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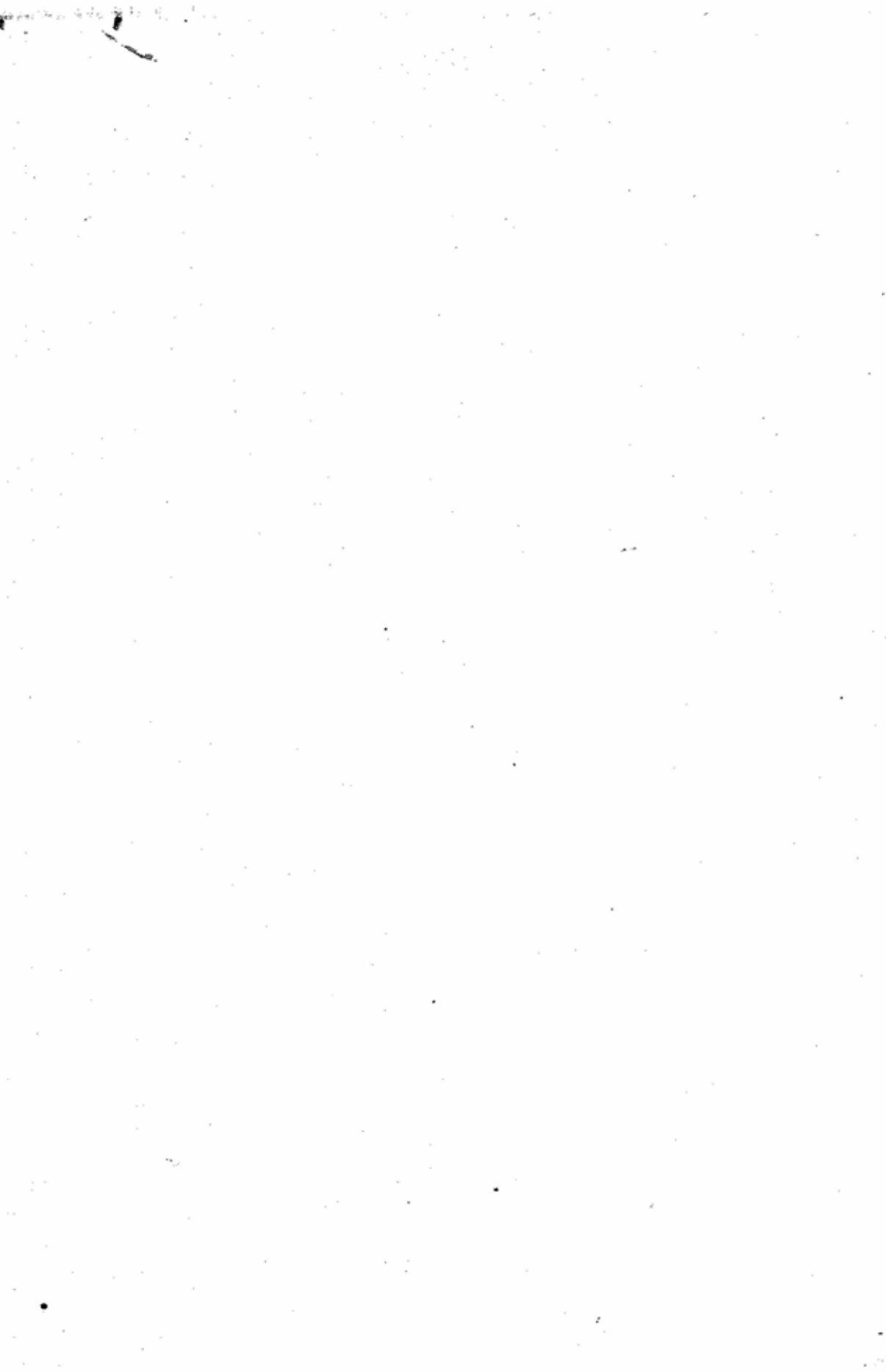
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Board of Scientific Advice
for India

ANNUAL REPORT

FOR THE YEAR

1919-20

39726



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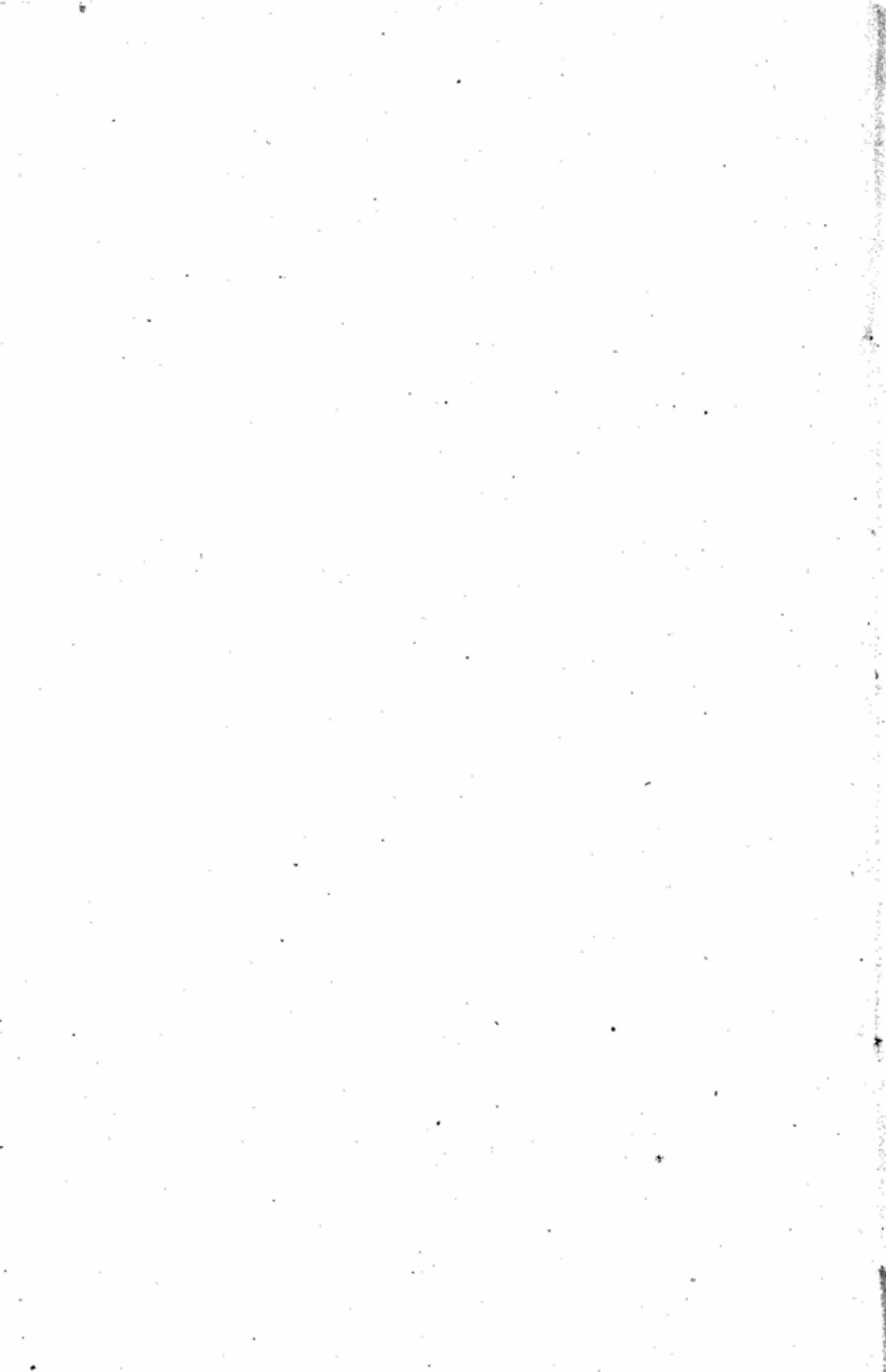
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Members of the Board of Scientific Advice.

Name.	Appointment.
The Hon'ble Mr. J. HULLAH, I.C.S.	Secretary to the Government of India (Department of Revenue and Agriculture) and <i>ex-officio</i> President, Board of Scientific Advice.
G. T. WALKER, Esq., C.S.I., M.A., Sc.D., F.R.S.	Director-General of Observatories.
S. W. KEMP, Esq., B.A., F.A.S.B.	Officiating Director, Zoological Survey of India.
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Lieutenant-Colonel G. K. WALKER, C.I.E., O.B.E., F.R.C.V.S.	Principal, Punjab Veterinary College.
Sir G. S. HART, K.B.E., C.I.E.	Inspector-General of Forests to the Government of India.
S. MILLIGAN, Esq., M.A., B.Sc.	Agricultural Adviser to the Government of India.
E. H. PASCOE, Esq., M.A., D.Sc., F.G.S.	Officiating Director of the Geological Survey of India.
The Hon'ble Major-General W. R. EDWARDS, C.B., C.M.G., K.H.P., M.D., I.M.S.	Director-General, Indian Medical Service.
The Hon'ble Colonel Sir S. D'A. CROOKSHANK K.C.M.G., C.B., C.I.E., D.S.O., M.V.O.	Secretary to the Government of India, Public Works Department.
Sir ALFRED BOURNE, K.C.I.E., F.R.S.	Director, Indian Institute of Science.
Lieutenant-Colonel A. T. GAGE, I.M.S.	Director of the Botanical Survey of India and Secretary, Board of Scientific Advice.

List of Sub-Committees.

Sub-Committee A.—(*Meteorology, Terrestrial Magnetism and cognate subjects*).

1. The Surveyor-General of India (Chairman);
2. The Director-General of Observatories;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman);
2. The Inspector-General of Forests;
3. The Agricultural Adviser to the Government of India.

Sub-Committee C.—(*Soils and Manures*).

1. The Agricultural Adviser to the Government of India (Chairman);
2. The Director, Geological Survey of India;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman);
2. The Agricultural Adviser to the Government of India;
3. The Director, Botanical Survey of India.

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1. The Principal, Punjab Veterinary College (Chairman);
2. The Agricultural Adviser to the Government of India;
3. The Director, Zoological Survey of India.

Sub-Committee F.—(*Libraries*).

1. The Director-General of Observatories (Chairman);
2. The Surveyor-General of India;
3. The Director, Geological Survey of India;
4. The Director, Zoological Survey of India.

Annual Report of the Board of Scientific Advice for India, 1919-20.

SUMMARY OF PROCEEDINGS.

Thirty-eighth meeting held at Simla on the 17th May 1920.

The Board considered and accepted the programmes of the various Scientific Departments for 1920-21.

A letter was read and recorded regarding the nomination of Mr. C. C. Calder as Officiating Secretary.

The question of reorganisation of the superior staff of the Zoological Survey of India raised by Dr. Annandale was referred by the Board to a Sub-Committee consisting of the Director-General, Indian Medical Service, the Director, Geological Survey of India, the Director, Zoological Survey of India, the Principal, Punjab Veterinary College, the Agricultural Adviser to the Government of India and the Officiating Director, Botanical Survey of India. This committee was asked to report on the scheme and to submit its report by the 20th May 1920 when the Board would meet to consider it.

A note by the Director, Zoological Survey of India on the question of co-operation and co-ordination between the different Scientific Departments in India was read and recorded.

At an adjourned meeting held on the 20th May 1920 the Board considered the report of the Sub-Committee appointed at their previous sitting. The report was accepted and it was decided that the scheme for reorganisation of the Zoological Survey be recommended to Government for adoption.

Thirty-ninth meeting held at Delhi on the 20th December 1920.

The draft Annual Report was discussed and adopted.

The Board considered a note submitted by the Director-General of Observatories on the utility of their programmes of work and reports. They decided to endorse the standing orders regarding submission of programmes, but as regards the reports the Board were of opinion that the preparation of the bibliography was unnecessary provided that instructions issued to all scientific departments to publish annually, either in their departmental reports or elsewhere, lists of works compiled by officers of the Departments or specially concerned with India.

On the question of enlargement of their functions referred to by Dr. Walker the Board considered that they might more usefully perform their functions as a Board of Scientific Advice if they were consulted by the Local Governments on schemes of scientific development or education. In this connection they would welcome the addition to their number of a representative of the Education Department with Scientific qualifications and recommended that the Government of India be asked to nominate such a representative.

The Board further resolved that the Library Sub-committee be asked to inform them at their next meeting as to what has been done regarding the provision of Scientific libraries in India and as to any practical outcome of the recent report on the perishing of paper in India.

APPLIED CHEMISTRY.**PART I.—AGRICULTURAL CHEMISTRY**

BY

J. SEN, M.A., PH.D.,

*Officiating Imperial Agricultural Chemist.***SOILS.**

Soil surveys.—Taylor has nearly completed his survey of soils from a traverse across the centre of south Bhagalpur, and the examination of a similar traverse of the Kosi area in Purneah is almost finished. The Purneah soils appear as a rule to be rich in phosphate, while those in south Bhagalpur seem generally poor in that constituent.

The survey of the Godaveri delta has been finished by Norris. The results indicate a deficiency of phosphoric acid in 25 per cent. of the samples and of nitrogen in 40 per cent. Survey of the Periyar delta is proceeding.

Pillai is carrying out a survey of the soils of the Vaikam taluk in Travancore and the officers of the Indian Tea Association are collecting data connected with the tea soils of North Eastern India.

Soil investigations.—Padmanabha Aiyer, in the course of his examination of the soils of orange gardens of the Central Provinces, has found that the soils of good gardens are rich in lime. The same officer has also examined the chemical and biological aspects of the Bhatta soils of Chandkhuri.

Sahasrabuddhe is continuing his study of the deterioration of the cardamom garden soils in North Kanara.

Tamhane has compared the salt lands of the alluvial tract of Sind with those in the Trap area in South Deccan. He has noticed the remarkable fact that sodium carbonate is not a necessary constituent of black *Kalar*. In the case of some Sind soils, the only salts to which the dark appearance may be attributed are calcium chloride and magnesium chloride. Tamhane's observations on the probable effect of the proposed Sukkur Barrage Scheme are being published soon.

Soil physics.—The problems of the measurements of vapour pressure of the soil water and the determination of the compressibility of the clay contained in soils are engaging the attention of Wilsdon. He is also studying the osmotic equilibrium of salt solutions in soil.

Soil gases.—Harrison has found that the fermentation of green manure under anaerobic conditions does not take an abnormal or unusual course, and

that the absence of carbon dioxide and hydrogen from paddy soil gases is accounted for by a subsidiary bacterial action taking place which results in the reduction of carbon dioxide by the hydrogen and the formation of organic matter and even marsh gas. This reaction between carbon dioxide and hydrogen is beneficial to the paddy crop, ensuring efficiency of root aeration. Mukherji has observed that the percentage of carbon dioxide in soil air is very high in plots over which grass is growing as compared with that in the soil air in cultivated plots. In plots which are grassed down but partially aerated by trenches the air is intermediate in composition. He has also studied the seasonal variation of carbon dioxide in the air of soils thus differently treated.

MANURES AND MANURING.

Green manuring.—Warth is continuing his investigations on the green manuring of paddy soils. He finds that lack of phosphoric acid does not hinder ammonification while it definitely hinders growth of paddy.

Phosphates.—In the way of the utilisation of the mineral phosphates for paddy, promising results have been obtained at Coimbatore by composting them with green manure. Results of experiments so far tried have been negative as to the value of "tetra phosphate."

Harrison has published the results of his investigations on the retention of soluble phosphates in calcareous and non-calcareous soils and has demonstrated that the phosphate manuring of calcareous soils is a very different problem to that of non-calcareous soils.

Potash.—The Indian Tea Association officers are carrying out certain experiments on the fixation of potash by the soil. The heavier acid soils of Assam behave in an abnormal way with regard to absorption of salts.

General.—The manurial requirements of cotton and the availability of organic manures in South Indian soils are being examined by Norris.

CROPS AND FEEDING STUFFS.

Paddy.—Harrison has carried out a series of experiments to compare the effect of ammonium sulphate as a manure on the yield and composition of paddy crops. The employment of ammonium sulphate resulted in a considerable increase in the percentage of nitrogen in the grain.

Pulses.—Clarke is continuing his study of the proteins of the more important Indian pulse crops.

Potatoes.—The chemical changes which accompany the rotting of stored potatoes at high temperatures have been worked out in the Poona laboratory, and the influence of moisture and aeration determined.

Oil seeds.—The oil content of certain selected varieties of castor being investigated by Taylor, and the various oil seeds of Mysore are being examined by Coleman.

Sugarcane.—Investigations in connection with sugarcane and sugar industry were, as usual, carried out by Clarke at Sahajanpur. The results obtained by Harrison as to the effect of windrowing on the composition of canes have been published. The weight of sucrose and crystallisable sugar increases rapidly at first to be followed by a period during which the values remain practically constant, after which deterioration sets in. The period during which canes can be stored varies with different seasons, but in any particular season appears to be determined by the incidence of heavy rain.

Palmyra palm.—Ghosh has drawn attention to the existence in Bihar of a neglected source of sugar in the palmyra palm.

Coconuts.—Norris is continuing his study of the composition of the different parts of the tree at different stages of growth. The chemical changes occurring during the germination of the nut are also under investigation.

Pillai has found in Travancore that the nuts harvested in February and March are found to be of better quality than those harvested in other times.

Sandal.—The separation and identification of some of the organic constituents in healthy and spiked sandal leaves and a study of the influence of various manures on the course of spike are being undertaken in Mysore.

Tea.—From sand culture experiments performed by the officers of the Indian Tea Association it seems that the incidence of Brown Blight of tea is associated with manures of high nitrogen content.

Indigo.—Bhailal Amin has succeeded in developing an easy and productive method of separation of indican from the indigo plant.

Poppy.—Annett is continuing his study of various factors influencing morphine production. The results throw much light upon the function of alkaloids in plant life. It seems that the plant loses the power of producing morphine well before the capsules are ripe. A study of codeine is being taken up on similar lines to that of morphine. The results indicate that the latex has practically a uniform codeine concentration in all parts of the plant, whereas the morphine concentration is highest in the latex in the capsules and diminishes in the lower parts of the plant.

Cyanogenesis.—Some further work has been done by Taylor in connection with the hydrocyanic acid content *jowar* (*Andropogon sorghum*). From these experiments it appears that the atmospheric humidity is a more important factor than soil moisture in deciding the poisonous quality of the young plants.

Warth is continuing his investigations on cyanogenesis in Burma beans (*Phaseolus lunatus*). He has succeeded in isolating some hopeful cultures.

Milk.—Plymen and Aiyer have drawn attention to the variations in the characteristics of the fat of buffalo and cow milk in India, as compared with those noticed in other countries. The departure from the usually accepted

figures is found by them to be greatest during the months when hot dry weather prevails. Annett and Sen have similarly found that the composition of butter fat undergoes a change after the breaking out of rains bringing the usual rush of green grass.

Gangolli and Meldrum have been carrying out an investigation on the production and utilisation of casein in India.

APPLIED CHEMISTRY.

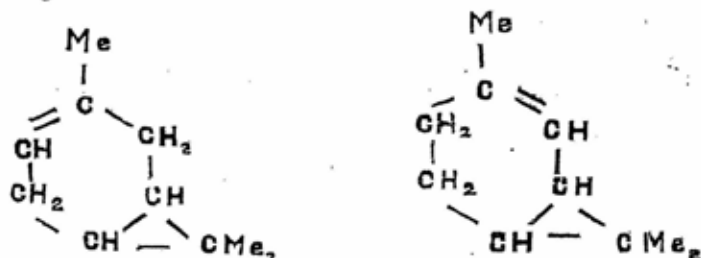
PART II.—FOREST CHEMISTRY

BY

J. L. SIMONSEN,

Forest Chemist, Forest Research Institute, Dehra Dun.

At Dehra Dun a study of the turpentines from the various species of *Pinus* occurring in India has been commenced. The turpentine from *P. longifolia* has been found to consist of 1- α -pinene, β pinene, a new unsaturated bicyclic terpene, to which the name *d-carene* has been given and a tricyclic sesquiterpene *d-longifolene*. *d-carene* is probably represented by one of the two following formulæ:—



The evidence upon which this structure is based will be found in a paper on the subject (Trans. Chem. Soc. 1920. 117. 570). The inferior quality of Indian turpentine is due to the presence of this terpene which is very readily oxidised.

The turpentine from the oleo-resin of *Pinus Khasya* from Burma has been distilled at Jallo and the oil examined at Dehra Dun. It consists almost solely (about 90 per cent.) of α & β Pinene. It is of some interest that the sesquiterpene present is *d-longifolene* identical with that present in the oil from *P. longifolia*. The turpentine from *P. Khasya* grown in Burma is quite equal in quality to American turpentine and if the collection of the oleo-resin is not too expensive it should prove a formidable competitor. There is some evidence that the turpentine from *P. Khasya* grown in Assam is of inferior quality and it is hoped to examine this oil also.

Camphor and Camphor Oil.—For some years past the leaves from coppiced trees of *Cinnamomum Camphora* grown at the experimental garden at Kaunli have been distilled at Dehra Dun. The results indicate that the leaves yield approximately 4 per cent. of camphor and camphor oil (about 3 per cent. of camphor and 3.7 per cent. of oil). As the oil contains over 30

per cent. of camphor in solution it seems possible that the cultivation of coppiced camphor trees for the extraction of camphor might be of industrial importance. It is hoped this year to complete experiments on the careage yield of leaves and camphor. The oil after the removal of the camphor will probably prove to be of little value, since unlike camphor wood oil, it does not contain any Safrol.

Boswellia serrata.—Dr. Fowler has continued his work on the best methods for the utilisations of the gum-oleo-resin of *Boswellia serrata*. It is understood that the results, which are very promising, will shortly be ready for publication.

Tanstuffs.—Mr. Pilgrim has published an account of his work on the tanstuffs in the Forest at the Rajabhatkhawa Concession granted to the Buxa Timber and Trading Company, Limited, North Bengal. (Report on an Investigation of the Forest Concession of the Buxa Timber and Trading Company, Limited, at Rajabhatkhawa, North Bengal. Government Press 1920.) The results obtained are of undoubted importance but do not lend themselves to summarisation.

Lantana.—At the Indian Institute of Science Mr. J. D. Edal Behram has investigated the Enzymes present in the leaf of *Lantana Camara*. (Journ. Ind. Inst. of Sc. Vol. II, page 195.) The use of the leaves as a tea substitute is suggested.

Morinda citrifolia.—The writer (Trans. Chem. Soc. 1920 117 561) shows that the root bark of *Morinda citrifolia* contains in addition to morindone, rubiadin monomethyl ether and alizarine α -methyl ether.

ASTRONOMY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar physics.—Researches in solar physics are carried on at Kodai-kanal under the direction of Mr. J. Evershed. A description of the instruments and of the routine work was given in last year's report. The only change to be noted is the mounting of a 6-inch refractor for general use on the 20-inch equatorial by Grubb received from Poona.

SPECTROSCOPIC RESEARCH.

A continuous series of sunlight and iron arc spectra was obtained in order to test the constancy of the sun-arc displacement. Confining attention to the region 4337-4531 and to lines that are not subject to pole effect in the arc, variations amounting to several thousandths of an angstrom are found in the sun-arc displacement. These variations are of two kinds (1) a general change affecting all the lines in the region studied, and (2) a change affecting particular lines or groups of lines. Whilst measures of the distances between iron lines in the sun and arc spectra show that the variations of the second kind are generally due to a slight instability of the wave-length in the arc there is some evidence that the solar lines are not absolutely stable. It has also been possible to demonstrate the small changes in wave-length in the lines of the iron arc but all efforts to trace the cause of such changes by varying the arc conditions have failed.

In order to test Einstein's prediction of the solar displacement due to the sun's gravitational field, Mr. A. A. Narayana Iyer has measured the displacement of the cyanogen bands near 3883 at the sun's polar limbs. Fifteen plates of limb spectra and carbon arc, and ten plates at the centre of the disc give the following mean displacements of ten prominent triplet bands :—

	in angstroms	in km/sec.
North limb	+0.0061	+0.47
South limb	+0.0083	+0.68
Centre of disc	+0.0043	+0.33

These values are, however, much higher than those obtained by St. John for some reason which is not apparent, but they are supported by the follow-

ing values for iron lines which, being free from pole effect and pressure shifts, are considered to be as reliable a test as the cyanogen lines :—

	in angstroms	in km/sec.
North limb	+0.0099	+0.67
South limb	+0.0134	+0.91
Centre of disc	+0.0070	+0.47

The general result is that the displacements are of the same sign and order of magnitude as that predicted by Einstein's hypothesis. The displacement differs, however, with different substances and for different lines of the same substance; moreover, the displacement is not proportional to the wavelength. Hence if the displacements are principally due to a gravitational effect, there must be some unknown modifying influence at work.

The study of the displacements in the Venus spectrum were continued until May 1920. After a considerable period of immunity from drifting of the spectrum during an exposure as a result of the remedies mentioned in the previous report, this trouble reappeared for a time but afterwards disappeared again. It was established that the drift was due to a rotation of the grating, presumably by a motion of the pier on which the grating is mounted caused by climatic changes. The measurements of the Venus spectra are still favourable to the hypothesis of the solar displacements being influenced by the earth, and unfavourable to the Einstein hypothesis.

The evidence with regard to the rotation of Venus commented on in the previous report is inconclusive since the effect observed may be caused, in part at least, by unequal illumination of the slit due to the wandering of the image during an exposure. Owing to this uncertainty, the true rotation period of Venus is still undetermined.

Photographs of sections of the sun's disc have been made in the $H\alpha$ region, and the region studied in the sun and Fe arc plates. It was found that the irregular displacements discovered in 1918 by superposing a reversed positive on a negative of the spectrum may be observed at the centre of the disc, but up to the present they have not been found very near the limb. It appears therefore that, unlike the displacements in the penumbrae of spots, they may be due to movements normal to the surface, or having a component normal to the surface.

A detailed study of the dark markings in $H\alpha$ spectroheliograms has been commenced, chiefly with a view of determining their exact relation to prominences. A preliminary investigation has led to the discovery of the following new features, which are forming the subject of a bulletin now in the press. (1) The average direction of $H\alpha$ dark markings changes from a direction nearly along a meridian in equatorial regions by inclining with the end which is nearer the pole more and more towards the east until in latitudes higher than about 35° , the markings lie nearly along a parallel of latitude. This can be explained as an effect of the polar retardation of the rate of the sun's rotation. (2) Dark

markings when near the limb have almost invariably a bright margin on the side nearest the centre of the sun's disc. The distance of the marking from the centre of the disc when the bright margin on the limb side begins to appear has led to the important conclusion that the dark marking does not generally reach to a level higher than about 10" above the chromosphere. (3) A narrow absorption strip at the base of prominences in profile at the limb is seen in more than 25 per cent. of the total number of prominences photographed in $H\alpha$ light and would appear to be typical of the majority of prominences when their base is exactly at the limb. This absorption strip has a width of about 6" and it is concluded that only up to this height is there sufficient hydrogen in the outer and cooler portions to effect absorption of light from the inner portions of the prominence.

Some experiments have been made regarding the application of interferometer methods to the study of displacements and a new method of using the interferometer which can be applied to study the variation of wave-length across the sun's disc is being made use of.

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Upper Air.—Work with pilot balloons was continued throughout 1919-20, and at more stations than previously. Lahore had been started in March 1918, and in 1919 three new balloon stations began work at Akyab, Calcutta and Bombay, to provide information for the Air Board. The station at Khojak was closed in January 1919. These new aviation stations will be useful also as an extension of the net-work of scientific balloon stations.

In Agra the results of all stations are tabulated, examined and reduced to the form of half-monthly and monthly resultants. This work was a good deal in arrears, but headway was made towards bringing the results up to date: much still remains to be done.

Normal values of wind direction and velocity at various heights above ground for 5 stations, and about one year's mean resultant values for 4 others, were worked out in Agra. This work is in the press for early publication for the use of the Air Board.

A paper on "Exposure of thermometers in India" was written and is about to be sent to press.

General Meteorology.—Owing to leave arrangements the numbers of the gazetted staff were as low as during the war years, and research was practically at a standstill.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Magnetic observatories.—Bombay (Alibag).—For a description of the instruments and of the routine work reference should be made to the Annual Report of the Director, Mr. T. K. Chinmayanandam.

Magnetic Survey.—No. 18 Party (Magnetic).—Since the magnetic elements undergo very appreciable changes within a short space of time, it was decided to take observations at the repeat stations at intervals of every five years in order to obtain reliable values of the annual changes; hence the repeat stations, where observations were taken in 1914-15, were visited again in 1919-20. Three detachments were employed in completing the field-season's programme, which comprised observations to determine the declination, dip and horizontal force at the 75 repeat stations in India, Burma and Ceylon, and at 5 new stations which were selected this season and permanently marked, two being in Upper Burma, one in Lower Burma, one in Bengal and one in Assam: these 5 extra stations were much needed for shaping the true course of the lines of annual change in these particular localities. Complete sets of observations were also taken at the Dehra Dun, Toungoo, Kodaikanal and Alibag observatories for the comparison of instruments.

Publication of the results of the Magnetic Survey.—It is regretted that the publication of the results of the magnetic survey from 1901 to 1915 and reduced to the epoch 1909-10, which was promised last year, will not be available before the coming year. Major R. H. Thomas, D.S.O., R.E., Superintendent of the Trigonometrical Survey, who was formerly in charge of the Magnetic Survey, had adjusted the constants used in the computations of the horizontal force before he proceeded to Europe on military duty; he has, on his return to the Department, considered it advisable to revise the constants of all the instruments employed in order to obtain a more accurate determination by utilizing the additional data derived in recent years. It has now, therefore, been decided to compute the results with greater refinement, and, as observations have been taken this season at the repeat stations, to include all the recent observations and bring the publication up to the 1st January 1920.

The reduction of the observations of the detail survey will next be taken in hand and revised. The results of the disturbed areas will then be studied to ascertain whether these areas reveal any prominent magnetic features. It

is doubtful, however, if any definite conclusions will be arrived at, as the results hitherto do not seem to indicate the existence of any centres of attraction. On the contrary, they are very conflicting and appear to show that the disturbances are of a purely local nature, depending entirely upon the unequally magnetized rocks hidden close below the ground surface.

The magnetic elements at observatories.—The computation and tabulation of the provisional values of declination, dip, horizontal force and vertical force for the three observatories (Dehra Dun, Toungoo and Kodaikanal) for the year 1919 have been completed: the mean values of these elements derived from all days, excluding those of great disturbances, are given in the table below:—

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
Dehra Dun . {	30° 19' 19" N 78° 3' 19" E	} N. 44° 54' .8	E.1° 56' .1 {	C.G.S. ·32962	C.G.S. ·32863
Toungoo . {	18° 55' 45" N 96° 27' 3" E	} N. 23° 8' .3	W.0 20' .2	·39097	·16707
Kodaikanal . {	10° 13' 50" N 77° 27' 46" E	} N. 4° 33' .5	W.1° 44' .5	·37753	·03010

GEOLOGY

BY

E. H. PASCOE, M.A., D.Sc., F.G.S.,

Officiating Director, Geological Survey of India.

Stratigraphy.—In the fossiliferous rocks recently discovered in the hills between Matiana and the Shali peak to the north of Simla nummulites were subsequently obtained, and *Assilina spira* has since been identified. This confirms the age suggested by the *facies* of the rocks, which is that of the Subathu beds of Solan. The sequence from the Shali limestone upwards through the fossiliferous beds to quartzites and slates of the Simla series has the appearance of being a conformable one. There is a considerable amount of disturbance and occasional inversion, and the true geological sequence has not yet been fully established. The matter is one of importance, as it may throw light on the age of the Shali and other similar limestones.

An examination of the Lameta beds of Jubbulpore district was made by Dr. C. A. Matley, who communicated the results to this Department. He divided the formation into five separate zones, and records that the succession from the Jubbulpore series through the Lametas to the Deccan Trap appears to be a conformable one. A number of parallel post-trappean strike faults affecting the Lameta beds were detected by him.

Dr. Matley also discovered in the Lameta beds of Jubbulpore numerous remains of dinosaurs. These include various portions of the skeleton of the great sauropod *Titanosaurus indicus*, Lydekker, and of the carnivorous (theropod) dinosaur allied to *Megalosaurus*.

Geological Surveys.—The survey in the ferriferous belt of Bihar and Orissa was continued, as was also the general systematic survey of the Central Provinces. The systematic survey of Mergui progressed during the year. A reconnaissance survey with the Waziristan Field Force on the north-west frontier, and a similar examination of Mesopotamia, especially with regard to the oilfields of that country, were carried out.

Economic Enquiries.—Investigations were made regarding the following minerals : bauxite in the central parts of the Peninsular area, chromite in the Zhob valley, coal in Tenasserim, iron in the Feudatory States under Bihar and Orissa, petroleum in Mesopotamia, soda in Sind, and sulphur in Baluchistan.

Several sites for dams were examined and reported on during the year, and the question of the water-supply of Quetta was gone into by Mr. Cotter

GEODESY

BY

MAJOR R. H. THOMAS, D.S.O., R.E.,

Officiating Superintendent of the Trigonometrical Survey.

The only Geodetic work done during the year consisted of Tidal Observations and Precise Levelling; no Triangulation was undertaken nor were any Pendulum or Astronomical Observations made.

LEVELLING OPERATIONS.

1. LEVELLING COMPLETED IN 1919-20.

During the year 1919-20, the following lines of precise levels were run:—

A.—In the Punjab.

- (a) Ferozepore to Ludhiana (Revision). This line was originally levelled in 1860-62.
- (b) Amritsar to Ludhiana (New).
- (c) In the Sind Sagar Doab for the Irrigation Department.
 - (1) From near Leiah to Shorkot Road Railway station.
 - (2) From near Khairwala to near Wanbhacharan Railway station.

The total distance levelled in the Punjab including branch lines was about 410 miles, (a) and (b) on the "Fore and back" and (c) on the "Simultaneous" double levelling systems respectively.

B.—In the United Provinces.

Sitapur to Shahjahanpur by the Grand Trunk road. (Revision) The line was originally levelled in 1868-69. The total distance including branch lines was 158 miles and was executed on a slightly modified form of "Fore and back double levelling."

C.—In Assam and Bengal.

Silchar to Comilla *via* Karimganj and Akhaura. Including branch lines the total distance was about 197 miles, executed on the old system of Simultaneous double levelling. It was originally levelled in 1911-12 and the revision was undertaken to investigate whether any disturbance of the bench-marks had taken place during the Earthquake of 8th July 1918, the epicentre of which was reported in the Records of the Geological Survey of India, Volume XLIX, Part III, 1918, to be in the Balisera Hills near Kalighat $3\frac{1}{2}$ miles South of Srimangal Railway station. It is to be regretted that the mark-stone of *Charamani H. S.* which was connected by spirit levelling in 1911-12, and the location of which cannot have been a quarter of a mile from the epicentre, was destroyed by the earthquake and the pillar razed to the ground. Thus no comparison of this point was possible. The knoll on which the H. S. stood and the spurs immediately south of it bore deep fissures ziz-zagging down the hill-sides.

The G. T. S. Bench-marks north of and within a quarter of a mile of Srimangal Railway station, which was practically destroyed by the earthquake, show no subsidence, nor is there any evidence of regular disturbance West of Srimangal until the low range of hills 6 miles west of it and lying between Satgaon and Rasidpur is crossed. $\frac{3}{4}$ of a mile north of Rasidpur Railway station, a tree bench-mark at Kamaichara shows practically no alteration; a mile and a half west of this the settlement of all Bench-marks begins. The settlement varies from $1\frac{1}{2}$ inches to 9 inches according to the nature of the soil and type of bench-mark and continues uninterruptedly past Mirpur Dak Bungalow, Shastaganj and Shahji Bazar up to a railway bridge 30 miles from Srimangal near Telegraph post No. 149-14 which shows practically no alteration in height (see table below). Thereafter settlement is occasional but very small to Kamalasagar beyond which no appreciable disturbance has taken place. The bench-marks that have settled include two of the embedded type, but unfortunately none on rock, which is situated some distance beneath the alluvial soil.

Comparing results with plate 11 of the Report in the Geological Survey of India Records, as far as can be ascertained no settlement took place in the epicentral area or N.-E. of the epicentral axis, but in the area between the epicentral area and Isoseist No. 2, West South West of the former, settlement up to 9 inches has occurred.

Those bench-marks situated on masonry above ground have generally been disturbed more than those embedded in the soil; the latter however show distinct settlement.

The following table shows the bench-marks disturbed in the area between Kamaichara and the railway bridge near Telegraph Post No. 149-14 mentioned above.

TABLE III.—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

BENCH-MARKS OF THE ORIGINAL LEVELLING THAT WERE CONNECTED DURING THE REVISIONARY OPERATIONS.			Distance between bench- mark.	OBSERVED HEIGHTS, ABOVE (+) OR BELOW (—) THE STARTING BENCH-MARK.			Difference (Revision— Original). The sign + denotes that the height was greater and the sign (—) less in 1919-20 than when originally levelled.	REMARKS.
Number.	Degree Sheet.	Description.		From published heights. Original levelling.	Date of Original levell- ing.	From revision 1919-20 (Unad- justed).		
			Miles.	Feet	1911-12	Feet	Feet	
35	83D	Embedded bench-mark at Karimganj.	0.0	0.000		0.000		
50	78P	Tree in Kamaichara Vil- lage.	77.6	+4.390	"	+4.336	—0.054*	* In 77.6 miles un- altered.
51	"	On wing-wall of road bridge.	1.4	—15.008	"	—15.103	—0.095	
52	"	On Kerb of well at Mir- pur I. B.	1.2	—13.131	"	—13.203	—0.132	
53	"	Embedded bench-mark at Mirpur I. B.	0.0	—17.523	"	—17.705	0.182	
54	"	On wing-wall of road bridge.	2.4	—14.304	"	—15.065	—0.761	
55	"	On wing-wall of road bridge.	1.8	—16.824	"	—17.360	—0.536	
56	"	On verandah flooring of Shaistaganj I. B.	0.7	—20.170	"	—20.469	—0.299	
57	"	Wing-wall of road bridge	1.7	—24.698	"	—24.845	—0.147	
58	"	On Railway Boundary Stone.	2.9	—3.693	"	—3.806	—0.113	
60	"	Embedded bench-mark at Shahji Bazar I. B.	0.9	—4.709	"	—4.991	—0.192	
61	"	Tree opposite telegraph post No. 152-7.	2.5	—0.067	"	—6.270	—0.203	
62	"	On wing-wall of railway bridge.	2.8	—12.835	"	—12.863	—0.028	Unalter- ed.

II. SYSTEM OF LEVELLING.

Up to 1913 the system of levelling in use in the Survey of India was that known as "Simultaneous Double Levelling." In that year the system adopted by the International Geodetic Conference of 1912 and known as "Fore and Pack Double Levelling" was adopted.

It has been decided in future to carry out levelling under both systems and to divide the programme into two portions—

(a) Geodetic levelling of high precision.

(b) Levelling of precision.

(a) Will be executed on the "Fore and back" system for the new level net of India, which will intersect and be superimposed on the old adjusted net. A programme for the new net is being made out by which it is hoped to complete the field work in 20 years. In the meanwhile all height values will be adjusted to the old net and published. When the new net is completed, it will be readjusted from its own records independently of the old net, which in turn will be readjusted on to the new net.

(b) Levelling of precision on the "Simultaneous double levelling" system. This method will be employed for all work not required for the new net—and will be executed of varying degrees of precision according to the requirements of each line. It will be temporarily adjusted to the present completed net and will afterwards be readjusted to the new net, described in (a).

It is hoped by separating the above two systems to include more levelling for other departments in the annual programme.

TIDAL OPERATIONS.

During the past year tidal registrations by means of automatic gauges have been carried out at the following stations :—

Aden, Karachi, Bombay (Apollo Bandar), Bombay (Prince's Dock.), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registrations.

All the tidal observatories were inspected during the year and the gauges were thoroughly overhauled and put in working order.

In addition to the automatic tidal registrations at the nine stations named above, observations of high and low water on tide poles were taken during day light at Bhaunagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registrations taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply this Department with tidal observations taken on a tide pole at Basrah. On the basis of these observations data for the preparation of tide tables for Basrah for the year 1920 were prepared and supplied to the National Physical Laboratory in England. The predictions were received from the Laboratory in January 1920 and supplied direct to the Director, Inland Water Transport and Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in January 1920.

Data for the preparation of tide tables for Basrah for 1921 were despatched to the Director, National Physical Laboratory in December 1919.

BOTANY.

I.—BOTANICAL SURVEY

BY

C. C. CALDER, B.Sc., B.Sc. (AGR.), F.L.S.,

Officiating Director, Botanical Survey of India.

General.—With the Director and Economic Botanist both absent for a considerable part of the year the work of the Survey had to be restricted to meeting the wishes of collectors throughout India and Burma who depend on the institution at Sibpur for botanical information concerning their local floras. No touring or field work was possible beyond what the writer was able to associate with Cinchona duties. Opportunity was taken to collect materials for a revision of Gamble's list of trees, etc., of the Darjeeling District, particular attention being paid to a checking of the native Lepcha and Nepali names.

Research work of a systematic nature continues, however, to receive the attention of the various botanists, both official and unofficial, whose papers have been noted in former reports. Mr. H. H. Haines has described and arranged the much confused Indian species of *Carissa*. Mr. Gamble has raised the number of known Indian *Mimosas* from three to seven with figures and full descriptions of the new species and a useful key to their determination. The synonymy and taxonomic position of *Dioscorea sativa* has been dealt with in an exhaustive manner by Sir David Prain and Mr. I. H. Burkill. Mr. T. A. Sprague has had the genera *Dolichandrone* and *Markhamia* under revision. Prof. Fyson has published a short resumé of a paper on *Eriocaulon* still to appear in the Records while Mr. Sedgwick has contributed several notes and articles to the current botanical literature of the year including an article on his views as to the uses of the term 'variety' in systematics.

Eastern India.—Dr. Annandale has contributed about 200 specimens from the Chilka lake region. He has under preparation a paper dealing with the biology of the lake and has had the aid of officers of the Survey in the working up of the botanical list which is to form part of the paper.

The most important botanical work dealing with Eastern India has been the examination at Kew of the material collected during the Abor Expedition. These plants have been under examination by Mr. Burkill and other experts at home. Some twenty species new to Science have been described from Abor land. These cover a range of natural families but probably the most important additions are the new *Begonias* described by Mr. Dunn, some of which

may prove to be useful horticultural plants. Mr. R. S. Hole has added a new species of *Ixora* from the Yamethin District of Burma, Mr. C. E. Rogers a new mangrove species—*Brouguiera Hainesii* from Mergui and Dr. Stapf a new *Aconite* from the Eastern Himalaya.

Northern India.—Prof. Kashyap continues his analysis of the distribution and descriptive morphology of the Himalayan liverworts. The Myxophyceae of Lahore is dealt with by Mr. S. L. Ghose and the flora of Persian Baluchistan and Makran by Blatter and Hallberg. Two new species—*Schefflera bengalensis* and *Rosa Saundersiae*—have been described from Northern India.

Western India.—The Journal of the Asiatic Society contains an interesting paper by Drs. Annandale and Carter on the vegetation of Seistan. The introductory part deals with the vegetation from the Ecological standpoint and the systematic list contains useful notes on the distribution and local names of the species mentioned. An analysis of the flora of the Indian desert of Jodhpur and Jaisalmer is being undertaken by the Rev. E. Blatter and Professor Hallberg. The physiological anatomy of the desert plants of Rajputana—the work of Mr. S. A. Sabnis—is appearing in the new Journal of Indian Botany. The *Alysicarpi* of Western India have been taken up by Mr. Sedgwick.

Southern India.—Mr. Gamble has been able to issue the third part of his flora of the Madras Presidency. The part deals with the flora from Leguminosae-Caesalpinioideae to Caprifoliaceae. The new species are appearing under Decades Kewensis in the Kew Bulletin. Some twenty species new to Science have been described including five new *Oldenlandias* and five *Meme-cylons* from the Wynaad, Nilgiris and Travancore. Professor Fyson has had some interesting finds of little known plants in the Pulneys. These are species of *Heterocarpus* which have remained practically unknown since Wight's time. The reason for certain variations in the floral coloring of these plants is referred to in a note in the Journal of Indian Botany.

Economic.—The initiation of the scheme for Cinchona Cultivation in Burma has been the most important economic work of the year. The scheme is at present, and must remain for some time, in an experimental stage. So far proof has been obtained that, even under very adverse conditions of climate, the seedling stage of Cinchona can be successfully got over, but the real test for Cinchona in Burma will not come till it is put out to open conditions. Information relative to the rainfall and general weather condition of the Reserve is being accumulated.

BOTANY.

II.—ECONOMIC BOTANY.

Part I.—Agricultural Botany

BY

G. P. HECTOR, M.A., B.Sc.,

Officiating Imperial Economic Botanist.

The present report deals with the progress in Botany as applied to Agriculture during the year ending June 30th, 1920, and as in previous years will deal with the staple crops in order.

Cotton.—The most important work reported during the year is that of Burt, who has completed the survey, examination and selection of the Bundelkhand cottons, and has in preparation a Bulletin dealing with the results, of which the following is a brief summary.

The principal commercial cottons of this tract were collected in 1912 and 1913, grown at Cawnpore, and sorted out, and a number of pure lines isolated and tested for yield, ginning percentage and spinning qualities. The strain finally selected has been widely tested, is an excellent yielder and gins 36 per cent. (as compared to 33 average), while it has a staple of about $\frac{3}{4}$ ths of an inch, as compared to $\frac{1}{2}$ " to $\frac{5}{8}$ " for local *Desi*. It is reported by two Cawnpore Mills, who have done spinning trials, to be superior to the best Bundelkhand cottons and to be the best *Desi* cotton they have handled. In 1919 cotton from the 1918 crop spun 18s warps and 20s weft, as compared to 10s from ordinary *Desi*. It was valued in Cawnpore as worth 10 per cent. more than local *Desi* cotton of the best quality. In Bombay it was valued much higher. In 1920 this cotton was reported in Cawnpore to be very good for 16s warp even at the worst season of the year, and the general opinion of Cawnpore spinners is that it will find its place on the market on the same basis as several of the finer cottons from Central India now sold as Oomras.

Selection work is now complete and pure seed for 1,000 acres is being distributed this year.

Sugarcane.—Barber (*International Sugar Journal*, November 1919, reprinted in *Agr. Jour. of India*, XV, III, pp. 334-340) has continued his account of the growth of the sugarcane. In a previous article he dealt with the growth of the plants from planting of the seed to the stage when the cane

appears above ground, while in the present he deals with the whole subsequent growth in the cane field.

As reported by Venkatraman, the outstanding feature of the work of the Sugarcane Breeding Station, Coimbatore, during the past season, has been (1) the great number of crossed seedlings raised during the year, a number which has beaten all previous records and (2) the increasing knowledge which the Station is acquiring of work in Northern India. This information is summarised in Pusa Bulletin No. 94. The behaviour of the seedlings distributed to Northern India farms is yielding valuable data as to the lines on which the breeding work should progress in the future. Examination of Coimbatore seedlings has shown that as far as growth is concerned they are satisfactory; and in the future, greater attention than hitherto will be devoted to other characters, such as early maturity and sucrose content. The last batch of seedlings distributed is said to have 1 to 2 per cent. more sucrose in the juice than those of previous years. In Northern India, early maturity is of great importance, as some of the distributions already made, gave comparatively poor results at time of harvest, not because of the poor quality of the seedling, but because of its being unripe at harvest time. This was especially so at Gurdaspur, where Coimbatore seedlings showed an easy increase over local varieties in tonnage.

In the *Agricultural Journal of India* (XV, II, pp. 173-80) Venkatraman gives a useful account of the method of packing seed sugarcane for transport. Kulkarni (*Agr. Jour. of India*, XIV, V, pp. 791-96) gives a further account of experiments and improvements in the method of planting sugarcane, and concludes that the most uniform crop can be obtained by the single eyebud method of planting, with the eyes pointing upwards, and by the removal of tillers.

Rice.—In Bengal, selection work has continued, and a number of strains, both simple selections and strains from crosses, are under observation. Special attention is being paid to the selection of early types for the Western Districts.

In Madras Parnell has continued his work on the lines of previous years. A large number of simple single plant selections from high-yielding strains, together with pure strains derived from crosses, have been tested for yield, and many show a large improvement on local varieties.

In Tanjore a pure strain from a local variety has yielded, consistently for 3 years, 16 per cent. higher than the original farm strain.

Work on inheritance of characters has continued, and the factors determining a large number of characters have been determined and shown to fall into a number of "linkage" groups. In a paper entitled "Experimental Error in Variety Tests with Rice", Parnell calls attention to the large experimental error involved in much of the work published in India, and figures are given, for the combined results of four of the principal crops, showing 13.5 per cent. as the Probable Error of the difference between any two plots.

For ordinary work on rice in Madras about the same figure was obtained, but this was very considerably reduced by using plots of a long narrow shape.

The results of experiments on different methods of conducting variety tests are given and the method adopted on the Paddy Breeding Station at Coimbatore is described. It is shown that the use of strips 50' x 4' reduces the Probable Error of the difference between two to about 6.6 per cent., and that with about 8 to 12 repetitions it should be possible to work to about 2 per cent.

Indigo.—A full account of work done on indigo at Pusa by the Howards has recently been submitted for publication and will shortly be published. According to the Howards wilt is nothing more than the effect of water-logging, and consequent lack of aeration. When there is heavy and continued rainfall, the water-level rises and the soil becomes water-logged, the air supply to the growing roots and nodules of the plants is cut off, and the roots, consequently, cannot thrive. Hence the new roots and nodules begin to die off below and wilt appears above.

Evidence of this has been obtained by growing indigo plants in cemented lysimeters, provided with drainage openings. In cases where the openings were closed all the plants in the lysimeter got wilt, even when growing in soil which was rich in phosphate, and those with free drainage all escaped, even when they were growing in a soil poor in phosphate.

By systematic examination of the roots, it is found that the nodule and new root-formation begin in April, but up to the break of the rains their formation is very slow. Soon afterwards, they begin to grow quickly. When the water-level begins to rise, new roots and nodules are formed towards the surface, and the older, lateral roots begin to change their direction, turning upwards, till by the end of July their tips reach very near the surface of the soil, and almost all new roots and nodules are found in the upper three inches. Weak plants which cannot form new roots in the upper soil, quickly get wilt. In all cases of wilted plants, nodules have been found to be absent and new roots very few.

As a result of Mr. Howard's investigations, five types of root-development have been recorded :

- (a) Early bush type, with all laterals at right angles and near the surface.
- (b) Early vertical type, with all laterals near the surface but pointing down.
- (c) Late bush type, with laterals at right angles, both near the surface and extending to some depth.
- (d) A similar type to (c), but with laterals pointing downwards.
- (e) No side branches, but tap root only.

Type (a) has been found much less subject to wilt than the others, and in the 1919 root examinations, every case of wilt examined was found associated with deep rooting.

It is hoped by a system of mass-selection to produce cultures showing such desirable qualities as earliness, surface-rooting and free branching, and thus to bring the crop back to a type which will thrive in the conditions of Bihar, giving good yields of both seed and leaf, and showing high resistance to wilt.

Opium.—Leake and Annett have published a summary of their work on the production and improvement of Indian Opium (*Agr. Jour. of India*, XV, II, March 1920). This work arose out of the failure of the supply of medical opium with the entry into the war of Turkey and Bulgaria, and its object was to increase the morphine content of Indian opium up to the standard required for medical purposes. The investigation has been both botanical and chemical. Large numbers of samples of seed were procured from all localities where the opium poppy is grown, and pure-line cultures started. Subsequent chemical analysis proved that the racial diversity in morphine content was large, ranging from 6 per cent. in some races to as much as 20 per cent. in others.

