

Locust Research Work in India.

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I. INTRODUCTORY.

DURING the last decade, locusts have, in many parts of the world, been so much in the limelight that they hardly stand in need of introduction. During the years 1929 and 1930 especially, there were not many days on which mention was not made of them in the Indian Dailies, either in regard to their flights or the damage done by them to crops. Nor are locusts to be counted as one of the recent upheavals of the modern age. Their history apparently dates back to hoary antiquity. They are mentioned in the Bible, and formed one of the plagues of ancient Egypt. In early Sanskrit literature, references are made to them as one of the recognised calamities of the people. The immensity of the swarms, whose countless myriads often form clouds hiding the sun from the face of the earth, the dramatic suddenness of their appearance, and the terrible severity of their onslaughts, have all combined to infuse a feeling of helplessness and awe in the mind of primitive man, with the result that incursions of locusts have from time immemorial been considered to be of the nature of an act of God. Indeed, the Indian cultivator, be he Moslem or Hindu, often expresses himself unwilling to lift his hand against these pests, ruinous though they may be to his food-crops, as he believes the visitation to be a manifestation of Divine Wrath, which he dare not resist.

II. INDIA'S LOCUSTS.

Few people are unfamiliar with grasshoppers, which may be found jumping about on the surface of lawns and fields. Locusts differ very little from them either in their general form, structure or habits, except for the fact that they often occur in large communities, which move about from place to place in gregarious swarms. There are several different species of locusts in the world, each of which has its own more or less restricted area of distribution. Not taking into account half a dozen species of Indian grasshoppers, which are known to increase in numbers periodically and cause immense damage to crops, there are only three species of true locusts in India, of which one, *Locusta migratoria*, though occurring widespread over the length and breadth

of this country in its solitary phase, has, for some hitherto unaccountable reason, been very rarely recorded in its swarming condition. The other two, viz., *Patanga succincta*, L.—the Bombay Locust,—and *Schistocerca gregaria*, Forsk.—the Desert Locust,—have in the past appeared in enormous swarms over large areas of India and caused a great deal of destruction to agricultural crops. Of the two, the Bombay Locust affects mostly the peninsular region of India. From the information available, mainly Lefroy's account in his *Memoir* on the Bombay Locust, this locust would appear normally to be a denizen of the forest areas of the Western Ghat ranges of the Bombay Presidency, whose flights may spread in years of heavy multiplication far and wide, as far as Guzerat to the north, as far as Central India and Hyderabad, and even Bihar and Orissa in some years, to the east, as far as Madras Deccan to the south, and upto Ratnagiri and Goa to the west. On the other hand, the Desert Locust is, *par excellence*, the Locust of North-West India. During years of outbreak, it infests chiefly Baluchistan, Sind, Punjab, the North-West Frontier, Rajputana, United Provinces and parts of Central India, but in years of extraordinary activity its flights may reach as far as east Assam and as far south as Madras Deccan. The Desert Locust is by far the more important of the two, for, the range of its spread is much wider, the periods of its outbreak are more frequent and prolonged, and the extent and degree of damage to crops is on the whole much greater. The scheme of Locust Research carried on under the auspices of the Imperial Council of Agricultural Research is concerned at present only with the Desert Locust.

III. THE ORIGIN AND SCOPE OF THE PRESENT SCHEME.

Although locust outbreaks have been fairly frequent in the past, and have often been serious enough to engage the attention of a huge staff and lead to the expenditure of large sums of money in connection with control work in a great many districts of North-West India, it is surprising how little had been recorded about the central facts of its life. There were but vague and

indefinite notions as to wherefrom the swarms originated or how they responded to changes in the environment. Except for the excellent account given by E. C. Cotes in his Report on "the Locust of North-West India", 1890, no comprehensive survey of the movements of locusts in India had been made during the various locust cycles of the past. The reasons for this are not far to seek. The incursions of locusts are periodic and even during outbreaks, their appearance is definitely seasonal in most places. While they are aggressively evident during times of invasions, and while the Government as well as the public are feverishly active with the carrying out of control measures against them, sooner or later they disappear from the areas of infestation, and before long they become a mere memory. People feel relieved at their non-appearance, and take no further interest in them till they are back once again menacing agriculture.

