| | | | | | 202 | 15 | 0 |

## 1962 CONFERENCE ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Conference Fees | 34 | 5 | 6 | Printing and Stationery | 14 | 1 | 2 |
| Dinner Tickets | 107 | 11 | 0 | Transport | | 14 | 0 |
| Accommodation Deposits | 17 | 17 | 0 | Postage and Telegrams | 4 | 4 | 0 |
| | | | | Secretarial Help | 10 | 10 | 0 |
| Total Income | 159 | 13 | 6 | Dinner | 105 | 0 | 0 |
| Deficits | 25 | 13 | 8 | Coffee and Special Lunch | 35 | 3 | 0 |
| | 185 | 7 | 2 | Accommodation Refunds | 15 | 15 | 0 |
| | | | | Total Expenditure | 185 | 7 | 2 |
| | | | | Deficit from 1962 brought down | 25 | 13 | 8 |
| Balance from 1960 Conference | 47 | 18 | 3 | Excess overall profit | 22 | 4 | 7 |
| | | | | | 47 | 18 | 3 |

## FUND FOR MEETINGS ACCOUNT

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| Balance from 1961/62 | 23 | 0 | 11 | Speakers' Fares 1962 Conference | 59 | 12 | 0 |
| From Federal Government Subvention | 200 | 1 | 7 | Attendance at Council Meetings | 30 | 12 | 6 |
| | | | | Fares for Speakers at W.A.S.A. Conference | 132 | 18 | 0 |
| | 223 | 2 | 6 | | 223 | 2 | 6 |

## BALANCE SHEET

(30th June, 1963)

| | £ | s | d | | £ | s | d |
|---|---|---|---|---|---|---|---|
| From General Account | 942 | 4 | 4 | Cash in Current Account | 813 | 10 | 6 |
| From Government Subvention Account | 307 | 8 | 10 | Cash in Savings Account | 434 | 0 | 7 |
| Cheques not presented or not claimed | 4 | 10 | 0 | Cash in hand | 6 | 12 | 1 |
| | 1254 | 3 | 2 | | 1254 | 3 | 2 |

I have inspected the account books and other relevant documents of the Science Association of Nigeria and I am satisfied that the above statements represent the true state of the finances of the Association up to [illegible] June, 1963.

S. O. Owolabi
*Auditor*

Theo. Ola. Fayiga
*Hon. Treasurer*