Fibres.—In Bengal Finlow and Hector have continued the investigation of chlorosis in jute. The inheritance of the character is being studied and the connection between chlorosis and root-formation is under investigation.

At Cawnpore, Burt reports that experiments with flax, both with imported English seed (Dutchchild) and Japanese seed, have given satisfactory results, confirming previous reports that flax can be profitably grown in the canal tracts of the United Provinces, provided capital will come forward to undertake the financing of the crop and the retting, scutching and marketing.

Fruit.—Robertson Brown has published an interesting paper relating to the effect of various stocks on the orange. (*Bulletin No. 93, Agr. Res. Inst., Pusa, 1920.*) As a result of his experiments he concludes that in North-West India, the "rough lemon," "khatti" or "kharna" gives greatest vigour and fruitfulness to the Malta, while the "sweet lime," "mitha" or "sharbete" is suitable for the Malta in small private gardens only, where a dwarf tree with but few fruits is desired. On the other hand, the "sweet lime" is in almost all respects the best stock for the Sangtara. The stock and scion influence each other profoundly in producing vigour and fruitfulness, and in developing colour, shape, size, quality, flavour, beauty and seedlessness.

The same worker also gives an account of the successful introduction of the European Olive into the North-West Frontier. (*Agr. Jour. of India*, XV, II, 150.) Trials of the Olive at Tarnab have shown that the foreign species grows and bears well and early under irrigation, despite the high temperature and early rainfall. At five years of age, several of the Tarnab trees yielded up to 20 pounds of fruit, and at eight years many are now producing 100 to 120 pounds of good fruit.

In Bombay, Burns has continued his work on fruit, mainly on mangoes, citrus fruits, guavas and plantains. Great progress has been made in bringing

mangoe stock into condition for grafting much earlier than can be done by local methods. The whole of the work on mangoes has been embodied in a book entitled "The Book of the Mango" by Dr. Burns and Mr. S. H. Prayag, shortly to appear from the Government Press. In citrus as in mango, Burns has been able to reduce the length of time the stock takes to be ready, and the length of time the finished budded plant requires. The drying of the banana has also been most successfully accomplished, a product of excellent colour, taste and keeping qualities being manufactured. An account of this work is given by Burns in the *Agr. Jour. of India*, XV, 1820, p. 166.

Miscellaneous.—Important work on the study and improvement of grass-land is being undertaken in Bómbay by Burns. Experimental plots at Ganeshkhind have given excellent results, and the species that prefer different kinds of land are being classified according to these preferences. A new area at Kalas of seven acres of the worst possible Deccan land has been taken up in order to determine whether the grass of such a spot can be improved. Similar studies are in progress at Chharodi, Tegur and Poona.

BOTANY.

II.—ECONOMIC BOTANY.

Part II.—Forest Botany

BY

S. H. HOWARD, B.A.,

Officer-in-charge, Forest Botanist's Office.

1. *Oecology of Sal and Soil-Aeration*.—The results of investigations of past years will appear shortly as a Forest Record. Further investigations are in progress at Dehra Dun. Owing to the poorness of last year's seed crop the work was considerably hampered but this year a better crop was obtained and all necessary sowings have been completed.

2. *Forest Grasses*.—Experiments on the cropping of Ulla grass (*Anthistiria gigantea*) for paper pulp were continued on the previous lines in the Pilibhit division of the United Provinces.

3. *Spike disease of Sandal and Zizyphus*.—Inoculation experiments are being continued in Dehra Dun and investigations continue in Madras and Coorg.

4. *Mycology*.—The root diseases of sal and sissoo, Polyporus Shoreæ and Fomes lucidus are being studied and investigations into the cause of "red-wood" in Spruce have been commenced.

5. *Systematic*.—Large numbers of specimens were received from Forest Officers for identification chiefly in connection with the preparation of descriptive lists and local floras. During the year 131 specimens were identified here. The work has incidentally brought to light species of the following genera which are probably new and descriptions of which will be published when verified—Berberis, Corydalis, Diospyros and Hopea.

6. *Publications*.—During the year the following publications appeared:—

Gupta, B.L.—New Indian Species of Forest importance, Indian Forester, Vol. XLV, pp. 388-392.

Hafiz Khan, A.—Red wood of Himalayan Spruce (*Picea Morinda*, Link), loc. cit., pp. 496-498.

Hole, R. S.—Note on Hopea canarensis, Indian Forest Record, Vol. VII, Part III.

Hole, R. S.—Note on Ixora Butterwickii, loc. cit., Vol. VII, Part IV.

and the following paper by Mr. R. S. Hole is in the press:—

Note on the Regeneration of Sal Forests.

BOTANY.

II.—ECONOMIC BOTONY.

III.—Mycology

BY

W. McRAE, M.A., B.Sc., F.L.S.,

Officiating Imperial Mycologist, Agricultural Research Institute, Pusa.

The following is an account of the chief investigations at Pusa during the year :—

Black band disease of Jute.—The research work on this disease which is caused by *Diplodia Corchori* was carried out by Dr. Shaw. In 1919 the state of the Jute crop in Bihar was similar to that in 1918. The attack was light and a considerable portion of the seed crop having been sown late was invariably clean and healthy. Nor was the incidence of the disease in eastern Bengal at all heavy. Observation showed that both the red-stemmed varieties of *Corchorus capsularis* and also *Corchorus olitorius* were subject to attack though not to the same extent as the common green stemmed variety of the former species and confirmed the fact that only stems of a certain size and maturity are susceptible under ordinary field conditions. Infection experiments on plants in pots and in the field confirmed this. It was also proved that the dissemination of the disease does not take place to any appreciable extent through spores mingled with the jute seed so that steeping the seed before sowing in a solution of copper sulphate is to be discontinued.

Diseases of temperate fruits.—Work on these was done in Kumaon and Peshawar. The apple mildew (*Podosphaera*) spraying series included a test of home-made lime sulphur, Berger's lime sulphur and Burgundy mixture, lead arsenate being added in each case. The trees stood even the "winter" strength of lime sulphur successfully and the experiments showed that an application of this fungicide made at the proper time will largely control the disease. Berger's mixture proved very satisfactory and simple to use. Further experiments with iron sulphide are, however, required before deciding on lime sulphur as the routine treatment. For the branch blister and apple cracking disease (*Coniothecium chromatoporum*) the same three sprays were used with good effect for two of them but Burgundy mixture caused so much damage to fruit and leaves as to be largely a failure. This is in conformity with recent work with this mixture in English orchards. There was little of

the fly speck and sooty blotch disease (*Leptothyrium Pomi*) present but the trees sprayed with lime sulphur and Burgundy mixture had certainly less than the others and injury from the latter spray was again marked. Peach leaf curl was entirely controlled by all three sprays.

Potato storage rots.—A series of experiments was conducted at Sialkot in collaboration with the Punjab Department of Agriculture. In storing potato tubers a two-storeyed well ventilated house was selected and fumigated with sulphur vapour. Two sorts of tubers were selected (a) from fields where potatoes were grown as ordinary routine crop (b) from fields where potatoes were grown for the first time. The selected potato tubers were then put into sterile gunny sacks and fumigated with petrol vapour for 24 hours. Some of these fumigated potatoes were stored (1) in dry sand (2) sacks, loosely packed (3) on racks made of wooden battens. The rest of the fumigated potatoes were treated in corrosive sublimate solution (1 in 2,000) for 1 hour and afterwards taken out and dried and were stored exactly in the above manner. The experiment lasted during May and June, 1919. The year being exceptionally trying on account of the excessive heat, potatoes started rotting very soon and in every case the bulk of the potatoes became rotten. These results bear out the conclusion previously come to that the rot is primarily a result of excessive temperature.

Root rot on cotton.—On a visit to Lyallpur Dr. Butler came to the conclusion that the root rot of cotton which occurs sporadically through most of northern and western India, is a non-parasitic one which is associated with some unknown soil condition.

Cereal diseases.—Species of *Helminthosporium* were found commonly attacking maize, jowar, bajra, rice, wheat, oats, barley and sugarcane. In every case the chief attack is on the leaves, and excepting the stripe disease of barley the symptoms are on the whole very similar. The parasite concerned was isolated from each of the above hosts and grown in pure culture for comparative study. Wheat was found to have a considerable range of forms on it in different parts of India. They appear to be related to *H. teres* Sacc. On rice the common species appears to be *H. Oryzae* Hori, previously described from Japan. *H. turcicum* Pass. occurs on maize and jowar but freely grows also on wheat, oats, barley and sugarcane. It does not attack bajra and only rarely attacks rice. The species on sugarcane and rice attack all the hosts on which they have been tried whereas the wheat and barley species give reciprocal successful results. An allied genus, *Acrothecium*, is parasitic on several of the *Gramineae* and one species attacks bajra at Pusa somewhat severely. It is a new species, which has been named *Acrothecium Penniseti*. The attack is on leaves, leaf sheaths and ears, the leaf form being the commonest but the ear attack probably doing most damage. The spikelets are attacked in clusters and the grain aborted. It is a vigorous parasite and can attack maize ears but not leaves, while jowar is immune. A second species, *Acrothecium lunatum* Wakker, is common at Pusa on maize and jowar, as well

as on several wild grasses. It appears to do a good deal of injury to the male inflorescence of the former, where it is sometimes associated with *Acrothecium falcatum* Tehon, but it is only a weak parasite on jowar. It is capable of attacking young leave of bajra to some extent. Another form is found on rice. All these are being studied in pure culture.

Other Scientific Departments.

Madras.—Blast of the rice plant caused by *Piricularia oryzae* was found in several other districts but nowhere epidemic on a large scale. On *Eleusine coracana*, however, a similar disease caused by a species of *Piricularia* caused serious damage in Coimbatore district, the value of the loss probably exceeding a lakh of rupees. This fungus has not hitherto been recorded on this crop. Species of *Piricularia* were also found on *Setaria italica* and on wheat. The results of many infection experiments show that a culture from any one of the four host plants, *Oryza sativa*, *Eleusine coracana*, *Setaria italica* and *Panicum repens* will affect its own host but not the other three and that all will infect wheat and barley. Infection experiments on other grasses have so far proved to be negative. In nature a case has been observed where a severely infected crop of maturing *Eleusine coracana* caused the infection of a young wheat crop.

Ephelis oryzae causing sporadic damage to the rice plant has not yet been got to cause infection artificially. An *Ephelis* has been found on *Panicum Crusgalli* and on *P. stagninum* and an *Ephelis* associated with a *Balansia* on *P. distachyum* and *P. javanicum*.

The bud rot of palmyra palm was considerably less in the Godavari and Kistna districts this year. During December and January after the rains, where hitherto a large number of deaths had occurred, there were very few diseased or dead trees apparent in the infected area though the staff had stopped the actual cutting operations in November and was concentrating on a publicity campaign before the introduction of the Pest Act in March. There is considerable hope of the disease being reduced to a small minimum. In Madura district grape vines were sprayed with Bordeaux mixture against mildew with profit. The vines were kept under observation for a year before work was started. The value of the sprayed crop was on the average eight times that of the previous year and in some of the unsprayed plots this year the produce was wholly destroyed.

Coconut palms in various localities were operated on for bleeding disease by excision of the diseased tissue and afterwards flaming and tarring the exposed surfaces. Further observation of these and of trees operated on in previous years showed that the treatment was effective.

Mysore.—Black rot of coffee [caused by *Corticium Koleroga* (Cooke) V. Hohnel]. Two alternate host plants have been found for this important fungus in the neighbourhood of Coffee estates. One of these belongs to the Rubiaceae, the other to the Oleaceae. The question of transfer of the disease

from one host plant to another is under investigation. A disease of the pods of *Ricinus communis* was observed for the first time. The fungus, a *Sclerotinia*, was obtained in pure culture. It appears to be identical with *Sclerotinia ricini* recently reported from America. A Pythium disease of Turmeric *Cureuma longa* apparently identical with *Pythium Butleri* recently described by L. S. Subramaniam as attacking Ginger, etc., is under investigation.

Bombay.—Experiments have shown that the tambara disease of potato is caused by a mite that could easily be controlled by sulphur treatment and that this mite causes the leaf-curl of the chilli plant. The black rot of potatoes ascribed in last year's report to *Rhizoctonia* has been found to be a heat effect. The tambara disease of citrus, hitherto thought to be scab, is also due to a mite. The standard and Dwarf strains of the American milo variety of *Andropogon sorghum* were found to be resistant to grain smut (*Sphacelotheca Sorghi*) but not to loose smut (*Sphacelotheca cruenta*). Mildew on Cumin *cuminum* has been completely controlled by spraying with Bordeaux mixture. The campaign against Koleroga disease of Arecanuts was continued and the branches of 20,000 trees were sprayed.

Bengal.—The control of ufra (*Tylenchus angustus*) on rice was continued by burning stubble and by observing the early varieties known as Digha Dhans that escaped the disease.

Central Provinces.—To check cotton wilt heating the soil has on occasion shown marked effect but the general results are said not to be very conclusive. A few strains of rust resistant wheats and wilt free cottons have been isolated.

Bihar and Orissa.—The fungus causing wilt of linseed was studied and considered to be *Fusarium lini*.

Indian Tea Association.—Mr. Tunstall, Mycologist to the Indian Tea Association gave special attention to Brown blight (*Glomerella cingulata*) and Grey blight (*Pestalozzia Theae*). The fructification of thread blight was observed and sent to Kew for identification. Spraying tests with lime sulphur, Bordeaux mixture, and Burgundy mixture were made in Darjeeling against blister blight (*Exobasidium vexans*). Plots of 200 badly blighted bushes were sprayed at intervals of a week and the blighted leaves were weighed to give a measure of the intensity of infection. The Burgundy mixture was much the most efficient.

AGRICULTURAL BACTERIOLOGY

BY

J. H. WALTON, M.A., B.Sc.,

Officiating Imperial Agricultural Bacteriologist.

WORK AT PUSA.

Soil Biology.

Nitrification.—Investigations of the nitrification of cowdung, cow urine, and sheep fold manure were carried out and a paper on the subject was read at the Indian Science Congress, Nagpur, 1920, by Mr. Joshi. In the case of cowdung it was found that when added in the fresh state, no nitrate accumulation took place, but when added after storing, under either aerobic or anaerobic conditions, about one-third of its nitrogen was converted into nitrate. The nitrogen of the urine was rapidly converted into nitrate in the soil. The inhibiting effect of excess of carbohydrate on nitrification was shown by the results obtained when straw was added with the dung or urine. The losses of nitrogen that take place during storage are being further investigated.

Observations of the effect of these manures on the crop yield of oats in pot culture showed the growth of the plant to correspond to the amount of nitrate formed in the nitrification tests, but where a bad physical condition was produced in the soil, the yield was smaller than that expected from consideration of the nitrate figures.

Oats were grown in both pots and plots to which roots, stems, and leaves or the whole plant of dhaincha and cowpea were added. The crops obtained corresponded to the nitrate formation obtained in the laboratory nitrification tests with these plants and their parts.

Study of the wide variations in the accumulation of nitrate during the decomposition of various oil cakes in Pusa soil tend to the conclusion that they are due to the differences in the relative proportions of carbohydrate and nitrogen in the cakes. The oil content had very slight influence on nitrification and the addition of such materials as cellulose, filter paper, sawdust, starch, cane sugar and glucose to cakes rich in nitrogen, retarded the accumulation of nitrate. Further, in the case of Mahua cake, no nitrate was found after eight weeks' incubation, except when the cake had previously been fermented.

The nitrogen content of soil under fallow and growing crops was studied. Both nitrate and organic nitrogen content of the cropped plots were lower than those of fallow plots and the differences were greatest during the period of most active growth of the crop.

Biological Analysis of soils.—Biological analyses of soil from an abandoned coffee estate in Mysore were carried out.

Nitrogen fixation.—Experiments on the effect of the accumulated products of its metabolism on the nitrogen fixing power of *Azotobacter* are being carried out. So far it appears that these products appreciably lower the amount of nitrogen fixation.

Numerous colonies of actinomycetes have invariably been found growing on Ashby's Mannite Agar plates, inoculated with a dilute soil suspension. Twelve species were examined for nitrogen fixing power. Only minute gains were recorded, but as this group of organisms is one of the most abundant in soil, their accumulated effect may be of considerable importance, and further investigations of their activities are being taken up.

Seven soils, two from Pusa and five from Mysore, were examined for nitrogen fixation under anaerobic conditions. In liquid culture gains of up to 6.5 Mgms. nitrogen per gram dextrose were obtained. Sugarcane megasse has proved an admirable medium for the growth of nitrogen fixing organisms, and its nitrogen content after inoculation with mixed cultures of nitrogen fixing organisms rose from 0.27 per cent. to 1.3 per cent. in two months.

Indigo.

Owing to the short rainfall and backward condition of the plant no experiments in manufacture have been carried out since those mentioned in the last report.

Pure cultures of indican hydrolysing bacteria were maintained in the laboratory; the culture In 10, the most efficient, isolated three years ago, has lost none of its efficiency in that period.

Sterilisation of Water:

Investigations on this subject were continued, and supplies of the steriliser (E.C.) were manufactured for the weekly disinfection of the wells on the estate.

Two to three per cent. of available chlorine was found to be the maximum possible obtainable with economy of current consumption, and in higher concentrations stability rapidly diminished. 2.5 per cent. is the optimum aimed at for economy in production and stability of the product.

Stability tests showed that solutions of this strength could be made stable for six weeks at plains temperatures (30° C.) and for six months or more at hill stations (20°-22° C.).

Work in the Provinces.

Punjab.—The effects of green manuring of sandy and clay soils are being studied. It has been found that green manure gives better results in both types of soil than the addition of available nitrogen in artificial manure equal

to that added to the soil by green manure. By green manuring, the yield from a sandy soil on the limit of cultivation has been raised above that of fertile, heavy soil. Work on the correlation of nitrogen fixation with seasonal factors and cultural practice was continued. In the reports published up to date no obvious correlation was found between quantity of rainfall and extent of nitrogen fixation. Correlation between good cultivation and nitrogen fixation was supported by the results obtained on the Hansi and Lyallpur farms, but not by those of village cultivation at Kaithan, Hoshiarpur.

Madras.—Work has been done on fermentation, ammonification and nitrification of organic manures, and on the influence of fermenting organic matter on the solubility of mineral phosphates. The experiments, however, have not been completed.

Central Provinces.—Biological analyses of the Bhata soil were carried out. The poor growth of leguminous crops in the newly cultivated Bhata soil appears to be due to want of phosphoric acid and scanty formation of nodules. The growth is improved by application of cake and inoculation with nodule bacteria.

Work was also done on decomposition of organic and green manures under various conditions, but is not complete.

No work on bacteriology has been reported from any other province.

Indian Tea Association (Assam).—Biological analyses of several acid soils were completed. Particular attention was paid to the influence of the variation of water-content, and the discovery of the optimum water content of each soil.

FORESTRY.

I.—SILVICULTURE

BY

S. H. HOWARD, B.A.,

Silviculturist.

Statistical work in typical forest crops.—The more accurate methods of measurement and the improved forms for recording, approved by the Board of Forestry in 1919, have been introduced in all measurements of crops this year. The conversion of the previous measurements, made by girth, into diameter measurements has taken up considerable time more especially as it was first necessary to find constants for converting the one to the other so as to eliminate the error introduced by the girth measurement. It appears that for sal (*Shorea robusta*) and deodar (*Cedrus Deodara*) to obtain the average of two diameters at right angles from a given measurement made by girth it is necessary to multiply by the constant 3.119 and to convert volumes measured over girth and calculated by the quarter girth formula into volumes from two diameters at right angles and calculated by the πr^2 formula, the quarter girth volume must be multiplied by the constant 1.2224 and not 1.2727—the ordinary conversion factor when the original measurements are made in an identical fashion, i.e., either by diameters or by girths.

The introduction of the newer methods will, it is hoped, shorten considerably the time necessary for the production of reliable yield tables besides giving more accurate results. From measurements made this year on sal and deodar it is considered that measurements made by girths gave a resulting volume on the average about 4.5 % larger than that calculated from two diameters measured at right angles.

During the year 26 existing sample plots were remeasured and 7 new ones inaugurated by the Central Institute.

In addition to crop statistics Mr. Trevor has recently published single tree yield tables for deodar, kail and chir from measurements made in Kulu and a tentative single tree yield table for deodar and chir is shortly to be published in the new Chakrata Working plan compiled by the writer from measurements made in Jaunsar combined with the Kulu figures and Troup's figures in his monograph on *Pinus longifolia*.

The Sal (*Shorea robusta*).—The results to date of the Bengal taungya system, as applied to sal and other species are to be published shortly. The new method gives good promise of overcoming the difficulty of regenerating the fire protected Sal forests of Bengal, with their accompanying evergreen undergrowth, if a labour force of sufficient size can be kept on the work.

The problem of the regeneration of the sal in other provinces is not yet definitely solved though work continues at the Central Institute and in the United Provinces. Nothing definite can yet be said regarding natural reproduction. As regards artificial reproduction the chief difficulties in the United Provinces are lack of labour during the rains, the fact that rain often does not fall till a fortnight after the seed has ripened and that sal seed loses its germinating power very rapidly. The obvious solution, for those divisions where labour can be obtained in the rains, of raising the sal for the first few weeks in nurseries and then transplanting is unfortunately impracticable as the sal bears transplanting badly.

The writer has this year experimented in keeping sal seed a fortnight before sowing but during that time encouraging instead of preventing germination. So far the results are promising but it is too soon to draw definite conclusions.

A tentative single tree yield table for first quality Bengal sal has been worked out by the writer from measurements made in Bengal this year and is to be published shortly.

Afforestation.—The work in Zabarkhet Tappar had previously been done on a very small experimental scale. It is considered that the time has now come to attempt something rather larger.

Experiments to date had proved that weeding in the rains is very essential but any solution depending on this is unfortunately quite impracticable in many divisions as labour is unobtainable during the rains. Of all the experiments tried the only results which appear possible on a practical scale are—

- (1) *Chir*. (*Pinus longifolia*)—sowings seem to thrive better unweeded than weeded. An acre has therefore been sown with chir half thoroughly ploughed up and weeded before the rains (when labour is available) and half ploughed in lines only. Though the chir is out of its habitat the object here is to get some crop on the ground as a start and it matters little what it is.
- (2) *Sissoo*. (*Dalbergia Sissoo*)—sown in December on cleared ground appears to attain such a height before the rains start that it may persist with no weeding. Half an acre will therefore be sown next December.
- (3) *Sissoo*.—Root and shoot cuttings put out in December are 3 feet in height before the rains and it appears highly probable that this height is sufficient for them to combat the subsequent grass growth. Three and a half acres will therefore be planted in this way next

December and the nursery has been increased in size to supply the necessary plants.

(4) *Bamboo*. (*Dendrocalamus strictus*).—Though seedlings have not been previously tried it appears probable that they may succeed. A quarter of an acre has been planted up.

(5) *Butea frondosa*.—One quarter of an acre has been sown as the tree often grows in these frosty localities.

A total of some 5½ acres is now or will shortly be under experiment which should be large enough to draw some practical conclusions.

The Silvicultural Garden.—The usual experiments in germination, sowing and transplanting continue.

In addition experiments under Mr. Champion's direction connected with the twist in chir pine have been started.

Measurements to ascertain the season at which height growth takes place were started in December and after a complete year's record the results will be published. So far it may be said that in Dehra Dun the period December to middle of February is a period of rest for most species indigenous and exotic and for many till the end of March. A period of rapid height growth then commences and continues till July. What happens after that is not yet known.

The experiment in Camphor cultivation continues.

Developments in Silvicultural systems.—There is nothing particularly new to record this year. Several new working plans are in the course of compilation introducing or continuing one of the many variations of the uniform systems.

The only noteworthy change is a system for working sal forests in the United Provinces introduced by Mr. P. H. Clutterbuck, C.B.E., C.I.E., as a result of his extensive experience of this species. The method has been to be written up by Mr. E. A. Smythies in the *Indian Forester* and the chief points are that a volume yield for the forest is given and all fellings count against this whether final or intermediate. The marking proceeds over the forest in a definite direction up to this yield annually but the actual system of regeneration is immaterial. Thus where regeneration is lacking the marking may be little more than a thinning, where regeneration is profuse it may conceivably be a clear felling. At the same time over a certain definite portion of the forest special methods are undertaken to induce reproduction such as cleaning, sowing, etc., etc.

The great point of the system is that while it confesses our present comparative ignorance in the matter of natural reproduction of sal it takes advantage of the fact that whatever the reason may be there is, in point of fact, always enough reproduction already established somewhere or other in the forest to admit of adequate exploitation.

Miscellaneous.—It is pleasing to note that the fundamental importance of silviculture in forestry (it is after all the real basis of all forest management) is being recognised. The creation of a special circle for silvicultural research and working plans this year in the United Provinces must have very far-reaching results and already there are four provinces Burma, Bengal, Madras and the United Provinces, which have their own local silviculturists working at provincial problems.

FORESTRY.

II.—ECONOMIC FOREST PRODUCTS

BY

C. E. C. COX, I.F.S.,

Forest Economist.

The feature of the year's work has been the deputation in August 1919 of the Forest Economist, Mr. R. S. Pearson, to America and England with the object of reporting on the organization of forest research in the former country and of purchasing plant consisting of timber testing machines, seasoning plant, a saw mill and other modern fittings for the Economic Branch of the Research Institute. With a similar object Mr. Raitt, Cellulose Expert, proceeded to England in October 1919 with a view to purchasing an experimental pulp and paper making plant. During the year under report therefore the work of the Branch has consisted mainly in the purchase of new plant and fittings for the proposed extension of the Institute and work at Dehra Dun has been practically limited to the routine work of replying to enquiries regarding sources, outturn and prices of forest products. Field work has similarly been limited to an examination of the markets for turpentine and rosin throughout India, inspection of the timber seasoning experiments in South India and an investigation regarding possible developments of the trade and the outturn and prices of timber in South India and the Andamans.

1. Observation and encouragement of the Paper Pulp Industry in India and Burma.—During October 1919 Mr. Raitt proceeded on leave to England with the object of purchasing the requisite experimental pulp and paper making plants for the new workshops. With the erection of these plants it will be possible to carry out exhaustive experiments on the various kinds of bamboos, grasses and other raw materials which exist in India and Burma and which now await the results of such experiments for their development.

2. Antiseptic treatment of Timber.—The experimental creosoting plant was received from England during the year and is being erected. A fresh supply of 350 green sleepers of Spruce and Silver Fir has been obtained from the Punjab for the conduct of the first series of experiments and steps are now being taken to purchase an electric motor to facilitate the working of the plant.

3. Physical and Mechanical Properties and Seasoning Powers of various Timbers. (i) *Natural Seasoning.*—The detailed seasoning ex-

periments initiated last year have now been started at various centres in the Punjab, United Provinces, Assam, Bengal, Bihar and Orissa, the Central Provinces, Coorg and Madras, the records for which have been compiled, examined and put in order while the experiments were inspected in detail at two centres in Madras.

(ii) *Artificial Seasoning*.—This subject has been studied in detail by Mr. Pearson while on deputation in America and England with the result that the standard American and English experimental seasoning plants, viz., a Tiemann and a Sturtevant plant, have been purchased and are expected shortly in India.

(iii) *Mechanical properties of timber*.—Since it has long been realised that the present timber testing machine in the Economist's workshop is quite inadequate, three of the latest standard pattern machines have been purchased in America and are now on their way to the Research Institute.

Detailed mechanical tests on *Eucalyptus globulus* and *Acacia Melanoxydon* from the Nilgiris and *Olea ferruginea* from the Punjab have been carried out during the year.

4. Finding of markets and new uses for timbers including the issue of bulletins.—Bulletins on the following timbers were completed during the year and are now in the press :—

1. *Bombax malabaricum*.
2. *Adina cordifolia*.
3. *Odina Wodier*.
4. *Lagerstroemia Flos Reginae*.
5. *Dipterocarpus pilosus*, while that of
6. *Hopea odorata* is still under compilation in Burma.

5. Gums, Resins and Oleo-Resins.—The possibilities of an industry based on the tapping of Salai (*Boswellia serrata*) for its gum-oleo-resin as a source of turpentine continues to attract considerable attention. Bulk samples obtained from Khandesh were examined at the Indian Institute of Science, Bangalore and samples of the products have been forwarded to an interested Bombay firm for transmission to London for valuation. Tapping operations, commenced in Khandesh and the Gwalior and Kotah States, are now being extended to Bhopal and further developments depend upon the erection of a distillery at some suitable centre.

6. Rosha Grass Oil.—The subject of improved methods of distillation continues to elicit numerous enquiries. The question is being investigated on a commercial scale in the Central Provinces and Bombay and it is

understood that the possibility of increasing the outturn of grass in the Central Provinces is a question which is now engaging the attention of the local officers.

7. Woods suitable for (i) *Wood paving blocks*.—This subject is under observation in Bombay and the experimental pavements of Xylia blocks have been considerably extended.

(ii) *Bobbins, Shuttles and Picking sticks for Cotton and Jute Mills*.—Experiments on a commercial scale on various Indian timbers are at present being undertaken by the Utilization Circle of the United Provinces. The leading firm of bobbin manufacturers in England has been approached with a view to starting a branch business in India.

(iii) *Rifle Stocks*.—It having been found impossible to find any really suitable substitute for Walnut timber, operations are now being concentrated on the supplies of properly kiln-dried walnut half-wroughts to the Ishapore Rifle Factory from the North-West Frontier Province and from Kashmir.

(iv) *Three-ply*.—The manufacture of three-ply has now passed beyond the experimental stage in Assam where ply boxes for tea are now being manufactured from a wide variety of timber species. Difficulties have, however, lately been encountered in the matter of a tendency to 'cheesiness' in certain timbers when used for this purpose. This matter is one of vital importance to the industry and the possible solution of the difficulty is now being made a subject for detailed investigation. The possibilities of three-ply for tea and rubber boxes are also being considered by several firms in South India as it is now becoming increasingly difficult to obtain adequate supplies of suitable timbers at a price which will permit of the ordinary box industry being run at a profit.

(v) *Cooperage*.—The general question is being investigated on a semi-commercial scale by the Utilization Circle, Bareilly. The problem of finding a suitable timber or timbers for cocoanut oil casks in South India in addition to White Cedar (*Dysoxylum spp.*) which is the only timber now being used for the purpose, remains to be solved. The subject was opened by Messrs. Tatas Ltd., who have erected a large Oil Mill at Ernakulam and intend to use imported Douglas Fir for the manufacture of oil casks, it being considered that this procedure is likely to prove more economical and satisfactory than that of depending upon a supply of the locally made casks. On the analogy that Douglas Fir has been found suitable for the purpose in the Phillipines and elsewhere sample casks and shooks of the chief Himalayan conifers have been supplied by the Utilization Circle, Bareilly and will be tested as soon as the Mill commences operations.

Steps have also been taken to purchase an experimental stave cutting and barrel making plant for the Economic workshops of the Research Institute so that there is every hope that a solution to the problem of a suitable timber for oil casks will be found reasonably soon.

8. **Charcoal Briquettes.**—An experimental briquetting press was purchased and erected during the year and the first series of experiments on charcoal dust with a binder of *Bauhinia retusa* gum have been carried out. The problem of an entirely suitable binding medium is as yet unsolved but valuable data on this subject have been collected during the Economist's tour in America which may be expected to indicate new lines for investigation.

ZOOLOGY.

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

N. ANNANDALE, D.Sc., F.A.S.B.,

Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department during the year :—

	Days.
To Madras from 1st to 3rd April 1919 by Dr. F. H. Gravely . . .	3
„ Coonoor and Kotagiri from 1st to 15th April 1919 by Dr. N. Annandale . . .	15
„ Bombay from 6th to the 19th July 1919 by Major R. B. Seymour Sewell . . .	14
„ Barkuda Island, Chilka Lake, from 1st to 20th August 1919 by Dr. F. H. Gravely . . .	20
„ Barkuda Island, Chilka Lake, from 10th to 20th August 1919 by Major R. B. Seymour Sewell . . .	11
„ Barkuda Island, Chilka Lake, from 20th to 24th September 1919 by Dr. N. Annandale . . .	5
„ Barkuda Island, Chilka Lake, from 3rd to 20th October 1919 by Dr. F. H. Gravely . . .	18
„ Coonoor, Wynaad, etc., from 23rd September to 11th November 1919 by Major R. B. Seymour Sewell . . .	50
„ Delhi from 22nd to 27th November 1919 by Dr. N. Annandale . .	6
„ Nagpur from 10th to 18th January 1920 by Dr. F. H. Gravely . .	9
„ Nagpur from 10th to 18th January 1920 by Dr. N. Annandale . .	9
„ Nagpur from 11th to 18th January 1920 by Major R. B. Seymour Sewell . . .	8
„ Manipur, Assam, from 14th February to 7th March 1920 by Dr. N. Annandale . . .	23
TOTAL . . .	191

The most important of these tours was the tour in Manipur, Assam.

Staff.—Dr. F. H. Gravely vacated the post of Assistant Superintendent in January, 1920 on his appointment as Superintendent of the Government Museum, Madras. Dr. Baini Prashad was selected to succeed him as Assistant Superintendent in April, 1920. As Dr. Prashad was unable to assume his new appointment immediately, Mr. E. Brunetti was appointed to act temporarily in the interval.

Research.—Major R. B. Seymour Sewell, I.M.S., Officiating Superintendent, Zoological Survey of India, has completed a detailed account of

over fifty species of Indian cercariae, which has been submitted to the medical authorities for publication. The rest of the work of the department has been devoted mainly to the study of the freshwater molluscs and fish of various Indian localities.

Publications.—The following publications have been issued during the year :—

“Records of the Indian Museum,” Vol. XVI, parts VI—VII.

“Records of the Indian Museum,” Vol. XVIII, parts I—II.

“Records of the Indian Museum,” Vol. XIX, Part I.

“Memoirs of the Indian Museum,” Vol. VII, part III.

Library.—The addition to the library during the year number 1880. 853 books and periodicals were purchased, 855 received in exchange and the rest presented.

Collections.—The collections have on the whole remained in good condition, but owing to depletion of the staff it has been found very difficult to cope with their proper preservation.

Galleries.—For the same reason it has not been found possible to do anything in the public galleries except to maintain the old exhibits in good order.

ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist.

It should be noted that, in compliance with orders of Government that the Report on Agricultural Entomology in India during the year ended 30th June 1920 should not exceed four pages exclusive of bibliography, only a very brief summary of the work done at Pusa and in the Provinces can be given here.

I.—Work at Pusa.

Insect Pests.—Numerous observations have been made and a fuller account of these will be found in the Scientific Report of the Pusa Research Institute for this year. The following abstract shows the main crops and insects dealt with :—

Cotton.—Experiments were continued to determine the relative immunity of cotton varieties against attack of insect pests. Work on Cotton Bollworms has been continued and other insect pests studied.

Rice.—Work on borer pests has been continued.

Sugarcane.—Work on borer pests of sugarcane and allied Gramineous plants was continued and several new borers were found during the year and our knowledge extended regarding those discovered in previous years.

Mulberry.—The mealy-bug, *Phenacoccus hirsutus*, Green, causing "Tukra" disease of mulberry has been further investigated.

Fruit-Pests.—Work was continued, especially on pests of apple and numerous new pests were discovered and observations made on them. The so-called Mosquito bug of tea (*Helopeltis theivora*) was found on apple at Shillong, sucking the shoots.

Lifeshistories of Insects.—Besides the various insects mentioned above, about one hundred and fifty lots of insects, most of which had not been reared before, were bred out, their lifeshistories investigated and figured as far as possible.

Grain Storage Experiments.—These have been extended to ascertain how far infestation occurs in the fields before harvest.

Bees, Silk and Lac.—The work was continued on previous lines.

Illustrations.—Coloured plates and black and white figures of numerous insects studied during the year were prepared.

Insect Survey.—Steady progress was made in additions to and arrangement and identification of the collection, which is now a large and important one and continues to expand at a rapid rate.

Catalogue of Indian Insects.—Work on this was pushed forward as far as possible.

II.—Work in the Provinces.

Madras.—Attention was chiefly concentrated on *Platyedra* (*Pectinophora*) *gossypiella* and in July 1919 the local Pest Act was put in force against this in the Coimbatore district, with most encouraging results.

The bionomics of *Pempheres affinis*, its seasonal occurrence and the attractiveness or otherwise of different strains of Cambodia cotton were studied.

Experiments on control of *Schoenobius bipunctifer* were in progress in the Kistna district.

Bombay.—Investigation of the Mango Fruit-fly was continued. *Pseudococcus sacchari*, a serious pest of sugarcane at Manjri, was also under observation. *Amsacta moorei* sara appeared as a bad pest of maize in the Panch Mahals district in 1919; at Dohad, of 1,254 moths attracted to light-traps. 702 were egg-laden females. Borers (*Chilo simplex* and *Sesamia inferens*) did much damage, amounting to 47 per cent., to the *kharij guar* crop in the Surat district in September, and some work on natural control by parasites was done. Work on cotton pests was also done in Gujarat.

Central Provinces.—Work was done on pests of *Citrus*, on Cossid and Teragrid tree-borers and a survey of the distribution of cane-borers was commenced. *Diatraea auricilia*, *Emmalocera depressella*, *Scirpophaga xanthogastrella*, *Sesamia inferens* and *S. uniformis* were all found to bore cane in various districts, but *Chilo simplex* was found to be entirely absent from cane.

United Provinces.—No entomological work is reported.

Punjab.—The attack by Cotton Bollworms in 1919 was about normal and was estimated at 11.7 per cent. at Lyallpur and 5.2 per cent. in Ferozepur. Work was done on the lifehistory and utility of the Braconid parasite, *Microbracon*, of Cotton Bollworms, and Chalcidid egg-parasites of *Earias* were also bred. Maize, intersown with cotton as a trap-crop for *Mylocerus blandus*, gave good results. The lifehistory of *Euphalerus citri* was studied. Control work was done on *Idiocerus* on mango and *Chaetodacus cucurbitae*.

North-West Frontier Province.—Spraying of orchards has been continued with "Katakilla," which is found effective in checking Aphids on

peach trees. *Dacus oleae*, although present in wild olives at Cherat, has not yet been found to attack the cultivated olives at Peshawar.

Bihar and Orissa.—Work on parasites of *Agrotis ypsilon* was continued and the campaign against this pest was continued at Mokameh, 101,205 moths being caught, of which 43,325 were females. The damage done during the year was estimated at 436 *bighas*.

Bengal.—Further work on control of *Cryptorrhynchus gravis* was done. Control of *Hispa armigera* on rice at Chandshi (Barisal) was effected by means of bagging.

Assam.—Observations were made on the lifehistories of Dynastid and Melolonthid beetle-pests of sugarcane at Kamrup.

Burma.—Some work was done on the prevalence of *Schoenobius bipunctifer* as a pest of paddy and the mean reduction in the crop due to this insect was assessed at about 16 per cent.

III.—Native States.

Travancore.—Special study was made of *Nephantis serinopa*, a Xyloryctid pest of palms. The lifehistory and habits of a dipterous pest of ginger were studied. Campaigns against rice pests were carried out on a large scale.

Mysore.—Operations under the Pest Act were continued, as in the previous year, on *Kumblihula* work in Chitaldrug and Shimoga Districts. The indications are that the pest is being kept down to a negligible number in areas where work has been in progress for several years. The *kumblihula* work was extended to new areas in Kadur and Hassan Districts. Somewhat similar work on another species of *kumblihula* was taken up in villages of Kolar and Hassan Districts. Extensive experiments on the treatment of coffee trees on estates where Coffee Borer is bad are under way; preliminary results are promising. The following pests are also under investigation, and practical measures for control are under trial; sugarcane borer, Rice weevil, Mango hopper, Rhinoceros beetle on coconuts, castor semilooper and lime tree borer.

A beginning has been made in investigating the possibilities of Apiculture in Mysore.

Hyderabad.—No report has been received.

Kashmir.—Work has been done on control of fruit-pests and the lifehistories of the Cabbage Butterfly, Cutworm and Hairy Caterpillars were studied.

Baroda.—No scientific work is reported.

IV.—Other Entomological Work.

Indian Tea Association.—Attention was devoted mainly to investigation of Mosquito Blight (*Helopeltis theivora*). Experiments conducted on the

inoculation of affected tea-bushes with potassium salts were carried to a successful issue in 1919, and bushes which had apparently succumbed entirely to the attacks of the pest were completely cured and threw off the pest entirely, giving vigorous and heavy flushes although situated in the middle of an area completely shut up by this insect. From the beginning of 1920, the Chemical Branch has also given attention to the matter and it has been found that circumstances can obtain in the soil in which the potassium present is rendered unavailable for plants, thus supporting the theories of the Entomological Branch. Experiments are being conducted to endeavour to discover a practical means of dealing with this state of affairs.

South Indian Planting Districts.—No scientific work is reported

ZOOLOGY.

II.—ECONOMIC ZOOLOGY.

Part II.—Forest Entomology

BY

C. F. C. BEESON,* M.A., I.F.S., F.E.S.,

Forest Zoologist.

Insects of the Sal.—BORERS. (a) *Field work.*—Observations were continued in the 2 permanent incidence plots established in the borer attacked parts of Thano forest, Dehra Dun, and a third plot of 60 acres in the peripheral zone was surveyed and enumerated. Analyses of trees showing different degrees of attack were made to determine (a) the number of successful emergencies, proportion of failures due to parasitism, disease, etc., and (b) the conditions governing the survival of slightly attacked trees. The control measures devised in 1918 which were tested over an area of about 250 acres prove to be completely successful.

To determine the seasonal succession of sal borers and its connection with felling dates an experiment has been started in which 12 sal trees are felled one in each month throughout the year, and from each tree a log is removed monthly and cand.aged.

(b) *Insectary work.*—Experimental rearing of larvæ from the prepupal stage in sealed tubes under varying conditions of moisture was continued with the object of determining the mortality due to parasitic fungi, bacteria, and diseases of unknown origin. The fungi were identified by Dr. E. J. Butler, Imperial Mycologist, who isolated a series of species of the genera *Acladium*, *Aspergillus*, *Botrytis*, *Cephalosporium*, *Dendryphium*, *Harpographium*, *Helminthosporium*, *Hormodendron*, *Penicillium*, *Stysanus* (Melauspora) and *Verticillium*.

The mixed nature of the fungus flora (which contains hyperparasites), and the variation in the morbid symptoms indicate that several factors cause the death of *Hoplocerambyx spinicornis* larvæ and that the prevalence of a specific parasitic fungus is less probable than was supposed.

* The writer was absent on leave for seven months of the year under review, during which period Messrs J. E. Macpherson, Personal Assistant to the President, Forest Research Institute and College, and F. M. Howlett, M.A., F.E.S., Imperial Pathological Entomologist, were in charge of this office.



Other Pests.—Insectary records have been obtained of pests of sal seed and the young seedling. The species primarily concerned are *Dichochrosis leptalis*, *Laspeyresia pulverula* and *Calandra* sp.

Insects of the Teak.—An illustrated note on the Beehole borer of teak with suggestions for its control, has been prepared, and is now in the press as a Forest Record. No Field work was carried out by the Forest Zoologist's staff, but observations are being continued in sample plot areas by divisional officers.

Insects of the Toon.—The chalcidoid parasites of *Hypsipyla robusta* have been described by Capt. the Revd. Waterston, Bureau of Entomology, in a paper that will shortly appear as a Forest Record. Work has been started on the biology of the hymenopterous parasites and the predators of the caterpillars of this borer.

Lac.—A microscopic examination of the internal morphology of lac insects has been carried out under the direction of Mr. F. M. Howlett with the object of discriminating specific differences in the form of lac insect from different kinds of host tree.

Miscellaneous Pests.—During the year under report 186 consignments of specimens (including 1,362 insects) were received for investigation. In collaboration with the Forest Economist the borer fauna of timbers laid down under different methods of seasoning is being worked out. A total number of 2,614 pieces of timber has been received from divisions in which season experiments are in progress and from this material, numerous species of borers (amounting to some 7,000 specimens) have been bred out, adding considerably to our information on the food trees and distribution of timber pests. The more important of the new records are:—*Aeolesthes holosericea*, Fab. ex *Drimycarpus racemosus*; *Batocera titana*, Th. ex *Sterculia villosa*; *Ceresium leucosticticum*, White ex *Anogeissus latifolia* and *Grewia tiliacifolia*; *Coptops aedificator*, ex *Aegle Marmelos*, *Careya arborea* and *Hololepta integrifolia*; *Dialeges pauper*, ex *Cassia fistula*; *Diorthus cinereus*, Fab. ex *Hardwickia binata*; *Epipedocera affinis*, Chev. ex *Grewia tiliacifolia*; *Gnatholea simplex*, Gah. ex *Hardwickia binata*; *Margites modicus*, Gah. ex *Anogeissus acuminata* and *A. latifolia*; *Nyphasia apicalis*, Gah. ex *Anogeissus acuminata*; *Plocaederus ferrugineus*, Linn. ex *Boswellia serrata* and *Hardwickia binata*; *Xylotrechus quadripes*, Chev. ex *Hymenodictyum excelsum*; *Xylotrechus renominatus*, Beeson ex *Shorea robusta* and *Amoora Rohituka*; *Xylotrechus semi*, L. et. G. ex *Careya arborea*; *Xystrocera globosa*, Oliv. ex *Accacia modesta* *Platypus solidus*, Wat. ex *Acrocarpus fraxinifolia*.

Insect Collections.—Small batches of insets have been identified and returned by the following specialists:—*Siricidae* and *Tenthredinidae* by Dr. S. A. Rohwer; *Syrphidae* *Stratiomyidae* and other *Diptera* by Mr. E. Brunetti; *Asilidae* by Miss G. Ricardo; *Odonata* by Major Fraser; *Apidae* by the Government Entomologist, Madras; *Microlepidoptera* by Mr. E. Meyrick; *Cara-bidae* by Mr. H. E. Andrewes; *Bostrychidae* by Mr. M. P. Lesne; *Tenebrionidae*

by Mr. K. Blair; *Lamellicornia* by Mr. G. Arrow; *Curculionidae* by Dr. G. Marshall; *Scolytidae* and *Platypodidae* by Col. Winn-Sampson; *Cerambycidae* and *Lamiidae* by Dr. G. Gahan. While on leave the writer visited specialists in England and France and distributed 5,000 specimens of Coleoptera and Hymenoptera.

Museum.—The principal additions to the museum, comprise 529 specimens of timber showing the work of borers, skins of palm squirrels, bats, bamboo rats, etc. A consignment of 86 specimens of damage by borers to the principal Indian Forest trees was presented to the School of Forestry, Oxford.

Staff.—Consequent on the sanction by the Secretary of State for the recruitment of four forest entomologists, arrangements were made for the post-graduate training of I. F. S. probationers in entomology. The new post of Systematic Entomologist has been filled by the appointment of Surgeon Commander M. Cameron, M. B. R. N.

The writer was deputed to attend the Imperial Conference of Entomology held in London, June 1920, as the representative of the Government of India.

VETERINARY SCIENCE

BY

W. A. POOL, M.R.C.V.S.,

Offg. Director and First Bacteriologist Muktesar.

As mentioned in the two previous years reports, shortness of staff, enhanced demand for the products of this Laboratory, increased routine and administrative duties and paucity of labour, fodder, etc., have immensely contributed to reducing the amount of time that could be devoted to research work.

Rinderpest and Haemorrhagic Septicaemia.—The same experiments which were in hand during the year 1918-19 regarding infectivity of hides of both of these diseases were continued during the year under report.

Johne's Disease.—A herd infected with Johne's disease in Bettiah Raj in Bihar was submitted to a test with avian tuberculin. As it was impossible to obtain permission to kill any of the reacting animals, the value of the test could not be determined.

Tuberculosis.—The experiments foreshadowed in last year's report have been completed and an account of them will be published shortly.

Bovine Lymphangitis.—With material received from the Madras Presidency experimental work has been carried out and the causal organism has been isolated.

Surra.—An experiment was initiated on the recommendation of the Surra Committee to ascertain the effects on different animals of the inoculation of strains of the *Trypanosoma evansi* derived from other species.

Some experiments in curative drug treatment were carried out.

Publications.—An account of *Syngamus Laryngeus* in Cattle and Buffaloes; Virulence of Tubercle bacilli isolated from bovine lesions in India and on Bovine lymphangitis was submitted for publication.

Reports from Veterinary Colleges and Provincial Laboratories.—No scientific work of any particular interest was carried out by the Veterinary Colleges or the Provincial Superintendents of the Civil Veterinary Department. Mr. Cross, the Camel Specialist, in his Annual Report for 1919-20 states that detailed reports on the course that Surra runs in the camel and also that camel surra runs in ponies and other animals are being published as Pusa Bulletins.

He further mentions the following investigations worthy of record:—

- (a) Further experiments with tartar emetic in connection with treatment of Surra in camels.
- (b) The treatment of Surra by other drugs.

MEDICAL RESEARCH

BY

The HON'BLE MAJOR-GENERAL W. R. EDWARDS, C.B., C.M.G., M.D.,
K.H.B., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the report of the Scientific Advisory Board of the Indian Research Fund Association for 1919-20.

Plague.—The inquiry into plague preventive measures at Poona continued under Dr. Chitre till November 1919. The Bombay Government have sanctioned field experiments on a large scale in Belgaum and Dharwar which are now proceeding. The practical application of the results obtained by Major J.C.G. Kunhardt, I.M.S., and Dr. Chitre after some years of laboratory investigation will be awaited with much interest.

Hookworm disease.—This inquiry is proceeding in Trichinopoly under Dr. Mhaskar. That officer has been attempting to estimate the effect of jail life on the natural elimination of Hookworm ova in convicts. In conjunction with Revd. Father Caius he has been investigating the chemical composition of various anthelmintics and comparing their safety and comparative efficacy. Various papers have been published.

Entomology.—Mr. Awati has published three papers on the bionomics of house flies in a recent Number of the Indian Journal of Medical Research and two more papers are in course of publication. Mr. Awati has recently been deputed to Assam to assist in the Kala-Azar Survey. He will attempt to estimate the relative frequency of various biting insects in infected and non-infected areas.

The Research Fund Association have also granted a sum of Rs. 5,000 to Major W. S. Patton, Pasteur Institute, Coonoor, for the purpose of carrying out researches on entomology and protozoology. That officer has submitted various papers which will be published early in the Indian Journal of Medical Research, on Arthropods of medical and veterinary importance in Mesopotamia and a Study on Flagellates of the Genera *Herpetomonas*, *Crithidia* and *Rhynchomonas*.

Kala-Azar.—Efforts were made to obtain an officer of the Bacteriological Department to be placed in charge of the whole of the Kala-Azar Inquiry in Assam, but owing to the shortage of the officers available for civil duty it has been found impossible to obtain one. Meanwhile Mrs. Adie continues to work at the development of the parasite causing Kala-Azar during its residence in the body of the bed bug.

Leprosy.—Dr. Sudhamoy Ghosh continues his work, under the general supervision of Major Knowles. A valuable report has been received from him which will be published in an early Number of the Journal.

The Fund has also given a grant to Dr. K. K. Chatterji for the purpose of experimenting with Neem or Margosa oil and its derivatives in the treatment of Leprosy. The Calcutta School of Tropical Medicine has joined with the Indian Research Fund Association in financing a large inquiry into special methods of treatment of this disease. This research will commence during the ensuing cold weather under Dr. E. Muir.

Deficiency Diseases.—The inquiry has ceased in India. Ten Sections of a paper on this subject have been published in the Journal by Lieutenant-Colonel McCarrison. The inquiry will reopen in England under that officer, at an early date it is hoped.

Malaria.—A report is in press from Lieutenant-Colonel Donovan detailing the result of his investigations into Malarial carriers (other than human)—a research conducted in the Nilgiri Hills during the months of May and June 1919.