The provincial entomologist, who is naturally occupied with and interested in the pests of his own province, attends to a study of locusts and to their control while they are active within the limits of his province, but cannot of course be expected to continue his researches when they have retreated beyond the limits of his jurisdiction. On the other hand, in the desert regions of Baluchistan and Rajputana, where the locust appears to linger on during the periods of its non-activity, no entomological staff is existent to study the question. This would appear to be the main reason why so little is known of the life-economy of the Desert Locust and why the problem has been so little investigated. In the case of a pest of this description whose distribution is not confined to a single province or country and whose powers of spread by direct flight are so enormous, a proper study of its life-habits or migration can obviously be undertaken by an organisation working under the ægis of a Central Government.

After a long period of quiescence lasting over six years, the Desert Locust appeared all of a sudden in Sind and Rajputana in August-September, 1926 and bred in enormous numbers, thereby starting the last great cycle of 1926-1931. The peak of the attack was reached in the years 1929-30, when almost all the provinces of North-West India were infested and the resulting swarms reached eastwards as far as Assam and southwards as far as Hyderabad

(Deccan). It was in the thick of the fight against this formidable outbreak of the pest in the rich agricultural areas of Punjab, United Provinces and Sind, that the Governments of the various provinces of Northern India realised what serious proportions the locust menace could assume and how imperfect the existent knowledge of the locust problem in India was. As a result the question was included in the agenda of the Board of Agriculture in India, which met at Pusa in December, 1929. After due discussion, resolutions were passed at this meeting recommending (1) the formation of a Locust Bureau under the auspices of the Imperial Council of Agricultural Research for the prompt collection, collation and distribution of locust intelligence within Indian limits, (2) the institution of a Locust Research Scheme in India for conducting research in regard to control methods, for locating the permanent breeding grounds and the migration routes of the locust in India, and for working out its bionomics thoroughly, and (3) the organisation of control methods on efficient and co-ordinated lines in all the affected states and provinces, including the central storage of anti-locust material by the Central Government.

Action was taken by the Government on all these recommendations in due course. The Central Locust Bureau of the Imperial Council of Agricultural Research began to function early in February, 1930 and has been of great service in giving prompt warnings to areas subject to infestation, in regard to the activities of locusts. An Entomologist—Rai Sahib G. R. Dutt, B.A.—was also attached to the Central Bureau from May 1930 to March 1932. Arrangements were also made for the storage of some anti-locust material at Delhi.

Last but not least, a Locust Research Scheme financed by the Imperial Council of Agricultural Research began to function from December, 1930 under the charge of M. Afzal Husain, Esq., M.A. (Cantab.), M.Sc., I.A.S., Entomologist to the Government of Punjab, as Locust Research Entomologist to the Imperial Council of Agricultural Research with head-quarters at Lyallpore. Through the kind permission of the Punjab Department of Agriculture, the Locust Research Scheme had the benefit of all the facilities of the up-to-date laboratories of the Entomological Section at Lyallpore, and various problems connected with the life-history and bionomics of the locust were

worked out during the years 1931, 1932 and 1933, by specially appointed staff under the direct guidance of Mr. Afzal Husain. Much difficulty was, however, felt during 1932 and 1933 in obtaining live material for experimentation owing to the disappearance of locust swarms by the end of 1931.

In regard to the location of the locust breeding grounds, a special touring staff was recruited in January 1931 for carrying out locust surveys of the desert areas in Baluchistan, Sind and Rajputana, and placed under the writer, as Deputy Locust Research Entomologist to the Council, with headquarters at Quetta. As specimens of the solitary phase of the locust were discovered by the staff during the tours conducted in 1931 in the coastal areas of Mekran, a special Field Research Station was established at Pasni in the midst of typical locust breeding grounds in January 1932 and placed under the charge of Dr. K. R. Karandikar as Assistant Locust Research Entomologist for studying the ecology of the solitary phase locust in its natural habitat.

Since April, 1933 Mr. Afzal Husain's services were required by the Punjab Agricultural Department for the Principalship of the Punjab Agricultural College. He could not, therefore, continue to be in charge of the Locust Scheme, but undertook to continue his work on bionomics at Lyallpore, with the help of a research grant from the Imperial Council of Agricultural Research and the responsibilities of the charge of the rest of the Scheme devolved on the writer from that date.

