

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

'an offshoot from the primitive Ciliata before the latter had acquired true binuclearity and the subsequent dimorphism of nuclei'. Metcalf has divided the family into sub-families, PROTOOPALINÆ and OPALININÆ according as the number of nuclei is two or many. The former are not represented in India, and both genera of the latter, viz., *Cepedea* and *Opalina* are known by 8 species of each from various frogs and toads. An examination of Anuran hosts other than those examined already is sure to reveal the existence of many new species. There are many problems about the morphology and physiology of the opalinids which also require further study. The cytoplasmic inclusions, the neuromotor complex as revealed by silver nitrate impregnation and exposure to light, the structure of the nuclei, the nuclear changes during life-history, the causes of the relatively greater abundance of these parasites in the tadpoles than in the adult, are some of the problems well worth further investigation.

The EUCILIATA are divided into 4 orders, viz., HOLOTRICHA, SPIOTRICHA, PERITRICHA and CHONOTRICHA. In the Holotricha the cilia are uniformly distributed over the body in longitudinal rows or limited to particular areas. They comprise the sub-orders GYMNOSTOMATA, TRICHOSTOMATA, HYMENOSTOMATA and ASTOMATA.

All the sub-orders of Holotricha are well represented in India. The Gymnostomata are represented by such well-known genera as *Holophrya*, *Urotricha*, *Prorodon*, *Lacrymaria*, *Enchelis*, *Didinium*, *Coleps*, *Spathidium*, *Bütschli*, *Litonotus*, *Loxophyllum*, *Dileptus*, *Loxodes*, *Nassula*, *Chilodonella*, etc. *Bütschli parva* has been recorded from the stomach contents of the ox, and *Chilodonella rhesus* from the intestine of the common Bengal monkey. No representatives have so far been found of the families ACTINOBOLIDÆ, METACYSTIDÆ, DYSTERIDÆ, PYNCHOTRICHIDÆ and FÜETTINGERIDÆ.

The Trichostomata are classified into 9 families of fresh-water genera, and 4 families of parasitic genera. The fresh-water Trichostomata are represented by species belonging to *Plagiopyla*, *Colpoda*, *Paramecium*, *Drepanomonas* and *Opisthostomum* and the parasitic ones by *Isotricha prostomum* and *Dasytricha ruminantium* from the stomach of ox, and *Charonella ventriculi* from the stomach of the mouse-deer, and three species of *Conchophthirus* which are commensals in the mantle chamber of *Lamelli-*

dens. There are no records of the families SCIADOSTOMIDÆ, SPIROZONIDÆ, TRICHOSPIRIDÆ, CLATHROSTOMIDÆ, MARYNIDÆ and CYATHODINIDÆ.

The Hymenostomata are represented by species belonging to *Frontonia*, *Sigmostomum*, *Trichoda*, *Glaucoma*, *Colpidium*, *Pseudoglaucoma*, *Stegochilum*, *Uronema*, *Ophryoglena*, *Cyclidium*, *Pleuronema*, *Balantio-phorus*, *Urocentrum* and *Telotrichidium*. The families PHILASTERIDÆ, LEMBIDÆ, ANCISTRUMIDÆ, and HYPOCOMIDÆ are not represented.

The Astomata are divided into 11 families of which the family ANOPLOPHRYIDÆ only is represented by 5 species of *Anoplophrya* and 1 species of *Maupasella*. The family HAPTOPHRYDÆ is doubtfully represented by two species of *Caudalina*, a genus inadequately characterised by Madhava Rao.

The Order SPIOTRICHA is characterised by the peristome possessing an adoral zone of cilia arranged in a left-handed spiral, leading to the cytostome. They comprise the sub-orders HETEROTRICHA, OLIGOTRICHA, ENTODINIOMORPHA, CTENOSTOMATA and HYPOTRICHA.

The Heterotricha are represented by species belonging to the well-known fresh-water genera like *Spirostomum*, *Stentor*, *Folliculina* and *Bursaria*, and equally well-known parasitic genera *Nyctotherus* and *Balantidium*. Nine species of *Nyctotherus* and sixteen species of *Balantidium* have been described from India and Ceylon. The families METOPIDÆ and LICNOPHORIDÆ are however not represented.

The Oligotricha are represented by species of *Halteria*, *Codonella* and *Tintinnopsis*, but the family STROBILIDIIDÆ is not represented.

The Entodiniomorpha including the parasitic genus *Entodinium* and other related genera has been exhaustively studied in a series of three monographs, by Kofoid and Mac Lennan on material collected some years previously at Coonoor and Colombo from the stomach of the ox. The original genera of the Ophryoscolecidae, *Entodinium*, *Diplodinium* and *Ophryoscolex*, have been split up, and variously shuffled and recombined by various authors. As many as 10 genera and 43 species are recognised by Kofoid and Mac Lennan as occurring in the contents of the stomach of the ox, and species from the stomach of the mouse-deer. The family CYCLOPOSTHIIDÆ is not represented.