Influenza Inquiry.—(a) Captain Malone is continuing his work on the bacteriology of the disease in Bombay. Three papers have been published in the Journal on this subject. He also published a paper on Encephalitis lethargica in Karachi. This is the first known appearance of this disease in India.

(b) An inquiry into the epidemiology of influenza was commenced in September 1919 by Major J. Morison, I.M.S. On his departure to England in April 1920, the inquiry was placed under Captain H. H. King, I.M.S. The questions which are being investigated refer to the rise, progress, and ending of individual epidemics and questions of the immunity conferred by previous attacks of the disease and by inoculation with vaccine. Very numerous reports received from all over India including Burma on the progress of the 1918 epidemic, in reply to a list of questions drawn up by the Office International D'Hygiene Publique, are under consideration.

Mollusc Survey.—This work conducted entirely by the members of the Zoological Survey under Dr. Annandale continued. A paper by Dr. Annandale and Captain Sewell on the subject will be published in an early number of the Journal.

Investigations in Karachi.—These ceased in January 1920 owing to the approaching demobilization of Captain Maitra's Hospital. A paper by Captain Maitra on "Observations on the cultural methods of *Gonococcus*" was published in the Journal.

Biochemistry.—Mrs. D. Norris' researches terminated on the 2nd November 1919. A paper by her on "The preparation of a simplified culture media for field workers" was published in the Journal.

LIST OF PUBLICATIONS.

Agricultural Chemistry.

- AIYER, A. R. PADMANABHA, AND BAL, D. V. The Chemical and Biological aspect of Bhatta soil of Chandkhuri Experimental Farm, Central Provinces. (*Read at the 7th Indian Scientific Congress, January, 1920.*)
- AMIN, B. M. . . . An improved method of preparing indican from indigo-yielding plants. (*Indigo publication No. 5.*)
- ANNETT, H. E. . . . Environmental factor influencing the alkaloidal content and yield of latex from the opium poppy (*Papaver somniferum*) and the bearing of the results on the function of alkaloids in plant life. (*Memoirs of the Department of Agriculture in India, Chemical series, in the press.*)
- ANNETT, H. E. . . . Factors influencing alkaloidal production in opium and the bearing of the results on the function of alkaloids in plant life. (*Communicated to the Biochemical Journal.*)
- ANNETT, H. E. AND SEN, H. D. The estimation of codein. (*communicated to the Analyst.*)
- ANNETT, H. E., SEN, H. D. AND SINGH, H. D. Non-environmental factors influencing alkaloidal content and yield of latex from the opium poppy. (*Papaver somniferum*), (*Memoirs of the Department of Agriculture in India, Chemical series in the press.*)
- ANNETT, H. E., SEN, H. D. AND SINGH, H. D. A survey of the Indian Opium growing districts for morphine content of the opium produced. (*Agricultural Research Institute, Pusa Bulletin, in the press.*)
- ANNETT, H. E. AND SEN, J. The use of poppy seed cake as a cattle food and its effect on yield of milk and composition of the butter fat. (*Journal of Agricultural Science, Vol. IX, part iv, October, 1919.*)
- AYYAR, P. A. SUBRAMANYA. The gases of swamp rice soil, V. A. methane oxidising Bacterium from rice soils. (*Memoirs of the Department of Agriculture in India, Chemical series, Vol. V, part viii, in the press.*)

- CLARKE, G., NAIB HUSSAIN, AND BANERJI, S. C. Notes on improved method of cane cultivation.
- GANGOLLI, D. M. AND MELDRUM, A. N. Indian Casein, part I, Preparation of "sulphuric" casein. (*Department of Industries, Bombay, Bulletin No. 1.*)
- GHOSH, M. N. A neglected source of sugar in Bihar. (*Agricultural Journal of India, Vol. XV, part i.*)
- HARRISON, W. H. The gases of swamp rice soil, VI-Carbon dioxide and hydrogen in relation to rice soils. (*Memoirs of the Department of Agriculture, Chemical series, Vol. V, No. viii, in the press.*)
- HARRISON, W. H. AND DAS, S. The retention of soluble phosphates in calcareous and non-calcareous soils. (*Memoirs of the Department of Agriculture in India, Chemical series, Vol. V, part ix, in the press.*)
- HARRISON, W. H. AND SANYAL, P. B. Effect of windrowing on the composition of sugarcane. (*Memoirs of the Department of Agriculture in India, Chemical series, in the press.*)
- LEAKE, H. M. AND ANNETT, H. E. Investigations concerning the production of Indian opium for medical purposes. (*Agricultural Journal of India, Vol. XV, part ii.*)
- MUKHERJI, J. N. The excretion of toxins from the roots of plants. (*Agricultural Journal of India, Vol. XV, part v.*)
- PLYMEN, F. J. AND AIYER, A. R. PADMANABHA. Variations in some characteristics of the fat and of buffalo and cow milk with changes in season and feeding. (*Read at the 7th Indian Science Congress, 1920.*)
- TAYLOR, C. SOMERS. The presence of aconitic acid in sugarcane juice and a new reaction for the detection of the acid. (*Transactions of the Chemical society, 1919, Vol. CXV.*)
- TAMHANE, V. A. Probable effect of the proposed Sukkur Barrage Scheme on the development of salt land in Sind. (*Bulletin of the Bombay Agricultural Department, in the press.*)

Astronomy.

- EVERSHED, J. Is Venus cloud covered? (*"Nature," 104, 675.*)
- " The Magnetic storm of August 11th—12th, 1919. (*"Nature," 104, 436.*)

- EVERSHED . . . The Pulsation theory of Cepheid Variables.
 (" *Observatory*," 42, 124.)
- " . . . The Moon in Daylight. (" *Observatory*," 42, 339.)

Meteorology.

- SIMPSON, G. C. . . British Antarctic Expedition, 1910-1913, Meteorology, Vol. I, Discussion; Vol. II, Charts.
 (Thacker, Spink & Co., Calcutta, 1919.)
- NORMAND, C. W. B. . Meteorological conditions affecting Aviation in Mesopotamia. (*Q. J. R. Meteor. Soc.*, Vol. 45, 1919, p. 368.)
- " . . . The effect of high temperature, humidity and wind on the human body. (*Q. J. R. Meteor. Soc.*, Vol. 46, p. 1.)

A complete bibliography of meteorological papers published during the year will be found in the Journal of the Royal Meteorological Society and in the American Monthly Weather Review.

Botanical Survey.

- ANNANDALE, N. AND CARTER, H. G. Notes on the Vegetation of Seistan. (*Journ. As. Soc., Bengal*, Vol. xv, 1919, No. 6, pp. 267-297.)
- BLATTER, E., HALLBERG, P. F., AND McCANN, C. Contributions towards a flora of Baluchistan. (*Journ. Ind. Bot.*, Vol. i, No. 2, p. 54, No. 3, p. 84, No. 4, p. 128, No. 5, p. 169.)
- BLATTER, E. AND HALLBERG, F. The Flora of the Indian Desert (Jodhpur and Jaisalmer).^{*} (*Jour. Bom. Nat. His. Soc.*, Vol. xxvi, No. 2, p. 525, No. 3, p. 811, No. 4, p. 968.)
- " . . . The Flora of Persian Baluchistan and Makran. (Vol. xxv., No. 4.)
- BURNS, W. . . Variation in Bombay Strigas. (*Jour. Ind. Bot.*, Vol. i, No. 6, p. 212.)
- DEEBARMAN, P. M. . A short note on the atrophic abortion of the inflorescence of the onion. (*Allium cepa* L.) (*Jour. Bom. Nat. His. Soc.*, Vol. xxvii, No. 1, 1920, p. 179.)
- DEMELLO, F. . . Contribution to the study of the Indian Aspergilli. (*Jour. Ind. Bot.*, Vol. i, No. 5, p. 158.)
- DRUMMOND, J. R. . *Miliusa* and *Saecopetalum*. (*Jour. Ind. Bot.*, Vol. i, No. 5, p. 162.)

- EKAMBARAM, T. . . Suspected parasitism in a moss. (*Jour. Ind. Bot.*, Vol. i, Nos. 6 and 7, p. 206.)
- FYSON, P. F. . . *Heterocarpus* Wight in the Pulneys. (*Journ. Ind. Bot.*, Vol. i, No. 4, p. 125.)
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- Stagetus denticornis*, n. sp., pp. 242-243, fig., W. Almora. Xylophilidæ: *Xylophilus bulbifer*, pp. 243-244, W. Almora; *Cnopus pinicola*, p. 244, W. Almora: n. spp. Bruchidæ: *Bruchus cœruleus*, pp. 244-245, W. Almora; *B. maculipyga*, pp. 245-246, Dehra Dun; n. spp.]
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- " " . Notes on the African and Asiatic species of *Melyris*, Fab. (sensu lato), with an account of their sexual characters. (*Ann. Mag. Nat. Hist. (9) iv*, 157-219, 7 figs.; Oct. 1919.) [Key to species, pp. 159-160; *M. abdominalis*, Fb., from W. and C. Africa, not India, pp. 176-177; *M. erythrodera*, n. sp., p. 213, India (? Barrackpore); *M. oblonga*, Fb., p. 214, Algeria to Persian Gulf.]
- " " . On some Eastern Xylophilids (Coleoptera). (*Ann. Mag. Nat. Hist. (9) v*, 393-406; May 1920.) [*Hylœbæus fasciatus*, Pic., pp. 393-394, Galle, Tenasserim, Penang, Borneo; *H. varicornis*, Champ., p. 394, Siam, Tenasserim, Philippines; *Xylophilus albolineatus*, n. sp., pp. 404-405, Kodaikanal; *X. brunneomaculatus*, Pic., p. 405, W. Almora, Kasauli, Simla; *X. himalaicus*, n. sp., pp. 405-406, W. Almora; *X. varus*, n. sp., p. 406, Kodaikanal.]
- CHAMPION, H. G. . A Cerambycid infesting Pine cones in India. (*Ent. Mo. Mag. lv*, 219-224, tab. 13, 14; Oct. 1919.) [*Chlorophorus strobilicola*, n. sp., p. 223, fig., W. Almora; lifehistory descr.]
- CHAPMAN, T. A. . Contributions to a life-history of *Tarucus mediterraneæ*, Bethune-Baker. [Lycænidæ.] (*Ent. Mo. Mag. lv*, 163-168, July 1919; l. c. 169-173, tab. 6-11, Aug. 1919.)

CLEARE, L. D. . A useful breeding-cage. (*Bull. Ent. Res.* x, 43-44, fig.; Nov. 1919.)

COCKERELL, T. D. Descriptions and records of Bees. LXXXVI. (*Ann. Mag. Nat. Hist.* (9) iv, 98-104.) [*Crocisa ramakrishnæ*, Ckll., pp. 98-99, Taliparamba; *C. histrio*, Fb., p. 99, Beeravalli; *C. macraspis*, n. sp., p. 99, Saidapet; *C. chionotricha*, n. sp., pp. 99-100, Coimbatore; *Anthophora violacea*, Lepel., p. 100, Parlakimedi; *A. cingulifera*, Ckll., p. 100, Sidapur; *A. confusa*, Sm., p. 100, Palnis; *A. zonata*, L. p. 100, Sidapur; *Calioxys apicata*, Sm., p. 100, Coimbatore, Devanakonda; *C. dormitans*, Ckll., p. 100, Coimbatore, Yemmiganur; *C. sexmaculata*, Cam., p. 101, Coimbatore, Devanakonda; *C. pachyrhina*, n. sp., p. 101, Devanakonda (Kurnul District); *C. ramakrishnæ*, n. sp., p. 102, Coimbatore; *Nomioides patruelis*, n. sp., pp. 102-103, Yercaud; *Stelis tuberculata*, n. sp., p. 103, Coorg; *Lithurgus australior*, Ckll. p. 104, Coimbatore, female descr.; *Ceratina binghami*, Ckll., p. 104, Salem; *Nomia iridescens*, Sm., p. 104, Bangalore; *N. histrionica*, n. sp., p. 104, Koilpatti.]

" " Descriptions and records of Bees, LXXXVII. (*Ann. Mag. Nat. Hist.* (9) iv, 355-360.) [*Bombus prshewalskii*, Moraw., p. 355, Gulmarg, China; *Anthophora confusa*, Sm., p. 356, Murree; *Megachile disjuncta*, Fb., p. 357, Madras, Bangalore, Kurnul; *M. aureobasis*, Ckll., p. 357, Bangalore, female descr.; *M. ramakrishnæ*, Ckll. p. 357, Bangalore, Devanakonda, Kurnul; *M. fletcheri*, n. sp., pp. 357-358, Bangalore; *Pasites indicus*, n. sp., pp. 358-359, Pusa; *Crocisa minuta*, Rad., p. 359, Chapra.]

" " †Fossil Anthropods in the British Museum, I. (*Ann. Mag. Nat. Hist.* (9)v, 273-279; Mar. 1920.) [Hymenoptera: Bethyridæ: *Epyris atavellus*, n. sp., pp. 276-277, ff. 2 A. D. Burmese amber.]

" " †Two interesting insects in Burmese amber. (*Entom.* lii, 193-195, figs.; Sept. 1919.) [Micropterygidæ. *Micropteryx pervetus*, n. sp., pp. 193-194, figs. 1 A-F. Embiadæ; *Burmitembia*, n. g., p. 194, *B. venosa*, n. sp., p. 195, figs. 2. 3.]

" " †Insects in Burmese Amber. (l. c. 241-243; Nov. 1919.) [Aleyrodidæ: *Aleurodicus burmiticus*, n. sp., p. 241, fig. 1. Psocidæ: *Psylloneura* ? *perantiqua*, n. sp., pp. 241-242, fig. 2. Chironomidæ: *Johannsenomyia swinhoei*, n. sp., p. 243, fig. 3.]

- COCKERELL, T. D. A. Some Indian Bees of the Genus *Andrena*. (*Entom.* liii, 133-135; June 1920.) [*Andrena ilerda inglisi*, subsp. n., pp. 133-134, Banhar (Bihar); *A. peridonea*, n. sp., pp. 134-135, Hangu, N. W. F. P.; *A. comberiana beharica*, p. 135, Banhar, Chapra.]
- Cragg, F. W. Secretion and epithelial regeneration in the midintestine of *Tabanus*. (*Ind. Journ. Med. Res.* vii, 648-663, tabs 61-63; June 1920.) [*Tabanus albimediis*, Wlk.]
- CRAMPTON, G. C. Notes on the Ancestry of the Coleoptera. (*Pomona Journ. Entom. Zool.* xi, 49-54, fig.)
- " " Notes on the Ancestry of the Diptera, Hemiptera and other Insects related to the Neuroptera. (*Trans. Entom. Soc., London*, 1919, pp. 93-118; Aug. 1919.)
- DAMMERMAN, K. W. On hybrids of *Batocera albofasciata* and *gigas*. (*Tijds. voor Ent.* lxvii, 157-160, tabs. 13, 14; Jan. 1920.)
- DISTANT, W. L. Report on Rhynchota of the Percy Sladen Trust Expedition to the Indian Ocean in 1905. Part II. Suborder Hamoptera (*Trans. Linn. Soc. Zool.*, (2) xvii, 273-322, tabs 49-51, figs. 1-17.) [Several Indian spp. recorded from Seychelles.]
- " " Descriptions of new species and genera of the Heteropterous Family Reduviidae from British India. (*Ann. Mag. Nat. Hist.* (9) iv, 71-79.) [*Ploiariola scotti*. Dist., p. 71, Mysore; *Stenolæmus hirtipes*, n. sp. p. 71, Mysore; *Eugubinus intrudans*, Dist., p. 71, Mysore; *Neoklugia*, pp. 71-72, n. g., *N. typica*, n. sp., p. 72, Mysore; *Neothodelmus*, n. g., p. 72, *N. typicus*, p. 73, Mysore; *Pasiropsis major*, p. 73, Mysore; *Edocla annulata*, pp. 73-74, Nandidrug; *Ectomocoris simulans*, p. 74, Mysore, Vizagapatam; *E. melanopterus*, p. 74, Mysore; *E. picturatus*, p. 74, Mysore; *E. apicimaculatus*, p. 75, Yercaud; *Sphedanolestes aurescens*, p. 75, Bangalore; *S. aterrimus*, p. 75, Mysore; n. spp.; *Endochus albomaculatus*, Stal., p. 75, Mysore; *E. erectus*, Nilgiris, *E. campbelli*, *E. parvispinus*, Mysore, n. spp.; *Brassivola hystrix*, Dist., p. 77, Mysore; *Isyndus modestus*, p. 77, n. sp., Mysore; *Coranus militaris* p. 77, *C. vitellinus*, p. 78, Mysore, n. spp.; *Allæorhynchus notatus* p. 78, Mysore, *A. bicoloratus*, pp. 78-79, Nandidrug, n. spp.; *Phorticus varicolor*, n. sp., p. 79, Mysore; *Lanca*, *Epidaus*, differences, p. 79.]

- DODD, A. P. . Notes on the Exotic Proctotrupoidea in the British and Oxford University Museums, with descriptions of new genera and species. (*Trans. Ent. Soc., London, 1919, 321-322; Jan. 1920.*) [Scelionidæ: *Baryconus pictus*, n. sp., pp. 334-335, Ceylon; *Opisthacantha bifasciata*, n. sp., pp. 335-336, Ceylon; *Sceliacantha subplana*, n. sp., pp. 336-337, Ceylon; *Sceliomorpha ceylonensis*, n. sp., p. 349, Ceylon; *Hadronotoides rugostriatus*, n. sp., p. 352, Ceylon; *Telenomus*, Haliday=*Immsia*, Cam. (*Ind. For. Rec. iv, 104*), p. 353; *T. carinifrons*, Cam., Dehra Dun, redescr., pp. 355-356; *T. barrowi*, n. sp., pp. 356-357, Dalhousie, bred from Sphingid egg. Proctotrupidæ: *Proctotrupes gravidator*, Linn., var. *partipes*, n. var., p. 365, Kashmir; *Exallonyx orientalis*, n. sp., pp. 365-366, Shillong. Ceraphronidæ. Belytidæ. Diapriidæ; *Aneurhynchus indicus*, n. sp., p. 382, Kangra Valley.]
- D'ORCHYMONT, A. . Contribution a l'étude des sous-familles des Sphæridiinae et des Hydrophilinae (Col. Hydrophilidæ.) (*Ann. Soc. Ent. France, lxxxviii, 105-168, 8 figs.*) [Sphæridiinae. Sphæridiini, pp. 106-108; *Sphæridium*, p. 112, fig. 3; *S. severini*, n. sp., pp. 116-118, fig. 7, Mahé (Malabar). Cercyonini, pp. 118-119, figs. 8; key to genera, pp. 126-127; key to spp. of *Paromicrus*, pp. 130-131; *Paromicrus annandalei*, n. sp., p. 130, Rotung (Aborland). Megasternini, pp. 131-132. Hydrophilinae. Hydrobiini, p. 136; *Scoliopsis*, n. g., pp. 138-141, type *spinosa*; *S. spinosa*, n. sp., pp. 141-142, Madulsima (Ceylon); *Oocychus latus*, n. sp., pp. 142-144, Madulsima; key to spp. of *Oocychus*, pp. 144-145; key to subgenera of *Helochaeres*, p. 149; *Pelthydrus*, n. g., pp. 150-153, type *sculpturatus*; *P. sculpturatus*, n. sp., pp. 153-154, Yunnan; key to subgenera of *Enochrus*. Hydrophilini; *Sternolophus*, pp. 156-158; *Hydrophilus similis*, n. sp., pp. 162-163, "E. India"; *Hydrous senegalensis*, Perch., p. 163, Kurseong, Sangli, probably *piesbergensis*, Reitt., from N. India, Salt Range. Amphipini, p. 164. Berosini, pp. 164-165; *Globaria leachi*, Hope, pp. 167-168 Kandy, Madras, Malacca; Synonyms.]
- DRACOTT, C.H. . Notes on the flying White Ant and Scorpions that feed on them. (*Bombay Nat. Hist. Soc. Journ. xxvi, 873-874; Oct. 1919.*)

- DUPORT, L. . Rapport à Monsieur le Président de la Chambre d'Agriculture du Tonkin et du Nord-Annam sur quelques nouvelles observations effectuées à la Station Entomologique de Cho-Ganh. (*Suppl. Bull. 122, Chambre d'Agric. Tonkin et Nord-Annam, No. 4, 10 pp.; April-May 1919.*) [Notes on *Xylotrechus quadripes*.]
- DUTT, G. R. . Second Hundred Notes on Indian Insects. (*Pusa Res. Inst., Bull. 89, pp. 102, 58 figs.*) [Notes 105, 106.]
- ELLIOT, E. A. . Two new Stephanidæ. (*Entom. lii, 162-163.*) [*Diastephanus bilineatus*, pp. 162-163, Pusa, Chapra; *Parastephanellus scitus*, p. 163, Pusa; n. spp.]
- ELTRINGHAM, H. . Butterfly Vision. (*Trans. Ent. Soc., London, 1919, pp. 1-49, 5 tabs.; Aug. 1919.*)
- EVANS, W. H. . Notes on Indian Butterflies. (*Bombay Nat. Hist. Soc. Journ. xxvi, 1021-1023; Jan. 1920.*)
- FELT, E. P. . New Indian Gall Midges. (*Diptera*). (*Agric. Dept. Entl. Mem., Vol. vii, No. 1., pp. 1-11; June 1920.*)
- FERRIS, G. F. . Notes on Coccidæ. VI. (*Canad. Entom. lii, 61-65, fig. 12; Mar. 1920.*) [*Lepidosaphes erythrinx*, Rutherford, 1914, from Ceylon, is synonym of *L. hawaiiensis*, Mask. 1894.]
- FLETCHER, T. . Second Hundred Notes on Indian Insects. (*Pusa Res. Inst., Bull. 89, pp. 102, 58 figs.*) [Miscellaneous notes nos. 102-104, 107-113, 115-118, 121-128, 130-145, 147-150, 152-153, 157-158, 160-165, 167, 168, 170, 172, 173, 176, 178-180, 182-185, 187, 189, 190, 193, 197, 199, 200.]
- BAINBRIGGE. . Report of the Imperial Entomologist. (*Sci. Rep. Agric. Res. Inst. Pusa, 1918-19, pp. 66-103, tabs. 7-9.*)
- Agricultural Entomology. (*Ann. Rept. Bd. Sci. Adv. Ind. 1918-19.*)
- FLEUTIAUX, E. . Les espèces indo-chinoises du genre *Adelocera*, Germar. [Col., Elateridæ.] (*Bull. Soc. Ent. France, 1920, pp. 112-115.*) [List of, and key to, species.]
- FRASER, F. C. . Indian Dragonflies, Part V. (*Bombay Nat. Hist. Soc. Journ. xxvi, 734-744, figs. 43-47; Oct. 1919.*)
- Notes on some new and other Indian Dragonflies. (*loc. cit. pp. 874-878; Oct. 1919.*) [*Hemianax ephippiger*, p. 874; *Orogomphus xantheptera* [error typogr. for *xanthoptera*], n. sp., pp. 874-875, fig., Madura District; *Macrogomphus annulatus*, Selys, pp. 875-876, Madura District; *Diplacodes parvula*, Rmbr., p. 876, N. W.

- India. *Disparoneura fletcheri*, p. 876, Shillong; *Caconeura mackwoodi*, pp. 876-877, Diyatalawa (Ceylon); *C. canningi*, p. 877, Coonoor; *Enallagma assamica*, pp. 877-878, Shillong: n. spp.]
- FRASER, F. C. Indian Dragonflies, Part VI. (*Bombay Nat. Hist. Soc. Journ.* xxvi, 919-932, figs. 48-52; Jan. 1920.)
- " " Notes on Odonata collected in Seistan and Baluchistan in winter. (*Rec. Ind. Mus.* xviii, 79-82, 2 figs.; Sept. 1919.)
- " " Descriptions of four new Indian Odonata. (*Rec. Ind. Mus.* xvi, 451-455; Dec. 1919.) [*Argiocnemis gravelyi*, p. 451, Saugor; *A. dyeri*, pp. 451-452, Hoshangabad Distr., Poona; n. spp. *Himalagrion*, n. g., pp. 452-453; *H. exclamationis*, pp. 453-454, Sitong, Darjiling Distr.; *Agriocnemis d'abreui*, pp. 454-455, Lamtā, Balaghat Distr.: n. spp.]
- " " Descriptions of new Indian Odonate larvæ and exuviae. (*loc. cit.* pp. 459-467, t. 32-37; Dec. 1919.) [*Epophthalmia frontalis*, Selys, pp. 459-460, t. 32, f. 1, t. 34, f. 2; *Tholymis tillarga*, Fb., p. 460, t. 32, f. 2, t. 34, f. 1; *Tramea limbata*, pp. 460-461, t. 32, f. 3, t. 34, f. 3; *Macrogomphus annulatus*, Selys, pp. 461-462, t. 33, f. 3, t. 34, f. 4, 4a; *Cyclogomphus heterostylus*, Selys, p. 462, t. 33, f. 1, t. 34, f. 5, 5a; *C. verticalis*, Selys, p. 462; *C. minusculus*, Selys, pp. 462-463, t. 33, f. 2, t. 34, f. 6, 6a; *Onychogomphus lineatus* Selys, p. 463; *Matrona basilaris*, Selys, pp. 463-464, t. 35, f. 1, t. 37, f. 1; *Lestes* sp., p. 464, t. 35, f. 2, t. 37, s. 2, 2a; *Copera marginipes*, Ramb., pp. 464-465, t. 35, f. 3, t. 37, f. 6; *Calicnemis miniata*, Selys, p. 465, t. 36, f. 4, t. 37, f. 5; *Protosticta gravelyi*, Laidl., pp. 465-466, t. 35, f. 4, t. 37, f. 7; *Chloroneura quadrimaculata*, Ramb., p. 466, t. 36, f. 3, t. 37, f. 4; *Pseudagrion microcephalum*, Ramb., p. 467, t. 36, f. 2; *P. hypermelas*, Selys, p. 467, t. 36, f. 1, t. 37, f. 3.]
- " " Notes on Indian Dragonflies. (*Rec. Ind. Mus.* xix, 31-33; June 1920.) [*Rhodischnura nursei*, Morton, dimorphic females descr., distribution; *Enallagma insula*, n. sp. pp. 32-33, Chilka Lake.]
- " " Description of a Rhinocyphine larva from Shillong. (*Entl. Mem. Dept. Agric. Ind.*, vii, No. 2, pp. 13-14, tab. 1; June 1920.) [*Rhinocypha ignipennis* larva descr.]

- FROGGATT, W. W. . The Black Banana Stem Weevil (*Cosmopolites sordidus*, Germ.). (*Agric. Gaz. N. S. W.*, Nov. 1919, pp. 815-818, figs.)
- GAHAN, A. B. . Report on a small collection of Indian parasitic Hymenoptera. (*Proc. U. S. Natl. Mus. lvi*, 513-524; 1919.) [Abstr. in *Rev. Appl. Ent. VIII*, A. 1919.]
- GILL, C. A. . Note regarding malaria in Kashmir. (*Ind. Jl. Med. Res. vii*, 610-617; June 1920.) [Notes on Anophelines.]
- GOUGH, L. H. . On the effects produced by the attacks of the Pink Bollworm on the yield of Cotton seed and lint in Egypt. (*Bull. Ent. Res. ix*, 279-324, t. 18, figs., tables; July 1919.)
- GRAVELY, F. H. . Descriptions of Indian Beetle larvæ, III. (*Rec. Ind. Mus. xvi*, 263-270, 1 f., t. 14; June 1919.)
- ” ” . Notes on some Asiatic species of *Palingenia* (Ephemeroptera.) (l. c. xviii, 137-143, t. 18-20; April 1920.)
- ” ” . The female of the Cockroach *Alluaudella* (l. c. xix, 17-18, ff.; Mar. 1920.) [*A. himalayensis*, female descr.]
- ” ” AND PRASHAD B. . A note on the marine invertebrate fauna of Chandipore, Orissa, with notes on Echiuroids. (l. c. xvi, 395-402, f.; Oct. 1919.) [Notes on *Cicindela biramosa*, Fb., and *C. quadrilineata*, Fb.]
- GREEN, E. E. . On a new genus and species of Coccidæ from North-Western India and Eastern Persia. (*Rec. Ind. Mus. xviii*, 117-119, t. 21-22; Dec. 1919.) [*Naiacoccus* n. g., type *serpentinus*, n. sp., Lahore, on *Tamarix*; *N. serpentinus* var. *minor*, Seistan, Pishin District, on *Tamarix*.]
- ” ” . Notes on Indian Coccidæ of the subfamily Diaspidinæ with descriptions of new species. (*Rec. Ind. Mus. xvi*, 433-449, t. 26-31; Dec. 1919.) [*Chionaspis annandalei*, p. 434, t. 26, f. 2a-c, Paresnath, on *Deudrocalamus strictus*; *C. caroli* pp. 434-435, t. 26, ff. 3a-b, Darjiling, on tea; *C. chir*, pp. 435-436, t. 26, ff. 4a-e, t. 27, f. 5f, Almora, on Chir pine; *C. gudalura*, p. 436, t. 27, f. 6a, b, Nilgiris, on bamboo; *C. spiculata*, p. 437, t. 27, f. 7a-d, 8e, f, Periaghat, on bamboo; *Aspidiotus pseudo-camellia*, pp. 438-439, t. 28, f. 10, Bellary, on *Capparis stylosa*; *A. tamarindi*, p. 439, t. 28 ff. 11a, b, Coimbatore, on tamarind; *Aonidia indica* p. 440, t. 28, ff. 12a, b, Calcutta; *A. tentaculata*, pp. 440-441, t. 29, ff. 13a-d, Quilon, on *Vateria*

indica; *Gymnaspis ficus*, pp. 441-442, t. 29, f. 14a, b, Kollegal, on *Ficus retusa*; *G. ramakrishnæ*, p. 442, t. 29, ff. 15a-f, Courtallum, on *Hemigyroza*; *Parlatoria artocarpæ*, pp. 442-443, t. 29, f. 16, Periaghat, on jak; *P. papillosa*, pp. 443-444, t. 30, ff. 17a-g, Palghat, on jak; *P. vateriæ*, p. 444, t. 30, ff. 18a-e, Quilon, on *Vateria indica*; *Lepidosaphes melicæ*, pp. 445-446, t. 30, ff. 20a-c, Coimbatore, on nim; *L. retrusus*, p. 446, t. 31, ff. 21, Dodabetta, on *Litsea whiteana*; *Fiorinia frontecontracta*, p. 447, t. 31, ff. 22a-d, Bombay, on *Garcinia indica*; *F. plana*, pp. 447-448, t. 31, ff. 23a-b, Coimbatore, on *Elæodendron glaucum*; *F. sapindi*, p. 448, Poona, on *Sapindus trifoliatum*; n. spp.]

- GREEN, E. E. On a new species of *Antonina* (Coccidæ) from Ceylon. (*Ent. Mo. Mag.* lv, 175-176, fig.; Aug. 1919.) [*Antonina zonata*, n. sp., p. 175, fig., Pundaluoya, on *Teinostachyum attenuatum* (a bamboo).]

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A list of Coccidæ affecting various genera of plants. (*Ann. Appl. Biol.* v. 261-273.) [Plant genera *Quercus* to *Zuccagnia*.]

- GUNASEKARA, S. T. Report on the anti-malarial campaign at Kurunegala. (*Ind. Med. Gaz.* liv, 471-472; Dec. 1919.)

- HAMPSON, SIR G. F. Descriptions of new Pyralidæ of the Subfamilies Crambinae and Siginæ. (*Ann. Mag. Nat. Hist.* (9) iii, 533-547; June 1919.) [*Coniesta*, n. g., for *Chilo arcaalis*, Hmps., p. 540; *Diatræa cashmirensis*, n. sp., Kashmir, p. 543; *D. ustalis*, n. sp., Cachar, pp. 543-544; *D. flavalis*, n. sp., Ceylon, p. 544; *D. calamina*, n. sp., Cawnpur, Moghal Serai, Pusa, Upper Burma, p. 544; *D. diaperalis*, n. sp. Bhutan, p. 545; *D. lunilinealis*, n. sp., Nawalapitiya (Ceylon), p. 545.]

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Descriptions of new Pyralidæ of the Subfamilies Crambinae and Siginæ. (*Ann. Mag. Nat. Hist.* (9) iv, 53-68; Aug. 1919.) [*Chilo rufulalis*, p. 58, Kinyua (Upper Burma); *C. submedianalis*, p. 58, Batticaloa; *C. gemininotalis*, p. 59, Cachar; *Eschata irrorata*, p. 61, Khasis; n. spp.]

- Descriptions of new Pyralidæ of the Subfamilies Crambinae and Siginæ. (*Ann. Mag. Nat. Hist.* iv, 137-154; Sept. 1919.) [*Surattha albicostalis*, pp. 138-139, Horsleykonda (Madras); *S. arenalis*, p. 139, Moghal Sarai; *Ancylolomia agraphella*, p. 144, Assam, Timor;

A. dives, p. 145, Belgaum; *Charltona rufalis*, p. 153, Nilgiris, Trivandrum; *C. endothermalis*, pp. 153-154, Belgaum; n. spp.]

- HAMPSON, SIR G. F. Descriptions of new Pyralidæ of the Subfamilies Crambinae and Siginæ. (*Ann. Mag. Nat. Hist.* (9) iv, 305-326; Nov. 1919.) [*Crambus chionocephala*, p. 307, n.n. for *C. chionostola*, Hampson, l.c. (9) iii, 290 (*præocc.*). *Siga*, Hb. (1827) antedates *Schœnobioides*, Dup. (1844), p. 307; *Topeutis*, Hb. (1827) antedates *Scirpophaga*, p. 319; *Topeutis flavidorsalis*, n. sp., p. 319, Bhutan; *T. brunnealis*, n. sp., p. 319, Upper Chindwin Distr. *Cirrhocrista bifurcalis*, n. sp., p. 325, Formosa, Khasis, Philippines, S. Celebes, New Guinea.]
- " " New Moths collected by Mons. A. Avinoff in W. Turkestan and Kashmir during his journeys in 1909-12. (*Trans. Ent. Soc., London*, 1919, pp. 431-434; Jan. 1920.) [Noctuidæ: Agrotinæ; *Euxoa dimorpha*, n. sp., pp. 431-432, Kashmir (12,000 ft.); *Feltia fuscifusa*, n. sp., p. 432, Kashmir (16,500 ft.); Hadeninæ: *Trichoclea elæochroa*, n. sp., pp. 432-433, Kashmir (10,000 ft.). Pyralidæ: Agrotinæ; *Pyrausta rubritinctalis*, n. sp., p. 434, Kashmir.]
- " " On new genera and species of Lepidoptera Phalaenæ with the characters of two new Families. (*Nov. it. Zool.* xxvi, 253-282; Jan. 1920.) [Zygænidæ: *Phacusa nicobarica*, pp. 272-273, Nicobars; *Illiberis endocyanea*, p. 273, Assam; *Artona flaviciliata*, p. 273, Raitdong (Sikkim); *A. digitata*, pp. 273-274, Dawnat Hills (Tenasserim); *A. phæozantha*, p. 274, Shevaroys; *Campylotes burmana*, p. 281, S. Khyen Hills; n. spp.]
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- " " . Field Experiments with anti-Tortrix Fluids. (*Ceylon Dept. Agric. Bull.* 46, pp. 23, 4 t., 2 f.; Nov. 1919.)
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- „ „ . A new *Chlamys* from Darjiling. (*Rec. Ind. Mus. xix*, 19-21, 2 figs. ; Mar. 1920.) [*C. pashokensis*, n. sp., from Pashok : Chrysomelidæ.]
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- Amblyteles negatorius*, Fb., = *Eristicus iridipennis*, Cam. (Cape Colony) = *Pompilus divisus*, Sm. (Kashmir, Nepal), p. 160; *Spilichneumon*, Thoms. = *Haliphera*, Cam. (1903) = *Eutanyacra*, Cam. (1903), p. 161; *Xenopoppa kali*, n. sp., pp. 162-163, Dehra Dun and probably Assam; *Heresiarchini*, list of genera, pp. 164-165; *Miojoppa*, Cam., redescr., p. 167; *Benecles*, Cam., redescr., p. 170.
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Calcutta, on *Bombax malabaricum* : *Aleuroplatus*, Q. and B., p. 381 ; *Aleuroplatus*, n. subg., pp. 382-383 ; *A. (A.) ficus-rugosæ*, n. sp., pp. 387-388, t. 49, ff. 13-16, Calcutta, on *Ficus rugosa* ; *A. (A.) incisus*, n. sp., pp. 388-389, t. 52, f. 2, t. 49, ff. 20, 21, Peradeniya, on *Ostodes* and *Garcinia* ; *A. (A.) pectiniferus*, n. sp., pp. 393-394, t. 53, ff. 10-14, t. 56, ff. 2, Lahore, on *Morus* ; *A. (A.) translucidus*, n. sp., pp. 397-398, t. 58, ff. 2, t. 60, ff. 8-14, Lahore, Wazirabad, on orange ; *Dialeurodes*, Ckll., key to subgenera, pp. 405-406 ; subg. *Dialeurodes*, key to species, pp. 406-408 ; *D. (D.) citri*, Ashm., pp. 408-412, t. 63, ff. 1-14, t. 64, f. 1, America, India, on orange ; *D. (D.) radiipuncta*, n. sp., pp. 418-419, t. 66, ff. 5-7, Peradeniya, on *Memezylon* ; *Rusostigma*, n. subg., p. 420 ; *D. (R.) eugeniae*, Mask., p. 421, t. 68, ff. 1-5, India, on *Eugenia jambolana* ; *Dialeuronomada*, n. subg., p. 424 ; *D. (D.) dissimilis*, n. sp., pp. 424-425, t. 70 ff. 1-4, Saharanpur, on *Phyllanthus myrtifolium* ; *Rabdostigma*, n. subg., p. 425 ; *D. (R.) radiilinealis*, n. sp., pp. 425-426, t. 70, ff. 5-8, Nuwara Eliya, on mistletoe ; *Rhachisphora*, n. subg., pp. 430-431 ; *D. (R.) trilobitoides*, n. sp., pp. 433-434, t. 75, ff. 6-11, t. 74, ff. 2, Peradeniya, on *Harpullia* and *Eugenia operculata* ; *D. (R.) rutherfordi*, n. sp., pp. 432-433, t. 75, ff. 1-5, t. 74, f. 1, Peradeniya, on *Loranthus* ; *Dialeuropora*, n. subg., p. 434 ; *D. (D.) decempuncta*, n. sp., pp. 434-435, t. 76, ff. 1-7, Peradeniya on cinnamon and Lahore on mulberry ; *Neomaskellia*, Q and B., pp. 436-437 ; *N. bergii*, Sign., pp. 437-439, t. 77, ff. 1-14, Java, Manila, on a wild grass.]

RAMACHANDRA Second Hundred Notes on Indian Insects. (*Pusa Res.*
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159, 169, 181, 196.]

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check on the spread of *Lantana* in India. (*Agric.*
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146, 166, 171, 174, 177, 188, 192, 194, 195, 198.]

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- Wlk., p. 106, Ceylon, India, Sunda Islands, Penang ;
P. pilifrons, Chap., p. 106, India, Indian Archip.,
 Penang ; *Xyleborus submarginatus*, Blandf., p. 109,
 India (Belgaum), Ceylon, Celebes, New Guinea,
 Sarawak ; *X. comptus*, n. sp., p. 111, Ceylon, on
Hevea brasiliensis ; *X. undulatus*, n.sp., pp. 111-112,
 Bengal ; *Phloeosinus jubatus*, n. sp., pp. 112-113,
 Dehra Dun ; *Cryphalus corpulentus*, n. sp., pp. 113-114,
 Nilgiris.]
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 (Bombay Nat. Hist. Soc. Journ. xxvi, 872 ; Oct. 1919.)
 [Sphingid recorded in this Journal Vol. xxv, part 1 ;
 was *Celerio euphorbiae nervosa*.]
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 lii, 166-167.)
- " " . Curious accident to Sphingid larvæ. (Entom. lii, 262 ;
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 189-191 ; Oct. 1919.) [Female descr.]
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 V. Cram. (Bombay Nat. Hist., Soc. Journ. xxvi, 1047 ;
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Inst., Bull. 89, pp. 102, 58 figs.) [Note no. 175.]
- SWAIN, A. F. . A Synopsis of the Aphididæ of California. (*Univ.*
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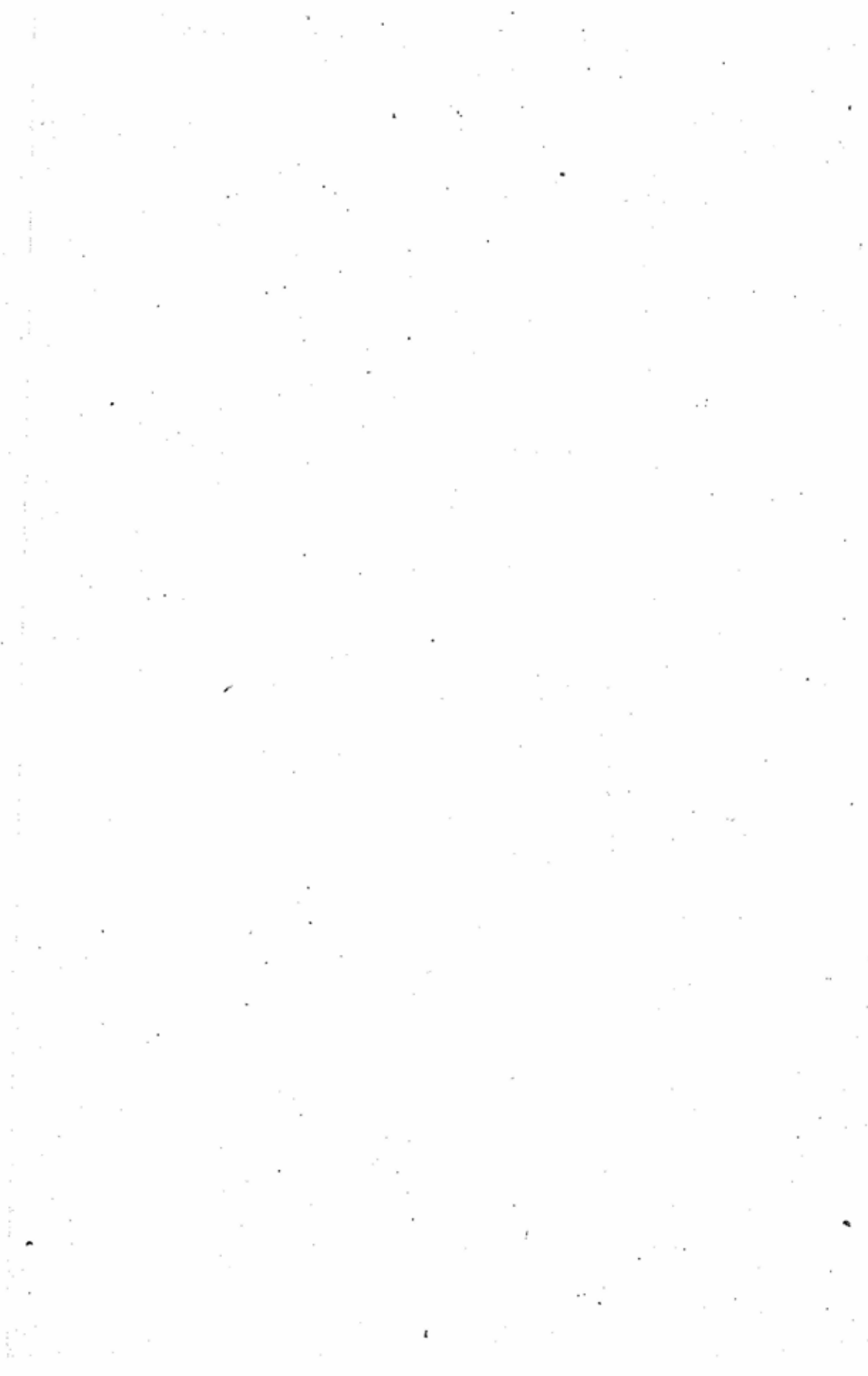
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Departmental Publications

I.—METEOROLOGICAL DEPARTMENT—

Government of India Office.

- (1) The Indian Daily Weather Report and Chart
- (2) The Weekly Rainfall Summary.
- (3) The Monthly Weather Review.
- (4) The Annual Summary.
- (5) The Rainfall of India.
- (6) Indian Meteorological Memoirs.

Bengal Office.

- (1) Bengal Daily Weather Report and Chart.
- (2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

- (1) Monthly Weather Summaries (*United Provinces Gazette*).
- (2) Annual Summary.
- (3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

- (1) Monthly Summary
 - (2) Annual Summary
- } of Punjab weather.

II.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 anna (6 pence) per plate.

Memoirs, Vols. I.—XLV, including the larger papers on geological subjects.

Records, Vols. I.—L, including the shorter papers and Annual Reports from 1868 to 1915 sold in parts, priced one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891 to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—SURVEY OF INDIA.

- (1) Annual General Report.
- (2) Professional Papers.

IV.—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

- (1) Annual Report of the Botanical Survey of India.
- (2) Records of the Botanical Survey, Vols. I—IX.
- (3) Annual Report of the Industrial Section, Indian Museum.

- (4) Annual Report of the Royal Botanic Garden, Calcutta.
 - (5) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII, Part II
- A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—DEPARTMENT OF AGRICULTURE.

- (1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).
- (2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in agriculture.
- (3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.
- (4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.
- (5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with Entomological subjects.

VI.—FOREST DEPARTMENT.

- (1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).
- (2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.
- (3) Indian Forest Records.
- (4) Indian Forest Memoirs.
- (5) The Indian Forester.—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, published monthly.
- (6) Bulletins are published from time to time.

VII.—ZOOLOGICAL DEPARTMENT.

- (1) The Annual Report 8vo.
- (2) Records of the Indian Museum, 8vo. Containing short papers on Indian Zoology. One or two volumes issued annually in quarterly parts.
- (3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.
- (4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.
- (5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—CIVIL VETERINARY DEPARTMENT.

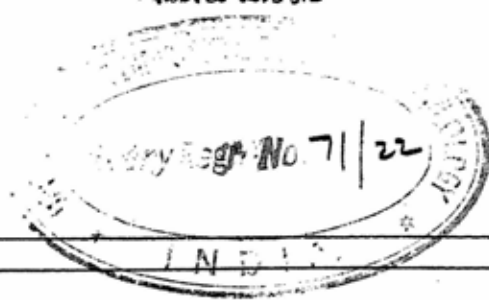
- (1) Annual Report.

Board of Scientific Advice
for India

ANNUAL REPORT

FOR THE YEAR

1920-21



CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

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Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.
P. S. King & Sons, 2 & 4, Great Smith Street, Westminster London, S.W.
H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.
Grindlay & Co., 54, Parliament Street, London, S.W.
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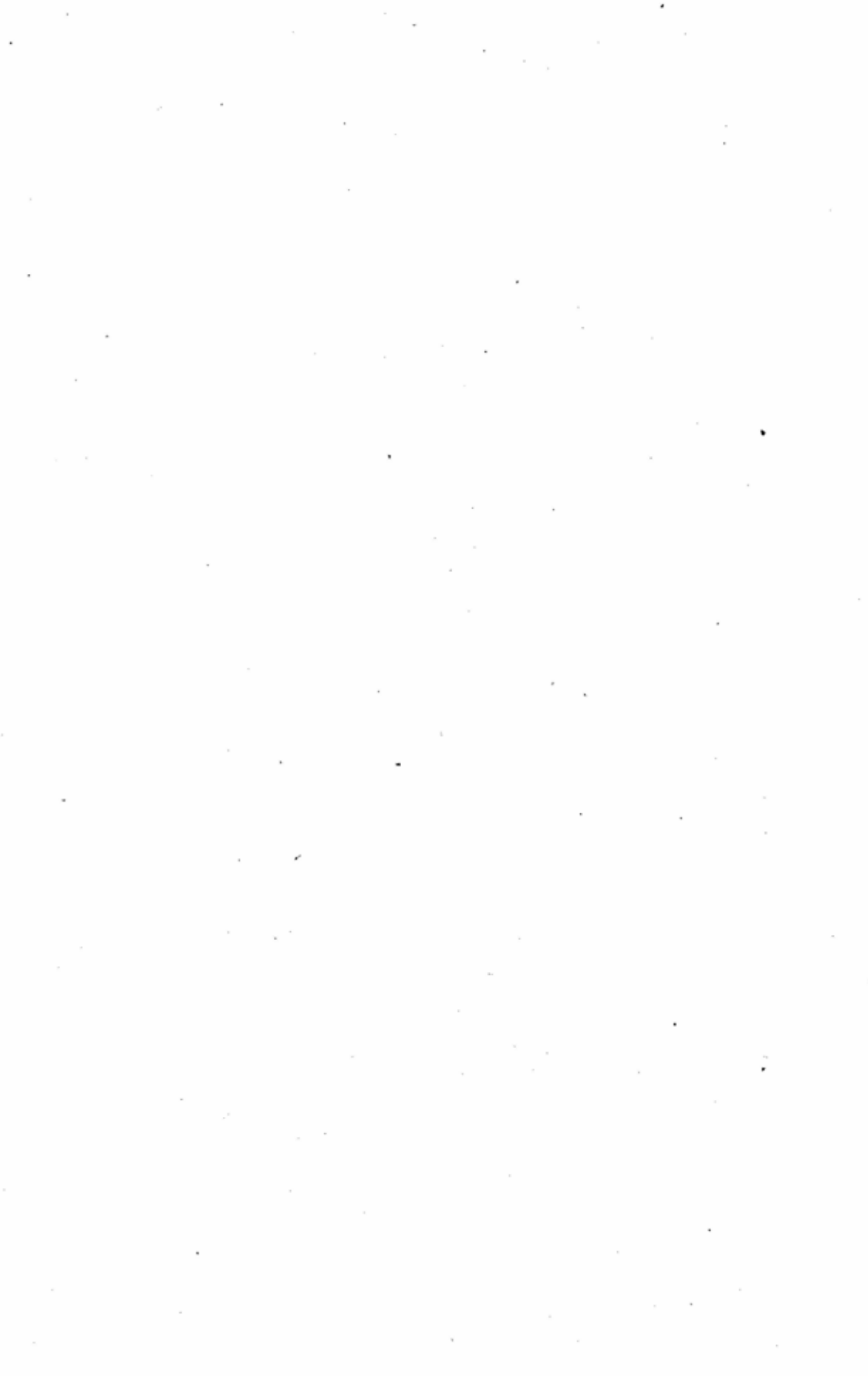
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1. The Surveyor-General of India (Chairman).
2. The Director-General of Observatories.
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman).
2. The Inspector-General of Forests.
3. The Agricultural Adviser to the Government of India.

Sub-Committee C.—(*Soils and Manures*).