IV. PROGRESS MADE IN THE LOCUST INVESTIGATION WORK.

Locust research has been in progress for over four years at the moment of writing, and it may be stated without exaggeration that quite a large amount of work has been accomplished. It may also be mentioned that the work done every year has been scrutinised by the Locust Advisory Committee of the Imperial Council and has had, therefore, the advantage of their approval and advice in most particulars. The progress made may be dealt with under the following heads:—

1. *Survey Work.*—In 1931 survey work was mostly confined to Baluchistan where most of the districts subject to locust infestation were examined, especially Mekran, Kharan, Lasbela and Chagai. A part of the Bahawalpore desert area was also examined. In 1932, survey staff was reorganised, and

work was pushed on by means of a motor-lorry purchased by the Imperial Council for touring purposes, and various centres in the Indus Valley of Sind, parts of Baluchistan, and the Dera Ghazikhan District, and parts of Bahawalpore, Bikaner, Jodhpur, Cutch and Western India States were visited. Wherever roads were non-existent, as in the interior of the Indian Desert, tours were carried out on camel-back. In this manner, quite a number of places were located in which locusts of a non-gregarious character were noticeable. During 1933, the plan of survey work was changed. The work was confined to the areas where locusts of a non-migratory type had been located, and the places were visited periodically throughout the year in order to note the effect of the seasons on the activities of the solitary locusts. In 1934, the same plan was pursued, but with the addition of two Desert Observation posts where intensive observations on locusts were to be carried out in addition to the recording of certain simple bioclimatic data.

Results of Survey Work.—While locust swarms easily attract regular attention and their movements may be expected to be reported by existing official organisations, the existence of locusts in their non-gregarious form is apt to be missed altogether unless specially trained staff is employed to look for them in their natural habitat. Owing to the enormous extent and the comparative inaccessibility of the area to be examined, and the sparsity of the locust population, it would be rather futile to expect a high degree of thoroughness from the small staff employed. The results actually obtained have, however, been sufficient to indicate that, in certain cases, specimens of locusts of what looked like the solitary type were either the remnants of the swarms of 1931 or their descendants. It was also noticed that at present locusts are either entirely absent or are very sparse in many of the places where they were found abundantly in 1932. The observations made have also shown that as in the case of the migratory type, the non-gregarious type of locust is dependent on rainfall for oviposition and breeding, and there appears to be some evidence to show that, like the migratory phase, the non-gregarious type is capable of making migrations over short distances though only as individuals. On the whole, it would rather look as if locusts were gradually disappearing from the areas

of the Indian Desert, and the present situation rather indicates that the 'rek' areas of the Mekran Coast are possibly more important from the locust-breeding point of view.

In addition to making observations on locusts the staff engaged on survey work have also as far as possible attended to the collection of the flora and the fauna of the tracts examined.

2. *Bionomics*.—The various known facts of the life-history and the habits of the locust are ultimately referable to the fundamental peculiarities of its structure and to the nature of its response to the impact of its environment. An exact knowledge of the nature and extent of the responses exhibited by the locust can only be obtained by an experimental study conducted under clearly defined conditions; and the results of studies would be valuable, not only for offering an explanation in regard to the activities of locusts under natural conditions, but also for devising efficient control measures. Valuable work on these lines has been done at Lyallpore in regard to various points in the life-history of the locust, *viz.*, pairing, oviposition, post-embryonic development, effect of crowding and other conditions on the colouration, etc., of hoppers, number of broods in the year, the effect of various tropisms, etc. The results of these studies are now under publication by Mr. Afzal Husain.

3. *Ecological Work*.—Most of the work on the life-history and habits of the locust published in the past is referable to the gregarious phase of its existence, and very little is on record in regard to its solitary phase. Since the areas around Pasni are apparently some of the true breeding grounds of the Desert Locust, the data collected during the last three years, in regard to the behaviour of the solitary locust in response to fluctuations of environmental conditions incident to seasonal changes, should doubtless be of great value. The central problem of these ecological studies in the elucidation of the conditions under the influence of which the change of phase—*viz.*, from solitary to the gregarious—would occur in nature. From the Locust Research point of view, the importance of a breeding ground would depend on how far conditions favouring the building up of the initial swarms of an outbreak are present, in which case alone it would function as an outbreak centre.

From the experience gained so far, it is

evident that seasonal rainfall is by far the most important factor in the life-economy of the solitary phase locust. Breeding can take place only if there is rainfall, and a building up of the population would become possible only if an acceleration of breeding and a rapid succession of generations are brought about by the persistence of the requisite favourable conditions of weather.

