Board of Scientific Advice for India

ANNUAL REPORT

FOR THE YEAR

1921-22

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1923

Price Re. 1.

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Sub-Committee A.—(*Meteorolgy, 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. HARISON, 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 Dooars.

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 latefolia* 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 preliminarily 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 *Melanorrhea 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 faculæ, 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 +·050 A (*i.e.*, to the red), with calcium +·035 A, with iron +·016 A, with silver +·015 A, with aluminium +·014 A, with nickel +·005 ? A. 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 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, 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 Ilaqa, 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 preoccupation 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 necessaries 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 havremained 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 × 125 miles. In France and Spain the average size is about 120 miles × 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 Equador 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	,,	13.967	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, 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 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.

1. (*a*) Viramgām to Navānār, *viâ* 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 *viâ* Manmād.

(*b*) Sholāpur to Bijāpur *viâ* Jhalki.

(*c*) Batghar to Jhalki *viâ* 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 Alīgarh.

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, *viâ* 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 Islāmgarh and on through Jaisalmer and Jodhpur States to Mārwār Pāli *viâ* 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 *viâ* Bārāsat, Husainābād Jessore and Jhenida

(*b*) Jessore to Bārāsat.

(*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) *viâ* 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, *viâ* 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 Kaliana, Birond and Bansgopal, 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 Tinnevelly 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 *Rubiaceæ* 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 *Jussiæa* 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. Debbarman, 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. C. 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 he 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 *cæsia* 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 versâ*. *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. irregulare* 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 *Helopeltis*. 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 antiseptic.

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 remeasured by the Central Institute on behalf of the United Provinces and many other plots were remeasured 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 Robasta*).

The experiments dealing with the natural reproduction of Sal by the Gorakhpur method were continued in Thano 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 boardcast 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 pepared 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 inauguated 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 Jubbulpore are being studied.

Testing.—About 2,000 routine tests were carried out under Project I, 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) Expèdition Antarctique Française 1903-5. A complete set.

(2) Deuxième Expèdition 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 *Chrysomyia 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 *Pempheres 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 carpomyiæ* has also a definite æstivation 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 æstivation 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 (*Cryptorrhynchus 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.

Chinboung (*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 mothborers 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 (*Diatræa* 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 Semilooper 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 (*Leptocorisa 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 *Sphærotrypes siwalikensis*. The genus *Sphærotrypes* is being revised in connection with the biology of *Sphærotrypes siwalikensis* 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 *Platypodidæ* and *Xyleborinæ* which are rich in species of Malayan forms new to India. In the evergreen forests trees like *Vatica lanceæfolia*, 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 *Diapus 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, Odonata	319
Orthoptera	146
Diptera	123
Other orders	50
TOTAL	5,411

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, Muktesar.

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 scene 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 nemocallosus.*

2. A new species of Ornithodorus.

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 Ornithodorus 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 Ornithodorus.
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 *Ornithodorus crossii.*

(3) *Tabanus suflis* (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 leprous 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 alaklies

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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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 } of Punjab weather.
(2) Annual Summary }

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 Foresty, 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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