1. The Agricultural Adviser to the Government of India (Chairman).
2. The Director, Geological Survey of India.
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

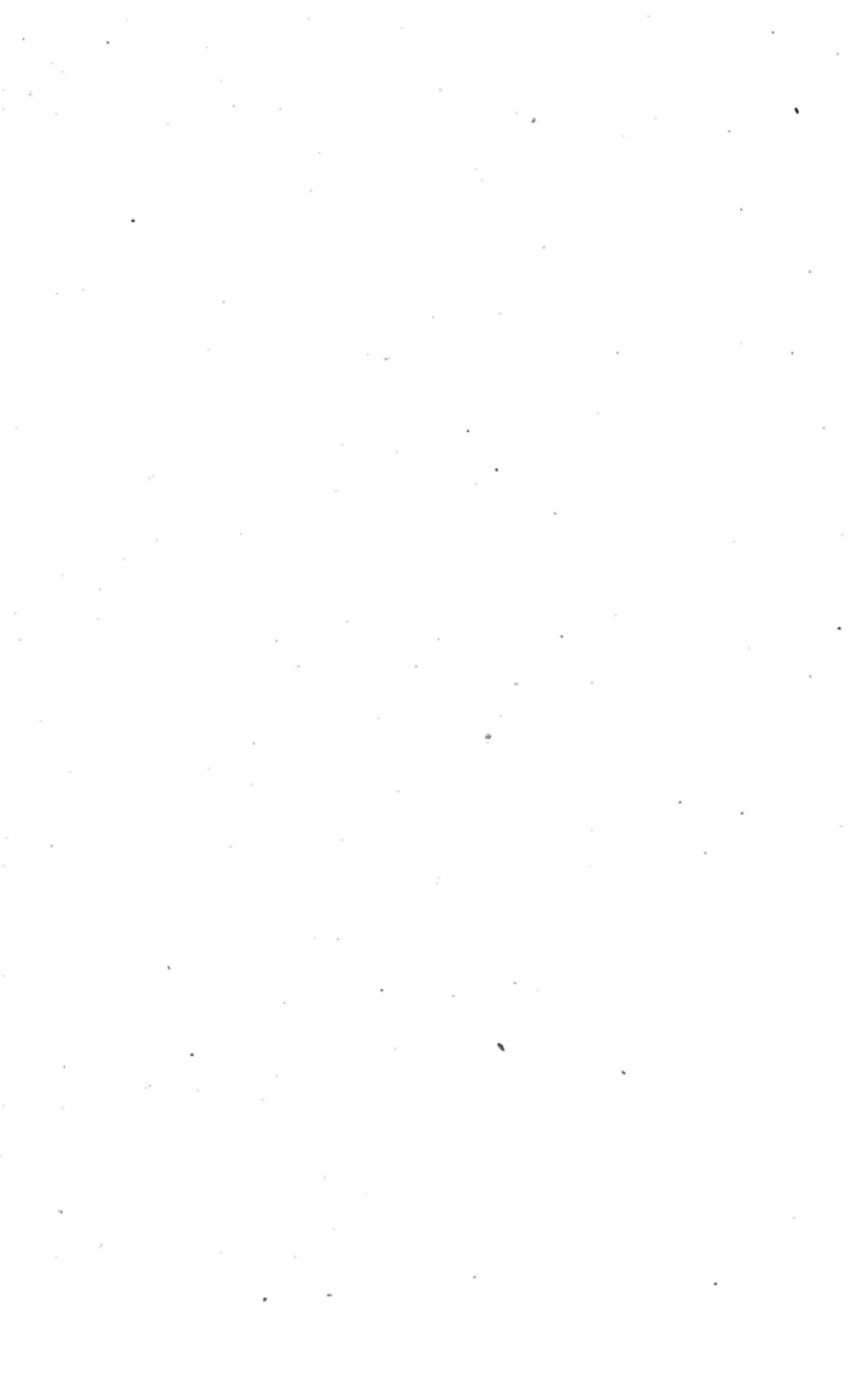
1. The Inspector-General of Forests (Chairman).
2. The Agricultural Adviser to the Government of India.
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary Subjects*).

1. The Principal, Punjab Veterinary College (Chairman).
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1. The Director-General of Observatories (Chairman).
2. The Surveyor-General of India.
3. The Director, Geological Survey of India.
4. The Director, Zoological Survey of India.



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Annual Report of the Board of Scientific Advice for India, 1920-21.

SUMMARY OF PROCEEDINGS.

Fortieth meeting held at Delhi on the 28th November 1921.

The programmes of the various departments for 1921-22 and the draft Annual Report of the Board for 1920-21 were considered and accepted.

The Board discussed the Report of the Libraries Sub-committee on the provision of scientific libraries in India and on the perishing of paper in India. It was resolved that the Education Department should be asked to publish the catalogue of scientific periodicals available in India outside Calcutta as soon as possible and that the Libraries Sub-committee should prepare a list of scientific periodicals suitable for libraries in India ; that if the catalogue and the list were ready in time the Education Department should be asked to nominate a representative specially to attend the next meeting of the Board to consider the action to be taken. In respect of the perishing of paper the Board referred the question to a Sub-committee to consider what action could be taken on the Report issued by the Indian Institute of Science and to report to the Board before the next meeting.

The proposal made by the Agricultural Adviser to the Government of India to abolish the sections of the Annual Report of the Board for which the Agricultural Department was responsible and a proposal by the Inspector-General of Forests that the Annual Progress Report of Forest Research work in India should be accepted by the Board for inclusion in its Annual Report instead of the special contributions hitherto supplied were discussed. The Board came to the conclusion that the present practice of compiling the Annual Report of the Board should be continued. They regretted they were unable to accept the suggestion of the Inspector-General of Forests, and expressed the opinion that the preparation of a special triennial Report or Review of all scientific work in India for the Board should not be attempted.

The Board then considered the qualifications of a representative of the Education Department to be nominated as a member of the Board. It was resolved that while the Board would prefer the representative of the Education Department to possess scientific qualifications, any nomination that the Education Department desired to make would be welcomed.

A proposal for the establishment of a Marine Biological Station at Port Blair and Andaman Islands was considered. The scheme was referred to a Sub-committee for report before the next meeting of the Board.

APPLIED CHEMISTRY

PART I.—AGRICULTURAL CHEMISTRY

BY

F. J. WARTH, M.Sc.

Officiating Imperial Agricultural Chemist.

SOILS.

Soil Surveys.—In Madras the survey of the Periyar tract has been almost completed.

The traverse survey which is being carried out by Somers Taylor in Behar has been extended to the foot-hills in Santhal Parganas. The deficiency of P_2O_5 already noted was found to be more marked as the hills were approached.

In the Central Provinces, a survey of the lateritic Bhatta soils has been completed by Plymen.

Soil Moisture.—In the Punjab, Wilsdon has continued his work on soil moisture movement. Interesting measurements relating to percolation from flowing water channels have been obtained. It was found that the vertical movement is much greater than the lateral.

Soil Nitrogen.—Somers Taylor has noted marked seasonal variation of Organic Nitrogen in certain Behar soils. The study of this important observation is being continued.

Soil Acidity.—Harler has shown that the acidity and toxicity of Assam tea soils are related to Alumina in solution. The toxicity of the soil may be reduced by treatment with super, potash salts or lime.

Soil gases.—Mukherji has continued his work on formation of CO_2 in grassed and fallow plots at Pusa. It is only during the rainy season that very marked increase in CO_2 on the grassed plots occurs.

Experimental area, Pusa.—Sen has carried out preliminary experiments which show that some marked variations in soil composition occasionally occur. Crop growth can be correlated with these differences.

The crops are however patchy also in places where soil composition is uniform. The factors affecting growth in such areas is under investigation.

MANURES AND MANURING.

The important experiments on availability of ground phosphate when composted with green manure have been continued in Madras.

The relative efficiency of super and ground phosphate in combination with green manure has been tested in Behar. For light phosphate dressings the efficiency of the two manures was practically identical. The ground phosphate however when used in larger amounts causes no further improvement such as is obtained with super.

In the Punjab the value of green manuring on sandy soils as a means of retaining soil moisture has been clearly shown.

Coleman has carried out experiments on the availability of nitrogenous manures on the Red Mysore soil. Am_2SO_4 was generally superior to NaNO_3 . The latter, it was shown, had a deleterious effect on the soil texture. Green manures were found to be less effective than cakes on this soil.

CROPS.

Sugar cane.—The question of ripening under different soil and climate conditions is under continuous study in Bengal, Behar and Assam.

Sanyal has carried out further experiments on windrowing at Pusa and shown that in certain cases here the condition of windrowed cane is better than corresponding uncut cane.

Oil seeds.—Norris has continued his enquiry on the cocoanut plant and fruit.

Somers Taylor has shown that high or low oil content is generally not an inherited character in castor seed. The oil content was found to depend upon cultivation and upon the degree of maturity of the seed.

Rice.—The rates of assimilation of nutrients and of development of the rice plant are being determined in Bombay.

Charlton in Burma has carried out an investigation on the parboiling of rice. The industry, though important, is a public nuisance owing to the objectionable fermentation which occurs.

Sterilisation by heat and bleaching powder, suppression of anaerobic bacteria by blowing air, and frequent changes of water were the methods first tested. They had all to be abandoned for various reasons. Eventually good results were obtained by using acidulated water ($P_h=5-P_h=2$) which inhibited bacterial activity.

Opium.—Annett has continued the enquiry on the lines previously described.

In studying the factors influencing the morphine content of the latex he found striking differences in distribution of the alkaloids in the plant.

Codeine was found to be uniformly distributed whilst morphine and with it meconic acid were concentrated in the capsule.

Annett has further improved his process for the determination of morphine for estimating such small quantities as occur in a single capsule. This will greatly facilitate selection work.

Tea.—The officers of the Indian Tea Association have been engaged in studying the tannin content of the leaf and the changes taking place during withering. The tannin content was found to vary considerably not only in plants of different species but also in different plants of the same species.

It was found that the initial moisture content of the leaf was an important factor in controlling the changes taking place during withering. Leaf plucked in the morning in the turgid state developed more tannin during 18 hours of withering than drier leaf plucked later in the day.

Jute.—The composition of the jute plant at different stages of development has been studied by the Fibre Expert in connection with the incidence of fungoid disease.

Beans.—Charlton in Burma has examined a large number of cultures for HCN. content. 5 of these have been chosen for further separation into pure strains.

Cotton.—In Madras it has been found that the staple and colour of lint from a pure variety of cotton was appreciably different when grown on two distinct soil types. The work is being continued.

Indigo.—In Indigo Publication No. 6, by W. A. Davis, a second series of reports of manurial trials carried out by Bihar planters is discussed. On certain areas notably in the Champaran District, Super alone has given very marked increase of crops, both indigo and rabi crops such as oats. The majority of the soils in Bihar however are defective in humus as well as soluble phosphate and in these cases combined treatment with green manures (Sannai) and Super have given big increases of crops. Most of the soils in Bihar have a very high lime content (20 to 40 per cent CaCO_3) but a few exceptional soils are deficient in this constituent and need liming to improve texture.

The mode of action of phosphatic fertilisers in Bihar is discussed and emphasis laid in the great increase of root development and nodule activity due to soluble phosphate.

Indigo Publication No. 8, by W. A. Davis, discusses the conditions affecting the quality of the Java indigo plant, especially indigo content of the leaf. Trials suggest that high quality is associated with a low nitrogen content in the soil, particularly with a low content of nitrate. When indigo is grown with a cover crop, such as wheat or mustard, the indigotin content of the leaf and the possible yield of indigo per acre may be increased 50 per cent or more.

Indigo Publication No. 9, by W. A. Davis, is a note on the possible development of indigo in Assam, where it grows with unusual luxuriance. Details are given of the difficulties encountered at Panchnoi Factory owing to the widely varying character of the water used for steeping from day to day as regards its contents of active indician-splitting bacteria.

Indigo Publication No. 9, by W. A. Davis, deals with the nature of the changes occurring during the extraction of indigo in the ordinary steeping

process. In this publication the very harmful effect of slight oversteeping—one or two hours—on both yield and purity of the indigo is emphasised. Such destructive action occurs when the bacterial fermentation in the vats produces much acidity, due to carbonic acid, the presence of which is very destructive of indoxyl. Different typical fermentations have been studied in detail and the results illustrated by graphs.

Indigo Publication No. 10 is a note by Major W. R. Atkins on the deterioration of indigo seed during storing and on the conditions necessary to avoid this.

APPLIED CHEMISTRY

Part II.—Forest Chemistry

BY

J. L. SIMONSEN,

Forest Chemist, Forest Research Institute, Dehra Dun.

Essential Oils—(1) Turpentine.—Experiments on the chemistry of the sesquiterpene longifolene obtained from *Pinus longifolia* have been continued and some light has been thrown on the constitution of this interesting substance. It is hoped that when once the constitution of this substance has been elucidated some technical use may be found for it as at the present time it only finds a limited market as an inferior turpentine substitute. It has been suggested that it might be utilised for mineral flotation and experiments are being made in Burma to determine whether it can be used for this purpose.

(2) Oil from the leaves of *Skimmia laureola*.—The examination of the oil from the leaves of *Skimmia laureola* has been completed and the results have been published (Journal of the Society of the Chemical Industry, 1921, Vol. XI, 126T.).

(3) Oil from *Zanthoxylum* seeds.—The oil from the seeds of one species of *Zanthoxylum*, which has not been definitely identified botanically, have been examined and shown to contain d-linalol (50 per cent.) phellandrene, dipentene and methyl cinnamate. As this oil would appear to be of some value the oil from other species of *Zanthoxylum* obtainable in India are being examined.

(4) Camphor.—The experiments on the yield of camphor and camphor oil from leaves grown in Dehra Dun have been completed and the results published (Journal of the Society of Chemical Industry, 1920, Vol. XXXIX, 296T.). It is hoped to publish shortly a detailed analysis of the acreage yield of camphor with special reference to the question of establishing the camphor industry in India.

(5) *Boswellia serrata*.—Fowler and Malandkar have published details of their method for the separation of the turpentine, rosin and gum from the gum-oleoresin from *Boswellia serrata* (Journal Ind. Inst. Sc., Vol. IV, 27).

Fixed oils.—Preliminary experiments have been made at Dehra Dun on the oils from the seeds of *Garcinia Morella*, *Garcinia Cambogia*, *Mimusops Elengi*. The oil from olive seeds grown at Rawalpindi was examined and though the yield of oil was low it was of good quality.

Wood distillation.—Sudborough and Watson with collaborators have published Part III of their researches on wood distillation (Journ. Ind. Inst. Sc., Vol. III, 281). This part of the research is concerned mainly with the distillation of certain Mysore and Baroda woods under conditions similar to those used in the previous experiments. The results are given in a number of tables.

Medicinal products.—As the result of a careful analysis of a large number of samples of the leaves and flower buds of *Artemisia maritima* from Kashmir the presence of Santonin has been definitely established. This result has been confirmed in London by Greenish and Pearson (Pharm. Journ., 1921) and the question of the commercial extraction of this valuable drug in Kashmir is under consideration.

Miscellaneous.—Sudborough and Vridhachalam (Journ. Ind. Inst. Sc., Vol. III, 61) have investigated the extraction of tartaric acid from tamarinds. They show that the acid is readily recovered and are of opinion that tamarinds would prove an economic source of tartaric acid. This research confirms an unpublished research made with a similar object by Dr. B. B. Dey at the request of the Indian Munitions Board.

Fowler and Joshi (Journ. Ind. Inst. Sc., Vol. III, 39) have studied the fermentation of cellulose. They consider that it should be possible under certain conditions to generate power gas (methane) by the fermentation of waste cellulose materials which are frequently available in quantity as for example on the West Coast.

A valuable study of the biochemistry of the Mahua flower has been published by Fowler and his collaborators (Journ. Ind. Inst. Sc., Vol. III, 81). For details the original paper should be consulted as the results cannot readily be summarised.

ASTRONOMY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on at Kodaikanal under the direction of Mr. J. Evershed. A description of the instruments was given in the report for 1918-19.

Routine Work.—Daily spectroheliographic records are obtained in calcium and in hydrogen light; the routine work also includes visual examination of sunspots and faculae, sunspot spectra, and bright lines or displaced lines in spots and in prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 66 have appeared and of the latter 2 have been published.

Spectroscopic Research.—The study of the variations in the Sun-arc displacements was continued up to the end of 1920, the spectrograph being adjusted for the spectral region 4300-4500 and remaining unaltered throughout. Local displacements on the Sun's disc were avoided by using general sunlight instead of taking the light from the centre of the disc. A small progressive increase in wave-length is shown in some of the lines, and the mean shifts of these lines for the year 1920 show an increase of about 0.002A as compared with similar values obtained in 1919. The changes of wave-length observed are far in excess of the probable errors of measurement.

A series of spectra of Sun and arc have been obtained and partly measured of the ultra violet region, including the high level calcium lines H and K, two aluminium lines, and numerous iron lines as well as the cyanogen bands. These spectra are taken at the polar and equatorial limbs of the Sun and at the centre of the disc. Other series taken at the same positions on the Sun include the iron lines at the red end of the spectrum and the D lines of sodium. The object in view is to redetermine as accurately as possible the displacements in the Sun of lines representing high levels and low levels, and to find the relation between displacements and wave-length at both limb and centre of disc.

The results of our measures of iron lines in Sun and arc will be used also to determine the absolute wave-lengths of selected lines in the solar spectrum based on the International system of iron arc standards. These will be communicated to the International Committee on Standards of wave-length.

Spectra of Venus have been obtained in December 1920 and in June 1921 with the planet near eastern and near western elongation respectively, and photographs will be continued until the angle Venus-Sun-Earth becomes as

large as possible. The spectra obtained near the elongations yield negative evidence as to the planet's rotation which appears to be much slower than that of the Earth. The shift of the lines in these spectra is practically the same as in the spectrum of direct sunlight, the angle Venus-Sun-Earth being small.

A new auto-collimating prism spectrograph of long focus and high resolving power has been partly constructed in the observatory workshop. It is intended to supplement the grating spectrograph for weak light sources and especially for Venus spectra when the available time of exposure becomes too short for satisfactory grating photographs, owing to the approach of the planet to superior conjunction with the Sun.

Prominence Frequencies.—In the study of the solar prominences a remarkable relation has been found between the eastern excess of prominences in the northern and southern hemispheres considered separately and the heliographic latitude of the Earth. It appears that during the series of years between 1904 and 1917 when there was a constant excess of eastern prominences this excess was always greater in the hemisphere inclined away from Earth than in the hemisphere inclined towards Earth. The mean results indicate that the eastern excess varied in accordance with the sine curve showing the variations in the inclination of the sun's axis to the line of sight.

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Upper Air.—Work with pilot balloons was continued at several stations under the direction of the Agra Upper Air Observatory. The shortage of funds which resulted from a general revision of pay necessitated the closing of the balloon stations at Akyab, Calcutta and Bombay and caused the loss of several trained members of the staff. Nevertheless it was possible to make some headway in the discussion of the upper air data of cloud wind and temperature gathered during the war years.

Normal values of upper winds at nine stations in India were published for the use of aviators, while a discussion of the cloud observations made between 1877 and 1914 was also printed; these two papers form parts IV and V of Vol. XXII of the Memoirs.

Daily and seasonal forecasting.—Shortness of staff prevented any of the gazetted officers from carrying on the preparation of type maps for daily forecasting; but the presence in the Simla office of Mr. J. C. Kamesvara Rao, who was deputed by the Calcutta University to work at meteorology, enabled progress to be made. Mr. Rao has made a careful analysis of all the cold weather storms of the past 20 years.

The methods of forecasting for the cold weather rains as well as for the monsoon have been advanced a stage further. The best result is that for the monsoon rainfall of the Peninsula for which a formula based on 45 years' data of only three factors yields a correlation coefficient of .73.

Theoretical Meteorology.—An investigation was made into the application of wet bulb temperatures in thermodynamical problems, and some important conclusions about the relationship between adiabatic processes and wet bulb temperatures were arrived at.

A short discussion on dust-raising winds was prepared for publication.

TERRESTRIAL MAGNETISM

BY

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Director-General of Observatories.

Magnetic observatories—Bombay (Alibag).—For a description of the instruments and of the routine work reference should be made to the Annual Report of the Director, Mr. T. K. Chinmayanandam.

Magnetic Survey.—No. 18 Party (Magnetic).—The declination, horizontal force and vertical force magnetographs continued in operation throughout the year at the Dehra Dun and Toungoo observatories, and daily absolute magnetic observations were taken regularly by the observers in charge. The observatories were visited during the field season and observations, consisting of declination, horizontal force and dip, were taken for the comparison of instruments.

The Kodaikanal and Alibag Observatories, under the control of the Meteorological Department, were also visited by the officer in charge of the magnetic survey for the same purpose.

Observations at repeat stations.—Six repeat stations at even distances apart, most of them *en route* to the observatories, were selected and observed at this field season. These stations will be visited annually to take magnetic observations with the object of ascertaining in what year, during the interval of the 5-yearly observations at all repeat stations, a turn in the curve of secular change is indicated, so that it may be possible to determine with greater accuracy the rate of annual change which the magnetic elements undergo in different parts of India.

Reduction of observations to epoch.—The reduction of the observations at the field and repeat stations in India, which was last year reported to be under revision, is now well in hand and will be completed about the end of this year.

The magnetic elements at observatories.—The computation and tabulation of the provisional values of dip, declination, horizontal force and vertical force for the three observatories Dehra Dun, Toungoo and Kodaikanal, for the year 1920, have been completed; the mean values of these elements

derived from all days, excluding those of great disturbance, are given in the table below :—

Mean values of the magnetic elements at observatories in 1920.

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
				C. G. S.	C. G. S.
Dehra Dun .	$\left\{ \begin{array}{l} 30^{\circ} 19' 19'' \text{ N} \\ 78 \quad 3 \quad 19 \text{ E} \end{array} \right.$	$\left\{ \begin{array}{l} \text{N. } 44^{\circ} 59' 9'' \\ \end{array} \right.$	E. $1^{\circ} 52' 0''$	-32951	-32949
Toungoo .	$\left\{ \begin{array}{l} 18 \quad 55 \quad 45 \text{ N} \\ 96 \quad 27 \quad 3 \text{ E} \end{array} \right.$	$\left\{ \begin{array}{l} \text{N. } 23 \quad 7.7 \\ \end{array} \right.$	W. $0 \quad 23.7$	-39114	-16707
Kodaikanal .	$\left\{ \begin{array}{l} 10 \quad 13 \quad 50 \text{ N} \\ 77 \quad 27 \quad 46 \text{ E} \end{array} \right.$	$\left\{ \begin{array}{l} \text{N. } 4 \quad 3.61 \\ \end{array} \right.$	W. $1 \quad 49.9$	-37787	-03042

Great magnetic storm.—A magnetic storm of great intensity, which seriously interrupted the working of the telegraphs in India, was recorded at the observatories from the 13th to the 17th May 1921. The magnitude of the storm was greater and its duration three times longer than the big storms of the 11th and 12th August 1919 and 22nd March 1920. The storm began suddenly and simultaneously in all the magnetic elements at 13h. 8m. G. M. T., on the 13th May; it was practically simultaneous at all the magnetic observatories, to the degree of accuracy with which it is possible to measure time on the magnetograms. There is much similarity in the main features of the disturbance at all the observatories. The horizontal intensity was principally affected, and a prominent feature in this element was the great speed and amplitude of the disturbance between 21h. 20m. and 21h. 41m. G. M. T. Minor rapid fluctuations followed, and the greatest activity in all the magnetic elements began on the 14th at 22h. 15m. G. M. T.; this lasted for about 10 hours, during which time the movements in the horizontal intensity were so rapid that no record was obtained on the trace in the downward movement, which was the greatest phase of the storm. After this there was a gradual rise in the horizontal intensity up to about 2h. 20m. G. M. T., on the 16th with frequent long and short period oscillations, and between 9h. and 10h., G. M. T., a depression again occurred when the trace once more went beyond the limits of the magnetogram. A gradual rise with minor oscillations then continued up to 7h. 48m. G. M. T., on the 17th when the storm ceased.

It is noteworthy that as usual this storm synchronized with a reported display of Aurorae and with the appearance of large sun-spots.

GEOLOGY

BY

E. H. PASCOE, M.A., D.Sc., F.G.S.,

Director, Geological Survey of India.

Stratigraphy.—The examination of the Tertiary outlier north of Simla was continued. The Shali Limestone was found to be dipping unconformably beneath a bed of white sandstone which has been called the Shali Sandstone and this in its turn was seen to be overlain by the series of slaty shales in which Sir Henry Hayden discovered nummulite bands and which have been called the Madhan Slates. Similar fossils have been found in two other localities in this series. A shelly limestone occurs also in the Madhan Slates, and for some distance forms the boundary between these Slates and a series of older overlying limestones and slates, of which the limestone bears a resemblance to the Krol Limestone. The nummulites in the Madhan Slates, so far as they are determinable, appear to be of Subathu age. The Shali Limestone is therefore either Eocene in age—perhaps the Lower Nummulitic of the Punjab—or Cretaceous. It seems probable that the older limestone and slate overlying the Madhan series has been thrust over the latter, or that an over-fold has inverted the sequence of the beds, the Madhan series having originally been a Tertiary outlier lying upon the older limestone and slate.

During an investigation of the Mandi salt deposits, the presence of bitumen in the associated marls was confirmed. The salt is a stratified deposit, and this recent work tends to confirm the view that it and its associated marls belong to the Subathu stage of the Nummulitic series.

Geological Surveys.—The survey of the ferriferous belt of the Feudatory States of Bihar and Orissa was continued, as was also the general systematic survey of the Central Provinces. Considerable progress was also made with the systematic survey of Mergui. A report on the geology of the Takki Zam valley and the Kaniguram-Makin area in Waziristan will shortly be published. The rocks encountered ranged from a series containing dark blue and black shales and occasional thin black and dark blue limestones, both types being characterised by plant impressions, up to Recent Alluvium. The plant series may prove to be Jurassic. Cretaceous, Nummulitic and Siwalik rocks are all represented, the Murree series not being recognised.

Economic Enquiries.—Investigations were made regarding the following minerals: coal in the Bedadanol coalfield, Godaveri district, Madras; iron in Keonjhar and Bonai States; kaolin in the Thaton district of Upper Burma

and also in the Belgaum district of Bombay ; salt at Guma and Drang in the Mandi State, and tin in the Mergui district, Burma.

Several sites for dams were examined and reported on during the year and the question of water-supply was gone into with regard to Matheran near Bombay, Amraoti in Berar, and Taungzin and Kyaukpadaung in the Myingyan district of Upper Burma. The superintendence of the boring for coal below the Deccan Trap at Bhusawal was continued, and a geological reconnaissance of the alignment of the proposed railway up the Ganges valley from Hardwar to Karanpryag was made.

GEODESY

BY

LIEUTENANT-COLONEL H. McC. COWIE, R.E.,

Officiating Superintendent of the Trigonometrical Survey.

The only systematic field work undertaken during the year by the Trigonometrical Survey consisted of Precise Levelling, Magnetic Observations and Tidal Registration. Experiments were made in connection with wireless Longitude determinations and investigations into atmospheric refraction and the adjustment of triangulation nets were continued. No Triangulation was undertaken nor were any Pendulum or Astronomical Observations made.

TIDAL OPERATIONS.

During the past year tidal registration by means of automatic gauges have been carried out at the following ports :—

Aden, Karāchi, Bombay (Appolo-Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registration.

All the tidal observatories were inspected during the year and the gauges thoroughly overhauled and put into working order.

In addition to the automatic tidal registration at the nine ports named above, observations of high and low water on tide poles were taken during day light at Bhaunagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registrations taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply to this Department tidal observations taken on a tide pole at Basrah. On the basis of these observations, data for the preparations of tide tables for Basrah for the year 1921 were prepared and supplied to the National Physical Laboratory in England. The predictions were received from the Laboratory in December 1920 and supplied direct to the Director, Inland Water Transport, and Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in December 1920.

Data for the preparation of tide tables for Basrah for 1922 were despatched to the Director, National Physical Laboratory, in January 1921.

Arrangements have been made to transfer the Tide Predicting Machine from the National Physical Laboratory at Teddington to Dehra Dun. This instrument was originally installed in the India Office Stores Department about the year 1879, and subsequently moved to the National Physical Laboratory. It is expected that the machine will be in working order in Dehra Dūn about the end of October 1921, after which date the preparation of Tide Tables will be undertaken in India.

LEVELLING OPERATIONS.

I. *Levelling completed in 1920-21—*

During the season 1920-21, the following lines of precise levels were run :—

A.—*Jacobābād to Hyderābād*, about 350 miles. This line traverses the area commanded by the Sukkur Barrage project and the Manchar Lake Irrigation Scheme, and forms data for irrigation work on the right bank of the Indus. In the course of time many of the old bench-marks had disappeared in this area. The determination of the heights of a considerable number of the Public Works Department bench-marks was completed. The work was of the "high precision" order, executed on the "fore and back" system, and forms one of the lines of the new level net.

B.—*In the United Provinces—*

- (a) Bareilly to Pilibhīt (Revision) ; originally levelled in 1867-68.
- (b) Pilibhīt, *viā* Mailānī, Kherī Lakhimpur, Sitāpur, Baghauli, Lucknow, Rāe Bārīely, and Sultānpur to Fyzābād.
- (c) Mailānī to Shāhjahānpur.
- (d) Shāhjahānpur to Baghauli.
- (e) Sultānpur to Allahābād.

This work was undertaken at the request of the Irrigation Department, in connection with the Sarda Canal Project, in order to furnish bench-marks accurately determined and referred to a common origin, which would provide a base to enable the Irrigation Engineers to co-ordinate all their cross-levels throughout the entire lengths of the main canals and their distributaries.

The total distance levelled including branch lines was 596 miles executed on the old system of simultaneous double levelling.

C.—*In Bengal (including branch lines about 460 miles).*

- (1) Chākdaha *viā* Berhampore to Chuādānga, with branch-line from Berhampore to Lālgolā (New).
- (2) Poradāha *viā* Nator, Rājshāhi, Godāgāri and Mālda to Hyatpoor, crossing the Padenā by direct levelling over the Sāra bridge, the observed difference (old-new) of height between the two embedded bench-marks on either bank being 0.112 foot. It was originally crossed by (a) Vertical Angles, (b) Levelling and (c) Tide pole methods.

- (3) Jiāganj to Bengal-Bihar boundary near Farakka police station, 59 miles.

This levelling in Bengal was taken up for the Nadiā Rivers Scheme, and was carried out on the simultaneous double levelling method.

D.—*In Bihar and Orissa.* (Including branch lines about 230 miles.)

- (1) Hyatpoor *via* Manihāri to Rautara for the Nadiā Rivers Scheme (New),
- (2) Tinpāhār to Bihar-Bengal boundary near Farakka police station, 26 miles (New, for Nadiā Rivers Scheme).
- (3) Darbhanga to Bagahā for the Irrigation Department (New).

The method adopted was simultaneous double levelling.

E.—*Muttra to Mārwar Pāli*, in the United Provinces and Rajputana. (Total distance about 360 miles.)

This line was levelled on the "fore and back" system and forms line 107 of the new level net.

F.—*Lahore City Levelling.*

The heights of 259 bench-marks in Lahore were fixed at the request of the Punjab Government in connection with the City Sanitation Scheme. In addition to these, the heights of about 100 traverse stations were fixed in connection with the large scale survey of the city now in progress.

II.—*Levelling for earthquakes.*—

In connection with the results of the levelling in the Srimangal Earthquake area, noted in the last report to the Board of Scientific Advice, it has been decided to send each year a copy of the levelling programme for the ensuing season to the Director of the Geological Survey, and to ask him whether there are any geological faults in the neighbourhood of the lines. Stable check level bench-marks will then be constructed and levelled to during the work, to enable relevelement to be undertaken after any future earthquake in that area.

GEODETIC RESEARCH AT DEHRA DUN

BY

J. DE GRAAFF HUNTER, M.A., Sc.D., F.INST.P.

(1) **Wireless Longitude Observation.**—January—March 1921. A Marconi Multi-valve amplifier and detector, type 55 A, was lent by D. D. A. S. : and Lieutenant C. E. Sketch, 3rd Wireless squadron with 4 B. O. R.'s brought this to Dehra and explained its use. Paris signals were picked up on the third day, and, after that, on most mornings of observations. Nauen (Berlin), Caernarvon and Tokyo were frequently heard. At the outset atmospherics were troublesome. Two aeriels were tried, one 72 feet high, in the Survey office compound among trees, and the other 100 feet high on the maidan, in the open. The latter gave somewhat louder signals, but atmospherics were not reduced, as had been hoped. A still greater disturbance was caused by the working of some Central Asian station, on the same wave-length as Paris. Quetta interfered several times, until the Director of Wireless issued orders that there should be no signalling of messages at the time of the time signals.

The Paris signals are of two kinds (1) ordinary, in which the precise times 11-45, 11-47, 11-49 (night) are indicated by the beginning of a bar, after suitable warning signals, and (2) scientific, in which 300 dots equally spaced are sent out in about 293 seconds, beginning shortly after 11-00 (night, Greenwich time). The precise times, to 0.01 second, of first and last dots, are signalled after the ordinary time signals are finished. These dots are heard in a double telephone receiver, in which the clock beats are also made audible. The dots gradually overtake the clock beats, and it is only necessary to note the moment at which the two coincide, as they do 5 times in a set.

Coincidences were successfully noted on 5 mornings by Dr. Hunter, and on two mornings by Major Mason. Time stars were taken before and after the wireless signals. The results obtained cannot at present be cleared of personal equation in time determination, as the Dehra transit is not fitted with an "impersonal micrometer."

The following are the values of the difference of Longitude from Greenwich that have been determined :—

5	hours	12	minutes	11-220	seconds,	by Dr. Hunter	} by wireless 1921,
5	"	12	"	11-383	"	, by Major Mason.	
5	"	12	"	11-267	"	, by Sir Sidney Burrard, and Sir Gerald Conyngham in 1894-96 by ordinary telegraph by land and sea.	

The experiments have shown the feasibility of the method for determining the longitude of any Indian station, by direct reference to the Greenwich meridian. It is also clear that it is necessary to fit an "impersonal micrometer" to transit instruments used for this work.

(2) **Investigation of atmospheric refraction.**—It was noticed in 1913 (*vide* Professional Paper 14 Survey of India, chapter iv) that the diurnal change in refraction was in some cases very closely a linear function of the temperature. In two cases examined the greater diurnal change occurred on the shorter ray. This was considered surprising and no explanation was forthcoming. In relation with this question simultaneous observations of barometers at Mussoorie and Dehra were made at several hours of the day for 23 days. The difference of height of the two barometers was deduced by formula from these readings and was found to differ from the spirit levelled difference of height by amounts which varied at the different hours as follows:—

Hour.	8	10	12	14	16
Barometric height minus Spirit Level height in feet.	—65	—19	+7	—4	—17

In endeavouring (1921) to explain the diurnal change in refraction, an attempt was made to work out the relation between temperature variation of the air at various heights with that at ground level. It appears that the variation may be split up into two parts (1) conduction effect, (2) radiation effect. The first effect diminishes rapidly with height, and at 100 metres will not exceed 1 per cent. of its value near the ground. The second effect, probably depending a good deal on the state of humidity, should be much the same at all heights dealt with.

As regards the refraction, the second effect has but little influence; for the main determining factor is the gradient of temperature with height. The conduction effect is very much greater. Its effect is easily computed for a ray of light which soon passes out of the conduction region. If α is the angle of elevation of the ray and $\delta\tau_c$ is the portion of the variation of temperature from its maximum value, which is due to conduction, the change in refraction resulting is given by applying $\mu \sin \phi = \mu' \sin \phi'$ at the ground level and at a height of (say) 100 metres. Then $\delta\mu \propto \delta\rho \propto \delta\tau$ and the refraction $= A\delta\tau_c \cot \alpha$ where A is a physical constant. It is found in cases dealt with that if $\delta\tau_c$ is taken equal to $\frac{5}{8} \delta\tau$, where $\delta\tau$ is the defect of temperature near surface from maximum, that the observed changes in refraction are closely explained.

It appears that the radiation portion $\delta\tau_r$ of the temperature variation is of the form $a \delta\tau + b \frac{d\tau}{dt}$, t being the time. In the barometric formulæ it is necessary to get the mean value of $\frac{1}{\tau} = \left(\frac{1}{\tau}\right)_m$: usual formulæ have put this

equal to $\frac{2}{\tau_1 + \tau_2}$ where τ_1, τ_2 are the temperatures observed at both ends.

This value of $\left(\frac{1}{\tau}\right)_m$ is not likely to be correct when there is a much larger variation of temperature near the surface than in the higher layers of air. In fact it is clear that much better results will be obtained if $\delta\tau_c$ is applied to the observed temperatures. The barometer results uphold this view and the observations at 8, 10, 12 hours fall nearly on a straight line when plotted against temperature observed near the ground. Observations at 14 and 16 hours fall distinctly to one side of this line. The explanation seems to be in the term $\frac{d\tau}{dt}$; in fact an empirical expression $a' \delta\tau + b' \frac{d\tau}{dt}$ can be found which closely represents the tabular quantities given above. This also leads to the partition of temperature variation into two parts about in proportion of 5 : 1 due to conduction and radiation respectively. What has been said about conduction effect is primarily applicable to a station in a plain. At a hill top convection will cause a readjustment. On this account the diurnal variation in refraction from a hill station is less than it would be at a plateau station. Observation has shown this to be the case.

According to this reasoning the following seems to be probable—

- (1) The line representing temperature of air plotted against height is practically straight at about 14 hours, right to within a few feet from ground.
- (2) At earlier hours in the day the general slope of this line is not much changed; but it is displaced as a whole to a smaller temperature and its termination near (say within 100 metres of) the ground is now curved towards the direction of lower temperature, the curvature increasing as the earth is approached.

It now appears possible to represent the refraction on a ray which does not lie close to the ground, at any time in the form, $kc + f A (\tau_m - \tau) \cot \alpha$ in which c is the length of the ray in seconds of arc, k is a factor depending on temperature and pressure of the air at the observing station, α is the angle of elevation of the ray, τ is the temperature and τ_m its maximum value, A is a constant and f is a factor so far found to be about $\frac{5}{6}$.

The observations to determine the height of Mount Everest have been partially dealt with, using this formula and this has resulted in improved accordance in the height obtained by each observation.

(3) **Adjustment of triangulation networks.**—The simultaneous adjustment of a network of triangulation to surrounding triangulation according to the general method of least squares involves the solution of such a great number of simultaneous linear equations as to be quite impracticable. To solve say 20 simultaneous equations is a work which will occupy a computer the best part of a week; and when it is remembered that the labour increases

as the cube of the number of equations it will be seen that to solve say 100 simultaneous equations will occupy some two years making no allowance for mistakes. Now in a network the errors to all the angles enter the equations simultaneously, so that quite a small network would give rise to an enormous amount of labour. By a little generalisation the problem may be solved in a way which leads to results wholly consistent *inter se* and departs but little from the adjustment which is most probable.

First consider the case of a network of equilateral triangles all of the same size, with angles all equally carefully measured and so all having the same probable error. Consider next that the size of these triangles is small compared with the area dealt with. Both of these modifications lead to a case not seriously different from the actual case — for it is always the object of the triangulator to select triangles nearly equilateral. We are led then to the case of a uniform plate which has to be strained to fulfil certain given conditions of closure.

If we take ξ and η to be the movement of any point parallel to axes Ox, Oy and introduce the condition that at any point the scale value and azimuth is changed by the same amount for all azimuths, the following equation must

hold $\frac{\delta^2 V}{\delta x^2} + \frac{\delta^2 V}{\delta y^2} = 0$ (1) where V is put equal to ξ or η .

$$\text{Also } \frac{\delta \xi}{\delta x} = \frac{\delta \eta}{\delta y} \text{ and } \frac{\delta \xi}{\delta y} = - \frac{\delta \eta}{\delta x} \quad (2) \quad \text{It also follows that}$$

the change is in azimuth δA and in scale value ϵ (i.e., new scale : old scale : $1 + \epsilon : 1$) that δA and ϵ are of form $\frac{\delta \xi}{\delta x}$ and $\frac{\delta \eta}{\delta y}$. These values are applicable to a point. To find the effect on a line they have to be integrated along that line, which is easily done. The problem is accordingly reduced to the solution of (1) subject to the given closing conditions.

The solution of (1) is of form $\sum A_n r^n \cos(n\theta + \delta_n)$. By taking enough terms it is possible to satisfy any number of conditions : whereby suitable values of A_n and δ_n are obtained. It is to be noted here that the number of simultaneous linear equations for solution is equal to the number of conditions to be satisfied.

A variety of solutions can be found : but it is clear that the most probable one is that which involves the smallest values of n and this solution is the actual most probable solution of the hypothetical case.

The solution is simple when there are only a few conditions to be satisfied—say the closure on a single side, which involves the solution of only four simultaneous equations.

After the equations have been solved it is necessary to compute values of ξ , η , at sufficient numbers of points to draw contours of equal value ; and this is the heaviest part of the work if large values of n occur. If this is done on tracing cloth, it can be superposed on the chart of triangulation and the correction at any point may be immediately read off.

To visualise the process we introduce the idea of change of azimuth and scale *at a point*, and so imagine in actual triangulation that the rays joining the points become slightly curved. If we imagine a plate of uniform strength with the triangulation marked out on it, then by straining the plate (within its elastic limits, and without buckling it) to fit the closures, all the triangulation on it would be deformed in the way described. It is clear from this that the actual case would be represented by the distortion of the plate of strength varying from point to point which enables us to estimate how far the solution departs from that actually most probable. The method has been devised primarily to deal with adjustment of minor triangulation.

BOTANY

I.—BOTANICAL SURVEY

BY

A. T. GAGE, LIEUT.-COL., I.M.S.

Director, Botanical Survey of India.

Systematic.—Eastern India and Burma.—In the forests of the northern third of Tavoy District in Southern Burma, Mr. P. T. Russell, Superintendent of Cinchona Cultivation there, has made excellent collections. The Director visited the same area early in 1921 and also brought back a collection. The district is botanically rich and these preliminary collections have already yielded rare and interesting species. The distribution of Floras in S. E. Asia as affected by the Burma-Yunnan range of mountains, has been studied by Captain Kingdon Ward. In the Kew Bulletin has been published a paper by the late Major S. M. Toppin, M.C., on the Balsams of the Kachin Hills. In the same journal descriptions of the new species in the collections made by Mr. I. H. Burkill some years ago in the Abor Hills continue to appear. In Notes from the Royal Botanic Garden, Edinburgh, Sir Isaac Balfour and W. W. Smith have published new species of *Primula*, *Omphalogramme*, *Rhododendron* and other genera from the Eastern Himalaya and Upper Burma.

Northern India.—Part II of Vol. III of the Flora of The Upper Gangetic Plain, by J. F. Duthie appeared in 1920. It contains the families from *Coniferae* to *Juncaceae*. This work is now nearly finished, and it is hoped that by another year publication will be completed. Mr. R. N. Parker of the Imperial Forest Service has discovered several hitherto-undescribed species in the North Western Himalaya. Professor S. R. Kashyap has published an interesting note on the vegetation forming the floating islands of Riwalsan, a lake in Mandi State. The Balsams of Chitral are referred to in Major Toppin's paper mentioned above.

Western India.—The Rev. Father Blatter and Professor Hallberg continue to show great activity on this side of India, their contributions to botanical literature during the year including a paper on new species of various genera found in the Bombay Presidency, studies of the Flora of Jodhpur and Jaisalmer, and of the Flora of Baluchistan. The drought resisting plants of the Deccan form the subject of a paper by Mr. R. K. Bhide.

Southern India.—During September and October Mr. V. Narayanswami of the Botanical Survey explored the Rampa country of the Godavari District. His collections, ranging from 500 to 4,500 feet of altitude are being worked out as opportunity allows, and promise interesting results. Collections were also made in Alamanda, Polakol, the Pulney and Nilgiri hills and in Kasargode and Tinnevely by Mr. K. Rangachariar Avergal, the Madras Government Systematic Botanist and his assistants. The same botanist has under preparation separate lists of plants for the various districts of the Madras Presidency to facilitate compilation of district Floras hereafter. Mr. J. S. Gamble, C.I.E., has published in connection with the preparation of his Flora of Madras a fresh lot of new species from Southern India. The *Volvocaceæ* of Madras form the subject of a paper by Mr. Ayyangar.

General.—A large number of papers not concerned with purely regional botany have appeared during the year, of which only a selection can be mentioned here. Mr. H. H. Haines, C.I.E., has cleared up a nomenclatural confusion hitherto obscuring the use of the names *Amoora spectabilis* and *A. Wallichii* and *Sapindus trifoliata* and *S. laurifolia*. Dr. H. H. Mann has published an account of variation in the flowers of *Jasminum malabaricum*, and Mr. S. H. Prayag observations on the inflorescence and flowers of the grape. The physiological anatomy of the plants of the Indian desert has been studied by Mr. T. S. Sabnis and the structure of some Cucurbitaceous tendrils by Mr. K. D. Sawhney. The ecological aspects of the vegetation of the Upper Gangetic Plain have been investigated by Dr. W. Dudgeon. A case of atrophic abortion of the inflorescence of the Onion has been recorded by Mr. P. M. Debbbarman.

II. Economic.—During the year Cinchona work in Tavoy has been continued under the difficult circumstances inseparable from all pioneer work in trackless tropical forests. So far as nursery work is concerned the results have been excellent, seedlings germinating and growing very well. The real test, however, as to how the young plants when planted out in the open, will stand the heavy monsoon precipitation that occurs in the south-western corner of the reserved area, where operations have been started, has yet to be passed. If the young plants planted in the open at the beginning of the monsoon do not come through it satisfactorily, it does not necessarily follow that the whole reserved area is to be incontinently condemned as unsuitable. It may be found that altering the period of planting out from the beginning of the monsoon to near its end will enable the young plants to be sufficiently established to withstand the full fury of the following monsoon. On the other hand it may be found necessary to move further inland, or to the southern third of Tavoy District or the northern third of Mergui District, where the rainfall is considerably less than in North Tavoy. Another year's experience will be necessary, before sufficient data can be gathered on which to base a definite opinion as to the future action to be taken.

BOTANY

II.—ECONOMIC BOTANY

Part I.—Agricultural Botany

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

The present report, which is limited to four pages of print, deals with the progress of Agricultural Botany in India during the year ending June 30th, 1921. Under these conditions, the best course would appear to be to limit this paper to an account of the more important results published during the year and to refer the student of Indian agriculture for further details to the various other annual reports and periodicals issued by Government which deal with the same subject but in greater detail.

The following publications contain a considerable amount of information on the improvement of crops :—

- (a) *Review of Agricultural Operations in India.*—This is an annual report, prepared by the Agricultural Adviser to the Government of India, Pusa, Bihar, and deals, among other matters, with the distribution of improved seed in various parts of India. It also contains a classified list of papers on Indian agriculture published during the year.
- (b) *Scientific Reports of the Agricultural Research Institute, Pusa* (including the Reports of the Imperial Cotton Specialist and of the Sugar Bureau). Copies can be obtained from the Director, Agricultural Research Institute, Pusa, Bihar.
- (c) *Administration Reports of the Provincial Departments of Agriculture.*—Bombay, Bengal, Madras, Central Provinces, United Provinces, Punjab, Bihar and Orissa, Assam and Burma. These are issued by the Government presses in these Provinces towards the end of each year and contain a general summary of the work of the Agricultural Department (including the farm reports) and also the annual reports of the Economic Botanists. These administration reports largely form the basis of the annual *Review of Agricultural Operations in India*.

- (d) *Proceedings of the Board of Agriculture in India*.—This contains the programmes of work in progress in Economic Botany as well as discussions on matters relating to the Agricultural Department as a whole. Copies can be obtained from the Agricultural Adviser to the Government of India, Pusa, Bihar.
- (e) Many of the original papers on Agricultural Botany in India are published in the following periodicals :—(1) *Memoirs of the Department of Agriculture in India (Botanical Series)*, (2) *Bulletins of the Agricultural Research Institute, Pusa* and (3) *The Agricultural Journal of India*. This latter contains classified lists of all papers published on Indian agriculture. Copies of these publications can be obtained from the Director, Agricultural Research Institute, Pusa.

The number of original papers which appeared during the year under review is smaller than usual due to the absence on leave of several of the investigators, to the promotion of others and to vacancies among the superior staff. A number of important papers, however, have recently been submitted for publication and are now in the press. These will be dealt with in the next report.

Cotton. An account of Kumpta cotton (*G. herbaceum* L.) has been published by G. L. Kottur (*Mem. of the Dept. of Agr. in India, Botanical Series, X, 221*). The paper contains full details of the distribution of this cotton in the Dharwar tract and of a number of promising selections which have been isolated. Further work on the improvement of these types by hybridization is in progress. Several papers dealing with the cotton flower have recently appeared. G. L. Kottur (*Agr. Jour. of India, XVI, 52 and 406*) working in the Southern Division of the Bombay Presidency with types of *G. herbaceum*, *G. neglectum* and Dharwar American cotton considers that continuous self-fertilization for a number of years does not encourage self-sterility. Further work on this question is desirable as other workers state that continuous selfing may be injurious. The matter can only be cleared up by critical work extending over a number of years on unit species of a number of the different varieties. K. I. Thadani in Sind (*Agr. Jour. of India, XV, 393*) finds from a study of single plant cultures that from 5 to 8 per cent. of natural crossing takes place. In several cases, cleistogamic flowers were noticed on plants going off their bloom. G. R. Hilson (*Agr. Jour. of India, XVI, 235*) gives an account of the deterioration of Cambodia cotton in Madras and the methods of improvement in progress.

Rice.—G. N. Rangaswami (*Agr. Jour. of India, XVI, 156*) has published an interesting account of the methods in use at Coimbatore in the breeding of swamp rice. K. V. Joshi (*Poona Agr. College Mag., XII, 4 and 106*) has commenced a series of papers on this crop. In transplanting, the old roots die, new ones being produced from 24 to 48 hours afterwards. In a week, the plants begin to recover from the process and with the rapid formation of the

secondary root system the crop loses its faded yellow colour and turns green. S. C. Roy (*Agr. Jour. of India*, XVI, 365) has published a preliminary classification of the wild rices of the Central Provinces which are important weeds in the rice areas of this tract mixing readily with the cultivated forms on account of the premature falling of the grain.

Sugarcane.—C. A. Barber, in the issue of the *International Sugar Journal* for October 1920, concluded a series of ten papers on the growth of the sugarcane. T. S. Venkatraman and R. Thomas (*Agr. Jour. of India*, XVI, 24) gives their experience of the methods tried at Coimbatore in dealing with imported sugarcane varieties during the first years of their trial under new conditions. N. V. Rao (*Agr. Jour. of India*, XV, 418) deals with the importance of habit in sugarcane varieties.

Indigo.—W. R. G. Atkins (*Pusa Indigo Publications*, 10) has investigated the deterioration of indigo seed during storage. The results indicate the importance of the seed being well matured before gathering. Those seeds with specially resistant cuticle retain their germinative vigour to the greatest extent.

Opium.—H. E. Annett and his assistants (*Bull. 116, Agr. Research Inst., Pusa*) find that the type of improved opium poppy recently isolated at Cawnpore does not produce opium of the same morphine content in every district. There appears to be some local factor still to be investigated which influences the power of the plant to form morphine. Certain Districts, such as Etawah, Cawnpore, Budaun and Bareilly, produce opium of high morphine content while others such as Fyzabad, Gorakhpur and Rai Bareilly yield a drug much lower in morphine.

Fibres.—Two papers on fibres have appeared during the year. B. C. Burt (*Agr. Jour. of India*, XV, 616) gives the results of preliminary experiments with flax at Cawnpore and discusses the possibilities of establishing a flax industry under canal irrigation on the alluvium. R. S. Finlow (*Agr. Jour. of India*, XVI, 265) has published an historical account of his experiments on jute in Bengal including the problem of the seed supply of improved types to the cultivators.

Fruit.—W. Burns and S. H. Pryag have published a detailed account of the mango in Bombay in Bulletin 103 of the Bombay Department of Agriculture. Although the paper is intended for growers, there is a useful chapter on the flowering and pollination of this tree and a classification of mango varieties. Several other papers on fruit have appeared in the *Agricultural Journal of India*. W. Burns and P. G. Joshi deal with the "top-working" of the mango. S. H. Pryag has written a general paper on the influence of the stock on the scion and has made some observations on the inflorescence and the flowers of the grape. The root systems of the guava and of the orange have been studied by Burns and Kulkarni under the soil conditions obtaining in the Deccan.

Millets.—L. C. Coleman and his staff have published an exhaustive account of the cultivation of *ragi* (*Eleusine coracana*) in Mysore and of the results obtained on this crop at Bangalore. Cross-fertilization is stated to be practically impossible under Mysore conditions, a fact which has greatly simplified the testing of varieties and the distribution of seed.