4. *Study of Past Outbreaks*.—The memory of the serious locust infestation which lasted for nearly six years from 1926 to 1931 is possibly still fresh in the minds of most people in North-West India. This cycle was preceded by a period of about six years, roughly from 1920 to 1925, in which there was no general infestation, and we are apparently now in a similar non-locust period which began from 1932 and has already lasted over three years at the present moment. From the data at present available it is difficult to say when this period would end and the next locust cycle would commence. In this connection, a study of the past invasions is of great importance and all attempts have been made to secure reliable data on the subject. It has, however, to be stated that past records on locusts have in most cases not been preserved, and the information obtainable in such as are existent is very fragmentary in character. In certain exceptionable cases, however, as in that of the season and crop reports published in the Gazettes of Punjab, Sind and Bombay, fairly detailed and continuous information is available from the year 1869, and these have been extracted, collated and studied. In certain other instances also, *e.g.*, the records of the Jaisalmer and Kalat States, detailed information was obtainable in regard to some years. A study of the old records has shown that there have been locust cycles during the following years since 1869: 1869 to 1881, 1889 to 1907, 1912 to 1919 and 1926 to 1931, the intervals being periods of locust disappearance. During years of outbreaks, it would appear that swarms are, during the earlier months of the year, active mostly in areas of winter and spring rainfall, such as Baluchistan and parts of the Punjab, Afghanistan and Persia, and lay eggs and breed there. The adult locusts produced by these broods would appear to commence their flights during the months of April, May and June, the general direction being eastwards towards Sind, Punjab and Rajputana, where

they breed after the receipt of monsoon rains. The resultant fliers would appear to fly during the autumn months, partly further east towards Bengal and Assam or to the south, and partly back to the west towards Baluchistan and Persia. The east-bound flights appear ultimately to perish while the west-bound ones are able to breed during the spring months in Baluchistan. It would also appear that the infestation is prolonged if this circulatory system of locust flight is kept up, and that the breakdown of the cycle is probably brought about by the failure of broods due to unfavourable conditions of weather in one or other of the breeding areas.

The data collected from the various files have been extracted and arranged and are being mapped out month by month for the various years, and attempts are being made to correlate the movements with available meteorological data.

V. PRESENT POSITION OF THE WORK.

Much ground has already been covered, but there is yet much work to be done.

In regard to bionomics, progress of work has been impeded mostly for want of material for experimentation, and experiments

will be resumed when there is sufficiency of material. The question of sex-maturation of the locust is specially important and needs being tackled. Experiments in regard to control measures will also be undertaken when sufficient material is available.

As to survey work, it is necessary that work should be continued until a decisive answer is obtainable to the question as to which of the areas in which the locust has been found in the non-gregarious state are really important in the production of swarms. It is also necessary to determine the exact conditions under which the transformation into the gregarious phase would take place in nature. In case it is definitely proved that there are outbreak centres within Indian limits, it would be imperative to undertake a trial of control measures on the breeding grounds to determine the best methods of tackling the pest in an early stage and thus nip the evil in the bud. When the migration routes followed by swarms during periods of infestation in India have been properly studied and plotted out, it ought to be possible to formulate a system of timely locust warnings, to neighbouring provinces or countries on the basis of such studies.

Gaps in Our Knowledge of the Indian Protozoa. I.—Ciliophora.

By B. L. Bhatia, D.Sc.

DURING the last four years, while preparing a volume on Ciliophora for the Fauna of British India, I have become aware of various gaps in our knowledge of these Protozoa. Although many more genera and species are now known from this sub-continent than was the case in 1916 when I first directed my attention to this group, there is still a vast and promising field for future workers to cultivate. The Ciliophora are a sub-phylum of the Protozoa, and include forms which live in water, soil, or as parasites of other animals. It is well known that species of fresh-water and soil protozoa are cosmopolitan. The record of Ciliophora known from India, Burma, and Ceylon now includes 274 species belonging to 101 genera. The majority of these are from fresh-water or from the soil. Most of them are the same as found in Europe or America, and there is every likelihood of those described as new, being found in other parts of the world also. This is due to the fact that the conditions of life in pools and

ponds are much the same all over the world, and the fresh-water forms can be easily carried from one place to another, especially in the encysted form, by wind and animals. Unlike the fresh-water protozoa, the geographical distribution of parasites usually follows that of their hosts. Some parasites are unable to live in any other host than the one in which they naturally occur and show a host-parasite specificity, though, not unoften, the hosts living in the same habitat may adopt each other's parasites.

The Ciliophora are divided into two classes, *viz.*, CILIATA and SUCTORIA. Following Metcalf, the Opalinid ciliates which do not show a differentiation of the nuclear material into a macronucleus and a micronucleus, have been separated into a subclass and designated as PROTOCILIATA, the rest of the Ciliata which show this nuclear differentiation being called the EUCILIATA.

The Proto-ciliata include a single family *Opalinidae* which were formerly lumped with other Astomatous ciliates. They are clearly