Forage plants.—The important question of the improvement of the poor grazing areas of the Deccan has been taken up by W. Burns and G. M. Chakradev (*Jour. of Indian Botany*, II, 84). An area of denuded grazing land has been leased for five years near Poona. This has been fenced and careful observations on the changes in the flora are being made. The results so far obtained are of considerable interest. Even in the higher and rocky parts of the area, the good perennial fodder grasses *Iseilema laxum* and *Andropogon monticola* have firmly established themselves. It is considered probable that the climax will be an *Acacia arabica* forest and that the ideal condition would be grass land containing the better fodder grasses with a scattered growth of this tree sufficient to shade not more than a tenth of the land. L. B. Kulkarni (*Agr. Jour. of India*, XVI, 388) gives an account of the importance of the grass *Andropogon purpureo-sericeus* in the Bombay Deccan. D. Clouston and F. J. Plymen (*Agr. Jour. of India*, XV, 380) have published an interesting paper on the principal fodders of the Central Provinces including the small bamboo (*Dendrocalamus strictus*). This plant promises to be a most useful fodder on poor light soils which cannot be irrigated. From the outturns already obtained, there is reason to believe that yields of from 40 to 60 tons of leaf per acre can be obtained from this variety of bamboo three years after planting. The authors state that "it should be possible in parts of India where tracts of poor land are available and where the rainfall is suitable, to establish bamboo fodder reserves from which useful supplies of green fodder could be obtained for seven or eight months of the year and from which bamboo hay could be made for utilization in years of fodder famine."

BOTANY

II.—Economic Botany

Part II.—Forest Botany

BY

R. S. HOLE, C.I.E., F.C.H.,

Forest Botanist.

Oecology of Sal.—The result of the sowings made in June 1920, in the local Dehra Dun forests, has supported the results obtained in previous years, viz., that sowings in small clearings are more successful than sowings under partial or complete overhead cover. The development of the older seedlings, also, has now clearly demonstrated the fact that, by artificial sowings in these clearings, seedlings can be raised in the local forests with little or no dying back and which attain a height of 6 feet in 6-7 years. A factor which has assumed some importance during the year with reference to the development of these older seedlings is the damage done by rats and porcupines which destroy a number of vigorous young seedlings by eating through the sappy tap-roots. It is believed that this kind of damage will be relatively unimportant when work is carried out on a larger scale and the supply of vigorous young seedlings is greatly increased. A very similar state of things has been noticed in the case of damage to the seed. In bad seed years when very little seed is available in the local forests, porcupines and other animals destroy a large proportion of the seed in the artificially sown areas, whereas in good seed years practically no damage is done. The main principle which has emerged from the work done up to date on this subject is that, in order to accelerate the growth and establishment of sal seedlings, it is necessary to secure, as far as possible, favourable conditions of soil-moisture and soil-aeration throughout the year, that these conditions can often be greatly improved by making small clearings, with a suitable arrangement and degree of side-shade, and by raising the seedlings in these open areas instead of under the shade of the forest.

In this way, favourable conditions of moisture and soil-aeration can be secured, dense and vigorous weed growth is not produced, frost damage is avoided and the soil surface does not become injuriously hardened or compacted. Whatever the precise systems of management may be which are ultimately adopted to suit the local conditions prevailing in the various types of sal forest, it is probable that increasing attention will be paid to the importance of this principle in the Indian Working Plans of the future.

It is satisfactory to note that the Conservator of Working Plans in the United Provinces has now agreed to test the suggested group-cum-strip system of regeneration, experimentally, on a larger scale than has been possible up to date.

Local officers in the United Provinces have also initiated large scale experiments with the object of determining the best way of applying the principle in question to sal forests which are managed under the uniform method of treatment.

Oecology of Teak.—In 1916 the Forest Botanist published the results of experiments which showed that clear felling had a decidedly favourable effect on the germination of the seed and on the development of the seedlings of teak (*Indian Forester*, XLII, pp. 51-57). During the year this matter has again received attention in an interesting article by the Hon'ble Mr. J. W. Best in the *Indian Forester*, XLVI, pp. 411-415, where the opinion is expressed with reference to teak plantations in Berar that "clear felling in strips is likely to lead to the best results." There is little doubt that the principles which have been found to apply to sal will also be found to apply to a considerable extent to teak, also, and it is believed that there is considerable scope now in India for oecologists working in co-operation with forest officers, in devising improved methods of treatment for many of our important species, the seedling growth of which is, at present, often unsatisfactory and very slow.

Root Disease of Sal.—Caused by *Polyporus Shoreæ*. In co-operation with Dr. Shaw of Pusa a number of healthy sal saplings at Dehra Dun were inoculated with *Polyporus Shoreæ* in 1916 by the Assistant Forest Botanist, Mr. Abdul Hafiz Khan. During the year under report, several of these saplings were dug up and examined. The results so far obtained indicate that, while the fungus is unable to attack a healthy unwounded root, successful inoculations were invariably obtained when the mycelium was placed in contact with the wood in the interior of the root by means of a wound. It is interesting to note that Mr. W. E. Hiley, in his recent work on the larch in the United Kingdom, has come to the conclusion that good soil-aeration is of great importance for that species and that the fungus *Fomes annosus* gains an entrance into this tree through roots which have been killed by bad soil-aeration (*Fungal Diseases of the common Larch*. Oxford, 1919, p. 184). It is probable that the most effective means of controlling troublesome root diseases such as that of the sal mentioned above and that of *Dalbergia Sissoo* caused by *Fomes lucidus* will consist in improved methods of treatment which will ensure a better water-supply and condition of soil-aeration.

The Forest Botanist attended the conference of mycologists at Pusa in February and read a paper on the physiology of disease.

Systematic.—The Forest Botanist, while on leave, studied the material in the Kew herbarium of the genus *Tamarix*. Mr. H. H. Haines continued work on the Forest Flora of Bihar and Orissa and the following publications are under preparation :—

A revised edition of the *Forest Flora of the Punjab* by Mr. R. N. Parker, a *Forest Flora and Descriptive Lists for Assam* by Rai Bahadur Upendranath Kanjilal and *Descriptive Lists* for the United Provinces by Messrs. A. E. Osmaston and P. C. Kanjilal. Mr. C. E. Parkinson has completed his draft of the *Forest Flora of the Andamans*. A new species belonging to a new genus *Dioticarpus Barryi* Dunn was discovered by Mr. D. T. Barry in Tinnevely.

BOTANY

II.—ECONOMIC BOTANY

Part III.—Mycology

BY

F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.,

Officiating Imperial Mycologist.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations carried out at Pusa during the year :—

Cereal diseases.—The study of the genus *Helminthosporium* on cereals and sugarcane was continued by Mr. M. Mitra. The cultural study of the species found on maize, jowar, sugarcane, rice, wheat, and barley was completed. All these, together with the four strains on wheat, were cultivated on a large number of media of different chemical constituents, and also on sterilised straw of paddy and wheat. They were also kept at different temperatures. No perfect stage of any of them was discovered. Some of the species kept constant characters in a particular media, even when grown on it repeatedly, but others such as *H. teres* Sacc. on barley, *Helminthosporium* on wheat from Pusa and Burma, and *Helminthosporium* on sugarcane showed occasional changes in the character of growth and also in the size of spores formed. Thus *H. teres* Sacc. of barley has sometimes a dark growth, sometimes a snowy white and wooly growth and occasionally a pinkish white growth. Similarly *H. Sacchari* Butl. generally produces a good aerial growth but sometimes a subculture gives a creeping dark mycelium full of spores and with very little aerial growth. Again a subculture from this may give rise to an aerial growth, or may keep the character of the parent culture for some time and then again revert to its old habit. Spores are also variable in size. *H. teres* Sacc. on barley produces pycnidia and chlamydospores on sterilised wheat straw. The latter have not been described before.

The study of *Helminthosporium* on maize and jowar was concluded. The species on maize and jowar appears to be two different strains of *H. turcicum* Pass. It is interesting to note that *Helminthosporium* is found on maize only, and not on jowar, in Bihar, and *vice versa* in the Punjab. From the results of cross-inoculations it is concluded that there is no specialisation of parasitism and that the fungus from one host can infect others. Thus cross-inoculations

with *Helminthosporium* on maize and jowar give reciprocal results and infections are also successful on sugarcane, wheat, barley, oat and to some extent on rice, but not on bajra. Rice and sugarcane *Helminthosporium* give positive results when cross-inoculated on maize, jowar, wheat, oat, barley, rice and sugarcane. All the four strains on wheat give positive results on rice, maize, jowar, oat and barley and some also on sugarcane. *H. teres* Sacc. which does a good deal of damage to barley in Pusa was inoculated with success on wheat, maize, rice, jowar and oat.

Helminthosporium on wheat, one of the causes of "Foot rot," was obtained from America and is being compared in culture with the forms on wheat and barley occurring in Pusa. On sterilised wheat straw, it agrees very much with *H. teres* Sacc. on barley and on wheat in Pusa. *Helminthosporium* on barley and oat does good deal of damage to seedlings and young plants. Last year it was present to a large extent on oats. It is intended to try control measures by treating the seeds before sowing.

Acrothecium lunatum Wakker has been found on *Setaria italica* Beauv., Sawan (*Panicum frumentaceum* Roxb.) and *Eleusine coracana* Gaertn. It forms small elliptical or elongated brownish or straw colour spots but it is not very common. It occurs on many other plants also and appears to be a weak parasite. A memoir was published on *Acrothecium Penniseti* n. sp. on bajra.

Miscellaneous.—The research work on diseases of paddy caused by *Piricularia* was continued by Mr. McRae. The results of Mr. Dastur's work on *Choanephora* and Anthracnose of chilli were published during the year under review and a paper dealing with "die back" of chillies (*Capsicum* spp.) in Bihar is in the press. A paper on the mode of infection of sugarcane with smut was published and the causes of the immunity of thick canes to this disease are being studied in the light of this new information.

The bud rot disease of palmyra palms, which has long been one of the major fungal diseases of Madras, appeared in the Burdwan district of Bengal. This new outbreak and a disease of areca palms in Assam, is being investigated. *Urocystis coralloides* Rostrup a rare smut on mustard was discovered for the first time in India in the vicinity of Pusa and was identified at the recently created Imperial Bureau of Mycology.

Other Scientific Departments.

Madras.—The operations against the bud rot of palmyra palms were continued under the new Pest Act by which owners are compelled to cut down dead trees. The results obtained during the past year showed an improvement on preceding years—the number of dead and outwardly infected trees being reduced. The appearance of this disease in Bengal, and the question whether infection reached Bengal from the Godavari, has to be investigated. Spraying of grape vines against mildew was extended during the past year with most beneficial results, the yield from 239 vines

rising from Rs. 710 to Rs. 3,950. Spraying was also carried out against the mahali disease of areca-nuts. The intensity of this disease appears to be waning.

Seed treatment against the smut diseases of cholam (*Sorghum vulgare*) and tenai (*Setaria italica*) was carried out in Bellary, Kurnool and Anantapur. Approximately 32,000 acres were sown with treated seed and the decreased incidence of disease may be estimated to have resulted in a gain of about Rs. 100,000 to the cultivator.

The treatment of "bleeding disease" of coconuts, by surgical excision of the diseased tissue and flaming and tarring the exposed surface, proved successful and was introduced among garden owners in the coconut growing areas.

Other diseases under investigation are a disease of ginger caused by *Vermicularia*, the long smut (*Tolyposporium filiferum*) of cholam and the green ear disease of cumbu (*Pennisetum typhoides*). A paper on the *Helminthosporium* disease of paddy is in the press. This disease appears to be of minor importance and only causes serious damage under conditions which are favourable to the development of the fungus.

Bombay.—Various smut diseases were investigated. Experiments with smut on *Eleusine coracana* failed to afford proof that the disease was carried on the seed. Smut on *Panicum frumentaceum*, however, proved to be seed borne and will probably yield to the usual seed steeping in copper sulphate. A variety of *Sorghum*, known as "milo," which is reported to be resistant to smut in America, proved to be very susceptible to Loose Smut (*Sphacelotheca Cruenti* Kuhn Pot.). A powdery mildew (*Oidiopsis*) was found attacking the potato crop in Khed and Chakan. Other new diseases were caused by a species of *Synchytrium*, parasitic on betel vine, and a species of *Diplodia* attacking the camphor tree. Sugarcane in certain areas developed a suspicious mottling of the leaf but so far the early suspicions of mosaic disease have not been confirmed.

Bengal.—Ufra disease of paddy was not severe anywhere in Eastern Bengal during the year under review. Sugarcane suffered from "red rot" (*Colletotrichum falcatum* Went) at Charnagardi and demonstrations of sett selection were given. Experiments in spraying against die-back (*Vermicularia Capsici*) of chilli were carried out in Rajbari and liming the soil as a remedy against wither tip (*Colletotrichum gloeosporioides*) was attempted at Kalimpong.

United Provinces.—Some preliminary experiment on storage rot in potatoes were carried out and operations against red rot of sugarcane were instituted at Gorakhpur. Further work was impossible in the absence of equipment in the new mycological section.

Central Provinces.—Investigations on wilt disease in cotton were commenced and two strains of a *Fusarium* were isolated.

Indian Tea Association.—The research work was mostly confined to leaf diseases. Articles on Brown blight (*Glomerella cingulata* (Stonem) S. & V. S.) and Grey blight (*Pestalozzia Theae* (Sawada) have been published in the Quarterly Journals of the Department. An article on Copper blight (*Laestadia Camelliae*, Cke) has been prepared for publication.

Some experiments were made to determine the vitality of the conidiospores of *Glomerella cingulata* (Stonem) S. & V. S. and the pycnosporos of *Laestadia Camelliae*, Cke. It was found that the pycnosporos of *Laestadia Camelliae*, Cke in spite of their thick coat were only able to survive about a week when kept in the shade under the laboratory conditions of humidity and temperature. The conidiospores of *Glomerella cingulata* (Stonem) S. & V. S. only survived 1 day.

A species of *Colletotrichum* was isolated from the root of a dead tea bush.

A species of *Nectria*, found in some Cankerous tea stems, was investigated.

AGRICULTURAL BACTERIOLOGY

BY

J. H. WALTON, M.A., M.Sc.,

Officiating Imperial Agricultural Bacteriologist,

WORK AT PUSA.

Soil Biology.

Nitrogen.—Estimation of losses of nitrogen from cattle dung and urine stored under either aerobic or anaerobic conditions show the necessity of anaerobic storage for proper conservation of the nitrogen of the urine. Only fifteen per cent of the urine nitrogen was lost under anaerobic conditions compared with eighty-five per cent under aerobic conditions.

Further experiments on the nitrification of mahua cake have been carried out. Composting the cake with rock phosphate and sulphur for four weeks has resulted in 25 per cent of the nitrogen of the cake becoming nitrifiable.

Indigo.

A simple colour test has been devised by Mr. W. A. Davis, the Indigo Research Chemist, by which the proper time of steeping the plant can be ascertained. An important factor in causing variations in the length of steeping required to give the best produce, quantity and quality both being considered, is the bacterial flora of the steeping water. Until Mr. Davis's test was employed, unsatisfactory results had been obtained with steeping water, inoculated with a pure bacterial culture that had worked well in the laboratory, both with and without sterilisation of the water before addition of the pure culture. When the steeping time was controlled by use of the test the first day's working gave produce of 78.5 per cent quality. The steeping water was first sterilised with E. C. the hypochlorite preparation made at Pusa and after 12 hours, inoculated with a culture isolated from water in Assam. Indigo of this high quality will prove of value for mixing with lower grades, for the manufacture of 20 per cent indigo paste for the far eastern market.

Detailed studies of the cultural characters and efficiency of indigo hydrolysing bacteria from various sources have been carried out in the laboratory.

Plant Diseases.

A bacterial rot of potatoes sent from Assam was investigated.

Work in the Provinces.

Biological studies of typical soils were carried on in the Central Provinces, Madras, and by the Indian Tea Association at Tocklai, Assam. In each of the soil types investigated at Tocklai, the soil optimum moisture for the best mechanical condition was the optimum for nitrate accumulation and carbon dioxide formation.

The decomposition of green manure plants at different stages of growth in the black cotton soil of the Central Provinces was investigated.

It was found that the earlier the stage of growth at which "sann" is used as a green manure, the more rapid are the processes of nitrification and the decomposition of carbonaceous substances. In the case of Dhaincha, there is no marked decrease in the rate of nitrification with the increasing age of the plant.

In the black cotton soil the stems of sann hemp did not retard the decomposition of the leaves, which is contrary to their effect in Pusa soil.

FORESTRY

Part I.—Silviculture

BY

S. H. HOWARD, B.A.,

Silviculturist.

The year under report is for nine months only owing to the recent change in the forest year which now coincides with the financial year. This report therefore can hardly be regarded as normal, especially as a large amount of work takes place between April and June none of which is included in this.

Perhaps one of the most important matters to comment on is that an efficient division of labour between the Local and Central Silviculturists is becoming more defined. It is beginning to be abundantly clear that the main division of labour will eventually be that Local Silviculturists will concern themselves more with experimental silviculture, pure and simple, while the Central Institute will control statistical work and be a general bureau of information. Bengal and Burma have, during the year, laid out the main lines of policy to be pursued in silvicultural research and it is hoped that other provinces will follow suit in the near future and appoint Local Silviculturists.

Statistical work.—A good many plots have been remeasured and a certain number of new plots have been laid out both by the Central Institute and by the Local Silviculturists. The new methods of calculation have now been finally adopted and a large portion of the former work has been converted to them. Data are as yet insufficient to publish proper yield tables but for certain species the time is rapidly approaching when approximate yield tables can be issued. When the policy of this work has been strictly laid down it should be possible to produce yield tables for several of the principal species and volume and form factor tables for others within the next five years provided staff is forthcoming. Owing to press difficulties the only statistical publication which has appeared is an article on Sal taper curves by E. A. Smythies and S. H. Howard in the *Indian Forester* but the following are in press:—

- (1) Note on weights of seeds by S. H. Howard, B.A.
- (2) Note on the rate of growth of Bengal Sal by S. H. Howard, B.A.
- (3) A code for the collection and compilation of statistical data with Appendices by S. H. Howard, B.A.
- (4) The Forest Pocket Book by the United Provinces Research Branch which contains various statistical data.

The Sal (*Shorea robusta*).—A good deal of experimental work was commenced in the United Provinces and in the Central Provinces on the natural reproduction of Sal, the cover being opened to various degrees and the ground cover being burnt or unburnt. Strip fellings, and ordinary clear fellings to let up established seedlings, both with and without burning of the slash, were tried by the United Provinces and Central Institute but there has been insufficient time at present to formulate definite opinions. An experiment in the Bengal taungya methods was projected in Dehra Dun but owing to no suitable arrangements having been made it had to be abandoned.

Various other minor experiments are in progress and the experiment on storing seed, commenced last year, gave promising results and will be repeated this year on a larger scale.

At present the problem of Sal regeneration is still unsolved in most districts.

Afforestation.—The experiments indicated for Zabarkhet in last year's report have as yet (March 31st, 1921) had no time to show any result except in the case of the Chir. Both in the ploughed lines and on the cleared ground this germinated well, has withstood the frost and looks promising. The afforestation area will be extended next year.

Many experiments have been made by the United Provinces in the Bhabar with various species. It has been conclusively shown that root and shoot cuttings of Sissoo (*Dalbergia Sissoo*) are a simple and effective method of afforestation even in lantana areas with no weedings if planted early and irrigated, but unfortunately irrigation is usually impracticable. It is hoped that the Zabarkhet method of winter planting with root and shoot cuttings will prove next year that the afforestation can be done in this way in grass areas with neither weeding nor irrigation.

Experiments with other species in the United Provinces have so far only shown again that weeding in the first rains is essential.

Work has been done by other provinces but up to date no conclusions have been reached.

Mr. Smythies brought out his Afforestation of the Jumna Ravines in Etawah (Indian Forest Record, Vol. VII, Part VIII). This is now being published in Urdu and Hindi. Mr. Benskin's book "Afforestation in the United Provinces" has been sent to Press.

Experimental Silviculture.—It is quite impossible to give any idea of the volume of work which has been done this year by the various provinces in a report of this length and reference is invited to Annual Report of Forest Research work in India. In most cases it is only the commencement of the work and no important results have as yet been obtained.

The camphor experiments have now yielded sufficient data and it is hoped to bring out a publication in the near future.

Mr. Champion's work on twisted fibre in Chir is being continued.

Two small interesting points reported from Behar and Orissa are worthy of notice., viz., that *Casuarina* is highly susceptible to any maltreatment of the taproot and that teak seed buried in the soil, covered with alternate layers of straw and watered regularly for a fortnight produced much healthier and stronger seedlings than seed merely soaked for 48 hours prior to sowing.

Many other provinces furnished a mass of information too detailed to be reproduced here.

Development in Silvicultural Systems.—There is nothing special to report this year. Burma and Bengal continued to develop the taungya system of regeneration and extremely fine results are being obtained in both provinces. Up to date working plans are being rapidly compiled wherever staff and money is available. The improvement in the standard of working plans in the United Provinces since the creation of the Working Plans and Research Circle is most noticeable and Burma has now followed suit by creating a Working Plans Circle though there has as yet (March 31st, 1921) been insufficient time to see the good effects from this.

It can be confidently asserted however that other provinces must follow suit and create these special circles if their plans are to attain that standard which they should attain now-a-days.

Miscellaneous.—Though this report deals with only nine months it is surprising the amount of new work which has been done. There is no doubt that this is largely due to the appointment of Local Silviculturists and the standard of experimental work in those provinces where they exist is most noticeable. It is however becoming increasingly evident that the same high standard is not being attained in the statistical work. The compilation of statistical data is likely to become far more centralised in the near future.

FORESTRY

Part II.—Economic Forest Products

BY

R. S. PEARSON, C.I.E., I.F.S.,

Forest Economist.

Considerable progress in the preparations for the expansion of the Economic Branch was made during the year. The staff was strengthened by the arrival of specialists in Timber Testing and Seasoning, from Canada and America respectively, and Mr. Raitt, the officer-in-charge of all enquiries in connection with Paper Pulp, returned from deputation in England to take up his appointment as a whole-time officer at the Institute. A Wood Worker was also appointed and took up his duties. The timber testing machines and seasoning plant for which orders had been placed in America by the Forest Economist, in consultation with the officers concerned, arrived during the year and steps were taken immediately to erect most of the former in an existing workshop as a temporary measure pending their removal to the site on which the new workshops are shortly to be built. The erection of the seasoning kilns had to be postponed until the new site is ready owing to lack of space, but it is proposed to put up a temporary kiln in the Institute grounds for the purpose of giving demonstrations at the Forest Conference to be held in January 1922 and for seasoning the timber to be used in making furniture for the new Institute. A portion of the necessary wood working machinery was obtained in India and an experimental Rotary Veneer Cutting Machine and a Sawmill were purchased in America. All were received during the year. The up-to-date experimental paper and pulp plant, to arrange for which Mr. Raitt had been deputed to England in 1919-20, was manufactured during the year and despatched to India, and will be erected as soon as the new site is ready.

The staff has been chiefly engaged on organisation work in the respective sections, especially on designs and workshop lay-outs, and though this has taken up a very considerable portion of their time nevertheless new investigations have been started, especially in connection with timber testing, seasoning, paper pulp, minor forest products.

The Wood Technologist is due to arrive about January 1922 but the post of Wood Preservation Specialist, though sanctioned, has not been filled, as a suitable officer has not yet been found. A complete experimental anti-septic pressure plant was received from England which will be made use of when the buildings on the new site are ready.

Observation and encouragement of the Paper Pulp Industry in India and Burma.—The preliminary work to carry out new surveys of possible bamboo areas in Bihar and Orissa and Madras was undertaken and the Officer-in-charge also paid a visit to Burma in connection with grass pulp schemes. As soon as the machines are erected a complete series of tests on Savannah grasses will be carried out. A large number of enquiries on the question of utilising bamboo for paper pulp were dealt with by this section and advice on how to obtain technical training was frequently sought.

Antiseptic treatment of timber.—The experimental sleepers laid down from 7 to 10 years ago in open lines and treated by four different methods were inspected. Those laid in the line 10 years ago and treated by the Powellizing Process show that *Terminalia tomentosa* (Sain, Asna, Taukhyan or Saj) are, with few exceptions, doing remarkably well. *Pinus longifolia* (Chir) and *Pinus excelsa* (Kail) are still doing well in dry localities, moderately so in damp and have all been rejected after from 9 to 10 years' service when placed in very damp localities. The two *Dipterocarps* (In and Kanyin) have lasted 10 years, the cause of rejection being deterioration under rail seat and around spike holes. Had both the *Pinus* and *Dipterocarps* been laid with bearing plates they would probably have lasted 2 or 3 years longer, bringing their life up to that of *Cedrus Deodara* (Deodar) or *Shorea robusta* (Sal) in similar localities. In the other experiments, treatment with Creosote and Earth Oil introduced in fairly large quantities has given better results than either treatment with a small quantity of high grade oil or treatment with Chloride of Zinc and Creosote. Several railways evinced increasing interest in these experiments and it is expected that a number of treating plants will be erected shortly. The results of the experiments are being prepared for the press.

Physical and Mechanical properties and seasoning powers of various timbers. (i) *Natural Seasoning.* The final inspection of the seasoning experiments in Bengal and the Central Provinces were carried out by the Officer-in-charge, Seasoning, and the results will be published in the near future.

(ii) *Artificial Seasoning.*—The apparatus for the four blower and three steam spray drying kilns is now coming to hand and it is hoped to erect the kilns next cold weather.

(iii) *Mechanical Properties of timber.*—The first tests being carried out on the new machines are on red and white wood of Spruce to determine its value for sleepers after impregnation. A complete project according to which tests on the more important Indian timbers will be undertaken is under preparation.

Finding of markets and new uses for timbers including the issue of bulletins.—A large number of enquiries from firms, both in India and abroad,

were replied to and bulletins on the following timbers were issued during the year :—

- (1) *Dipterocarpus pilosus*.
- (2) *Lagerstroemia Flos-Reginæ*.

Gums, Resins and Oleo-Resins.—The question of utilising the gum-oleo-resin of *Boswellia serrata* (Salai) was advanced a step further by the publication of Dr. Fowler's valuable note on the work he had carried out at the Indian Institute of Science, Bangalore. His process differs from that advocated by Mr. Puran Singh in that alcohol is not used as a solvent. The Gwalior State are about to erect a plant working by the solvent process, the results of which will be watched with great interest.

Rosha grass oil.—The steam distillation of Rosha grass oil is now carried on successfully as a commercial undertaking in the Central Provinces and the industry is likely to expand.

Tanstuffs.—The Officer-in-charge carried out a detailed investigation on tanstuffs in the Sunderbans, completing 80 analyses of various products in that locality, the results of which are given in his report entitled "Tanstuffs of the Sunderbans Forest Division" and published by the Department of Industries, Bengal. The Officer subsequently proceeded to North Burma and carried out analyses of Chestnut, Oak, *Dipterocarp* and other timbers, barks, fruits and leaves, the results of which indicate considerable possibilities of working them commercially.

Charcoal Briquettes.—Investigations have been continued in consultation with an American Briquetting firm to whom a consignment of 500 lbs. of charcoal and 100 lbs. of binding material has been sent for experiments. The main difficulty to be overcome is to devise a process of grinding the charcoal without undue danger of combustion taking place.

Woods suitable for :—(i) *Bobbins, Shuttles and Picking Sticks for Cotton and Jute Mills.*—Nearly 5,000 sample pieces of the following species :—

- I. *Odina Wodier*.
- II. *Albizia procera*.
- III. *Adina cordifolia*.
- IV. *Wrightia tinctoria*.
- V. *Holoptelea integrifolia*.
- VI. *Stephegyne parvifolia*.
- VII. *Michelia Champaca*.
- VIII. *Stereospermum xylocarpum*.
- IX. *Stereospermum chelonoides*.
- X. *Anogeissus latifolia*.
- XI. *Dyospyros macrophylla*.

XII. *Lagerstroemia tomentosa*.

XIII. *Dillenia pentagyna*.

XIV. *Polyantha ceracoides*.

XV. *Garcinia Morella*.

XVI. *Homalium tomentosum*.

were collected and sent to a leading firm in England for trial after they had been put through the seasoning kiln at Bareilly, which has kindly been placed at our disposal by the Conservator, Utilization Circle, until the kilns at Dehra Dun are ready.

(ii) *Ply woods*.—A visit was paid to the leading firms and it is satisfactory to note that the tendency to "cheesiness" in certain timbers referred to last year has been overcome and the prospects of the industry developing in India are bright.

ZOOLOGY

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

S. W. KEMP, D.Sc., F.A.S.B.,

Officiating Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department :—

	Days.
To Bombay from 7th April to 18th April 1920 by Major R. B. Seymour Sewell	12
„ Barkuda from 24th April to 1st May 1920 by Major R. B. Seymour Sewell	8
„ Simla from 14th May to 22nd May 1920 by Dr. N. Annandale	9
„ Barkuda from 17th June to 28th June 1920 by Dr. Bains Prashad	12
„ Barkuda from 13th August to 22nd August 1920 by Dr. N. Annandale	10
„ Naini Tal, Moradabad, Delhi from 31st July to 2nd September 1920 by Dr. Bains Prashad	34
„ Barkuda from 22nd September to 27th September 1920 by Dr. N. Annandale	6
„ Barkuda from 22nd September to 27th September 1920 by Dr. Bains Prashad	6
„ Delhi from 18th December to 25th December 1920 by Dr. S. W. Kemp	8
„ Waltair from 19th January to 29th January 1921 by Dr. S. W. Kemp	11
„ Port Blair from 12th February to 20th March 1921 by Dr. S. W. Kemp	37
	153

Dr. Bains Prashad's tour to Naini Tal and Moradabad was undertaken in continuation of the survey of the freshwater molluscs which is being made at the request of the medical authorities. Barkuda island was visited on a number of occasions in order to carry out experiments in the intensive study of the fauna of a small localised area.

Dr. Kemp's visit to Port Blair was undertaken in order to discuss the establishment of the proposed Marine Biological Station with the Chief Commissioner of the Andaman and Nicobar Islands and to select a site.

Publications.—The following publications have been issued during the year :—

“Records of the Indian Museum,” Vol. XVII.

“Records of the Indian Museum,” Vol. XVIII, parts III—V.

“Records of the Indian Museum,” Vol. XIX, parts II—V.

“Records of the Indian Museum,” Vol. XX.

“Memoirs of the Indian Museum,” Vol. V, Nos. 7 & 8.

Library.—The total additions to the library number 1538. Of this number 826 books and parts of periodicals were received in exchange, 583 were purchased and the remainder presented.

Collections.—The collections have remained in good condition and numerous additions have been made to them apart from those obtained by the officers of the Survey themselves.

Valuable collections of Crustacea have been obtained by exchange from the British Museum and from the museums at Paris, Cambridge and Milan. Professor Max Weber has sent us a duplicate set of the Molluscs which he obtained in his Expedition to the Dutch East Indies and a valuable collection of shells has also been obtained by purchase from Lieutenant-Colonel H. H. Godwin Austen, F.R.S.

Additions to the insect section include a number of valuable specimens presented by Major F. B. Scott, Mr. C. J. Drake and Major F. de Mello.

Our collection of hill-stream fishes belonging to the genus *Discognathus*, which had been lying with Dr. Pitschmann in Vienna since before the beginning of the war, has now been returned. A collection of flies belonging to the family Dolichopodidae which had been in Germany throughout the period of the war has also been received back.

Galleries.—The Invertebrate Gallery still remains closed but it is hoped that half of it will be refitted and opened to the public during the course of the next financial year. Owing to the present high price of plate glass it has been difficult to complete the alterations in this gallery expeditiously.

To the Ethnological Gallery a number of specimens from Manipur and Baroda States have been added. A special collection from the Nicobar Islands was made and presented by Mr. H. Hart making the exhibit of the ethnology of these Islands almost complete.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist.

It should be noted that, in compliance with orders of Government that the Report on Agricultural Entomology in India during the year ended 30th June 1921, should not exceed four pages, exclusive of bibliography, only a very brief summary of the work done at Pusa and in the Provinces can be given here.

I.—Work at Pusa.

Numerous observations on Insect Pests were made and a fuller account of these will be found in the Scientific Report of the Pusa Research Institute for this year. Investigations were continued on pests of cotton, rice, sugarcane and other gramineous crops, fruit and stored grain. Life histories of numerous insects have been worked out and illustrations prepared. Work on Bees, Lac and Silk was continued on previous lines. Steady progress was made in the additions to and arrangement and identification of the collection. The scheme for the preparation and publication of a catalogue of Indian insects has been approved and is being pressed on. The Fourth Entomological Meeting, held at Pusa from 7th to 12th February 1921, was attended by over forty members who contributed fifty papers which are being issued in the Report of the Meeting.

II.—Work in the Provinces.

Madras.—Attention was mainly devoted to the study of *Platyedra gossypiella*, *Pemphres affinis* and *Schænobius bipunctifer*. The rate of increase of *P. gossypiella* in green cotton bolls and the comparison of the percentage of attack of areas under the Pest Act as compared with those outside its jurisdiction were studied, with the result that a notable decrease was found in the Pest Act area. The study of *P. affinis* was continued in connection with the intensity of attack in different strains of Cambodia cotton; the natural enemies were found to include a Braconid parasite and a fungus. Experiments with the control of *S. bipunctifer* in the Kistna district were continued and gave

satisfactory results. The study of *Yerra tegelu*, a mysterious disease of paddy in the Godavari delta, was taken up. Other pests dealt with included *Spodoptera mauritia* on paddy in Malabar and Capsid bugs attacking cotton.

Bombay.—Demonstrations and lectures on control of pests were given in Gujarat. Investigations of granary pests and of their parasites were made. Experimental work was also done on control of Hairy Caterpillars, *Juar* stem-borers (*Chilo simplex* and *Sesamia inferens*), cotton-pests, surface grasshoppers (*Chrotogonus* spp.), *Urentius echinus* on brinjal, pests of *tarwad* [apparently *Sesbania* sp.] and cattle ticks.

Central Provinces.—Rearing of wood-borers in mango, *Lagerstrœmia indica*, *Zizyphus jujuba*, *Ficus religiosa* and *Phyllanthus emblica* showed that both "*Arbela*" *tetraonis* and *A. quadrinotata* were present. Observations of the occurrence of *Carpomyia vesuviana* and *Meridarchis scyrodes* in *ber* fruits showed that the pupal stages of both these insects may be prolonged for several months in the hot weather. Observations were made on the parasitization of *Sphenoptera gossypii* by *Xanthopimpla punctata*. Study of the insect fauna of weeds was continued. A small undetermined weevil was reared from flowers of *Zizyphus jujuba*.

United Provinces.—The main work has been the investigation of cotton pests and has been preliminary to a study of *Platyedra gossypiella* and other pests of cotton. Some attention has also been paid to pests of sugarcane and mango.

Punjab.—The percentage of bollworm attack on cotton was not very high this year and in most places was below normal. The life history of *Microbracon* sp., parasitic on *Earias*, was studied and it was found that a single female may lay over 200 eggs, the life-cycle being completed in about ten days in summer, lengthened to 30 days in winter. The life history and control of mango-hoppers (*Idiocerus atkinsoni* and *I. clypealis*) were studied and winter spraying with a strong contact poison was found effective. Spraying operations with tobacco decoction or crude oil emulsion were found effective against *Euphalerus citri*, on Citrus trees, and are becoming very popular. Some work has also been done on control of rats, mainly by the use of strychnine. Experiments were carried out to test the efficacy of the use of heat for the control of granary pests. Sericultural work has been continued and 1750 ounces of eggs were under rearing in 1921, as compared with 600 ounces in 1920; unfortunately, the unusually hot season killed off most of the worms at the time of spinning their cocoons.

Bihar and Orissa.—Work on the Braconid parasite of *Agrotis ypsilon* was continued on the lines of (1) breeding the parasite through the hot weather and Rains, and (2) ascertaining the factors which may be utilized in inducing dormancy in freshly-formed cocoons. As a result it has been found impossible to carry this parasite on in an active condition in the Plains in the absence of a cool room, and that freshly-formed pupæ, when exposed to a constant humidity of 5°, at once become dormant and remain healthy until revived by

exposure to favourable conditions of temperature and moisture. A large number of pupæ is being kept this summer for experiment and use at the beginning of the cold weather.

Bengal.—The use of cloth bags, to protect young mango fruits before egg-laying of the weevil, was found successful against *Cryptorrhynchus gravis* in the case of small trees of valuable fruits, which are worth the cost and trouble. Control work was done against *Arbela tertaonis*, Litchi Mite, and *Brachytrypes portentosus*.

Assam.—Work was done on the control of rice pests (*Hispa armigera*, *Leptocorisa varicornis* and *Schœnobius bipunctifer*). Serious damage by *Hispa* occurred in an extensive area near Srimangal, whilst there was an unusually severe attack of Rice Grasshopper in the neighbourhood of Hajo. *Diacrisia obliqua* attacked pulse, crops and jute.

Burma.—Investigation of *gwabo*, a disease causing yellowness in growing paddy and empty grains in a part or whole of the ear, was commenced, but only about 5 to 8 infestation by borers was found. The borers found in rice prove to be *Schœnobius bipunctifer*, *Sesmia inferens* and *Diatraea* sp. (Pusa, C. S. 1674), of which the first-named is the most important. At Hmawbi where paddy selection work is being carried on, some varieties showed markedly greater infestation than others, thus indicating that some varieties are more resistant to insect attack. *Hispa armigera* occurred in Kyaukse district in June and was found only on Ngasein paddy. The main damage to sugarcane in Upper Burma appears due to Termites. *Andropogon sorghum* is quite free from borers at Mandalay, apparently due to the absence of *Chilo simplex* in Burma. The main pest of cotton is *Platyedra gossypiella*. *Oryctes rhinoceros* was under investigation, the grubs breeding chiefly in the village manure heaps. Fruit-flies in peaches and pears at Maymyo do serious damage, apparently due to a complete absence of parasites.

III.—Native States.

Travancore.—*Nephantis serinopa* on coconut was the most important pest of the year and was dealt with by cutting and burning the affected leaves, the Pest Act being enforced and more than 35,000 trees treated. The method of control of *Leptocorisa varicornis* on rice, by bagging the bugs, was demonstrated with success. Pests of ginger were also under observation and a species of *Calobata*, boring in the rhizome is stated to be very destructive.

Mysore.—Field-work against *Amsacta albistriga* and *Disacrisia obliqua* has been continued; against the former the Pest Act has been continued to be enforced over a considerable area with satisfactory results. Field-work on the control of *Xylotrechus quadripes*, on coffee, by painting the stems with Brunolineum just after oviposition, has yielded successful results. Control of *Oryctes rhinoceros* has been carried out on an extensive scale in a Government Date Reserve, by destruction of rotting stumps and of the larvæ found in manure pits. Parasites of mangoleaf-hoppers have been under investi-

gation and their life histories worked out. Work has also been done on cane borers, *Juar Cecidomyiad*, *Spodoptera mauritia* and *Chloridolum alcmene*.

Hyderabad.—
Kashmir.—
Baroda.—

} No scientific work is reported.

IV.—Other Entomological Work.

Indian Tea Association.—The attention of the entomological branch was devoted to further investigations into the control of "mosquito blight" (*Helopeltis theivora*, Waterh.). Experiments on the inoculation of bushes were carried out on an extensive scale in all districts and have confirmed the result, previously obtained, that inoculation of the bush with salts of potash gives a decided increase to the resisting power of the bush to attack. The manuring experiments have also shown that the degree of resistance to attack can be altered by manuring, but that whereas bushes on different types of soil respond similarly to direct inoculation with potash, the results obtained from manurial applications differ with the type of soil.

Observation of cases where the intensity of attack differs greatly on areas on the same soil, but under different management have afforded evidence that bushes on the same soil will differ in liability to attack when the soil is treated differently, this difference in degree of liability to attack being correlated with an increased proportion of potash in the growing leaf, and examination of bushes throwing off attack has shown that this increasing resistance is accompanied by a distinct increase in the proportion of potash present in the growing leaf.

Breeding records have been kept throughout the year in connection with the green fly pest of tea (*Empoasca flavescens*, Dist.).

South Indian Planting Districts.—No work on Entomology was carried out.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part II.—Forest Entomology

BY

C. F. C. BEESON, M.A., I.F.S., F.E.S.,

Forest Zoologist.

Insects of Sal.—Borers (*a*) *Field work.*—In the area of the epidemic occurrence of *Hoplocerambyx spinicornis* in Thano Forests, Dehra Dun, observations were continued on the plan of previous years involving enumerations and plane-table surveys. Particular attention was paid both in the insectary and field to the effects of edaphic and climatic conditions on the incidence of the borer, which is now correlated with rainfall. The recognition of a connection between the periodic abundance of the borer, the resistance of the host tree to attack and rainfall during the flight period of the beetles, has materially altered existing conceptions of the economic status of the pest. It is now apparent that in a series of years of high rainfall, the increase of the borer is favoured and the resistance of the host tree is lowered ; in years of low rainfall the reverse effect occurs. If the monsoon fails during the course of a borer epidemic the proportion of trees fatally attacked is reduced (in spite of the relatively increased incidence of the borer) to such an extent that the pest receives a marked check. Control measures based on above results have been formulated and put into practice during the 1920-21 season. It is anticipated that given a valuation of the growing stock and its increment, a safety limit expressed in deaths per acre and a safety period for control operations can be determined. A note on the connection of *Hoplocerambyx* with the dying off of sal has been published in the Indian Forester for February 1921.

In tours made in Singhbhum and Porahat Divisions, Bihar and Orissa, it was determined that *Hoplocerambyx* is rare or absent in dry and hill type sal forests, and that it is usually a secondary effect of *Polyporus shoreæ* in the moist and valley type sal ; a condition suspected some years before in the Bengal Duars forests. The frequent mortality of sal without the assistance of borer attack leads one to consider that borers of the type of *Hoplocerambyx* are essentially secondary factors, which however under epidemic conditions may determine the death or survival of a weakened tree.

(b) *Insectary work*.—Further insectary records of the development of *Aeolesthes holosericea*; *Xylotrechus smeii*; *Platypus* spp; *Diapus* spp. and *Xyleborus* spp. have contributed to the establishment of the economic status of these species and revealed the extent to which their prevalence is affected by climber-cuttings and girdling or felling without removal of inferior species.

Other pests.—The seed weevil, *Calandra shoreæ*, has been found to have a wide distribution and a variety of dipterocarp host-plants.

Insects of the teak.—Work on the collection of further statistical data on the beehole borer, *Duomitus ceramicus*, has been in abeyance. Further records of the minor sap-wood borers and shot-hole beetles have been obtained in the insectary.

Miscellaneous pests.—During the year under report 125 consignments of specimens (including 903 insects) were received for investigation. The determination of the borer fauna of timbers seasoned by various natural processes received attention. A total of 910 pieces of timbers has been received from divisions and some 8,500 insect specimens have been bred out, adding considerably to our information on the food trees and distribution of timber pests.

A short survey was made in the Sunderbans, Bengal, of the borer fauna of swamp, slump and cyclone-killed trees and drift timber to obtain evidence on the survival or destruction of boring insects by immersion in brackish and salt water.

The compilation of the food-plants of forest insects has been continued with the issue of the families *Platypodidæ* and *Scarabæidæ*.

Insect collections.—Small batches of forest insects have been identified and returned by the following specialists: *Endomychidæ*, *Erotylidæ* and *Lamellicornia* by Dr. G. Arrow; *Adephaga* and *Carabidæ* by Mr. H. E. Andrews; *Tenebrionidæ* by Mr. K. G. Blair; *Diptera* by Mr. E. Brunetti; *Cleridæ* by Mr. J. Corporaal; *Formicidæ* by Mr. St. J. Donisthrope; *Odonata* and *Pyrallidæ* by Mr. T. B. Fletcher; *Odonata* by Major Fraser; *Bostrychidæ* by Mons. P. Lesne; *Curculionidæ* by Dr. G. A. K. Marshall; *Micro-lepidoptera* by Dr. E. Meyrick; *Asilidæ* by Miss G. Ricardo; *Termitophila* by Mr. Wasman; *Apidæ* by the Government Entomologist, Madras.

Some 350 species new to the Research Institute collection have been added during the period under review.

Staff.—Messrs. D. Atkinson and J. C. M. Gardner who have been selected for appointment to two of the posts of Divisional Forest Entomologist complete their training in forestry and entomology at the close of 1921. Mr. J. M. D. Mackenzie, I.F.S., will be appointed as Divisional Forest Entomologist to investigate the beehole borer in Burma.

VETERINARY SCIENCE

BY

W. A. POOL, M.R.C.V.S.,

Officiating Director and First Bacteriologist, Muklesar.

Rinderpest.—The following experimental work was taken in hand:—

- (1) The preparation of anti-rinderpest serum using animals of moderate susceptibility as virus producers.
- (2) A further investigation into the duration of the immunity conferred by serum alone.
- (3) An investigation into the nature of the immunity conferred by very large doses of serum when given simultaneously with a dose of virulent blood.
- (4) The elaboration of a special apparatus for bleeding the virus producers and injecting the serum producers for use in large scale rinderpest serum production. Bulletins on these subjects are in course of preparation and will shortly be sent for publication.

Equine Contagious Abortion.—Experiments were carried out with a bacillus obtained from aborted foetuses at the Government Cattle Farm, Hissar, which proved to be the *B. abortivo equinus*.

An account of these experiments will be published shortly.

Reports from Veterinary Colleges and Provincial Laboratories.
—With the exception of those detailed below no scientific work of any particular interest was carried out by the Veterinary Colleges and the Provincial Superintendents of the Civil Veterinary Department except that the Superintendent, Civil Veterinary Department, Madras, states that “a special work is being conducted on the causation of lymphangitis in cattle as occurring in Madras at the Madras Veterinary College, but is not yet completed.”

The Director of Agriculture, Punjab, gives the following short summary of the Scientific Work carried out by the local Veterinary Officers in the Punjab during the year 1920-21:—

I. *Camel Specialist, Sohawa.*

“The treatment of surra in camels by intravenous injections of Tartar Emetic. As the result of these experiments Tartar-Emetic gives promise of being efficacious in the treatment of this disease. Several months after

these camels had been returned to duty Sir John Moore informed me he had inspected them and found them in excellent condition. These camels are now working in Waziristan.

2. Experiments in connection with camel mange and its treatment. Of different dressings tried, the best results have been obtained by Taramira oil.

3. Surra Transmission Experiments.

4. Experiments were carried out in connection with spirochaetosis of fowls, from which it was shown that 95 per cent. of infected fowls can be cured by intravenous injections of Soamin.

5. Observations were made with reference to Hypoderma larvæ of goats and the best means to be adopted to reduce the loss caused by these larvæ were studied, the life history of the fly was also studied.

II. *Principal, Veterinary College, Lahore.*

1. Work at Antirabic inoculation in dogs by Mr. W. Taylor.

2. Investigations in a curious Poultry disease by Messrs. Taylor and Sewell.

III. *Government Cattle Farm, Hissar.*

Feeding experiments on cattle with cake and leaves of certain trees."

MEDICAL RESEARCH

BY

The HON'BLE MAJOR-GENERAL SIR WILLIAM RICE EDWARDS, K.C.I.E.,
C.B., C.M.G., M.D., F.R.C.S.E., K.H.P., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the Annual Report of the Scientific Advisory Board of the Indian Research Fund Association for 1920-21 :—

Relapsing fever.—An enquiry into relapsing fever with particular reference to the mode of transmission in India was sanctioned in November 1920 but started in February 1921. It is being carried out by Major F. W. Cragg, I.M.S., of the Central Research Institute in the United Provinces, Central Provinces and Punjab.

Plague and Rat-fleas.—The Governing Body of the Indian Research Fund Association have sanctioned an investigation on rat-fleas in India by Major Cragg.

Leprosy.—1. *Dr. E. Muir* is engaged at the Calcutta School of Tropical Medicine in carrying out an inquiry into leprosy with an allotment of Rs. 20,000 a year of which Rs. 10,000 will be donated by the Calcutta School of Tropical Medicine. The inquiry commenced on the 1st November 1920.

2. *Dr. Sudhamoy Ghosh* continued his researches under the supervision of Lieut.-Colonel J. W. D. Megaw, I.M.S., on special duty, at the School of Tropical Medicine and Hygiene. He is especially studying the chemistry of chaulmoogra oil with a view to obtaining substances of therapeutic value in the treatment of leprosy.

Grant to Rev. Dr. Frank Oldrieve for—

- (1) Training of medical subordinates in modern methods of leprosy treatment, and
- (2) Trial of the latest treatments of leprosy.

A grant of Rs. 21,650 was made to the Mission for Lepers in India in 1918 in connection with the experiments relating to the medical treatment of leprosy.

Inquiry on neem or margosa oil and its derivatives.—This inquiry has been extended for one year from 1st March 1921 and Dr. Chatterjee is concentrating his attention on the treatment of malignant growths with neem or margosa oil and its derivatives.

Influenza.—1. *Epidemiological inquiry.* This inquiry was under Major H. H. King, I.M.S., and terminated on the 7th April 1921 on his departure on leave. He has drawn up an important report for All-India dealing with the questionnaire regarding the epidemiology, etc., of influenza issued by the

office d'Hygiene International, Paris. This has been received and sent to Paris. (Since published in the Bulletin de L'office D'Hygiene Institute, August 1921.)

2. *Bacteriological inquiry.* Captain R. H. Malone, I.M.S., concluded his influenza bacteriological inquiry on the 4th December 1920.

Pneumonia.—On the conclusion of the influenza bacteriological inquiry Captain Malone was employed on the Pneumonia inquiry. This inquiry was sanctioned for one year in the first instance with effect from 5th December 1920.

Deficiency Diseases.—Colonel McCarrison started this research on the 29th January 1921 in England. This investigation is being carried out at Oxford in the Laboratory of Professor Sherrington, P. R. S.

Indian Mosquitoes.—The Indian Research Fund Association have provided funds for this inquiry to be continued for three years by Capt. P. J. Barraud. It commenced on the 26th February 1921.

This inquiry is on the culicidæ of India and has a direct and important bearing on the problem of prevention of yellow fever.

Kala-azar.—1. *Mrs. H. A. Adie* concluded this inquiry on the 25th January 1921. She published* a paper on "Developmental forms succeeding the multiplicative stage in *C. lectularius* fed on Kala-azar spleen mice". The Indian Research Fund Association has sanctioned the further continuance of the inquiry under her at Shillong for one year and she commenced fresh researches on possible insect vectors of this disease from 26th April 1921. She will work at the Pasteur Institute, Shillong, under the direction of Major F. P. Mackie, I.M.S.. She has already obtained some very suggestive and interesting results.

2. The Governing Body have sanctioned a further extension of Dr. U. N. Brahmachari's enquiry for one year. He has been provided with a chemical and physiological assistant and he will continue his researches on the organic preparations of antimony.

3. *Mr. P. R. Awati*, Medical Entomologist, commenced his insect survey in connection with Kala-azar in Assam in May 1920. He continued his work during the year. He is one of the team of workers engaged in Assam in the research on the etiology of Kala-azar.

Hookworm disease.—The inquiry into this disease was continued by Dr. K. S. Mhaskar during the year. In conjunction with Father Caius he published six more papers on the chemical composition of various drugs used in the treatment of the disease. Under instructions from the Working Committee in Madras, formed at the end of the year under review, he has been directed to proceed with new lines of research.

Ground nuts and sterilisation of water supplied by chlorogens.—Dr. Mackenzie Wallis is continuing his research in England. A report of his investigation has been called for.

* Indian Journal of Medical Research, Vol. 8, No. 7, October 1921.

Schistosomiasis cercariae of Egypt.—Major Sewell has written a very important monograph entitled *Cercariae Indicae* being the result of his investigations on this subject in India. This paper is being published by the Indian Research Fund Association as a Monograph in a special number of their Journal.

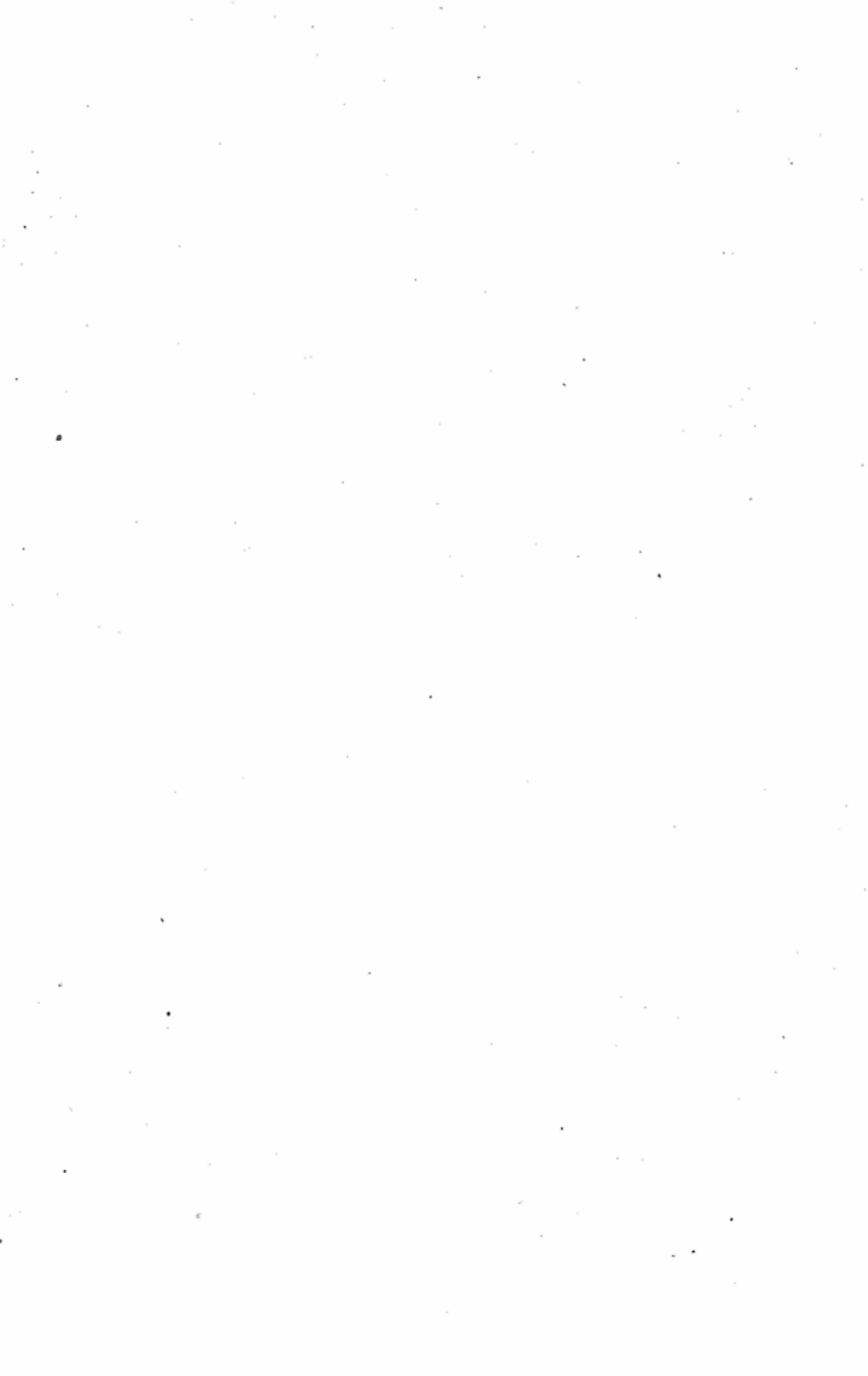
Entomology and Protozoology.—In the month of January 1921, Major W. S. Patton, I.M.S., conducted his inquiries on entomology and protozoology for which a grant of Rs. 5,000 was sanctioned by the Governing Body of the Indian Research Fund Association.

Immunity with special reference to antivenin.—The Governing Body of the Indian Research Fund Association have sanctioned for a period of one year a research on immunology with special reference to antivenin by the Rev. Father J. F. Caius of Trichinopoly. One of the main objects of this inquiry will be the concentration of the antivenin serum now prepared at Kasauli.

Malaria and its treatment by Cinchona derivatives.—This inquiry will be carried out by Major J. A. Sinton, V.C., I.M.S., under the direction of the officer in charge of the Malarial Bureau of the Central Research Institute of Kasauli. The inquiry will be carried on over a period of five years.

Grants to the schools of Tropical medicine and Hygiene at Bombay and Calcutta.—The Indian Research Fund Association have sanctioned :—

- (a) The sum of Rupees one lakh towards the extension of the buildings of the Calcutta School of Tropical Medicine to provide for teaching and research in hygiene and (b) a non-recurring grant of 1½ lakhs towards the establishment of the School of Tropical Medicine at Bombay.



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Departmental Publications.

I.—METEOROLOGICAL DEPARTMENT—

Government of India Office.

- (1) The Indian Daily Weather Report and Chart.
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- (4) The Annual Summary.
- (5) The Rainfall of India.
- (6) Indian Meteorological Memoirs.

Bengal Office.

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- (2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

- (1) Monthly Weather Summaries (*United Provinces Gazette*).
- (2) Annual Summary.
- (3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

- (1) Monthly Summary
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- } of Punjab weather.

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Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

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- (2) Records of the Botanical Survey, Vols. I.—IX
- (3) Annual Report of the Industrial Section, Indian Museum.

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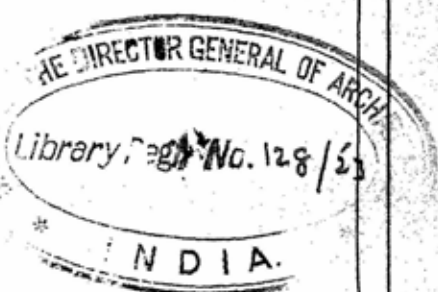
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ANNUAL REPORT

FOR THE YEAR

1921-22



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The Hon'ble Colonel Sir S. D'A. CROOKSHANK, K.C.M.G., C.B., C.I.E., D.S.O., M.V.O.	Secretary to the Government of India, Public Works Department.
J. A. CHAPMAN, Esq., ...	Librarian, Imperial Library.
C. C. CALDER, Esq., B.Sc., B.Sc. (Agri.), F.L.S.	Officiating Director of the Botanical Survey of India and for Secretary, Board of Scientific Advice.

List of Sub-Committees.

Sub-Committee A.—(*Meteorology, Terrestrial Magnetism and cognate subject*).

1. The Surveyor-General of India (Chairman).
2. The Director-General of Observatories.
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman).
2. The Inspector-General of Forests.
3. The Agricultural Adviser to the Government of India.

Sub-Committee C.—(*Soils and Manures*).

1. The Agricultural Adviser to the Government of India (Chairman).
2. The Director, Geological Survey of India.
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

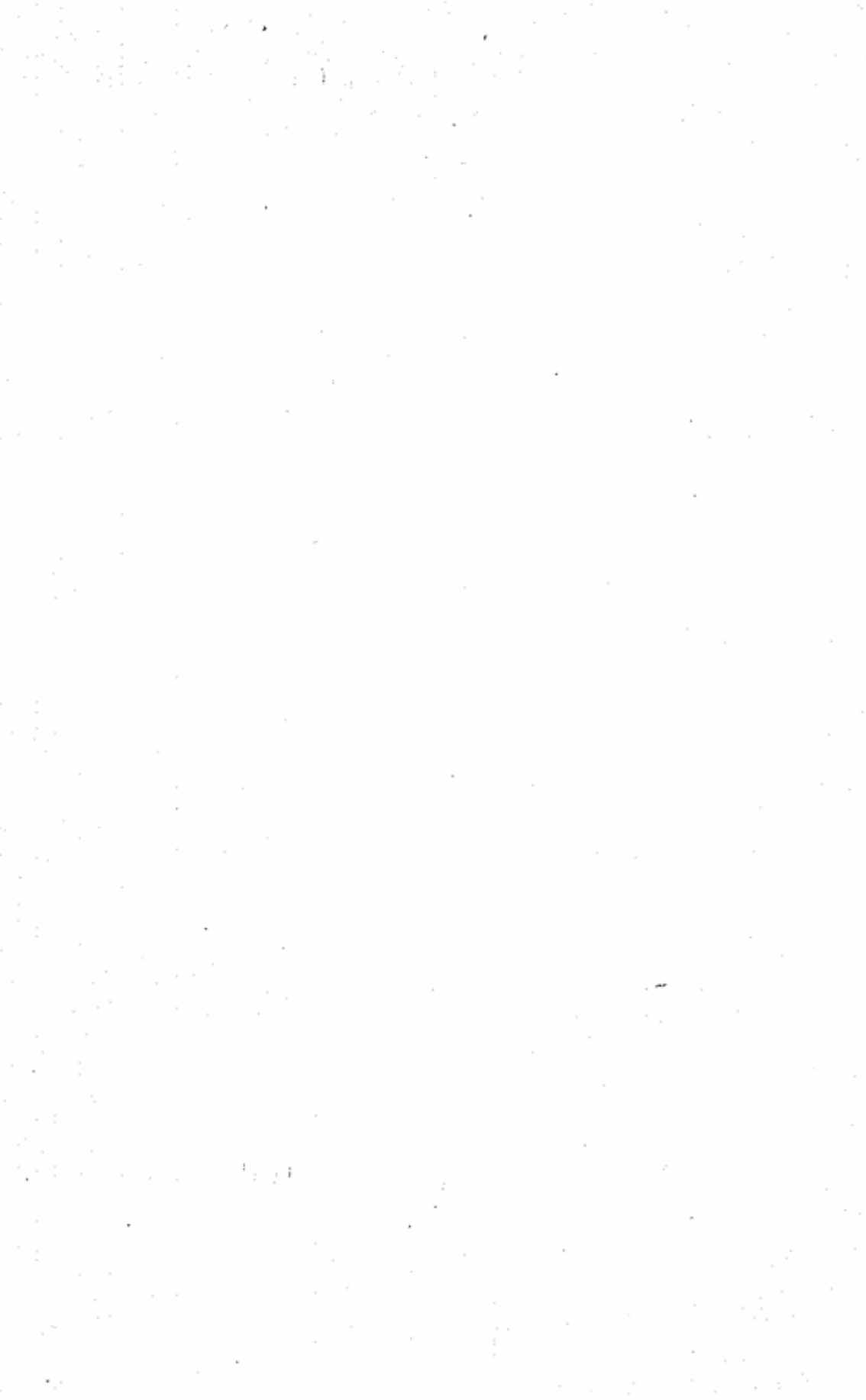
1. The Inspector-General of Forests (Chairman).
2. The Agricultural Adviser to the Government of India.
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary Subjects*).

1. J. T. Edwards, Esq., B.Sc., M.R.C.V.S. (Chairman).
2. The Agricultural Adviser to the Government of India.
3. The Director, Zoological Survey of India.

Sub-Committee F.—(*Libraries*).

1. The Director-General of Observatories (Chairman).
2. The Surveyor-General of India.
3. The Director, Geological Survey of India.
4. The Director, Zoological Survey of India.



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Annual Report of the Board of Scientific Advice for India, 1921-22.

SUMMARY OF PROCEEDINGS.

Forty-first meeting held at Simla on the 22nd May 1922.

The Board considered and accepted the programmes of the various Scientific Departments for 1922-23.

The President announced that the Government of India had selected Mr. J. T. Edwards, B.Sc., M.R.C.V.S., Director, Imperial Bacteriological Laboratory, Muktesar, as a member of the Board in place of Lieutenant-Colonel G. K. Walker, Principal, Veterinary College, Lahore, who had proceeded on leave.

It was resolved to approve the proposal of the President that Mr. J. T. Edwards, B.Sc., M.R.C.V.S., be appointed Chairman of Sub-Committee E. (Veterinary subject) in place of Lieutenant-Colonel G. K. Walker.

An endorsement from the Government of India regarding the nomination of Mr. J. A. Chapman as a member of the Board and of the Sub-Committee on the perishing of paper was read and recorded.

As regards the Catalogue of Scientific Periodicals in places in India outside Calcutta it was decided to elicit from the Education Department information as to what stage the publication had reached and to ask that the Library Sub-Committee submit a list of Scientific Periodicals suitable for Libraries in India.

The interim report by the Libraries Sub-Committee on the perishing of paper was read and recorded.

The report of the Sub-Committee appointed at the 40th meeting to consider the proposed establishment of a Marine Biological Station in the Andaman Islands was next read and considered.

The Board approved the report and recommended that its forwardal to the Education Department of the Government of India for acceptance.

APPLIED CHEMISTRY

PART I.—AGRICULTURAL CHEMISTRY

BY

W. H. HARRISON, D.Sc.

Imperial Agricultural Chemist.

SOILS

Soil Surveys.—In Madras, the soil survey of the Periyar Delta has been completed and a general deficiency in P_2O_5 and lime is reported.

Somers-Taylor has extended his previous work by including the soils of the South Ganges diara which, unlike the soils further south, show no deficiency in either P_2O_5 or Nitrogen.

The soil survey of the Tea districts of North-east India has been continued by Carpenter who has published a note dealing with a peculiar class of soil, very well suited for tea, and found particularly in the Bengal Doars.

Soil Nitrogen.—This important subject is at present receiving a considerable amount of attention. Somers-Taylor has made observations on the variations in Total Nitrogen in Bihar Soils, and Meggitt, in Assam concludes that a serious loss of Nitrogen may take place during the rainy season if the land is fallowed, and kept clean and cultivated. Vegetation in these conditions exerts a protective influence.

Clark has studied, and is publishing his observations on, the fluctuations in the amount of Nitrate in uncropped cultivated soils of the Gangetic plain and Harrison is investigating the movement of the Nitrate in soils to a depth of nine feet in connection with their availability for crop production.

Saline Soils.—The reclamation of Bara and Saline soils in the Montgomery District has received attention from Lander who reports hopeful results from treating the former with gypsum and castor cake followed by suitable cropping.

Miscellaneous.—Mukerji has extended his observations to the relative formation of CO_2 in irrigated and unirrigated grassed plots and has confirmed his previous conclusions. Sen is endeavouring to correlate the unevenness of the crop in certain fields at Pusa with variations in sub-soil characteristics.

Atkins has determined the Hydrogen-Ion concentration of certain Indian Soils and finds variations of PH 8.7 in the Calcareous silts of Bihar to PH 5.3 for a black peaty soil from Shillong.

MANURES AND MANURING.

Phosphatic Manures.—A study of the availability of different phosphates in Mysore Soils has been made by Narasinha Iyengar, and Carberry reports striking results from applications of Bone meal and lime to the red laterite soils of Eastern Bengal.

Norris in Madras has found on the Manganallur Farm that mineral phosphates composted with green manures have not proved successful; better results being obtained by direct application of the phosphate to the soil in conjunction with green manuring. Plymen is also studying the effect of fermenting green manure on P_2O_5 solubility.

Organic Manures.—The nitrification of oil cakes in soils is under observation by Plymen in the Central Provinces and Norris in South Malabar. The former finds that *Bassia latifolia* cake is very resistant. Comparative test with oil cakes against sodium nitrate and ammonium sulphate have been carried out by Narasinha Iyengar.

Fowler is studying the chemical changes producing loss of nitrogen in manure heaps, whilst the production of artificial Farmyard manure is being investigated in Madras and the Central Provinces.

Manuring of Special Crops.—Carpenter has attempted to correlate the effect of various manures on the composition of the Tea leaf, and finds that potash manuring gives immunity to mosquito blight in sandy soils but in clay soils it is unlikely that similar results will be obtained.

Narasinha Iyengar, from field experiments in Mysore, reports the Nitrogen and P_2O_5 are most wanted by sugar cane while with areca palms oil cakes are more effective than ammonium sulphate.

Meggitt and Somers-Taylor have studied the changes taking place in sugar cane during the ripening stage and Norris is endeavouring to devise a rapid refractometric method for determining the ripeness of cane in the field.

CROPS.

Sugar Cane.—A large scale trial of Coimbatore seedling canes has been carried out by Clarke under U. P. conditions with very satisfactory results and one seedling, CO. 214, is reported to be of considerable merit.

Rice.—Sahasrabuddhe has completed a study of the composition of the crop at various stages of growth and Charlton has investigated methods of mitigating the nuisance caused by par-boiling paddy.

Cocoanut and Date Palms.—The tapping of coconut palms and the production of improved jaggery or gul has been independently investigated

by Norris in South Malabar and Sahasrabuddhe in Bombay, while Carberry in Eastern Bengal has evolved a more economical type of furnace for the production of date-palm sugar.

Tea.—Carpenter from observations made on the tannin content of the leaf concludes that this increases at the time when poor quality teas are being made. He has also investigated the effect of the manufacturing process on the tannin content of the finished product.

Opium.—In continuation of his previous work, Annett has devised new improved methods for the determinations of Narcotine, Papaverine, Codein, Morphia and Meconic Acid. He finds that the alkaloids in opium are present as meconates and that the darkening of the poppy latex is due to oxidizing enzymes. Observations upon the oil content of poppy seeds are ready for publication.

ANIMAL NUTRITION.

With the appointment of a Physiological Chemist to the Pusa staff in October 1921 work in connection with the nutrition of Indian cattle has been started.

The results hitherto obtained are necessary only of a preliminary character but they distinctly point to the fact that food values of Indian fodder fed to Indian cattle will be very different to similar values obtained in other countries.

It is also of interest to note Lander in the Punjab and Narasinha Iyengar in Mysore have feeding experiments under observation.

APPLIED CHEMISTRY

PART II.—FOREST CHEMISTRY

BY

J. L. SIMONSEN.

Forest Chemist, Forest Research Institute, Dehra Dun.

Essential Oils—(1) **Carum Copticum**.—Lakhani, Sudborough and Watson (Journ. Ind. Inst. of Science, Vol. IV, p. 59) have published a long and detailed account of their work in the manufacture of thymol from Ajowan seed (*Carum Copticum*).

(2) **Lantana Camara**.—The oil from the shrub *Lantana Camara* has been investigated by Moudgill and Vridhachalam (Perf. Ess. Oil Rec. 1922, Vol. 13, p. 173). The oil would not appear to have any commercial value.

(3) **Pinus excelsa**.—The turpentine from the oleo-resin of *Pinus excelsa* has been examined at Dehra Dun. It has been found to contain *d-l*-pinene, *d*-terpineol, a sesquiterpene and *n*-undecane. The presence of the last named hydrocarbon, belonging to the paraffin series, is interesting.

(4) **Abies Pindrow, Spach**.—The needle oil from *Abies Pindrow, Spach* has been examined and the results of the investigation published. (Ind. For. Rec. 1922. VIII. 363).

(5) **Blumea Malcolmii**.—The essential oil from this grass has been found to consist almost entirely of *d*-carvotanacetone and *l*-tetrahydrocarvone (Journ. Chem. Soc. 1922. 121. 877).

(6) **Andropogon Jwarancusa, Jones**.—The oil from the grass grown in Hazara has been shown to contain over 70% of *d*-piperitone and approximately 20 per cent. of a new bicyclic terpene which is at present under investigation. (Journ. Chem. Soc. 1921. 119. 1644). An examination of the oil obtained from the grass grown in Sind has shown it to possess very different properties. Full details of this work will appear in a forthcoming paper in the Indian Forest Records.

(7) **Zanthoxylum alatum, Zanthoxylum budrunga, Zanthoxylum acanthopodium**.—The oils from the seeds of these three species of *Zanthoxylum* have been investigated and a paper on the subject is now in the press.

Fixed oils.—The oils from the seeds of *Chloroxylon Swietenia, Calophyllum Wightianum, Shorea robusta, Mimusops Elengi* and *Garcinia Cambogia*,

have been investigated at Dehra Dun and a paper embodying the results of the investigation is in the press.

A number of papers were read at the 9th meeting of the Indian Science Congress on fixed oils from the seeds of Indian Forest trees but mention may be deferred until the full papers were published.

Miscellaneous.—Fowler and Bannerjee (Journ. Ind. Inst. of Science, Vol. IV, p. 241) have made a preliminary study of the use of megasse as a source of paper pulp and power alcohol.

Majima (Berichte 1922, 55, B. 191) in continuation of his valuable study of the chemistry of Japanese lac has also studied Burmese lac the so-called "Thitsi" gum from the stems of *Melanorrhœa usitata*. Wall. The Japanese and Burmese lacs show marked chemical differences.

Nierenstein (Journ. Chem. Soc. 1922, 121, 604) has published some further results of his experiments on the constitution of catechin.

ASTRONOMY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., Ph.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on at Kodaikanal under the direction of Mr. J. Evershed, F.R.S.

Routine work.—Daily spectroheliographic records are obtained in calcium and in hydrogen light; the routine work also includes visual examination of sunspots and faculae, sunspot spectra, and bright lines or displaced lines in spots and in prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review" while for more technical purposes bulletins and memoirs of the Observatory are issued. Of the former 69 have appeared and of the latter 2 have been published.

Spectroscopic Research.—It was shown in Kodaikanal Observatory Bulletin No. 38 that lines which are unsymmetrical in width in the electric arc have abnormal displacements in the solar spectrum. These lines also undergo displacements under varying conditions of the electric arc which have been designated as the "pole effect." A new condition affecting their wave-length in the arc has now been discovered, namely, the nature of other substances in the arc simultaneous with the element whose spectrum is under investigation. It has been found that one of the unsymmetrically widened copper lines undergoes the following displacements according to the nature of substance introduced into the arc: with sodium $+0.050 \text{ \AA}$ (i.e., to the red), with calcium $+0.035 \text{ \AA}$, with iron $+0.016 \text{ \AA}$, with silver $+0.015 \text{ \AA}$, with aluminium $+0.014 \text{ \AA}$, with nickel $+0.005 \text{ \AA}$. The cause of the displacements of unsymmetrically widened lines was suggested in K. O. Bulletin No. 38 as due to differences in vapour density, although it was stated in K. O. Bulletin No. 40 that density of ions might have to be substituted for density of vapour. It now appears likely that differences of density of ions are the true cause of the displacements of unsymmetrically widened lines, for it can be shown that the displacement of these lines goes parallel with their displacement in an electrical field. It would appear that the displacements in the electric arc are caused by the electrical field due to neighbouring ions, and that in the Sun the density is sufficiently low for ions to be separated to distances at which their electrical field is small. These experiments are now being continued and extended for their complete elucidation and to test the above explanation of their cause.

Wave-lengths have been determined on the international scale of selected solar lines in two spectral regions, and including spectra of general sun-

light, the centre of the Sun's disc, and the equatorial and polar limbs. The results have been communicated to the International Astronomical Union. In this work some remarkable differences are found for certain lines in spectra photographed in 1914 and others obtained in 1921.

Two series of plates of the sodium lines D_1 and D_2 in Sun and arc have been obtained to determine the displacements of these lines in the Sun. The two series give slightly different results but agree in indicating a nearly zero pressure in the Sun's absorbing atmosphere. The Sun-arc shift when corrected for the higher pressure of the arc in air would appear to be very approximately in agreement with the shift predicted by Einstein.

A new autocollimating prism spectrograph was completed and brought into use in October 1921. This instrument has proved very efficient, and a fine series of Venus spectra were secured in November and December 1921 when the planet was a morning star approaching superior conjunction; and again in April and June 1922 as an evening star. Measures of the earlier series give mean wave-lengths differing only very slightly from those in direct sunlight; a result that is also favourable to Einstein interpretation of the shift of the solar lines.

With the same instrument a series of spectra of Sirius was obtained on the same scale as the Venus spectra. Comparing the Venus (solar) and Sirius spectra with this high dispersion has revealed the fact that the metallic lines in Sirius are very much wider and less dark than in the sun. The possible causes of this widening are discussed in a paper submitted to the Royal Astronomical Society in May.

METEOROLOGY

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., Ph.D., F.R.S.,

Director-General of Observatories.

Upper Air.—Observations with pilot balloons had to be much restricted in the year 1920-21 and at the beginning of the year this work was being done only at Bangalore (with the co-operation of the Government of Mysore), Agra, Simla and Lahore. Later in the year it was found possible to extend the work to a few other stations: Calcutta and Akyab were re-opened in May and August respectively, and two new stations Quetta and Peshawar were started, the former in June and the latter in September.

The Central Observatory at Agra, besides exercising a close supervision over the current work of these outstations, was busy clearing up the war-time arrears in the computations of the upper air data.

A complete analysis of cloud observations made from 1914 to 1919 and also of observations with kite and sounding balloons made up to the year 1918 were undertaken, and three papers giving the results of this work were compiled for publication in the India Meteorological Memoirs.

The paper "On exposures of thermometers in India" is in the Press and about to be published.

Prof. P. C. Mahalanobis of the Presidency College, Calcutta, spent some months in Simla on research work and wrote two papers, the first on the seat of activity in the upper air and the second on the effect of the errors of observations on upper air relationships. These will be shortly published.

Daily and seasonal forecasting.—Shortness of staff prevented any of the gazetted officers from carrying on the preparation of type maps for daily forecasting.

Statistical work for investigating the relation of pressure at centres of action with the monsoon rainfall of the Peninsula was undertaken and a formula was obtained which would enable the department to make a forecast in February with a correlation coefficient nearly as high as that obtained with the old formula for the June forecast. For the forecast in June itself a formula was obtained which gave a correlation coefficient of .8. The investigation was extended to the monsoon rainfall of north-west India also, but the results have not so far been very successful.

The normals of all the elements recorded at our observatories and of the rainfall at all the authorised rainguage stations were revised and brought up to the year 1920 and are being arranged for publication.

A memoir on the local distribution of monsoon rainfall has been published.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, C.S.I., M.A., Sc.D., Ph.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories—Bombay (Alibag).—For a description of the instruments and of the routine work reference should be made to the Annual Report of the Director of the Observatory. The quinquennial volume giving the magnetical, meteorological and seismological observations made at Bombay and Alibag Observatories during 1911-15 has been published during the year. The volume for 1916-20 is in the Press. A selection from the disturbed magnetic records obtained at the Alibag Observatory during 1906 to 1915 has been printed and will shortly be issued by the Bombay Observatory with a brief discussion.

Magnetic Survey.—No. 18 Party (Magnetic) Survey of India.—The declination, horizontal force and vertical force magnetographs continued in operation throughout the year at the Dehra Dun and Tougoo Observatories and daily absolute magnetic observations were taken regularly by the observers in charge. The observatories were visited during the field season and observations, consisting of declination, dip and horizontal force, were taken for the comparison of instruments.

The Kodaikanal and Alibag Observatories, under the control of the Meteorological Department, were also visited by the officer in charge of the magnetic survey for the same purpose.

Observations at Repeat Stations.—Magnetic observations were taken this field season at the six repeat stations—Quetta, Karachi, Bina, Dibrugarh, Barrackpore and Waltair—these stations are visited annually to supplement the 5-yearly observations at all repeat stations, in order to obtain accurate determinations of the annual changes in the magnetic elements, as explained in last year's report.

Publication of the results of the magnetic survey.—The final reduction of the magnetic observations at the field and repeat stations in India, Burma and Ceylon, to the epochs 1909-0 and 1920-0, have been completed. The results, which are now in the press, will be published as soon as the maps, diagrams, etc., have been printed.

Special observations.—In response to a request by Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, special magnetic observations will be taken during the Total Solar Eclipse of September 21, 1922 at Alibag, Kodaikanal, Dehra Dun and Toungoo for investigating the eclipse effects on the Earth's magnetism.

GEOLOGY

BY

L. L. FERMOR, O.B.E., A.R.S.M., D.Sc. (LONDON), F.G.S., F.A.S.B.,
M.INST.M.M.

Offg. Director, Geological Survey of India.

Mineralogy.—A brief examination was made of the occurrences of solid bitumen or mineral pitch found in cavities in basalt west of Seori Fort, Bombay. It is suggested that the origin of this bitumen is due to the distillation of the carbonaceous matter of the organisms in intertrappean beds invaded by a sill of intrusive dolerite.

Palæontology.—Descriptive work has been continued on the Tertiary fossils of Burma and North-Western India, upon the intertrappean fossils of Peninsular India, upon Devonian fossils from Chitral and the Pamirs, and Anthracolithic and Triassic fossils from Yunnan. Amongst vertebrates, studies have also been made of Anthracotheridæ from Baluchistan and Dinosaurian remains from Jubbulpore. Short papers have been completed on various Gondwana plants.

Stratigraphy.—An interesting discovery was made by Mr. Sinor, State Geologist to the Rewah Durbar, of marine fossils of Gondwana age at Umaria in Central India. Two species have been recognised belonging to the genera *Productus* and *Spiriferina*. This discovery indicates the extension in Talchir times of the northern Carboniferous sea as far south as Central India, giving a northern limit to the edge of Gondwanaland in this neighbourhood in Talchir times.

Geological Surveys.—A survey was made of a considerable tract on the southern edge of the Khasi Hills, connecting up previous work to the east and to the west. The survey of the ferriferous belt of Singhbhum was continued, and also the general systematic survey of the Central Provinces. A portion of the Aravalli range in Jodhpur State (Rajputana) was surveyed and a detailed examination of Salsette Island (Bombay) was undertaken. In Burma, the systematic survey of Mergui was continued, and also the mapping of the Tertiary formations in the Pakokku and Lower Chindwin districts. In addition, the recently discovered occurrences of oil shales in the Amherst district adjoining the Siamese frontier were examined, and geological observations made that permit of a comparison between the geology of Amherst and that of the Southern Shan States. The railway survey carried out from Ledo in Assam through the Hukong valley to Mogaung in the Myitkyina district of Upper Burma afforded an opportunity for the

geological examination of a tract not previously visited. During the hot weather a beginning was made with the systematic geological examination of Chitral State, and the results obtained during the first-season's work confirm and amplify the results previously obtained in a traverse by Sir Henry Hayden. A beginning was also made with the systematic survey of the Poonch Ilāqa, the most interesting result obtained being the discovery of two or more bands of bituminous limestone carrying nummulites intercalated in steeply dipping Murree beds. An officer was deputed to accompany the Mount Everest Reconnaissance Expedition, this resulting in the preparation of a geological map of over 8,000 square miles of territory, comprising the western portion of the Tibetan section of the Arun drainage area, and the region drained by the headwaters of the Bhotia Kosi and its tributaries. The tract mapped lies to the west of that mapped by Sir Henry Hayden at the time of the Tibet Expedition in 1903-4.

Economic Enquiries.—Investigations were made regarding the following minerals: amber in Upper Burma; orpiment in Chitral; bauxite and building stones in Salsette Island, Bombay; coal in the Talcher coalfield; graphite and mica in the Ruby Mines district of Burma; iron-ores in Singhbhum, Orissa and Chitral; lead-ores on the Burma-China frontier; oil shales in Amherst district, Burma.

Amongst engineering questions the sites for a tunnel of the Sutlej River hydro-electric project were examined, and also the sites of the Anu Khad hydro-electric project. Examinations concerning water-supplies were made at Quetta, Chittagong, Amraoti, Dhanbad, Salsette Island and Jodhpur. The superintendence of the boring for coal below the Deccan Trap at Bhusawal was continued, and an inspection of the manganese mines of the Central Provinces was undertaken in order to advise the Local Government of the extent to which the concessionaires were complying with the general terms of their leases, and with a view to suggesting directions in which improvements in methods of work could be effected.

GEODESY

A RETROSPECT

BY

LIEUT.-COL. H. McC. COWIE, R.E.,

Offg. Superintendent of the Trigonometrical Survey.

Owing to the exigencies of war, geodetic operations in India have been for many years in abeyance. The absence of experienced officers and the pre-occupation of the Survey of India Department generally with matters of greater present importance and urgency precluded the continuance of geodetic research. Amongst the investigations which had to be suspended for the time were those concerned with the interpretation of gravitational anomalies and the bearing of such interpretation on current theories of isostasy and the evolution of the structure of the Earth's crust. These investigations, which had reached a most interesting stage, were being followed somewhat closely in Europe and America. Other matters which had necessarily to await more favourable times included the inception of wireless longitude determinations, the measurement of essential base-lines and the adjustment of extensive triangulation lying outside the older and already adjusted geodetic framework of India, the determination of the relation between the original 10-foot Indian Standard of length and the modern metric standards acquired shortly before the outbreak of war, and the examination of triangulated heights in India and Burma with reference to the spirit-levelling.

Such were amongst the future activities contemplated by the programme interrupted at the end of 1914. It is hoped that the long period of enforced quiescence will shortly come to an end and, so, the present is, perhaps, not an inappropriate time for glancing at the past and taking stock of the present geodetic situation in India.

The Indian Triangulation.—Commenced in 1802 under the direction of Colonel Lambton, the general framework of triangulation, elaborated by Sir George Everest had, about 1880, reached the confines of what were then the attainable regions of India and, for a time, geodetic operations were suspended. The establishment, for the next few years, was employed on special secondary triangulation along the coasts of India to serve the purposes of the Marine Survey. At the end of 1888, geodetic triangulation was resumed and continued steadily until the season of 1913-14. By that year, extensions had been carried from Everest's framework eastwards to the boundaries of Siam

and Yunnan, westwards to Persia and northwards to effect a junction with Russian triangulation in the Pamirs. In 1907, the programme of trigonometrical operations was widened to include secondary triangulation supplementary to the principal framework and, by 1914, a definite beginning had been made to a regularly co-ordinated system of secondary triangulation.

At different times the principal triangulation of India has been criticised as being too precise. These criticisms, however, were generally based on an imperfect appreciation of the situation in India. The criteria by which the triangulation was judged were derived from European experience; the enormous area over which the triangulation would extend was but dimly realised and, perhaps more important still, the difficulties of making frequent base measurements in country where communications were few and bad, where little was procurable locally and most ordinary necessities had to be transported over great distances, were not understood; neither was the fact appreciated that if the accumulation of inconveniently large errors in outlying parts of the triangulation was to be avoided, without the checks afforded by frequent base-lines, the degree of precision of the work would have to be higher than that deemed sufficient for the much smaller networks of Europe. The precision of the Indian triangulation is by no means unduly high. It ranks equally with the best of the older operations in Europe but by reason of the greater part of the work having been done before the construction of instruments, more especially of the dividing engine, had reached its present high quality, its average figure of merit is less than that of good modern triangulation.

At the end of the 19th century it was the precision of the Indian triangulation that was under criticism. To-day it is its sufficiency, in point of amount, for the future needs of India. Every year sees a certain number of the old stations of the principal triangulation disappear and unless considerable sums are spent on protective measures, this must occur. In that they are accurately fixed points, valuable as controls to the topographical surveyor, their loss must be viewed with concern unless there exists some system of secondary triangulation offering a sufficient number of points of adequate precision to render the disappearance of a principal station of small account. There has thus arisen the question of how much supplementary or secondary triangulation, properly co-ordinated with the principal framework, there is in India to provide for the needs of the future. Up to the beginning of the 20th century, it may be said generally, there was no such supplementary triangulation. Up till then there was no regular programme of such work and no definite agency to carry it out. As occasion arose, necessary triangulation was executed by either a topographical or a trigonometrical party as circumstances dictated. The marks were rarely permanent and it is probable much good work has been lost. In 1908, however, a commencement was made to a definite, enduring framework of secondary triangulation and by 1917, nearly 2,000 miles of secondary triangulation had been completed. At this point, operations were discontinued and up to date, conditions have remained so far abnormal that it has not been possible to resume them. Relae

tively to the areas to be provided for, only a very small amount of secondary work has been carried out and the Indian triangulation scheme is still far from complete. It may be pointed out that the trigonometrical survey of a country is not complete until a framework of secondary triangulation has been constructed, breaking down the large figures of the principal work to such extent as will economically suit the needs of the topographical surveyor. In India very little has been done towards this end and the average size of the principal figures is still very large. The average sized figure—

in the United Provinces is about	300 miles	×	70 miles	
„ „ Northern Punjab	200	„	×	150 „
„ „ Southern	250	„	×	150 „
„ „ Bengal	200	„	×	100 „
„ „ Central India	300	„	×	130 „
„ „ Burma	200	„	×	120 „

Over these there is nothing of the nature of the permanent supplementary triangulation existing in other countries. In Germany the largest principal figures are about 190 miles \times 125 miles. In France and Spain the average size is about 120 miles \times 120 miles. In all these countries the principal figures have been completely filled in with permanent supplementary frameworks. In Italy, Switzerland, Greece, and Japan there is a principal network covering the whole country with points about 35 miles apart. In Belgium and Holland there is a similar network with points 25 miles apart.

It is not claimed that the Indian principal and secondary triangulation network should be as dense as it is in Europe but it is affirmed that by reason of the disappearance of much of the old work and the failure, for want of means, to supplement the principal triangulation by co-ordinated permanent secondary work, much difficulty will be found in satisfying the future topographic needs of many parts of the country.

As the industrial development of India proceeds, the future will bring demands for maps on special scales or of special areas and in the preparation of such the absence of permanent, systematically placed marks to serve as easily attainable bases for the work will be seriously felt. It is true that over certain parts of India the need for secondary triangulation is not pressing, *e.g.*, over a great part of South Punjab and the forest tracts of Central India, but after allowing for such parts, there still remain large expanses where the absence of permanent secondary triangulation is a serious defect, placing India at a disadvantage as compared with many other countries.

During the last twenty years, the principal framework of India has been extended in Burma and in Baluchistan and a connection with Russian triangulation has been effected in the north but, as has been said, scarcely anything, by force of circumstances, has been done by way of amplifying the old framework, of remeasuring the old base-lines with modern apparatus, or of measuring new lines for the adjustment of considerable extensions of triangulation.

These twenty years were marked by considerable activities in Europe and America. Between 1903 and 1912, France, Germany and Russia had

each measured nine new base-lines with modern apparatus; Italy, seven and Japan, two, Austria, Norway, Sweden, Switzerland, Roumania and Greece all measured new bases for the rectification of existing triangulation or the needs of new work. A considerable amount of triangulation was carried out in Europe, North America and Africa and, in a lesser degree, in Australia, South America and Japan. In France, indeed, a new network was constructed specially for the 1:50,000 scale maps it was intended to produce. France, also, executed triangulation of a high quality in Peru and Ecuador in order to strengthen the data on which rests our knowledge of the figure of the Earth. For the same purpose, Roumania, Austria and Bavaria undertook new geodetic operations for the completion of the arc from Brest to Astrakhan, and triangulation to supplement existing frameworks was executed in Germany, France, Switzerland, Russia, the Tyrol, Roumania, Norway and Sweden.

Relatively, India has been losing ground. The experience of Europe and America has been that as the development of the country proceeds there is an increasing demand for precisely fixed permanent marks and national surveys have frequently found it necessary to strengthen and amplify existing triangulation. India has been under the necessity of employing her small triangulation party in extending the principal framework over areas where, as yet, there was no triangulation at all but of which topographical maps were much needed and while, as has been pointed out above, the old marks were gradually suffering reduction in number, she has not as yet been able to undertake systematic work on a supplementary secondary network.

It is hoped that in the near future it will be possible materially to improve India's position by the measurement of new and some of the old base-lines (the last was measured in 1881) with modern apparatus acquired in 1914, to ascertain the relation between the old standard of length of India and the modern standards of Europe, and vigorously to continue operations on the framework of secondary triangulation.

Spirit-Levelling.—Spirit-levelling was begun in India in 1858 but not on a definitely co-ordinated system nor by a special agency. In 1874, General Walker, Superintendent of the Great Trigonometrical Survey, drew up a scheme for a well-conditioned, co-ordinated system of levels, covering the whole of India and adjusted to careful determinations of Mean Sea Level at selected points round the coasts. For the prosecution of this scheme, Tidal Observatories were established and a definite organization formed to undertake the investigation of tides, the determination of Mean Sea Level and the commencement of the great network of spirit-levelling. Since that time, operations have been steadily continued, but, until a few years ago, it was part of the policy regulating the spirit-levelling operations that the Survey of India should concern itself only with levelling of the highest degree of precision and the construction of the fundamental network covering India and that the execution of levels of inferior quality should be left to other agencies. But of recent years, owing, on the one hand, to increasing demands springing from the gradual development of the country

and, on the other, to the insufficiency of the fundamental network, as it then was, to meet these demands satisfactorily, the propriety of relaxing the rigidity of adherence to the policy came under serious consideration and it was eventually decided to endeavour so to design operations as to satisfy, as far as possible, the demands for levels of something less than high precision quality as well as to strengthen and amplify the fundamental network.

As a general principle, the Survey of India policy of concerning itself only with the scientific framework may have been correct, but it was not yet rightly applicable to India where, in spite of levelling operations having been in progress for more than 50 years, the lines of precise levels of the network were still at great distances apart owing to the magnitude of the area that had to be dealt with. It, thus, generally happened that when levels were required in any locality for engineering or industrial projects, it was found that the nearest precise bench mark was at such a great distance that to carry levels therefrom into the areas in which they were required, with the requisite degree of accuracy, a branch line of high quality would have to be run from some limb of the network. It was perhaps not necessary that this quality should be that of "high precision" but it had certainly to be superior to that of ordinary engineering levels. Engineering staffs were not, as a rule, equipped or trained to run levels of the required quality and the survey was faced with the alternative of setting its policy aside by concerning itself with a line of levels, the demand for which had arisen not from itself but from an outside agency or of allowing such outside agency to base its levels on an assumed datum, independent of and not co-ordinated with the scientific network of India. The difficulty arose from this network being still on much too large a scale and from engineering demands having developed before there was time to subdivide and amplify its meshes.

The result of the modification of policy has been that the operations now embrace two classes of levelling, one of "high precision" for the purposes of the fundamental network and the restoration of many of the old lines which, owing to the fugitive nature of the original bench marks, have been almost entirely lost and a second class of "precision" for the provision of accessible data to industrial projects as well as for the amplifying of the "high precision" network.

By the end of the season 1919-20, 30,247 miles of levels of "precision" and high precision had been run since the commencement of operations in 1858. The subsequent season, 1920-21, added some 2,600 miles to the total outturn.

Glancing at what has been done in Europe and elsewhere, we find that by 1912 (reports for later years were interrupted by the war and are not yet available),

France	had run	58,466 miles of primary levelling.
Germany	"	33,757 do.
Russia	"	21,417 do.
Japan	"	13,907 do.
Switzerland	"	2,784 do.

Such figures, however, give no clear idea of the density or "efficiency" of the respective level nets, that is to say, of the ratio between the length of level lines and the area of the country concerned. If, for the sake of comparison, we take the ratio given by India's level net at the end of 1919-20 as unit, we get the following figures representing the efficiency of other countries as they were in 1912 :—

Belgium	4.35	Portugal	2.71
Spain	2.59	Roumania	3.00
France	16.88	Russia and Siberia	0.12
Germany	9.53	Switzerland	10.24
Austria-Hungary	3.24	Algeria-Tunis	0.82
Denmark	7.82	Japan	4.70
Italy	1.06	Sweden	1.35
Holland	7.18	India	1.00

Relatively, India is low in the scale, but it will be remembered that over large portions of India, the density of spirit-levels need not be nearly as great as over others where, on the other hand, the levels ought to be particularly dense. But the former cannot be ignored entirely. It should be possible, without great difficulty, to carry levels into any part of the country, for however unimportant a region may appear to-day, by to-morrow, thanks to the extension of railways or irrigation, the discovery of mineral wealth or other causes, it may have acquired considerable value and demand spirit-levelled data, and spirit-levelling, to be useful, must be completed before demands for its data arise. The "efficiency" figures given above represent averages for the whole area. India's average figure should be raised, during the next twenty years, to about 3.

Gravimetric Surveys.—In 1852, the Surveyor General, Sir Andrew Waugh, brought to notice that in the amplitudes of the two northern-most sections of the Great Arc of India, there were discrepancies of about 5" and 4" between the computed and observed values, the observed value of the northern section being in defect, that of the southern in excess. These effects were attributed to the influence of the Himalayas.

Archdeacon Pratt of Calcutta, whose interest had been roused by the phenomenon, then calculated the theoretical values of the effects of Himalayan attraction and found that these were much larger than were required to explain the observed discrepancies of amplitude. Out of this result there gradually developed the idea of mountain compensation and the existence of irregular variations of density within the crust of the Earth, and it was concluded that before geodetic measurements could be usefully employed in the determination of the mean spheroid, a greater knowledge of the local effects of irregularities of density was necessary. This led to a criticism of Everest's Arc of India. Sir H. James, Superintendent of the Ordnance Survey, remarked that "if there had been a larger number of astronomical points in this Arc, they would have added very greatly to the weight of the determination of the Earth's figure" and much disquiet was aroused by Colonel A.R. Clarke's

conclusions that the value of the Indian Arc had been considerably diminished since the investigations of Archdeacon Pratt. At the same time the Superintendent of the Great Trigonometrical Survey, addressing Government, stated that the paucity of astronomical observations in India had been unfavourably contrasted with the number taken elsewhere. As a result, two survey parties were formed in 1863 for "the sole purpose of fixing the absolute or astronomical latitude of various trigonometrical stations at moderate distances all over the peninsula of India" and "to obtain a tolerably complete series whence to deduce an approximation to the amount of the deviation of the plumb-line from the normal of each of those stations and thereby gain some insight into the law of local attraction and that of the Himalayan mass."

Such were the beginnings of the investigation into the nature of plumb-line deflections which continued up to 1914, supplemented between 1865 and 1874 and after 1904 by pendulum determinations of variations in the intensity of the gravitational force. The propriety of combining pendulum determinations with plumb-line observations had been recognised from the middle of the 19th century, but, owing to the nature of the apparatus, the actual carrying out of such determinations was a matter of considerable difficulty, until the commencement of the 20th century when the half-seconds pendulum apparatus was devised. With such apparatus, the second period of pendulum operations in India began in 1904, supported by a resolution of the International Geodetic Conference in 1903, that it was most desirable that an exhaustive study of the intensity of gravity should be made in India, in the mountains as well as in the plains, in view of the fact that it was only by research work of this nature that an exact indication of the distribution of masses within the crust and the true shape of the geoid could be acquired.

By the end of the season 1913-14, the astronomical latitude and the plumb-line deflection had been observed at 302 stations and between 1904 and 1914, 113 determinations had been made of the intensity of the force of gravity.

To show how the number of deflection determinations compares with what had been done abroad up to 1912, the following statement gives the "density" figure for different countries on the convention that the density in the case of India is 1·00.

Denmark	20·29	Switzerland	37·12
Italy	4·94	United States of America	0·76
France	2·47	Japan	1·18
Austria-Hungary	3·24	India	1·00
Germany	10·53		

The actual density of latitude stations in India, represented here by 1·00 is one station per 6,000 square miles, still considerably below that in Europe.

It may be noted that, unlike that of the results of triangulation and levelling, the utility of plumb-line deflection determination is not affected by the surface conditions of the region in which the station lies. The deflections afford data upon which may be based conjectures as to the distribution of mass below the surface but, so far as we are aware at present, the surface conditions give

no indication of the particular manner according to which the invisible masses are arranged, nor of the importance of that particular arrangement. Leaving out of consideration certain definite gravitational problems, it cannot be said, at present, that in any one part of India the surface characteristics foreshadow a particular or an important sub-surface condition and that therefore deflection determinations should there be of greater "density." Consequently local "densities" should not differ much from the average and as there is no reason for supposing that the knowledge of sub-surface conditions in India will be of less value than that of other countries, the average for India should be of the same order as that considered desirable elsewhere. At the present time it is low compared with that of other countries; against India's one astronomical latitude determination in every eleven triangulation stations may be compared Egypt's Nile Valley triangulation with a latitude determination at every other station.

A similar paucity of results characterises also the gravity determinations at present. For the solution of the scientific problems before us and much more so for the investigation of the applicability of gravimetric determinations to the interests of industrial development, the number of results in India is too small. New methods and new apparatus have achieved much during the last eighteen years but, in a country of India's area, the building up of a series of pendulum determinations to the stage at which the work begins to be productive of sound teaching, either scientific or economic, is not to be effected under a considerable number of years.

The gravimetric work of the Survey of India, like that of other countries, can now, less than ever, be considered an isolated line of research. It constitutes a branch of geophysics whose problems overlap more and more those of geology and the two lines of investigation are dependent on one another for data and assistance in explaining phenomena. There is also held out the possibility of economic value.

In Hungary, the Eotvos torsion balance, for the determination of small variations of gravity, has been used to discover, in detail, the arrangement of sub-surface masses and to indicate favourable fields for oil prospecting and drilling and there is no reason to suppose that, as we gain experience by extending our investigations and by determining the characteristics of gravity over known deposits, it may not be possible, to-morrow, to locate coal and iron.

During the next several years, it is hoped that gravimetric research will be continued and will extend in greater detail over the Himalayas, the Gangetic plains, the coal field areas and the Salt Range, amplifying our knowledge and enabling us to derive a fuller return from work already done.

TIDAL OPERATIONS.

During the past year tidal registration by means of automatic gauges was carried out at the following ports:—

Aden, Karāchi, Bombay (Apollo-Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, Moulemein and Port Blair.

All the tide gauges have worked satisfactorily, and there have been no serious breaks in the tidal registration.

All the tidal observatories were inspected during the year and the gauges thoroughly overhauled and put into working order.

In addition to the automatic tidal registration at the nine ports named above, observations of high and low-water on tide poles were taken during day-light at Bhāvnagar, Chittagong and Akyab, with the object of testing the accuracy of predictions which were based on tidal registrations taken many years ago.

The Director, Inland Water Transport, Basrah, has continued to supply to this Department tidal observations taken on a tide pole at Basrah up till 11th March 1922, and thereafter these observations, taken on an automatic tide gauge at Margil, were supplied by the Port Officer, Basrah. On the basis of these observations, data for the preparations of tide tables for Basrah for the year 1922, were prepared and supplied to the National Physical Laboratory, Teddington, England. The predictions were received from the Laboratory in December 1921 and supplied direct to the Director, Inland Water Transport and Port Officer, Basrah, and the Director of the Royal Indian Marine, Bombay, in December 1921.

The tide predicting machine was brought out from Teddington to India in October 1921 and was set up in the office of the Superintendent of the Trigonometrical Survey, Dehra Dūn. The predictions of Tides and preparation of tide-tables for Indian Ports as well as for Basrah for 1923 are now undertaken entirely in India and the tables will shortly be published.

LEVELLING OPERATIONS.

Levelling completed in 1921-22.

During the season 1921-22, the following lines of precise levels were run :—

A.—In the Bombay Presidency.

- I. (a) Viramgām to Navānār, *viā* Rājkot, Jorya and Shikārpur (Cutch) (Revision, originally levelled in 1874-76).
- (b) Navānār to Nakhtarāna (Revision, originally levelled in 1889-90).
- (c) Jacobābād to Shikārpur (Sind) (Revision, originally levelled in 1909-10).
- (d) Shikārpur (Sind) to Rohri (Revision, originally levelled in 1904-06).
- (e) Rohri to Reti (Revision, originally levelled in 1909-10).
- (f) Surat to Dhūlia (new line).

In all about 721 miles of "high precision" levelling was done on the "fore and back" system for the new level net. In addition to redetermining the heights of the old benchmarks new benchmarks were established on short branch lines at the request of the Geological Department.

- II. (a) Shikārpur (Sind) to Kambar.
 (b) Wāriāso to Rato-Dero.
 (c) Madad Chāndia to Mehar.
 (d) Ruk to Sehwān.
 (e) Daur to Lundo.
 (f) Shāhpur to Mahrābpur.
 (g) Tando Alāhyār to Hyderābād.
 (h) Rohri to Jam Sāhib.

In all about 890 miles of new level line on the old system of simultaneous double levelling. The work was undertaken for the Sukkur Barrage Project.

- III. (a) Nāndgaon to Ahmadnagar *viā* Manmād.
 (b) Sholāpur to Bijāpur *viā* Jhalki.
 (c) Batghar to Jhalki *viā* Nira Bridge.

In all about 360 miles of new level line of simultaneous double levelling.

The work connects two old level lines and provides heights of benchmarks required by the Irrigation Department in connection with the Nira Right Bank Canal.

B.—In the United Provinces.

- (a) Jhānsi to Saugor.
 (b) Garhmuktesar to Aligarh.

In all about 160 miles of simultaneous double levelling undertaken to provide cross-connections between two old level lines.

C.—In the Punjab and Rājputāna.

- (a) Reti to Jhang, *viā* Khānpur, Bahāwalpur and Multān (Revision of old Main line originally levelled in 1860-61 and branch lines levelled in 1909-15).
 (b) New level line Khānpur to Islāmpur and on through Jaisalmer and Jodhpur States to Mārwar Pāli *viā* Jaisalmer, Khodyal, Sheo, Barmer, Balotra and Luni Junction.

In all about 722 miles of "high precision" levelling on the "fore and back" system undertaken for the new level net.

D.—In Bengal.

- (a) Calcutta to Chuādānga *viā* Bārāsāt, Husainābād Jessore and Jhenida
 (b) Jessore to Bārāsāt.
 (c) Dhuliān to Jangipur (for the Nadiā River Project).

In all about 310 miles of simultaneous double levelling undertaken for the Irrigation Department.

E.—In Bihār and Orissa.

- (a) Jhārsugrā to Purūlia (to connect two old level lines).
- (b) Tinpahār to Berharwa (for the Nadiā River Project).

In all about 229 miles of simultaneous double levelling.

F.—In the Central Provinces.

51 miles of simultaneous double levelling from Jhānsi to Saugor to connect to old level lines.

G.—In the Punjab and Kashmīr.

From Wazirābād to Anantnāg (Islāmābād) *viā* Siālkot, Jammu, Dausal, Rāmban and Banihāl Pass.

In all about 207 miles of simultaneous double levelling were undertaken in order to complete the circuit of levels taken into Kashmīr, *viā* the Jhelum Valley cart road in season 1912-13, an important mountain circuit.

GEODETIC PUBLICATIONS

BY

MAJOR C. M. THOMPSON, I.A.

Survey of India.

An important contribution to geodesy during the year under review was the Survey of India Professional Paper No. 18 by Lieutenant-Colonel H. McC. Cowie, R.E., entitled "A criticism of Mr. R. D. Oldham's Memoir—The structure of the Himalayas and of the Gangetic Plain, as elucidated by Geodetic observations in India."

In the outer Himalayas and in the plains at their foot, geodesists have long been confronted with problems arising out of the observed gravitational anomalies. The situation in respect to this problem is briefly explained in the opening lines of this Paper. "Along the southern fringe of the Himalayas, where they rise abruptly from the plains, and in the Gangetic Plain itself, the force of gravity has been found to possess, in respect to intensity and direction, marked peculiarities whose meaning has, for long, been the study of geodesists. Neither Bouguer's nor Hayford's hypothesis completely explains the observed facts."

"The Bouguer hypothesis fails completely to account for the facts observed in the Himalayas Gangetic region. Hayford's hypothesis, though it goes far towards interpreting them, still leaves us with unexplained residuals that can not be justifiably considered as accidentals, due to purely local departures from the general law, until it has been shown that modifications of the initial hypothesis will not produce a closer agreement between the calculated and observed quantities. As based on this hypothesis the

theoretical values of deflection as compared with the observed, at stations in the Himalayas and immediately at their foot are *too small* towards the north while over north-west, north-central and north-east India at distances of more than about 30 miles from the hills, the values are *too large* towards the north. This characteristic of the Hayford quantities and the magnitudes of the residuals may still require some modification before we accept them as the best approximation to the general law governing the actual distribution of densities in India."

Mr. R. D. Oldham, however, in his Memoir*—"The structure of the Himalayas and of the Gangetic Plains, as elucidated by Geodetic observations in India" puts forth the view that a reconsideration of the hypothesis is not necessary, and appears to be of the opinion that it is unnecessary to look further than the Gangetic Trough filled with alluvium for the explanation of the anomalies of the plumb-line deflection and intensity of gravity. He, accordingly, directs his investigation towards an estimate of what the dimensions of this trough ought to be to suit the geodetic determinations throwing into the background the consideration of other allied issues without a knowledge of which, the deflection and gravity anomalies, as they now stand, are not calculated to give reliable quantitative results as to the structure of the trough.

The method of calculating theoretical effects adopted by Mr. Oldham is of doubtful validity. To derive effects of masses he has substituted an imaginary Range for the real Himalayas and has restricted his calculations to masses within a distance of 100 miles only from the station, omitting from consideration the masses beyond as of no consequence, on the assumption that the effects of such masses, when coupled with complete local compensation, are negligible and has assumed that the Gangetic Trough itself is not compensated. This is not in conformity with facts. Table IV on page 23 clearly shows that the effects of masses beyond 100 miles and which have been disregarded by Mr. Oldham, are considerable and vary from 29" to 65" showing a range of 36".

A perusal of the tabular statements on pages 29 and 30 will show the error to which the supposition of the Imaginary Range leads.

Further, for simplicity of computation, Mr. Oldham has introduced other innovations such as "centre of effect," "Concentration of mass"—conceptions which, though perhaps applicable to masses within short distances, are entirely out of place in investigations involving masses covering many thousands of square miles. He has, moreover, overlooked other rigorously determined Geodetic facts which are inconsistent with his theory.

Mr. Oldham based his theory of overcompensation on Basevi's incomplete gravity determinations at More and the faulty latitude-observations at Gogipatri and Poshkar.

Mr. Oldham's treatment of the Gangetic Trough is somewhat different from his treatment of other masses. For general purposes he limits the area

* Memoirs of the Geological Survey of India, Vol. XLII, Part 2, Calcutta 1917.

to be considered to the 200-mile square, arguing that the effects of masses outside this limit, when combined with those of complete compensation are negligible. But as he subsequently considers the alluvium of the Trough to have no compensation, the argument and the imposing of the 100-mile limit are inapplicable to the trough and the omission to take count of this would lead to error. On page 32 of his paper Colonel Cowie has calculated the effects of alluvium for a large number of stations on the assumption (1) that it is compensated, (2) that it is uncompensated, and also the total deflections with and without the trough. An inspection of this table will show that the introduction of the trough has not had the effect of removing the abrupt change in the residuals along the northern fringe of the Gangetic plain. There still exists between Dehra Dun and Kalia, Birond and Banskop, Siliguri and Jalpaiguri the rapid variation which contributed to the evolution of Sir Sidney Burrard's rift theory. There is no marked general improvement and the characteristic anomaly, the rapid fall in the value of the residual, remains unexplained, a problem still awaiting solution.

ASTRONOMICAL LATITUDES.

During the year under review, astronomical latitudes have been observed at Gogipatri, Poshkar, Zebanwan and Reban. The previous observations made at the first two stations in 1862 were considered below the standard of precision required for geodetic purposes and have accordingly been repeated. The results of the observations are now being computed and must be held over for discussion in next year's report.

MOUNT EVEREST EXPEDITION.

The scientific results of the expedition have not yet been fully worked out but in general outline some 13,000 square miles of new country have been surveyed and mapped, part of this by the "Canadian photo-topographical method of survey."

BOTANY

I.—BOTANICAL SURVEY

BY

LIEUT.-COL. A. T. GAGE, I.M.S.,

Director, Botanical Survey of India.

I. Systematic.—Eastern India and Burma.—The most important event of the year with regard to the botany of Eastern India is the appearance of Parts I and II of the Botany of Bihar and Orissa by Mr. H. H. Haines, C.I.E., late of the Imperial Forest Service. The two parts now published contain the account of 76 families from *Ranunculaceæ* to *Cornaceæ*. The work is a valuable addition to the provincial Floras of India. In Bengal Professor Bose has studied the geographical distribution of the species of *Polyporaceæ* found in that province and has described several new species. The species of *Dipterocarpus* occurring in the Chittagong District have been studied and form the subject of a paper by Mr. and Mrs. Cowan of the Imperial Forest Service. In Assam Mr. Kanjilal carries on his investigation of the forest vegetation in preparation for the publication of a Forest Flora of that province. In Burma attention continues to be given to the botany of the Cinchona area in Tavoy and collections are being steadily accumulated by Mr. P. T. Russell, Superintendent of Cinchona there, as his other duties permit. It is all the more fortunate that Mr. Russell is taking up this work, as owing to lack of funds it has been impossible to depute any of the Assistants of the Botanical Survey for field work. The latter however are working up at head-quarters as opportunity permits the collections made by Mr. Russell and the Director. A considerable number of new orchids have been described by Mr. W. W. Smith, from collections made in Upper Burma and the Burmo-China frontier by Mr. G. Forrest, Captain Kingdon Ward and the late Mr. R. Farrer. New species of *Phtheirospermum* and *Pedicularis* from the same region have been published by Mr. G. Bonati. A new genus of Moss—*Chionoloma*—founded on material collected many years ago by Parish at Moulmein, has been described by Mr. H. N. Dixon. During the year 1921 Mount Everest Expedition collections were made by Mr. A. F. R. Wollaston which have yielded several new species, that have been described by various botanists.

Northern India.—An interesting illustrated account of the Forest formations and successions of the Sat Tal valley in the Kumaon Himalaya has been published by Mr. L. A. Kenoyer. The Liverworts of the Western

Himalaya continue to be investigated by Mr. S. R. Kashyap. The *Astarga* of the Subgenus *Aegacantha* form the subject of a paper by Mr. R. N. Parker of the Imperial Forest Service and a considerable number of new species from the North-West Himalaya has been published by the same botanist and by Mr. S. T. Dunn. In Nepal collections were made by Dr. S. P. Agharkar and Professor R. S. Inamdar.

Western India.—Mr. L. J. Sedgwick, I.C.S., has published several new species of flowering plants from the Bombay side, and a collection of Mosses made by him in North Kanara has formed the subject of a paper by Mr. H. N. Dixon. An ecological study of Deccan grassland has been made by Messrs. W. Burns and G. M. Chakradev. The vegetation of Northern Gujarat has been further investigated by Mr. W. T. Saxton, I.E.S., and his results are now in the Press as a number of the Records of the Botanical Survey.

Southern India.—Since last year Part IV of the Flora of the Presidency of Madras by Mr. J. S. Gamble, C.I.E., F.R.S., has appeared, containing the Families *Rubiaceæ* to *Ebenaceæ*. Supplementary Note No. IV on the Flora and descriptions of new species from the south of India by the same author have also been published. A new species of grass from Coimbatore has been described by Messrs. K. Rangachariar and C. Tadulingam and a new genus of Moss from the Nilgiris by Mr. H. N. Dixon. Mr. K. Rangachariyar, the Madras Government Systematic Botanist, has published a handbook of some common South Indian Grasses and a second edition of his Manual of Botany. Mr. Jacob, his Assistant, made a collection in the Tinnevely Hills. As usual, material was supplied to Mr. Gamble to help in the preparation of his Flora of Madras.

General.—Mr. T. S. Sabnis continued his investigation of the physiological anatomy of the plants of the Indian Desert and Mr. P. F. Fyson his account of the Indian species of *Eriocaulon*. Professor Hallberg has recorded several instances of malformations in various Indian species. A revision of the genus *Canavalia* has been published by Messrs. C. V. Piper and S. T. Dunn. The flowering of *Arundinaria falcata* is the subject of a paper by Mr. J. S. Gamble. Short general accounts of the Family *Winteraceæ* and of the genera of *Fumariaceæ* have been published by Mr. J. Hutchinson. Asiatic Sedums have been studied by Mr. R. L. Praeger and a considerable number of new species described. Mr. H. H. Haines has published critical notes on the Indian species of *Carissa* and *Bridelia*. The Indo-Malayan species of *Jussiaea* have been studied by Mr. H. N. Ridley. Messrs. R. N. Parker and B. L. Gupta continue to publish their useful index to new Indian species of Forest importance. The first instalment of the systematic account of the *Euphorbiaceæ* of the Malayan Peninsula by the Director of the Botanical Survey has been in the Press for many months now and descriptions of the new species were published during the year in the Records. The species of *Artemisia*, a genus of economic importance as the source of Santonin, were studied at Kew by Mr. C. C. Calder, Curator of the Herbarium of the Royal Botanic Garden, Calcutta, while he was on leave. Mr. P. M. Debbarmar, Assistant in the Botanical Survey, contributed five papers on various branches

of Botany to the last meeting of the Indian Science Congress and has published notes on Syncarpy in various species of Indian plants.

II. Economic.—By far the most important work under this heading is Cinchona Cultivation in Southern Burma. As it would take up too much space to mention in detail all the work of the year and as detailed monthly reports are submitted to Government, only a general account is given here. The results so far obtained have been instructive, if not so satisfactory as could be desired in every respect. As the site selected early in 1920 for establishing nurseries was found on account of the excessive rainfall and high winds to be unsuitable for planting out the seedlings in the open, the latter were planted out about 4 miles to the South-East of the Huingye Taung amphitheatre—the site of the nurseries—on the Southern flank of the most South Westerly tributary of the Heinze river at an elevation of about 1,700 feet. Planting out could not be commenced until near the end of May 1921 and was continued throughout June. As a result of the unavoidable lateness in planting out the young plants had not time to consolidate their position in their new quarters before the full fury of the Monsoon burst upon them. As the South-West end of the valley acted as a funnel for the Monsoon current the young plants fared badly. The rainfall can be described only as terrific. During June, July and August of 1921 over 240 inches of rain fell, some of the falls being from 11 to 16 inches in twenty-four hours. More than half the tender young plants succumbed to the ordeal. Those that survived, however, put on excellent growth and up to the time of writing (July 1922) a year later are quite healthy and growing well. The vacancies were filled in at the end of the rains of 1921 and planting extensions were continued as weather conditions permitted up to May 1922. Of the later plantings from October 1921 to May 1922, those plants planted out up to the end of January 1922 are at the time of writing quite healthy and putting on good growth, but those planted out later than January 1922 have had to withstand a scarcity of rain during the early months of 1922 followed by a very heavy Monsoon rainfall, and it is probable that a considerable percentage of them will be unable to hold out over the Monsoon.

Although the experience so far gained shows that Cinchona, if planted out at a favourable time of the year can stand up against the enormous rainfall—which is far more than was ever expected—of the present plantation site, which appears to be the point of impact of the very arrow-head of the Monsoon, it is inadvisable to continue to expose young plants to more risks than are unavoidable. As the rainfall further South in the Tenasserim Division of Burma is not only considerably less in amount but is also less unevenly distributed over the year than is the case in the Tavoy District, it would be preferable to select another plantation site or sites considerably to the South of the present one, say in Mergui District, where there are enormous tracts of virgin evergreen hill forest land available rather than to continue to take risks that are unavoidable on the present area in Tavoy District. Proposals for taking action on these lines will be submitted to Government at an early date.

In addition to Cinchona, the cultivation of Ipecacuanha has also been experimentally started in the Cinchona area. The latest report—received in August 1922—states that the Ipecacuanha plants planted in 1921 have made very fine growth. The climate of Southern Burma being as regards temperature more equable than that of the Eastern Himalaya, Ipecacuanha is likely to flourish in Tenasserim, while it has not to run the risks of being exposed to the direct battering force of exceedingly heavy rain, as it is a small plant and is cultivated in protected nurseries. The extremely arduous pioneering work of exploring and opening up under very trying conditions has been carried out throughout the year by Mr. P. T. Russell, the Superintendent, whose energy and zeal have formed an essential factor in the knowledge so far attained and call for the highest commendation.

At headquarters a large number of minor economic inquiries—too numerous to mention here—from other Government departments, Botanical institutions in India and abroad, Universities and private individuals were dealt with.

IV. Publications.—During the year the following parts of the *Records of the Botanical Survey* appeared :—Vol. VIII, Nos. 2 and 3 being the continuation of the *Flora Arabica* by the Rev. Father E. Blatter, S.J. ; Vol. IX, No. 1, *A Survey of the Flora of the Anaimalai Hills* by Mr. C. E. C. Fischer, I.F.S.; Vol. IX, No. 2, *Euphorbiaceæ novæ e Peninsula Malayana* by A. T. Gage. A list of the more important extra-departmental publications concerned with Indian Botany is appended to this report.

BOTANY

II.—ECONOMIC BOTANY

Part I.—Agricultural Botany

BY

ALBERT HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.,

Imperial Economic Botanist.

The present report, which is limited to four pages of print, deals with the progress of Agricultural Botany in India during the year ending June 30th, 1922. Under these conditions, the best course would appear to be to limit this paper to an account of the more important results published during the year and to refer the student of Indian agriculture for further details to the various other annual reports and periodicals issued by Government which deal with the same subject but in greater detail.

The following publications contain a considerable amount of information on the improvement of crops:—

- (a) *Review of Agricultural Operations in India*.—This is an annual report, prepared by the Agricultural Adviser to the Government of India, Pusa, Bihar, and deals, among other matters, with the distribution of improved seed in various parts of India. It also contains a classified list of papers on Indian agriculture published during the year.
- (b) *Scientific Reports of the Agricultural Research Institute, Pusa* (including the Report of the Sugar Bureau):—Copies can be obtained from the Director, Agricultural Research Institute, Pusa, Bihar.
- (c) *Administration Reports of the Provincial Departments of Agriculture*.—Bombay, Bengal, Madras, Central Provinces, United Provinces, Punjab, Bihar and Orissa, Assam and Burma. These are issued by the Government presses in these Provinces towards the end of each year and contain a general summary of the work of the Agricultural Department (including the farm reports) and also the annual reports of the Economic Botanists. These administration reports largely form the basis of the annual *Review of Agricultural Operations in India*.

(d) *Proceedings of the Board of Agriculture in India*.—This contains the programmes of work in progress in Economic Botany as well as discussions on matters relating to the Agricultural Department as a whole. Copies can be obtained from the Agricultural Adviser to the Government of India, Pusa, Bihar.

(e) Many of the original papers on Agricultural Botany in India are published in the following periodicals :—(1) *Memoirs of the Department of Agriculture in India (Botanical Series)*, (2) *Bulletins of the Agricultural Research Institute, Pusa* and (3) *The Agricultural Journal of India*. This latter contains classified lists of all papers published on Indian agriculture. Copies of these publications can be obtained from the Director, Agricultural Research Institute, Pusa.

Cotton.—B. C. Burt and Nizamuddin Hyder (*Pusa Bulletin 123*) have carried out a survey of the cottons grown in Bundelkhand. The best of the types most suitable for field conditions has a lint length of about seven eighths of an inch and an average ginning percentage of 33. This cotton is being brought to the notice of the cultivators and in 1920 the area was 1,000 acres. B. C. Burt (*Pusa Bulletin 126*) has also published an account of further field and spinning trials of improved Cawnpore-American cotton in the United Provinces. G. R. Hilson (*Agr. Jour. of India, XVI, 564*) finds Balls' maximum combed length method suitable for the determination of the lint length of Indian cottons. M. L. Patel (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 75*) gives a detailed account of *goghari* cotton and has defined the ideal type of *herbaceum* for Lower Gujerat. In a bulletin published by the Bombay Agricultural Department, G. L. Kottur has dealt with the history, cultivation and improvement of Dharwar-American cotton.

Two other matters, which affect research work on this crop, have to be recorded. A Royal Charter has been granted to the Empire Cotton Growing Corporation whose functions include the provision of facilities for training future investigators, the strengthening of the Agricultural Departments of the Dependencies and Colonies, the establishment of a bureau for the dissemination of information on cotton growing and assistance in the marketing of the crop. The Corporation will be financed by means of a Government grant of £1,000,000 and by a levy on the raw material used in Great Britain. In India, a Central Cotton Committee, with headquarters at Bombay, has been constituted by the Government of India for the purpose of carrying out the work outlined in paragraph 261 of the recent Report of the Indian Cotton Committee. The Central Committee has already held a number of general meetings, has appointed a research sub-committee and proposes to carry out research work on the improvement and testing of cotton. Local Cotton Committees have since been formed in several of the Provinces.

Wheat.—O. T. Faulkner (*Agr. Jour. of India, XVI, 508*) has reviewed the various field trials and milling tests carried out since 1915 on Punjab 11 and 8A. These two wheats are very similar as far as yielding power is con-

cerned but Mr. A. E. Humphries considers that the grain quality of Punjab 11 is the better of the two. According to the last Administration Report of the Punjab Agricultural Department, the area under Punjab 11 is now over 634,000 acres. This variety was included in the twenty-five types of Punjab wheats selected by the Botanical Section of the Pusa Institute and handed over to the local Department for field trials in 1908. Punjab 11 has so far proved to be the best of these wheats for the Canal Colonies. The methods employed in the introduction of Pusa 12 and Pusa 4 in the Central Circle of the United Provinces are dealt with by B. C. Burt, A. Howard and G. L. O. Howard in Pusa Bulletin 122. The features of this undertaking are, firstly, the extent to which the co-operation of other Departments and of the people themselves has been secured in the work of seed distribution and secondly, the comparatively small cost of the work. The area under Pusa wheats in the United Provinces is now over 500,000 acres and the increased profit to the growers is at least Rs. 15 an acre. This works out at 75 lakhs a year for this Province alone. The various water saving experiments carried out during the last few years at Quetta, Mirpurkhas, Gungapur, Haripur, Sargodha and Shahjahanpur have been dealt with in Pusa Bulletin 118.

Sugarcane.—The principal item for record in the case of this crop is the publication of the *Report of the Indian Sugar Committee*, the members of which made extensive tours in India and also visited Java. The report contains a number of suggestions and proposals with regard to future research work on this crop and lays great stress on the importance to India of the improved methods of cultivation worked out at the Sugar Experiment Station at Shahjahanpur. Two papers have been published on this crop during the year. Jai Chand Luthera (*Agr. Jour. of India*, XVI, 519) described two species of *Striga* found damaging cane in the bet areas alongside the Sutlej in the District of Ludhiana. T. S. Venkataraman (*Agr. Jour. of India*, XVII, 127) finds that the viability of sugar cane pollen can be tested by germinating it on the living stigmas of *Datura fastuosa* var. *alba* and that pollen can be preserved for eleven days by preventing the dehiscence of the anthers. A new variety of cane, Shahjahanpur No. 10, has been found to resist frost in Queensland.

Water hyacinth.—K. McLean (*Agr. Jour. of India*, XVII, 23) gives an account of this pest in the delta of the Ganges and of the methods adopted in Bengal and elsewhere for its eradication. The Bengal Government has appointed a Committee, with Sir Jaghadis Chunder Bose, F.R.S., as Chairman, to enquire into the spread of the water hyacinth and to suggest measures for its eradication. It will be interesting to find whether there is any connection between the spread of this weed and the local drainage conditions in the Gangetic delta. It may be that the root of the trouble is not the weed itself but the falling off in efficiency of the natural drainage in certain areas of Bengal which in turn would provide favourable conditions for the rapid vegetative propagation of a plant of this character. Should this prove to be the case, artificial methods of eradication by themselves are likely to be inadequate. That there may be a connection between the spread of the water hyacinth and the life history of the local rivers is supported by the fact that 1917, a

year of high floods and therefore of good natural drainage, was followed by a reduction of the pest in 1918 and 1919. Silt bearing rivers are remarkable in the way they keep their beds free from vegetation during the rains.

Jute.—Nibaran Chandra Chaudhury has published a new edition of his book *Jute in Bengal* in which he gives an account of his discovery, in 1899, of the variety known as *Kakya Bombai*, which yields on the average about two maunds of fibre more than the average. In 1919, the area under this type, was said to be 100,000 acres. B. C. Burt and R. S. Finlow (*Agr. Jour. of India*, XVI, 618) described preliminary experiments in jute cultivation in the *ganjar* tracts of the Sarda and Gogra rivers. Provided suitable land is selected and proper care is taken in cultivation and retting, marketable jute can be profitably produced in this tract.

Rice.—G. P. Hector (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 153*) gives an account of the inheritance of the various colour characters in rice including those due to soluble pigment in various parts of the plant, the colour of the grain and of the inner glumes. Many of these characters are found to be inherited in groups or patterns and not independently. S. K. Mitra (*Agr. Jour. of India*, XVII, 248) describes simple methods of selection practised by the cultivators of Assam. S. K. Basu (*Agr. Jour. of India*, XVI, 69) has dealt with an interesting method of green manuring broad casted paddy in Orissa by means of *dhaincha* (*Sesbania aculeata*). S. S. Salimath (*Bull. 107, Bombay Dept. of Agr.*) describes a wild rice found in drilled paddy in certain parts of the Bombay Presidency.

Barley.—W. Youngman (*Mem. of the Dept. of Agr. in India, Bot. Ser. XI, 714*) has completed interesting experiments on the influence of atmospheric conditions on the germination of barley. A vapour pressure of 0.87 inches (0.0213 grm. of water vapour per litre of air) may be taken as the safest maximum to which Indian barley intended for malting may be exposed. Vapour pressures above this at first reduce and then totally destroy the germinating power in a comparatively short time. In practice this means that after May in North-East India it is not safe to ship malting barley to Europe by way of Calcutta without the risk of serious damage in transit.

Oil seeds.—C. S. Taylor (*Pusa Bulletin 117*) has given an account of various preliminary experiments carried out at Sabour on the influence of the environment on the oil content of various varieties of the castor oil plant. A. Howard and J. Stewart Remington in *Pusa Bulletin 124* describe the work done on safflower oil and its possible utilization in the arts. The conclusion is drawn that this oil should become a very useful economic product for the colour, paint and varnish industries, for soap and linoleum manufacture and for edible and culinary purposes.

Miscellaneous.—H. H. Mann (*Bull. 100, Dept. of Agr. Bombay*) has brought together, in a form very useful for future workers, a large amount of information on the fodder crops of Western India. W. R. G. Atkins in the issue of *Science Progress* of July 1921 has given an account of past work on indigo in Bihar and of his views on the impracticability of improving this crop

by chemical selection. S. H. Prayag (*Agr. Jour. of India*, XVII, 41) describes various methods of increasing the yield of grapes in Western India. A. T. Gage in the last report of the Cinchona Plantations in Bengal refers to the excellent results obtained at Munsong after coppicing various species of *Cinchona*.

BOTANY

II.—ECONOMIC BOTANY

Part II.—Forest Botany

BY

R. S. HOLE, C.I.E., F.C.H.,

Forest Botanist.

Oecology of Sal (*Shorea robusta*).—A summary of most of the experimental work carried out up to date on the factors influencing the development of sal seedlings was published during the year (*Indian Forest Records* Vol. VIII, Part II, 1921). Based on these results an experimental trial with a group-cum-strip system of regeneration was suggested for certain types of sal forest. This system possessed two features which rendered it troublesome to work on a large scale, viz. :—

- (1) the prescription that only alternate strips should be regenerated, the regeneration of the intervening strips not being undertaken until the second half of the rotation.
- (2) the prescription regarding a chess-board arrangement of patch fellings which are gradually extended in the form of strips.

The object of (1) was to insure as complete security as possible from drought and frost damage, by the provision of adequate side-shade both from the east and west, and of (2) to diminish damage by heavy weed growth. An inspection during the year of one of the Dehra Dun experimental areas, 180 feet in diameter, which was clear felled in 1915 and sown with sal in patches revealed the fact that the seedling growth here now was much more satisfactory than appeared probable at first. The seedlings here suffered considerably from drought during the first few years but now, after 6½ years, several have become thoroughly established with height growth attaining 5-8 feet. This, it is believed, justifies the conclusion that the more convenient system of continuous strip fellings (which will always insure side-shade from at least one direction) can be safely adopted instead of that of alternate strips. In the second place, it is probable that, as suggested by Mr. C. G. Trevor, weed growth can be sufficiently controlled by varying the width of the strips instead of by a chess-board arrangement of felling. With the co-operation of local officers in the United Provinces large scale tests of strip fellings on these

modified lines have been carried out during the year in the Dehra Dun and Haldwani Divisions.

The only factor which at present appears likely to militate against the success of the system is damage by rats. In the Dehra Dun experiments these animals have been responsible for very heavy mortality among the young sal plants by biting through the sappy tap roots of vigorous seedlings and saplings. As mentioned in last year's report, however, it is believed that this damage will be relatively unimportant when work is carried out on a larger scale. During the year, also, it was noticed that rat damage appears to be invariably worst where there is a heavy growth of grass especially of *Imperata* and large tufted species of *Saccharum*. The rats appear to be primarily attracted by the succulent rhizomes of the grasses on which they feed and incidentally they bite through the succulent sal roots which they come across in their burrowings in the grass. It is believed that grass growth and consequently rat damage can be adequately controlled by keeping the strips narrow, by allowing all good coppice growth to develop on the strips and form a part of the future crop and by sowing sal thickly and weeding during the early years, so that the seedlings may quickly form a close canopy.

The advantages of this strip system over the ordinary seeding felling method at present appear to be that it provides more suitable conditions of soil moisture for seedling growth, greater security against weeds, greater concentration and better control of artificial sowings and cultural work. It also avoids the damage to the young growth occasioned in seeding felling areas by the felling and export of the mother trees. At the same time the strips get the benefit of most of the natural seed produced by the trees on the edges of the cleared strips. Whatever success is eventually obtained with the strip system will be mainly due to Mr. C. G. Trevor, Conservator of Working Plans in the United Provinces, to Mr. E. A. Smythies, Sylviculturist, and to Messrs. H. G. Champion and M. P. Bhola, Divisional Forest Officers of Haldwani and Dehra Dun, who have heartily co-operated in the work of testing this system experimentally.

During the study of the oecology of sal which has been carried out in recent years it has frequently been noticed that the attacks of wood boring insects appear to depend greatly on the vigour of growth of the tree and on whether or not the "sap" in the tree is in active circulation. This to a great extent depends on the conditions of soil and soil moisture and these can be regulated to a considerable extent by the operations of practical silviculture. It is possible that an improvement of these conditions at seasons coinciding with particular stages of the life histories of such insects as *Hoplocerambyx spinicornis* in sal and the bee-hole borer in teak may materially reduce the damage done by these injurious pests. It is hoped that oecological work in this direction will shortly be developed in co-operation with the Forest Zoologist. The study of the effect of soil and moisture conditions in lowering the resistance of sal and sissu (*Dalbergia Sissoo*) to the attacks of the injurious fungi *Polyporus Shoreae* and *Fomes lucidus* was continued.

Systematic.—A matter the importance of which has become increasingly evident during the year is that of disseminating widely through all ranks of the Department a good practical knowledge of our forest species. The urgent need for an economic survey of forest resources is frequently emphasized by forest officers and the first step towards such a survey is to acquire a knowledge of the local species. It is not generally realised how much economic development is hindered by an insufficient knowledge of species on the part of local officers which makes it difficult to collect information regarding the local distribution and yield of commercial products and to obtain samples of them for research purposes. It is believed that two causes are chiefly responsible for this viz. :—

- (1) a tendency which has been somewhat prevalent in the past to think that a forest officer who studies and tries to know well the plants in his forest is gradually becoming "only a botanist" and is therefore decreasing in value as a practical forest officer.
- (2) the fact that the classical detailed floras now available in India, indispensable though these undoubtedly are, do not sufficiently facilitate the successful identification of species by the average forest officer.

As regards the first point, the idea appears to be due to a misunderstanding, on the one hand, regarding the lines of work which fall within the legitimate scope of the science of botany and on the other hand as to the kind of botany which an efficient forest officer ought to know. The decision as to the correct botanical name for any particular species or other group depends upon herbarium work and a study of the herbarium specimens, plates and original descriptions on which those groups are based and which are the authority for the various published specific and varietal names. Forest Officers, as a rule, have neither the time nor the opportunity for doing much work of this kind which should be done by the expert herbarium botanist. On the other hand, what is usually called field work which comprises a study of the living plants in the forest, of the characters which enable us to recognise them in the forest at different seasons of the year and of the range of variation which these exhibit forms a necessary part of forest botany and, to a more or less considerable extent, forms an essential part of the equipment of every efficient forest officer in India. A great deal could be done by those local forest officers who know their plants well in the way of helping other forest officers to increase their knowledge in this respect while if senior officers make it clear that they consider a good knowledge of local species necessary for efficiency it is believed that a considerable improvement would result.

As regards the second point, efforts have been made for many years to encourage forest officers who have studied their plants in the forest to prepare small simple floras, each one of which dealing with a small area and therefore a restricted number of species and in which forest characters are utilised as far as possible in the keys and descriptions. With the object of accelerating this work a scheme for the systematic preparation of descriptive lists of species was drawn up by the Forest Botanist in 1913 which subsequently received

the sanction of the Government of India (see *Forest Bulletin* No. 23, Calcutta, 1914). Descriptive lists of this kind provided with useful keys are really very efficient local forest floras and it is believed that such pocket companions for the field dealing with restricted areas will always possess a permanent value of their own. The first lists issued under this scheme were those for the 3 Forest Circles of the Central Provinces by Messrs. H. H. Haines and D. O. Witt which were published at Allahabad in 1916. Similar lists but in a preliminary form were under preparation during the year for the United Provinces by Mr. A. E. Osmaston and Mr. P. C. Kanjilal. This work has also been carried a definite stage further during the year by the completion of a local forest flora for the Andamans by Mr. C. E. Parkinson, a former forest student of Dehra Dun. Mr. Parkinson's work has materially increased our knowledge regarding the species of the Islands. Four new species have been discovered and more than 130 of the indigenous species described in his book either have not been mentioned at all or have not been reported as occurring in the Andamans in Brandis's *Indian Trees*. Mr. Parkinson's work has also indicated that several species which have been previously recorded for the Andamans probably do not occur in the Islands and that the well known Andaman Marblewood is not yielded by *Diospyros Kurzii* Hiern as has been hitherto thought to be the case. At the present time when methods of concentrated artificial regeneration are being extensively introduced into Indian forests, particularly in Burma and Bengal, it is especially desirable that forest officers should know their local species well and should have a good knowledge of the value of the products yielded by them so that steps may be taken to increase the proportion of the more valuable species in the regeneration areas, a point which has been drawn attention to by Mr. Shebbeare in Bengal. If this is not done it is possible that species of great potential value may be altogether eliminated from the forests. The following books were under preparation during the year: the *Flora of Bihar and Orissa* by Mr. H. H. Haines, a revised edition of the *Forest Flora of the Punjab* by Mr. R. N. Parker, a *Forest Flora and Descriptive Lists for Assam* by Rai Bahadur Upendranath Kanjilal, a revised edition of Lace's *List of Burmese Trees* by Mr. A. Rodger, of the *List of the Trees of the Bengal Duars* by Mr. E. O. Shebbeare, of Gamble's *List of Darjeeling Trees* by Mrs. Cowan and of a *Manual of Forest Botany* by the Forest Botanist and his staff. During the year 154 specimens were identified at Dehra Dun for inquirers and Mr. Parker, the systematic botanist, made a special study of *Dipterocarpus*, *Acacia* (groups *casia* and *eburnea*), *Berberis* and exotic species cultivated in India. Several excellent specimens of flowering bamboos were received from forest officers in Burma during the year. These include what is probably a new species and material which will considerably alter existing ideas regarding the limits of *Teinostachyum* and allied genera.

Pathology.—A careful study has been carried out by the Assistant Forest Botanist, Mr. Abdul Hafiz Khan, in co-operation with forest officers in Madras, with reference to the location and progressive accumulation of starch in the tissues of spiked sandal and the question as to whether truly spiked plants ever recover from the disease.

With the extension of plantations and the establishment of more or less pure crops over considerable areas there is a danger that the damage done in Indian forests by what are probably our most injurious fungi, *viz.* those which live in the soil and attack the roots, may increase in the near future but it is hoped to prevent this, on the one hand, by providing for the repeated and careful inspection of young crops so that the earliest attacks may be noticed and the infected trees and stumps removed with as little delay as possible and, on the other hand, by paying increasing attention to the soil conditions and seeing that, so far as possible, these are kept suitable for healthy root development.

BOTANY

II.—ECONOMIC BOTANY

Part III.—Mycology

BY

W. McRAE, M.A., B.Sc., F.L.S.,

Officiating Imperial Mycologist.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations carried out at Pusa during the year:—

Cereal Diseases.—*Piricularia oryzae* Br. et Cav. that causes a leaf spot and a discolouration and collapse of the haulm resulting in empty or partially filled ears of *Oryza sativa* (paddy) has been recorded from Baluchistan, Punjab, Bihar, Bengal in Northern India and from both the east and west coasts and the central area of Madras. Only in 1918 in Madras is it definitely known to have been epidemic but its having caused a small but noticeable amount of damage has been the reason for its collection in the other places. The loss in grain during the epidemic was as high as 90 per cent. in fields of an acre and 76 per cent. over 1,700 acres observed. The appearance of the disease is erratic. In the year after the epidemic in Madras the fungus was not found in the previously infected area though careful search was made for it during a period of two and a half months. Yet *P. repens* that is the common grass of the rice "bunds" and water channels was attacked by a *Piricularia* in a severe epidemic form. In Madras and Bihar fifty per cent. of the seedlings in the seed bed may be infected slightly and after being transplanted the plants may ultimately become almost free from disease. Infection experiments and the available meteorological records indicate that highly moisture charged air and a definite temperature are the limiting factors most concerned in deciding whether the disease is to be absent or cause slight or great loss. Species of *Piricularia* similar to that on the rice plant have been found on *Eleusine coracana*, *Panicum repens*, *Setaria italica*, *Paspalum sanguinale*, *Triticum vulgare* and *Panicum ramosum*. On the first two only has the fungus been found in epidemic form. The loss in grain in *Eleusine coracana* has amounted to 50 per cent. while *P. repens* is a wild grass of no economic value. Cross infection experiments indicate that the *Piricularias* on *Oryza*, *P. repens* and *Paspalum*, though each infecting its own host, will

not infect the others and that those on *Eleusine*, *Setaria* and *Triticum* are interchangeable among themselves though they will not infect the three previously mentioned hosts. The *Piricularia* on *P. ramosum* has been but recently found and nothing is known of its behaviour. The question whether there are four physiological strains of one fungus or four different species is left undecided as yet. Their anatomical and cultural characters are not very distinct but their ability to infect different hosts under our conditions is definitely restricted. Similar indications are observed in the field. While rice plants were infected with epidemic violence, plants of *P. repens* remained free and *vice versa*. *Eleusine* and *Setaria* growing in the same field were both infected as also *Eleusine* and *Triticum*. Of *Eleusine*, *Setaria* and *Paspalum* in the same field only the last was infected.

Two other diseases of paddy have been under investigation. One of them is caused by a sclerotial fungus which has not at present been identified. The sclerotia of this fungus are irregular brownish structures of considerable size (1—4 mm.) and this parasite is thus easily distinguished from the relatively commoner *S. Oryzae* Catt. It resembles in some respects the species *S. irregularare* Miy., which is known as the cause of damage in rice fields in Japan, and also the species *S. glumale* Ces., which has been recorded in Borneo. In India the parasite produces spots on the leaf sheath. These spots are very characteristic consisting of a light yellow brown area sharply demarcated by a dark reddish brown line. Under favourable conditions the fungus spreads over the whole plant which is speedily killed. The symptoms of the disease and the morphology of the parasite closely resemble those of a disease of sugarcane, which has been described in Java, under the name Djamoer Oepas, and has since been collected in India. Work is in progress to determine whether the causal fungus of the disease on paddy is identical with that on sugarcane.

The second disease of paddy is possibly caused by a species of *Cephalosporium*. The symptoms of disease in this case are a failure of the plant to produce grain. Paddy showing these symptoms, and infected with this fungus has been obtained from Burma and Assam and cases are recorded from the Central Provinces. It is as yet by no means certain whether the fungus which has been obtained in culture is the cause of the disease. It is not improbable that soil conditions may be the predominant factor in determining the incidence of this fungus as a parasite.

The smut (*Tolyposporium Penicillariae* Bref.) on *Bajra* (*Pennisetum typhoideum*) was investigated, at the request of the Director of Agriculture, Baroda State. This millet is one of the most important agricultural crops of the State and considerable annual loss in yield is caused by the smut. Preliminary experiments have shown that this disease is amenable to treatment. Plants from seeds treated with hot water at 60°C. for 10 minutes and with hot formalin vapour at 98°C. for 20 seconds gave considerably less number of smutted heads than plants from untreated seeds. Ordinarily the percentage of smutted heads is between 30 and 40 but the percentage was reduced to 8 and 15 in the case of the plants raised from seeds treated with hot water and

hot formalin vapour respectively. The seed treatment reduces a little the percentage of germination. Spraying flower-heads with Burgundy mixture and Lime sulphur and bagging the inflorescence from the time it was in the enveloping spathe to the time the seeds were set, had no effect in controlling the smut. The presence of the smut mycelium has been traced in seeds which look apparently normal; this confirms the field observations which had suggested that the disease was being carried in the seed. In seeds, not much infected, the mycelium is found in the scutellum and in the seed coat near the embryo.

Experiments on a field scale are being tried in the present season for controlling the smut by treating the seeds with hot water and with formalin and copper sulphate solutions. Hot formalin vapour treatment is not practicable for treating seeds on a field scale under our conditions, and so it is not continued this season. Seeds from Mirpurkhas and Lyallpur where this smut does not occur, are being tried at Baroda and Pusa.

Sugarcane.—A suspected outbreak of Mosaic disease of sugarcane in Sind was investigated and proved to be unfounded. Suspicious symptoms in two varieties—American D99 and Sathi at Pusa were also studied. Hypodermic injections from Sathi canes caused a discolouration of the leaves similar to that found in the leaves of suspected plants. Neither the “diseased” nor the infected plants were the worse for this discolouration.

The thick varieties of sugarcane are generally reported to be smut resistant, while the thin varieties are susceptible to the smut. While investigating the cause of this reported immunity of thick canes to smut, it has been observed that they are not necessarily smut resistant. The resistance of the following thick varieties—American D99, Sepaya, Malabar, Badela and Sathi—was studied and it has been found that they are susceptible to artificial infection; though in nature they are as a rule free from smut.

Jute.—Experiments to determine the influence of applications of sodium sulphate, as manure, on the growth of jute and the incidence of disease in the crop were continued throughout the year. The study of *Macrophoma Corchori* Saw. was continued both at Pusa and at Dacca. The fungus causes a stem rot of jute, similar to that already described as due to the attack of *Diplodia Corchori* Syd. The disease is most severe when there is a deficiency of potash in the soil. Applications of sodium sulphate appear to have had a considerable influence in reducing the incidence of this parasite. The spore stage of this fungus occurs only on the jute plant and in artificial culture the fungus remains sterile producing a small black sclerotia. This sclerotial form of the fungus appears to be identical with that previously described in India as *Rhizoctonia Solani* Kuhn.

Other Scientific Departments.

Madras.—Treatment of cholam seed (*Sorghum vulgare*) was carried out in Coimbatore, Bellary and Kurnool districts. Sufficient copper sulphate to treat seed for 46,000 acres was supplied to the ryots. The operations of

the Madras Agricultural Pest Act 1919 were extended to the Taluqs of Polavaram, Ellavaram and Chodavaram. Research work was carried out on *Helminthosporium* disease of paddy, *Vermicularia* attacking ginger, turmeric, chillies and cabbage and other diseases. The results of the investigations on *Vermicularia* on ginger were published.

A new series of spraying experiments on coffee were conducted during the past year with the object of reducing the cost of spraying against *Hemileia vastatrix* B. & Br. Evidence was obtained indicating that the incidence of the diseases Brown and Grey Blight of tea is more severe after attacks of *Hemileia*. The prevalence of *Rosellinia arcuata* Petch on tea bushes is directly connected with the presence of decaying *Cinchona* roots in the soil of tea gardens. Removal of decaying stumps and roots of *Cinchona* combined with liming of the soil has proved efficacious in some estates. During the past year a Rubber Mycological Station was opened at Mundakayam and a Rubber Mycologist was appointed. The loss of rubber, due to the attack of *Phytophthora Meadii*, during the past season was, on an estate, estimated at 18—28 per cent.

Bombay.—The storage rots of the potato were investigated. The work was directed mainly to the determination of the characteristic effects of the various suspected physical and biological causes of the rots and evidence was obtained which throws considerable doubt on the correctness of identifying the "Heat Rot." previously described with the "Black heart" of American authors. The symptoms described as Heat Rot appear to be the combined effect of certain Fungi and bacteria acting vigorously at the high temperatures obtaining in potato storage. These symptoms are not produced when heat alone (even up to 42°C.) is allowed to act on the tubers in the absence of micro-organisms and they are found to occur at the lower temperature of 85°F. which has been previously regarded as a suitable temperature for checking "Heat Rot." Study of the temperature relations of the fungi associated with the rots further showed that some of them, e.g., the Dry rot fungus, thrive best at 85°F. No treatment of tubers with fungicides is found to be effective in keeping out or destroying the rot fungi. The solution of the problem of potato storage has therefore to be sought in still further reduction of the temperature in storage.

The wilt disease of cotton was investigated and the races known as Dharwar 2 and Wagale showed considerable resistance to the disease.

Bengal.—The districts of Noakhali and Comilla were surveyed in order to find out the extent of the damage done to the paddy crop by ufra disease. On enquiry it was found that a decrease in the amount of disease had taken place. This is attributed to an improvement in drainage. The outbreak of bud rot on the palmyra palm in the districts of Burdwan and Hooghly was investigated. In some villages 300—400 trees have died in the last 6 years. As the palmyra-palm is not of much economic importance the inhabitants are not greatly concerned with the outbreak. The spraying of chilli against die back was carried out with satisfactory results.

Central Provinces.—A special enquiry into the smuts of jowar prevalent in the Province was made and propaganda for seed disinfection was commenced. A leaflet describing the method of treatment and a larger pamphlet were printed to assist in propaganda.

Assam.—An outbreak of early blight (*Phytophthora infestans*) on potato in Sibsagar was dealt with by spraying with Burgundy mixture. Bordeaux mixture was also used extensively for the same purpose on Shillong Farm.

AGRICULTURAL BACTERIOLOGY

BY

C. M. HUTCHINSON, B.A., C.I.E.,

Imperial Agricultural Bacteriologist.

Work was done at Pusa on the following subjects :—

Nitrogen fixation, symbiotic and non-symbiotic.

Nitrification in soils : relation of seasonal and controlled variation to crop development.

Green manuring.

Solubilisation of mineral phosphates and refractory organic manures by bacterial fermentation.

Treatment and use of cattle manure.

Sterilisation of water and milk ; preparation of an indigenous anti-septic.

Indigo.—The use of pure cultures in its manufacture. Investigation and classification of types of hydrolysers from various sources.

Yeasts.—Study of types suitable for use in various Indian Industries.

Biological analysis of soils.

FORESTRY

Part I.—Silviculture

BY

CAPTAIN H. TROTTER, M.C.,

Silviculturist.

The year under report was of special interest in that it recorded an important step in the progressive history of Indian Silviculture. That step was the convening of the second Silvicultural Conference at Dehra Dun in January 1922. The agenda of the Conference was limited to matters of policy and organisation and much useful work was accomplished. It is not proposed to give a detailed account of the various subjects discussed at the Conference in this report as they will be published *in toto* at an early date. It is of interest to note, however, that the relation between the Local and Central Silviculturists mentioned in last year's report has now been satisfactorily defined. In future it is suggested that the Central Silviculturist will confine his activities to investigations connected with seeds and seedlings and all other experimental silviculture will be done by the Provinces themselves. In the matter of statistics the field work is to be done locally and all results are to be worked out by a special computing staff at Dehra Dun. This division of labour should undoubtedly tend to further efficiency and the mutual co-operation resulting from it will do much to stimulate research work in this important science.

Statistical Work.—During the year 18 existing Sample Plots were re-measured by the Central Institute on behalf of the United Provinces and many other plots were re-measured by the Local Silviculturist in the same province.

A great deal of time was spent in converting the various statistical data collected in the past, into the new form as prescribed under the present Code. This conversion from the old method to the new has been a long and tedious business and it is satisfactory to note that most of the Sample Plots records have been now brought up to date.

Two Volume Tables were compiled and published during the year both for Sal. The first concerns I Quality Bengal Sal only and the second contains a general Volume Table and Form Factors for the same species.

It was hoped that sufficient data would be collected during the year to prepare a Yield Table for *Cedrus Deodara* and with this end in view a hot

weather tour in the hill Divisions of the Punjab had been arranged but owing to the unsettled condition of the Province this tour had to be abandoned.

The following publications were issued from this Branch during the year :—

- (1) Note on the Weights of Seeds by S. H. Howard, B.A.
- (2) Note on the Rate of Growth of Bengal Sal by S. H. Howard, B.A.
- (3) Code for the Collection and Compilation of Statistical Data with Appendices by S. H. Howard, B.A.
- (4) Volume and Form Factors by S. H. Howard, B.A.

The Sal (*Shorea Robusta*).

The experiments dealing with the natural reproduction of Sal by the Gorakhpur method were continued in Thanu Forest (U.P.) where frost damage is usually very severe.

It was unfortunate that this comparatively small area opened out in the centre of a large forest at once became the centre of the attraction to all deer and cattle in the neighbourhood and within a very short while every plant was nibbled down to 3 ft. or less. The area was fenced immediately and it is hoped that some reliable data will be forthcoming. This question of grazing would probably not occur on a large regeneration area and as grazing incidence was not the subject under experiment it was considered that fencing was quite legitimate in this case. Any small opening made in a dense forest is bound to attract animals from all round.

The results from the existing Sal Coppice Experiments are now being classified and the result will be submitted to the United Provinces Silviculturist for his opinion and if considered of sufficient interest will be published shortly. This question of Sal Coppice has been very thoroughly gone into by the United Provinces and it is understood that some reliable information will shortly be forthcoming.

The experiments on the storage of Sal seed were carried out on a large scale at the Central Institute at Derha Dun and the results will be published shortly. A short note on the transplanting of Sal seedlings raised in sawdust already appeared in the Indian Forester and it is hoped that a detailed account of the above experiment will be published during the coming year.

Afforestation.—The experiments in the afforestation of grassy blanks liable to heavy frost are being continued at Zabarkhet. It is too early yet to say whether root and shoot cutting of Sissoo (*Dalbergia Sissoo*) are preferable to line sowings of Chir (*Pinus longifolia*) or broadcast sowing of Sissoo.

All these methods appeared to be doing well up to date but no conclusions can be drawn until another hot weather and rains have passed. It is expected that something definite will be published during the coming year. It may be noted however that owing to the very severe drought in the abnormal hot weather of 1921 the root and shoot cuttings suffered a great deal and many

plants died off without shooting. Much better results might be expected in a normal year. The unweeded line sowings of Chir (*Pinus longifolia*) are so far looking extraordinarily healthy but it remains to be seen whether the young plants are able to endure the coming hot weather and rise above the vigorous growth of rank grass, which covers these areas during the rains. The broadcast sowings of Sissoo are most successful up to date and the area is covered thickly with young plants. It is now considered however that sowing broadcast is a mistake as no grass cutting can be done once the seedlings are established. In line sowings the difficulty is overcome and line sowings of Sissoo will be tried next winter. It may be mentioned that grass cutting pays for itself, the villagers being allowed to cut the grass and remove it for their own use. No weeding or irrigation has been done in any of the above mentioned experiments.

Experimental Silviculture.—This work is now done almost entirely by the provinces and it is impossible to detail the vast amount of experimental silviculture carried out by the provinces in this report.

The Central Institute has confined its activities to experiments dealing with seeds, germination, sowings and transplantings. A lot of useful information with regard to germination and the early growth of seedlings has been collected. Monthly height measurements have been started for the following six species, *Shorea robusta*, *Terminalia tomentosa*, *Dalbergia sissoo*, *Acacia Catechu*, *Bombax malabaricum* and *Cedrela Toona*. These will be published after one year's growth and will give an interesting idea as to the exact growing periods of these species. The nursery beds at Kaunli Experimental Garden are now being made 6' wide instead of 4', as heretofore. These wider beds are found to be more economical and practical and are the result of an interesting discussion which followed the reading of a paper on "The importance of Nurseries as an aid to success in the Taungya System" by Mr. L. E. S. Teague at the Silvicultural Conference. The beds are all protected from the direct rays of the sun during the hot weather by moveable sections of grass thatch. These have proved most beneficial to the young plants.

The most important work now being done at Kounli is the study of transplanting. Experiments on a large scale were started during the year with various species. Transplanting seedlings entire and with root and shoot cut back is being done both at the commencement of the rains and during the winter. Thus every species has 4 distinct chances and as 200 plants are used for each species, some reliable data on this important subject should be forthcoming at an early date.

The mass of information which has been accumulating in the ledger files at the Central Institute during the past few years is now being sorted and written up in concise form. It has not yet been decided in what form this information will be published.

The Camphor experiments were continued throughout the year and it is now considered that sufficient data is available to publish the result. This

note has been prepared in conjunction with the Forest Economist and rest Chemist and will probably be published during the coming year.

Development in Silvicultural Systems.—There is nothing of outstanding importance to record under this heading.

Several new working plans have been brought into force during the year most of which introduce or continue one of the many variations of the Uniform System.

The United Provinces have maintained the high Standard which was begun with the creation of the Working Plans Circle and other Provinces are now following suit. Burma and Bombay have already inaugurated Working Plans Circles and Madras, Bengal, the Central Provinces and Bihar and Orissa have appointed special officers for Silvicultural Research during the year.

Miscellaneous.—It is satisfactory to note that the importance of Silviculture in India has at last been recognised. Silviculture must form the basis of forest management and it must therefore find expression in Working Plans, and the creation of new posts for Working Plans Circles and the appointment of no less than 5 Provincial Silviculturists during the year is sufficient evidence to show how rapidly Silviculture in India is coming into its own. The division of labour between provinces and the Central Institute is now more or less clearly defined and with the decentralisation of experimental silviculture and the centralisation of statistical work the standard of efficiency should rise rapidly and the effects of such a policy will undoubtedly be reflected in a corresponding period of prosperity in the history of silviculture in India.

A list of publications received during the year is given below and special attention is drawn to Professor Troup's "Silviculture of Indian Trees." This book marks a very definite and important stage in the history of Indian Silviculture. It is the outcome of several years work in silvicultural research in the Forest Research Institute at Dehra Dun and outlying experimental stations, combined with observations recorded in many parts of India and Burma for a period extending over more than 20 years. The work deals with the trees of India mainly from a silvicultural point of view and takes its place as one of the most important standard works yet published. The author modestly states that it is but an attempt to pave the way for further silvicultural research and now that the importance of such research is becoming more fully realised in India, it is hoped that this work does really indicate the beginning of a rapid advance in the science of silviculture.

FORESTRY

Part II.—Economic Forest Products

BY

W. A. ROBERTSON, I.F.S.,

Forest Economist.

Owing to the new workshops and laboratories for the Economic branch not having been completed, no large developments of research could be undertaken particularly in the Paper Pulp, Seasoning and Minor Forest Products sections.

The balance of the new plant arrived but could not be erected.

A conference of Forest Officers specially concerned with Economic Research was held in January and had a large attendance. A temporary seasoning kiln was erected and various demonstrations were given in the other laboratories.

The Wood Preservation Specialist was not appointed during the year but the appointment is believed to be still under consideration.

Antiseptic Treatment of Timber.—All the experimental sleepers which have now been in the line from 8 to 11 years were inspected and the statistics brought up to date. On August 1st, 1921 Mr. R. S. Pearson, C.I.E., Forest Economist, read a paper at a meeting of the Chief Engineers of Indian Railways in which he explained the objects of these experiments and gave the results to date. At the request of the Railway Board this note was subsequently amplified and handed over to it to publish as a Technical Record for the use of Railway Engineers. A further note on the subject is in the press. It will appear as a Forest Record in continuation of Mr. Pearson's Indian Forest Record, Vol. VI, Part IV. The two methods of treatment which have proved most successful are a mixture of Creosote and Earth Oil introduced in fairly large quantities, and the Powellizing Process, a patent process employing sugar and arsenic. During the year the North-Western Railway have been treating as many Pine sleepers as possible with Creosote in an open tank and have now set up a pressure plant which is about to start work.

Paper Pulp Section.—The machinery and plant for the experimental pulp and paper factory has now arrived and will shortly be erected.

Enquiries continue to be received from parties desirous of exploiting the industry and samples of raw materials forwarded by them and by Forest

Officers have been examined and reported on. The laboratory has also been engaged on an investigation of Bhabar grass with the object of reducing its bleaching cost on the lines which have been successful with bamboo. This promises to yield good results and has reached a stage at which operations can be transferred to the experimental factory as soon as it is erected.

The bamboo survey of the Angul Division, with which this section has been assisting, has been completed.

Substantial progress has been made on the commercial side. A new factory at Naihati, near Calcutta, is now successfully producing paper from bamboo. Another, proposing to use Savannah grass, is in course of erection in Assam.

Seasoning.—(i) *Natural*—Final inspections were made by the Officer in Charge of Seasoning, of the natural seasoning experiments in Madras and Coorg. The complete report on all these natural seasoning experiments is in the press.

(ii) *Artificial*—A temporary semi-portable kiln was erected in Dehra Dun for demonstration purposes. Both hardwoods and softwoods have been successfully treated.

The special seasoning requirements of the Gun Carriage Factory at Jubulpore are being studied.

Testing.—About 2,000 routine tests were carried out under Project 1, technically known as "Control tests." For immediate results about 1,000 "Suitability tests" have been made notably for sleeper woods, sucker rods, hammer handles, and wooden plugs for concrete sleepers. In addition to this, tentative grading rules have been drawn up at the request of the Military Works Department for which purpose additional special tests had to be made.

The activities of this section have been most successful, a large amount of information having been made available.

Wood Technology.—Dr. H. P. Brown of Syracuse University arrived to take over charge of the section. A large number of timbers have been identified at the request of forest officers, railway companies and the timber trade generally. Information has been supplied on the suitability of various timbers for special industries.

A start has been made towards preparing general and special keys for the identification of Indian timbers.

Finding of Markets, etc.—As usual a large number of enquiries regarding timber supplied were dealt with and bulletins on the following timbers were issued during the year :—

Odina Wodier.	}
Bombax malabaricum.	
Adina cordifolia.	

Gum Resins and Oleoresins and other Minor Produce.—Further areas suited for the tapping of *Boswellia serrata* were considered and a trial

consignment of raw gum sent to England to determine its market value in respect to grade and colour. Further examination of the turpentine is being carried out by the Forest Chemist.

Experiments to improve the yield of the gum of *Sterculia urens* were initiated in several divisions. A large number of enquiries were received dealing with drugs, fixed oils and gums.

Tanstuffs.—On return from leave the Officer in Charge proceeded to Mergui to continue the investigation of the mangroves. During the year he collected the tanstuffs required for the tannage of the exhibits for the British Empire Exhibition.

Charcoal Briquettes.—Briquettes prepared from materials supplied last year were received from America. These together with briquettes made locally were subjected to crushing, rolling and burning tests.

The briquettes were found to be quite well suited to industrial purposes but were not quite satisfactory for domestic use.

ZOOLOGY

I.—GENERAL ZOOLOGY AND PHYSICAL ANTHROPOLOGY

BY

N. ANNANDALE, D.Sc., F.A.S.B.,

Director, Zoological Survey of India.

Tours.—The following tours were undertaken by members of the department:—

	Days.
To Simla from 7th May to 22nd May 1921 by Dr. S. W. Kemp	16
„ Simla from 8th June to 27th June 1921 by Mr. S. L. Hora	20
„ Kashmir from 23rd May to 27th July 1921 by Dr. B. Prashad	66
„ Kashmir from 28th May to 22nd July 1921 by Mr. B. N. Chopra	56
„ Simla from 23rd September to 19th October 1921 by Dr. S. W. Kemp	27
„ Cherrapunji from 24th October to 8th November 1921 by Mr. S. L. Hora	16
„ Delhi from 25th November to 4th December 1921 by Dr. S. W. Kemp	10
„ Madras from 27th January to 8th February 1922 by Dr. N. Annandale	13
„ Madras from 25th January to 8th February 1922 by Mr. Srinivasa Rao	15
„ Siju Cave, Garo Hills, from 22nd January to 23rd February 1922 by Dr. S. W. Kemp	33
„ Siju Cave, Garo Hills, from 22nd January to 23rd February 1922 by Mr. B. N. Chopra	33
„ Southern Shan States from 28th February to 30th March 1922 by Dr. N. Annandale	31
„ Southern Shan States from 28th February to 30th March 1922 by Mr. Srinivasa Rao	31
„ Southern Shan States from 28th February to 31st March 1922 by Mr. S. L. Hora	32
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The most important of these tours were those to the Siju Cave, to Kashmir and to the Southern Shan States. From the first of these in particular interesting results are expected. The other two tours were undertaken primarily in connection with the survey of the freshwater molluscs of India and both were successful in attaining the objects for which they were undertaken.

Publications.—The following publications have been issued during the year:—

“Records of the Indian Museum” vol. XXI., part I.

“Records of the Indian Museum” vol. XXII., parts I—V.

“Memoirs of the Indian Museum” vol. V., Nos. 8 and 9.

Library.—Progress has been made in the library, but we have been much handicapped by lack of staff.

The total additions are 2,055 in number. Of these, 728 books and parts of periodicals were purchased and the remainder received in exchange and by presentation.

The following important additions may be specially mentioned :—

- (1) *Expédition Antarctique Française* 1903-5. A complete set.
- (2) *Deuxième Expédition Antarctique Française* 1908-10.
A complete set.
- (3) *The Norwegian North Polar Expedition* 1893-96 vols. I-VI. A complete set.
- (4) *Natura*, vols. II-XII : Milan (1911-21).
- (5) *Feuille de Jeunes Naturalistes*. 1872-1913.

All of these except the last were obtained by presentation or exchange.

Collections.—The collections have for the most part remained in good condition but have suffered severely from lack of supervision, due to a numerically inadequate staff both technical and scientific. It has been found impossible to prevent petty thefts of spirit and bottles, which often involved the loss of valuable specimens including a number of "types."

The most important additions to the collections were those made by the members of the department while on tour. The most important received from those not connected with the Museum were a large set of insects, reptiles, etc., collected by Mr. R. P. Mullins in the Chittagong Hill Tracts and presented by him.

Galleries.—The lack of staff and funds have stood in the way of any progress in the public galleries of the Museum. The hope expressed by Dr. Kemp in the last report that a part of the invertebrate gallery would be refitted and opened to the public has not been fulfilled.

In the Ethnological Gallery the additions to the collections were mostly made by the officers of the department and were collected in various parts of India and Burma. A small number were also acquired by purchase, including a set of musical instruments from Baluchistan.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part I.—Agricultural Entomology

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist.

I.—Work at Pusa.

This has followed on the lines of previous years and a more complete account is given in the Annual Report of the Imperial Entomologist.

Work on Borers in sugarcane and other gramineous plants has been continued. Insect Pests have been dealt with as occasion arose. Investigation of life-histories of Indian insects has been continued, their early stages described and figured, the insects reared out including many new to science. A good deal of attention has been paid to an endeavour to ascertain the life-history of *Ochromyia*, but hitherto without success, although it is suspected that the larva lives in the soil and is predaceous, possibly on earth-worms. Further work has been done on the role of blood in ovulation in Culicidæ but no definite results can yet be chronicled. Several cases of human myiasis, due to *Chrysomya bezziana*, came under notice during the year.

Work with Bees and Lac has been continued and the sericultural experiments were continued until 31st March 1922, when the silk section was transferred to the Department of Industries under the Bihar and Orissa Government.

The usual steady progress has been made, as regards the Insect Survey, with the increase, arrangement and identification of the Pusa collection of insects, which is now a large and important one, and is increasingly taken advantage of by the Provincial Staffs and other workers on Indian Entomology for the identification of their material.

The first part (Acrydidæ) of the Catalogue of Indian Insects was issued during the year and the second and third parts, on Culicidæ and Bombylidæ respectively, were in the press at the close of the year. Active preparation of other parts has been in progress.

Five parts of Entomological Memoirs and the Report of the Fourth Entomological Meeting, containing fifty papers on Indian Entomology, have been issued during the year.

II.—Work in the Provinces.

Madras.—The main lines of research work during the year consisted of:—

- (1) Continuation of study of strains of cotton resistant to *Pemphres affinis*.
- (2) *Platyedra gossypiella*. Confirmation of last year's results. Effects of application of the Pest Act, etc.
- (3) Bionomics of *Siga incertellus* and other borers in paddy in the Godavari Delta.
- (4) *Hispa* control campaign in South Kanara. A sub-station is now being opened at Kasaragode for the study of this pest.
- (5) Study of bacterial infection of cotton bolls and the causes of bud and boll fall. The former with the Government Agricultural Bacteriologist and the latter with the Cotton Specialist.
- (6) Preliminary investigation into *Helopeltis theivora*.

Central Provinces.—Observations on the emergence of the *ber* fly (*Carpomyia vesuviana*) were continued last year and the results were written up. In that paper an attempt has been made to correlate the attack of the fruit fly with sweetness of the fruits by quoting results of chemical analysis of the fruits. The Nagpur variety of *ber*, being much sweeter, is attacked more than other wild varieties. The emergence of the fly is shown to have some relation with humidity and temperature. Of the two Braconid parasites of the fly, *Biosteres carpomyiae* has also a definite aestivation period like that of its host; while *Bracon fletcheri* does not seem to occur when the fruiting season is well advanced. As regards control measures the power of the penetration of the maggots into the soil for pupation, the nature of the soil and aestivation period suggest that the soil underneath the *ber* trees should be disturbed and burnt during the hot weather in order to kill the pupæ.

Bengal.—The following were the chief insect pests under observation during the year: (1) *Rhynchocoris humeralis*, (2) *Cappæa taprobanensis*, (3) *Monohammus versteegi*, (4) *Indarbela tetraonis*, (5) *Rhytidodera simulans*; the life-histories of these pests were worked out and a note was published and distributed amongst the orange growers.

With regard to the Mango Weevil (*Cryptorhynchus gravis*), the bagging of fruits was continued with success. It has also been found that general failure of a year's crop after the last cyclone of 1919, which meant starving out the weevils, has done a good deal in checking the pest, and so fruits of even the worst-affected trees were almost free from the pest in 1921.

Assam.—Very serious damages were caused by Rice grasshoppers over an extensive area near Hajo in Kamrup where a demonstration in control measures by bagging was conducted.

Cutworms (*Agrotis ypsilon*), which are a regular pest of cold weather crops, cause seriously extensive damage only in cases of commercial growers of onion and potatoes such as those in the South of Habiganj. Two Andres Maire traps were set up near the villages of Khorki and Katora in Bejura Pargana, where about 100 acres of concentrated onion fields were kept under observation from the middle of December to the middle of March last. The idea was to attract the parent moths with molasses, etc., and to trap them before they laid eggs in the fields and so avoid an outbreak of the pests. A large number of moths was captured and the crop suffered no appreciable damage.

Regular classes of Agricultural Inspectors were held and instructions were given to enable those officers to recognize common pests, know their life-history and control measures, to report intelligently on outbreaks and to collect and despatch specimens for identification. Considerable progress has been made with systematic work in this line.

Burma.—Paddy.—Investigation of the pests of this crop was carried out at various places. A Conference was held at Sagu (Minbu District) in March with the cultivators in order to inaugurate concerted measures against insect and rat pests in the Mon Canals area.

Seedlings, damaged by *Nymphula depunctalis*, planted separately without any treatment at Hmawbi, were observed to recover and yielded a fair crop.

The damage caused by borer pests, as far as could be observed at different places, was not more than about one per cent. *Chilo simplex* was not met with anywhere. *Siga incertellus* (*Schoenobius bipunctifer*) was, however, observed to injure seriously *Mayin* paddy at Paunglin in the Minbu district. Means of preventing this damage were demonstrated.

Rats were investigated in Leiktho Hills and in the Mon Canals area and a campaign started in the former area with the help of the Deputy Commissioner, Toungoo.

Sugarcane.—Observations were made on the pests. *Holotrichia* grubs were reported as very injurious at Singaing. The life-history of this beetle was traced in the laboratory.

Cotton.—Observations on the bollworm pests were made in the laboratory and in fields.

Chinboun (*Hibiscus cannabinus*) was damaged by *Anomala antiqua* beetles in July and August at Mandalay. Experiments in checking the damage were successful with Kerosine emulsion spray and shaking the plants with a rope in the evening. The life-history of this beetle was traced fully in the laboratory as well as in the fields.

An attack of Aphids on *Pe-Byu-gale* at Mandalay and Tatkon was successfully checked with simple soap solution.

Brachytrypes portentosus (Payit) was investigated at Madaya.

Palms.—*Oryctes rhinoceros* was fully studied both in different districts and in the laboratory throughout the year. A poster was prepared and will be printed and distributed soon.

The red weevil (*Rhynchophorus ferrugineus*) also was under observation. An attack on coconut by *Nephantis serinopa* at Mandalay was checked by cutting off and burning the affected lower leaves.

Tea.—Zeuzerid and Arbelid pests were reported from Thandaung and proper remedies were suggested.

Silk.—Work in the Maymyo nursery was started in October and microscopically-examined eggs have since been regularly supplied to the rearers in Prome. A full demonstration of rearing, reeling, etc., was given in the exhibition held in connection with the Biennial Co-operative and Agricultural Conference held in August 1921 at Mandalay.

Lac.—Arrangements were made for growing the proper variety of *Cajanus indicus* (*pe-sinn-gon*) at Maymyo, Mandalay, Padu, Tatkon, Hmawbi, Allanmyo and Pwinbyu for trying lac.

Bees.—A start was made with four colonies of *Apis indica* at Maymyo.

Bihar and Orissa.—The work on the parasite of *Agrotis ypsilon* was continued. It has been seen as in the previous year that for a successful rearing of the host a cooler temperature than that prevailing in the Plains in August and September is necessary.

Observations were made on the life-histories of a large number of major and minor pests and the life-histories of some pests have been and are being worked out in the Insectary.

Eggs of Eri silkworms were supplied to the Department of Agriculture, U.S.A., at the request of their Agricultural Explorer.

United Provinces.—Research work in the United Provinces was almost entirely confined to pests of cotton, and centred largely upon the pink bollworm, *P. gossypiella*, Saund. and the spotted bollworms, *E. fabia*, Stoll., *E. insulana*, Boisd., and *E. cupreoviridis*, Wlk., as being the most important economically. An extensive investigation of these insects was carried on throughout the whole year both in the field and laboratory, from biological and statistical standpoints. Particular attention was given to the variation in length of life-cycle, and rate of increase, and to hibernation; and, in the case of *P. gossypiella*, to the assumption of the "long cycle" habit, and dates of subsequent emergence of moths. Considerable data were collected upon the percentage of infection and consequent loss of crop. The work must be regarded as preliminary only to a fuller investigation, and its main object was to indicate the lines of future research. Experimental sowings of heat-treated seed were made for the ensuing season. Investigations were also conducted on the moth-borers of *juar*, *Idiocerus* spp., and *Monophlebus* sp., on mango, and *Galerucella singhara*, Lef., on water-nut (*Trapa bispinosa*).

Punjab.—Cotton Bollworm was not a serious pest in this Province last year. The percentage of attack was about five to seven per cent.

Figures of the percentage of parasitization of the bollworms have been collected from the different parts of the Punjab. At Hissar as many as fifty per cent. of the bollworms were found parasitized by *Microbracon lefroyi* and *Rhogas testaceus*.

Experiments were started on various lines to control the stem-borers of maize and sugarcane. Light traps (50 candle power) were set up to attract the moths. This was done for a fortnight, two hours every day. In all 499 *Chilo* sp. (51 males and 448 females), 84 *Scirpophaga* (17 males and 38 females), 62 *Polyocha* (17 males and 35 females), were trapped.

Euphalerus citri, a Psyllid pest of *Citrus* trees, was successfully controlled by means of spraying at several places. The attack of *Dialeurodes citri* (*Citrus* Aleyrodid) was noticed for the first time last year. Sprayings were tried against this pest also, but the percentage of mortality was not so high as in the case of the Psyllid.

Winter sprayings against the mango hoppers (*Idiocerus atkinsoni* and *I. clypealis*) were again done during the last year. The hoppers were considerably reduced in numbers in the treated gardens.

With regard to pests of stored grains, confirmation has been obtained of Prof. Dendy's results on air-tight storage; about sixty experiments were performed and in all the completely air-tight vessels the larvæ of the *Khapra* beetle died within a few days. Even very badly infested wheat, when kept under air-tight conditions, improved in so far that all the stages of insects attacking it, were killed.

A long series of experiments on superheating of the infested grain was also performed and superheating was successfully employed in killing the larvæ in several seed godowns. When treating godowns empty of grain, but infested with the pest, desiccation is cheaper and is as successful as fumigation with carbon bisulphide or hydrocyanic acid gas.

Laying of the poisoned baits (Strychnine and arsenious acid) and fumigation with carbon bisulphide by means of the Suddeath Rabbit Exterminator have proved very useful in killing rats.

III.—Native States.

Mysore.—The most important result obtained during the year is the discovery of a very simple method of controlling sugarcane borer (*Diatraea* sp.). The method consists in trapping the moths in small trash heaps appropriately placed in the cane field. Trials have shown that damage can be reduced from forty to two per cent.

The usual campaign against the *Kamblihulla* pest (*Amsacta albistriga*), conducted in 23 villages, resulted in the capture and destruction of 1,20,000 moths representing six million caterpillars. The control of the Castor Semi-looper pest (*Achæa janata*) was successfully carried out in six villages and demonstrated in twenty others.

From results obtained with *Brunolineum* as a wash against *Xylotrechus quadripes* it appears that chemicals going by that name are not all identical in composition.

Other investigations related to the Rhinoceros beetle, mango hoppers, Lime tree borer, Paddy stem borer, a new beetle pest of cane, *Epilachna* on potato, Bruchids, and Tobacco Aphid.

Travancore.—The swarming caterpillar (*Spodoptera mauritia*) caused considerable damage to the *punja* rice crop in Kuttanad. The attack of rice stem borer (*Siga incertellus*) was very severe on the rice crop in South Travancore; observations were made under field conditions of the habits and life-history of the pest. The rice leaf roller (*Cnaphalocrocis medinalis*) is another serious pest which appeared in several places during the year; beating the crop with a stout cane held in a horizontal position and sprinkling a mixture of wood ashes and lime in the proportion of 4 : 1 was tried with great success. An attempt was made to study the life of the rice bug (*Leptocoris varicornis*) after the harvest of the rice crop; the remedy suggested in "The short notes on insect pests of crops in Travancore" was found more effective than any other. Other minor pests of rice dealt with during the year were the rice *Hispa*, rice case-worm and rice skipper.

Of the pests of the coconut palm, *Nephantis serinopa*, owing to its expansion throughout the sea-board taluqs and the highly destructive nature of its attack, was by far the most important pest that engaged the attention of the Department during the year. Rules have been framed under the Plant Pest Regulation to enable the officers of the Department to adopt prompt measures to eradicate this pest. Temporary fieldmen were engaged in several places to bring the pest under control. Despite all these efforts the attack of the pest still continues.

Baroda.—The main work done during the year was demonstration of control measures against grasshoppers.

ZOOLOGY

II.—ECONOMIC ZOOLOGY

Part II.—Forest Entomology

BY

N. C. CHATTERJEE, B.Sc., F.E.S.,

Assistant to Forest Entomologist.

The office of the Forest Zoologist (Entomologist) was held by Mr. C. F. C. Beeson, M.A., I.F.S., F.E.S., up to the 15th May 1922. From the 16th May to present date Mr. W. F. Perree, C.I.E., President, Forest Research Institute and College, held charge of the office.

Insects of Sal.—Borers (a) *Field Work*.—In Thano Forests, Dehra Dun, an area of epidemic occurrence of *Hoplocerambyx spinicornis*, enumerations were made to obtain comparison of the annual attack as affected by climatic conditions and control measures. During the season 1921, the number of trees attacked was estimated at 6,000 which was 24% of the attack in the heaviest year when the rainfall was 117 inches being 34 inches above normal. The rise in the total annual rainfall has resulted in an increased mortality of the attacked trees as was expected; but the actual number of deaths in 1921 in the seven compartments used as sample plots was 30 % of the number in 1917, a year with approximately the same rainfall. This reduction is considered to be due to the control measures formulated in 1920. Under all conditions of rainfall, the distribution of attack was found to be uniform throughout the girth classes.

(b) Experiments on the correlation of rainfall and periodic emergence of *Hoplocerambyx spinicornis* were repeated in the Insectary and previous results were confirmed. The survival and successful emergence of the borer in sleepers, beams, rafters, slabs, etc., was demonstrated.

(c) The length of life, fecundity, oviposition, incubation of beetles and early development of the larvæ were studied under variable conditions of humidity in the laboratory. Dry conditions were found to be unfavourable in all cases and fatal below 60% relative humidity. Extreme wet conditions were found to be less favourable. The limits of the optimum conditions have not yet been determined.

(d) Further informations have been collected on the life-histories of other borers in particular of *Xylotrechus smei* and *Sphaerotrypes sivalikensis*. The genus *Sphaerotrypes* is being revised in connection with the biology of *Sphaerotrypes sivalikensis* and preliminary conclusions have been published by Mr. Beeson in the Indian Forester.

Insects of Teak.—(a) *Beehole borer*.—A preliminary note on the ecology and economic status of the beehole borer, *Duomitus ceramicus*, by Mr. Beeson was published during the year.

(b) *Other pests*.—A compilation of the available information on teak pests has been started, but completion of the work is postponed until Divisional Forest Entomologists are available for further research.

(c) Examinations of the possible host trees of a sister-species of the beehole borer *Duomitus leuconotus*, are being carried out in the Dehra Dun forests with a view to study the biology and life-history of the genus *Duomitus*.

Miscellaneous Pests.—The shothole borers of the evergreen forests.

A tour in May and June 1921, in Sibsagar and Lakhimpur Divisions, Assam, indicated that the dominant feature of the borer fauna of felled timber, is the numerical superiority of the shothole borers *Platypodidae* and *Xyleborinae* which are rich in species of Malayan forms new to India. In the evergreen forests trees like *Vatica lanceaefolia*, and *Dipterocarpus pilosus* are attacked in addition to the local series by almost all the shothole borers occurring in *Shorea robusta* in Bengal and North West Assam. Passing into the drier Dipterocarp forests with fewer tree species in admixture, the shothole borer fauna grows sparse and species like *Diaprus furtivus* and *Platypus solidus*, which in the moist evergreens are less abundant, become the dominant members of the association.

THE BORERS OF TIMBER UNDER SEASONING.—

Work was continued on the liability to attack, by borers, of timber under different methods of seasoning, and on the species of insects responsible for the various forms of damage. A summary of the results has been prepared for the press in collaboration with the Timber Seasoning Officer.

A general survey made of dead trees, on the variety and extent of borer injury, yielded the unexpected information that the living tree is commonly subject to attack by insects of the beehole borer type, which damage the timber without seriously affecting the vitality of the tree. Recognition of this type of damage permits a correct appreciation of value of empirical methods of seasoning.

Insect pests of Afforestation.—Field work in September 1921, in Afforestation Division, U.P., indicated that plantations of *Acacia arabica*, *Dalbergia Sissoo*, etc., are not subject to serious damage by insects, except under epidemic conditions.

Borer of Museum exhibits.—The biology and life-history of a polyphagous species, *Stromatium barbatum*, Fabr., a serious pest of stored timber polished and unpolished museum wood specimens, etc., is under study.

Parasites of Scale-insects and wood borers.—Dr. Waterston's paper describing new species of *Chalcidoidea* parasites on pests of Chir, Sal, Toon, Sundri, etc., is in the press as a Forest Record.

Miscellaneous pests.—A total of 131 consignments including 311 wood specimens, and many shoots and cones, etc., were received for investigation during the year under report. From these some 11,000 insect specimens belonging to various orders have been bred out, which have added considerably to our knowledge of host plants and distribution of forest pests.

SYSTEMATIC ENTOMOLOGY

BY

DR. M. CAMERON, M.B., M.R.C.S., L.R.C.P., R.N.,

Systematic Entomologist.

Work in this section has been continued on the identification of material in the Institute and its incorporation in the collections as under :—

	Specimens.
Lepidoptera	1,640
Rhynchota	1,568
Coleoptera	856
Hymenoptera	709
Neuroptera }	319
Odonata }	
Orthoptera	146
Diptera	123
Other orders	50
TOTAL	<hr/> 8,411

The number of species added is 636 of which 30 are either types or co-types.

Numerous parcels of insects received from Forest Officers have been determined and their habits noted.

The number of insects set during the year under consideration is 15,800.

VETERINARY SCIENCE

BY

J. T. EDWARDS,

Director, Imperial Bacteriological (Veterinary) Laboratory, Multesar.

For the greater part of the year the higher technical staff was limited to the officiating director, third bacteriologist, veterinary officer, and hence the researches of the laboratory were restricted in view of the contingent demands of routine serum manufacture and administration.

Rinderpest.—The investigations foreshadowed in last year's report were carried out. Experiments showed that it is possible to utilise animals of moderate susceptibility to rinderpest, namely, buffaloes, as virus producers in the process of hyper-immunising animals for routine serum preparation. Carefully controlled tests indicated that inoculation with a single protective dose of anti-rinderpest can be depended upon to confer a passive immunity upon susceptible animals for nine days, after which interval the protection needs to be repeated in the case of persisting massive infection. Increased doses of serum confer an immunity of perceptibly longer duration, which however, appears to be far short of being in direct proportion to the increase in dosage.

The immediate and lasting benefits that would accrue from widespread active immunisation, by the simultaneous or serum-virus method, are demonstrated in the laboratory publications; the administration of a large protective dose of serum in this method with the object of diminishing the severity of the reaction due to the virus-injection did not seem to inhibit the production of the desired degree of active immunity. A type of apparatus was devised which had for its object the easy and efficacious hyper-immunisation of animals on a large scale with virulent blood.

Contagious Abortion in Equines.—Experiments were carried out in order to determine the infectivity of strains of *Bacillus abortivo-equinus*, isolated from the outbreaks on the Hissar Cattle Farm, upon pregnant pony and donkey mares. Attempts were commenced to control this disease by the systematic application of serological tests.

Hæmorrhagic Septicæmia.—Methods of estimating the efficacy of the serum issued for the protection of cattle against this disease were tested.

Mange.—Some preliminary work in laboratory methods of testing the commonly used acaricides of the country was undertaken.

Black quarter.—Material is being collected with a view to making a systematic study of the strains of micro-organisms responsible for this condition in India.

II.—Camel Specialist, Sohawa, Punjab.

The work carried out by this officer is covered in the following summary :—

(a) A simple, inexpensive and practical method of treating surra in camels (*viz.*, by tartar emetic) has been found. Camels treated here have been inspected by officers of the Royal Army Veterinary Corps before they have been returned to military duty.

(b) Surra transmission experiments.

Transmission experiments were carried out during the year with :

1. *Tabanus nemocallus*.

2. A new species of *Ornithodoros*.

A. From these experiments it would appear that the spread of surra by *Tabanidæ* is by direct transmission and that there is no cycle of the trypanosome in the fly, whereas by the new species of tick, transmission is not direct, but there is probably a cycle of the trypanosome within the tick.

The transmission of surra by *Tabanidæ* would appear to depend upon :—

(a) The number of trypanosomes per field in the blood of the surra infected animal at the time the flies are feeding.

(b) The interval of time between the interrupted surra feed and the feed on the healthy animal.

(c) The number of flies that are interrupted in their feed on the surra infected animal and proceed to finish their feed on a healthy animal.

B. The new species of *Ornithodoros* was found capable of transmitting surra to healthy rabbits 67, 83 and 101 days after feeding on a surra infected animal, but was not infective after intervals of 1 minute to 46 days.

3. The course that camel surra runs in other animals. Further experiments were carried out; from these experiments it was ascertained that the blood of buffaloes, sheep and goats remains infective for many months, though these animals may appear in perfect health and no trypanosomes can be found in the blood.

4. Collections of flies, etc., have been made in many areas.

The following species were found :—

(1) *Hypoderma* of goats.

Major Patton examined this fly and has named it *Hypoderma crossii*.

(2). Species of *Ornithodoros*.

Specimens of this tick were sent to Professor Brumpt of the Paris University, who states it is a new species and proposes to name it *Ornithodoros crossii*.

(3) *Tabanus suffis* (Jaenæke).

Major Patton identified this fly; he stated that as far as he was aware this species has not been reported before from India.

(4) *Lipoptina caprina* (Austen).

This hippoboscid was identified by Major Austen of the British Museum; he stated that up till then the hippoboscid had only been found in Palestine.

(5) Bot flies.

Bot flies and their larvæ, of camel, sheep, goat, horse and oorial have been collected.

III.—*Superintendent, Government Cattle Farm, Hissar, Punjab.*

The following subjects were treated during the year under report:—

- (a) Feeding experiments at the Government Cattle Farm, Hissar, by Mr. R. Branford and Captain E. Sewell.
- (b) Contagious orchitis in donkey colts, by Mr. R. Branford and Captain E. Sewell.
- (c) An experiment in breeding varieties of oats along Mendelian lines, by Mr. R. Branford and Captain E. Sewell.
- (d) Experiments in *Bir* cultivation, by Mr. R. Branford.
- (e) Anthrax at Hissar, by Mr. R. Branford.
- (f) Cattle stock and Fodder Famine, by Mr. R. Branford.
- (g) The importance of the genus *Habronema* as an economic factor amongst the equidæ of Punjab and North-West Frontier Province, by Captain E. Sewell.
- (h) Contagious abortion in pony and donkey mares (still in progress), by Mr. R. Branford and T. M. Doyle.

IV.—*Madras Presidency.*

Contributions of local professional interest were made by members of the Provincial Veterinary Service in the "The Madras Veterinary Journal," now the only veterinary periodical in India. Five numbers appeared during the year. Of special interest are short articles on (1) Infective nasal granuloma or "snoring disease" of cattle, (2) the treatment of ankylostomiasis in dogs, and (3) epizootic ulcerative keratitis of cattle.

MEDICAL RESEARCH

BY

The HON'BLE MAJOR-GENERAL SIR WILLIAM RICE EDWARDS, K.C.I.E.,
C.B., C.M.G., M.D., F.R.C.S.E., K.H.P., I.M.S.,

Director-General, Indian Medical Service.

The following is an extract from the Annual Report of the Scientific Advisory Board of the Indian Research Fund Association for the year 1921-22 :—

Relapsing fever.—Major Cragg submitted a final report on the results of his inquiry. This has been published in the Indian Journal of Medical Research, Vol. X, No. 1, July 1922 (Relapsing Fever in the United Provinces of Agra and Oudh). The paper is a long and valuable one.

Plague and Rat-fleas.—Along with his inquiry on the Relapsing Fever, Major Cragg made investigations on the Indian rat-fleas and the results were published in the Indian Journal of Medical Research, Vol. IX, No. 2, October 1921 (The geographical distribution of Indian rat-fleas as a factor in the epidemiology of plague). Major Cragg examined 17,339 rat-fleas from the Punjab, Bombay, Central India, Madras and Burma.

Leprosy.—(1) Dr. Muir continued to study the effects of the derivatives of the chaulmoogra oil in the treatment of leprosy on modern lines. He has carried out serological studies in connection with leprosy, and, in collaboration with Major R. B. Lloyd, I.M.S., is studying the Wassermann re-action in cases. He is carrying out histological examination of leprosy nodules and skin at different stages.

(2) Dr. Sudhamoy Ghosh continued his researches on leprosy under the supervision of Lieutenant-Colonel J. W. D. Megaw, I.M.S., up to 15th December 1921. On the 1st March 1922 Mr. Nishi Kanta De was appointed in his place. He is investigating the bactericidal properties of various oils and fatty acids in the destruction of acid-fast bacilli.

(3) Grant to the Rev. Frank Oldrieve. In October 1918 a sum of Rs. 21,650 was allotted for the medical treatment of lepers and training of Sub-assistant Surgeons. In this inquiry trial treatment on modern lines have been carried out at various Leper Asylums. Dr. Muir, who is supervising the work during the absence of Mr. Oldrieve in England, writes, "that the death rate at Purulia Leper Asylum has been reduced by almost 25 per cent. since special treatment and hookworm treatment began."

(4) Inquiry on Nim or Margosa oil and its derivatives. Dr. K. K. Chatterjee continued his experiments with the products of nim oil in the treatment of malignant disease during the year under report.

Influenza.—(1) A selected Sub-assistant Surgeon was employed on the termination of Major King's inquiry to collect statistics regarding the efficiency of the new influenza vaccine. Statistical figures from different parts of India have been received. On return from leave, Major King may take up this question.

(2) Captain R. H. Malone concluded his bacteriological inquiry on 4th December 1920. The following articles by him were published in the Indian Journal of Medical Research :—

- (a) The production of B influenza vaccine on a large scale. Vol. IX, No. 1, July 1921.
- (b) A bacteriological investigation of influenza carried out under the Indian Research Fund Association, Part II. Influenza in Bombay, July 1919 to June 1920. *Ibid.*

Pneumonia Inquiry.—Captain R. H. Malone conducted this inquiry throughout the whole year under review. "A note on the large scale production of Pneumococcus Vaccine" by him was published in the Indian Journal of Medical Research, Vol. IX, No. 1, July 1921. Captain Malone during the year carried out trials with an anti-pneumococcic vaccine in the Waziristan Force.

Deficiency Diseases Inquiry.—Lieutenant-Colonel R. McCarrison was deputed by the Indian Research Fund Association to work at Oxford from the 29th January 1921. He worked there under Professor Sherrington, P.R.S. He delivered a course of lectures on deficiency diseases in America. During 1921 he published a book entitled "Studies in deficiency diseases." A paper on "Pathogenesis of deficiency disease, Part XI," has been received and is in course of publication in the Indian Journal of Medical Research.

Indian Mosquitoes Inquiry.—Captain P. J. Barraud is conducting this inquiry which will terminate on the 25th February 1924. An important paper by Mr. F. W. Edwards, the British Museum, entitled "A synopsis of adult oriental culicine (including megarhinine and Sabethine) mosquitoes" was published in the Indian Journal of Medical Research, Vol. X, No. 1, July 1922. This paper will form an introduction to the articles which Captain Barraud will publish on his researches in India.

Kala-azar Inquiry.—(1) Mrs. Adie resigned on account of ill-health on the 3rd January 1922. Lieutenant-Colonel Mackie proceeded on leave to England on the 31st January 1922 and Major Shortt took over the work from him. Mr. Awati was transferred to the Education Department as Professor of Zoology in the Institute of Science, Bombay, on 1st June 1922. The following papers dealing with this inquiry have been published in the Indian Journal of Medical Research :—

- (a) A preliminary note on the development of Leishman-Donovan Parasite in spleen juice and in the Alimentary tract of cimex Lectularius, by Mrs. Adie, Vol. IX, No. 2, October 1921.

(b) A note on bodies observed in *Cimex Rotundatus* Linne collected in a kala-azar infected area in Assam, by Mrs. Adie, Vol. X, No. 1, 1922.

(c) Some notes on *Conorhinus Rubrofasciatus* (de Geer), by Mr. Awati, Vol. IX, No. 2, October 1921.

(d) Survey of biting insects in Assam with reference to kala-azar for the whole year from November 1921 to October 1922, by Mr. Awati, Vol. X, No. 2, 1922.

(2) Dr. U. N. Brahmachari's inquiry is associated with the investigations on kala-azar. He has been engaged during the year in carrying out researches on organic preparations of antimony at Calcutta for the treatment of kala-azar. His results to date were published in the Indian Journal of Medical Research. "Chemotherapy of Antimonial compounds in kala-azar infection, Part I," Vol. X, No. 2, October 1922.

Ankylostomiasis Inquiry.—Dr. Mhaskar in co-operation with Dr. Kendrick of the Rockefeller Foundation carried out, under the auspices of the Indian Research Fund Association, an anti-hookworm campaign in the Tea Estates of Mudis, Coimbatore District, and (2) Kalianapandal. The campaign was followed by a marked improvement in the health of the coolies working on the estates. The results of Dr. Mhaskar's and Father Caius's inquiries have been published in the Indian Journal of Medical Research in :—

Vol. VIII, No. 1, 1920.

Vol. VIII, No. 2, 1920.

Vol. IX, No. 1, 1921.

Vol. IX, No. 2, 1921.

Vol. IX, No. 4, 1922.

Vol. X, No. 2, 1922.

Immunology with special reference to Antivenin.—This inquiry was commenced in June 1921 by Father Caius. The main object of his investigations on the Antivenin is to concentrate the serum now prepared at Kasauli, the idea being to obtain greater potency for less bulk, thus enabling larger doses to be more easily given and also obviating to some extent the possibility of serum sickness. He is attacking this problem both by physical and chemical methods. Some of the physical methods depend on evaporation, others on dialysis and others on electrolysis.

Analysis of quinine and cinchona Derivatives.—Father Caius is also conducting an inquiry on this subject. He is co-operating with Major Sinton and is conducting the chemical analysis of quinine, etc., for him. He visited the Government quinine factories in Madras and Bengal.

Anthelmintic Properties of Drugs.—Father Caius continues to carry out researches on Anthelmintic Properties of Drugs.

Quinine and Malaria.—Major Sinton, V.C., O.B.E., I.M.S., conducted this inquiry throughout the whole year. He has elaborated and simplified a method for the cultivation of the malarial parasite. He is at present engaged in elaborating and testing a method of treatment of malaria in which alkalies

are combined with quinine. The following papers have been published in the Indian Journal of Medical Research in connection with this inquiry :—

- (a) A simplified method for the cultivation of *Plasmodium Falciparum* in vitro, Vol. X, No. 1, 1922.
- (b) Further remarks on a clinical method for the cultivation of sub-tertian parasite in vitro, *Ibid.*
- (c) A case of malaria due to *Plasmodium tenue* (Stephens), Vol. X, No. 2, July 1922.
- (d) A possible fallacy in the 'thick film' method of examination for malarial parasites, Vol. X, No. 2, October 1922.

Research on Cinchona Alkaloids.—This research was commenced at the Calcutta School of Tropical Medicine and Hygiene by Major H. W. Acton on the 4th January 1922. A paper dealing with this research has been published in the Indian Journal of Medical Research entitled "on the Behaviour of *Paramecium Caudatum* towards the Cinchona Alkaloids," Vol. IX, No. 2, October 1921. Other papers on quinine prophylaxis and treatment of malaria have been published by Major Acton and his colleagues in the Journal.

Composition of River Waters.—This research on the seasonal variations in the composition of the river waters in Bengal and influence which these variations exert on the processes of sedimentation and filtration of water is being conducted by Rao Sahib V. Govinda Raju.

Lathyrism.—The chemical aspect of this investigation is being carried out by Dr. J. L. Simonsen, the botanical aspect by Mr. Howard, and the pharmacological part by Captain Anderson, I.M.S. The inquiry commenced in December 1921 and will last for three years. The results of this inquiry so far have been interesting and suggestive.

Ground-nuts and Sterilisation of water supplies by chlorogens.—Dr. McKenzie Wallis, who is continuing his researches in England, has not yet submitted his report.

Cercariæ Indicæ.—The results of Major Sewell's investigation are incorporated in an important monograph which has been published by the Indian Research Fund Association as a supplementary number Vol. X, June 1922 of the Indian Journal of Medical Research. This work is a most important addition to our knowledge of this subject and will form the basis of future investigations connected with Bilharzial infection.

Entomological section of the Central Research Institute, Kasauli.—The Governing Body of the Indian Research Fund Association met the expenses of this section for the year under report.

Training of Sub-assistant Surgeons and Laboratory attendants.—This scheme will furnish officers in charge of inquiries with trained subordinate personnel immediately. One Sub-assistant Surgeon and two laboratory attendants are being trained at four Institutes.

Indian Journal of Medical Research.—The Indian Journal of Medical Research has just completed its ninth year of existence.

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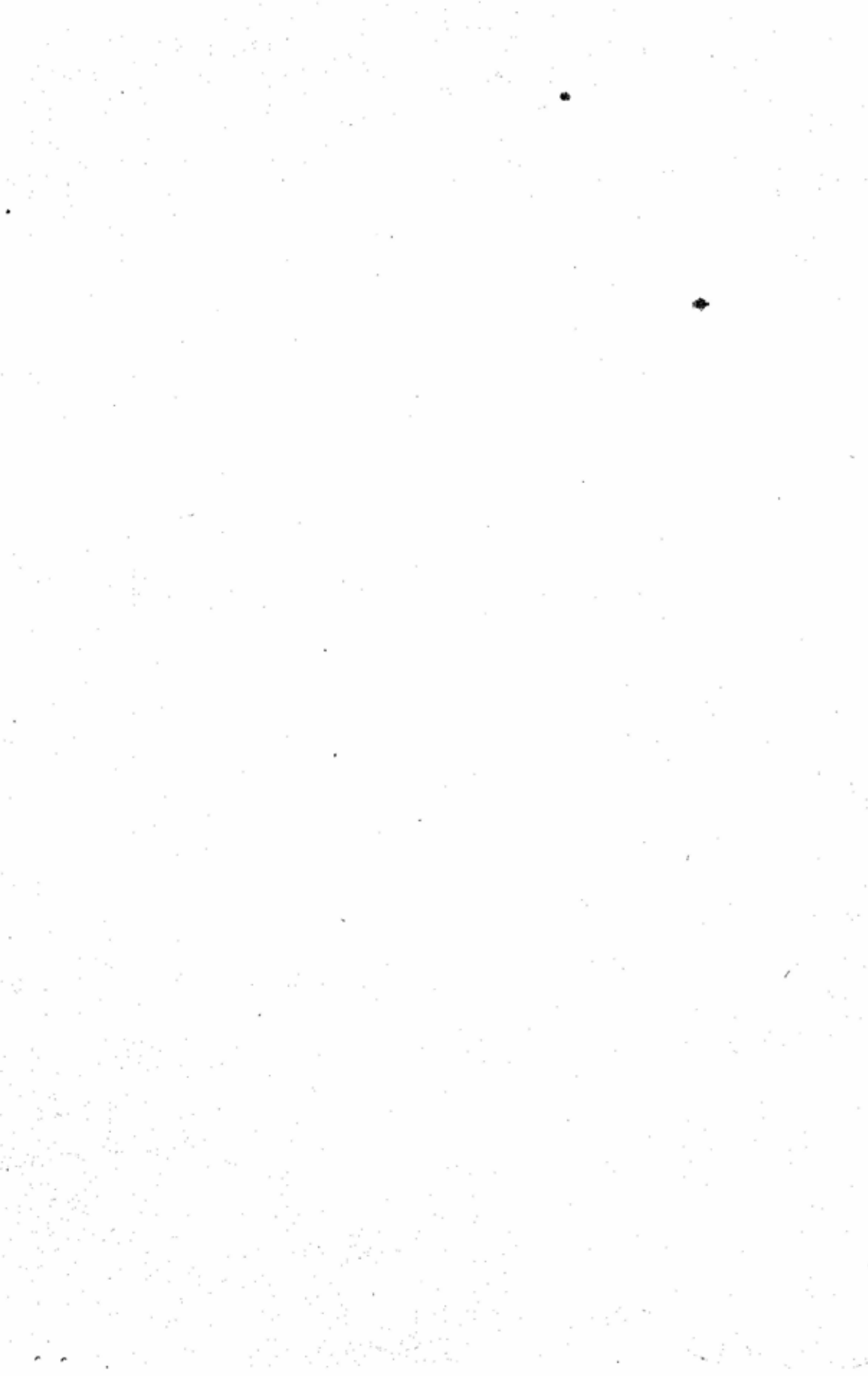
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Departmental Publications.

I.—METEOROLOGICAL DEPARTMENT—

Government of India Office.

- (1) The Indian Daily Weather Report and Chart.
- (2) The Weekly Rainfall Summary.
- (3) The Monthly Weather Review.
- (4) The Annual Summary.
- (5) The Rainfall of India.
- (6) Indian Meteorological Memoirs.

Bengal Office.

- (1) Bengal Daily Weather Report and Chart.
- (2) Monthly Rainfall Tables and Summaries of the chief feature of the weather of the month over Bengal.

Bombay Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Abstracts of the Bombay observations (*Bombay Gazette*).

Madras Office.

- (1) Bombay Daily Weather Report and Chart.
- (2) Monthly Rainfall Tables (*Madras Gazette*).

Allahabad Office.

- (1) Monthly Weather Summaries (*United Provinces Gazette*).
- (2) Annual Summary.
- (3) Monthly Rainfall Tables (*United Provinces Gazette*).

Lahore (Simla) Office.

- (1) Monthly Summary
 - (2) Annual Summary
- } of Punjab weather.

II.—GEOLOGICAL SURVEY.

The publications of the Department include—

Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XLV, including the larger papers on geological subjects. Records, Vols. I—L, including the shorter papers and Annual Reports from 1868 to 1915 sold in parts, priced one rupee each.

Manual, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhee Road, Calcutta.

Indexes to the Genera and Species described in the *Palæontologia Indica* up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

III.—SURVEY OF INDIA.

- (1) Annual General Report.
- (2) Professional Papers.

IV.—BOTANICAL SURVEY AND ROYAL BOTANIC GARDEN, CALCUTTA.

- (1) Annual Report of the Botanical Survey of India.
- (2) Records of the Botanical Survey, Vols. I—X.
- (3) Annual Report of the Industrial Section, Indian Museum.

- 4) Annual Report of the Royal Botanic Garden, Calcutta.
- (5) Annals of the Royal Botanic Garden, Calcutta, Vols. I—XII, Part II. A list of the contents of the Records and of the Annals with prices of the numbers and volumes still available can be obtained by applying to the Superintendent, Royal Botanic Garden, Calcutta.

V.—DEPARTMENT OF AGRICULTURE.

- (1) Annual Report.—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology, and the like).
- (2) The Agricultural Journal of India.—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in agriculture.
- (3) Scientific Memoirs of the Department of Agriculture.—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.
- (4) Bulletin.—An occasional publication containing information on agricultural matters of a temporary nature.
- (5) Leaflets.—Short notes of practical instruction in agricultural matters, dealing mainly with Entomological subjects.

VI.—FOREST DEPARTMENT.

- (1) Review of Forest Administration in British India by the Inspector-General of Forests (issued annually).
- (2) Annual Progress Report of Forest Administration in each Province.—Issued by the Local Governments annually.
- (3) Indian Forest Records.
- (4) Indian Forest Memoirs.
- (5) The Indian Forester.—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal, Published monthly.
- (6) Bulletins are published from time to time.

VII.—ZOOLOGICAL DEPARTMENT.

- (1) The Annual Report, 8vo.
- (2) Records of the Indian Museum, 8vo. Containing short papers on Indian Zoology. One or two volumes issued annually in quarterly parts.
- (3) The Memoirs of the Indian Museum, 4to. Containing monographs and other important papers. Published at irregular intervals.
- (4) Descriptive Catalogue of Indian Decapod Crustacea, 4to. Parts published at irregular intervals.
- (5) Descriptive Catalogue of Indian Echinodermata, 4to. Parts published at irregular intervals.

VIII.—CIVIL VETERINARY DEPARTMENT.

- (1) Annual Report.





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