The sub-order Otenostomata recently constituted by Kahl for including the families Epaleidæ, Mylestomidæ and Discomorphidæ, is altogether unrepresented in India, so far as our present knowledge goes. The Hypotricha have not been adequately studied, but still representatives have been recorded of all the principal families. Species of the genera *Peritromoides*, *Urostyla*, *Holosticha*, *Uroleptus*, *Pleurotricha*, *Gastrostyla*, *Gonostomum*, *Oxytricha*, *Balladinopsis*, *Euplotes*, *Aspidisca*, *Aspidiscopsis* have been recorded from different parts of the country.

In the order PERITRICHIA are included cone-shaped or bell-shaped organisms, usually attached to various objects by a stalk arising from the dorsal surface. The stalk is frequently retractile like a spiral spring or is divided into a branching system. In the adult organism, the cilia are present only on the ventral surface which forms the vase of the cone. The adoral cilia are arranged in a right-handed spiral. The adoral row of cilia (in some forms two parallel rows), commences at a point on the ventral surface, and follows a course like that of a flat watch-spring till its outer end passes into a cone-shaped depression (or vestibulum), within which lies the cytostome leading to the cytopharynx. The cilia may be continued into the pharynx as such or may fuse to form an undulating membrane. Species of the genera *Scyphidia*, *Vorticella*, *Carchesium*, *Epistylis*, *Cothurina* and *Vaginicola* are known, but representatives of the family Urceolaridæ which includes such ectoparasites as *Urceolaria* and *Trichodina* have not been met with.

The order CHONOTRICHIA has been constituted for a small group of forms formerly included in the Peritricha. The peristome is developed as a hyaline, spirally convolute, membranous funnel, one limb of which descends into an oral funnel. The order includes ectoparasites or commensals of crustacea and other aquatic creatures. No one has studied these forms in India so far.

The class SUCTORIA has been almost completely neglected in India. Only a very few species belonging to the genera *Tokophrya*, *Acineta*, *Podophrya* and *Spharophrya* have been noted. No representative is known of 5 families out of 7 into which the group is divided. Some one should take up the study of this group, in order to make our records of the Protozoan fauna somewhat fuller.

We will now briefly survey some of the

major groups of the animal kingdom and indicate from what particular hosts the parasitic ciliates have been studied, and from what others it should be possible to obtain suitable material. There are records of *Balantidium coli* from man, from Calcutta and Lahore but so far as we are aware not from any other part of the country. Cattle, sheep, goats, pigs and horses are our most useful domestic mammals. The rumen (paunch) and reticulum (honeycomb) of the ruminant stomach are oesophageal derivatives and as such contain no glands to secrete either acid or ferments. The contents consist of water and large quantities of saliva mixed with the partially triturated food of the animal, which consists of succulent or dried green plants and grain. The fluid serves as an ideal medium for the growth and multiplication of ciliates, flagellates, amoebæ and bacteria, and there is a Protozoan fauna more or less specific to the ruminants. Buisson (1923), Becker and Talbot (1927) and Dogiel (1927) have published useful work on the intestinal parasites of mammals. Till 1927, according to Dogiel, 65 species and varieties of Ophryoscolecidæ had been found in cattle, 32 in sheep and 19 in goats. As noted above, thanks to the labours of Kofoed and Mac Lennan (1930-33), no less than 43 species belonging to as many as 10 genera are now known from the stomach of the Indian ox (*Bos indicus*) from Coonoor and Colombo.

Jameson has described *Charonella ventriculi* from the cattle, and *Entodinium ovalis* from the mouse-deer from Ceylon. Cooper and Gulati (1926) described *Balantidium coli* var. *bovis* from the cattle. Apart from these interesting records, no one seems to have recorded or described any ciliate parasites from the sheep, goats, pigs or horses. E. Ghosh (1929) described what he regarded as new species of *Balantidium* and of *Chilodonella* from the monkey.

Ciliates are not generally found to occur in the alimentary canals of birds, reptiles or fishes, though one species each of *Balantidium* is known from a bird, a tortoise and a fish from other parts of the world. Frogs and toads are commonly infected with Opalinids, *Balantidium* and *Nyctotherus*. Eleven species of frogs and toads have been studied for their parasites and 17 species of Opalinids, 7 species of *Nyctotherus*, and 10 of *Balantidium* are known from them. Dobell (working in Ceylon in 1910), Ghosh and recently H. Ray in Calcutta, de Mello in Nova Goa, and

Bhatia and Gulati in the Punjab have contributed to our knowledge of these parasites.

Parasites and commensals from Mollusca include a species of *Nyctotherus*, a species of *Balantidium*, 3 species of *Conchophthirius*, and 3 species of *Anoplophrya*. Species of *Nyctotherus* and *Balantidium* are also known from the Cockroach and certain other Arthropods. Species of *Anoplophrya* and *Maupasella* are known from the fresh-water Oligochaete *Aelosoma* and from 2 species of the earthworm *Pheretima*. And lastly, Protozoa are known to parasitize other Protozoa, and a suctorian *Sphaerophrya* sp. has been recorded from *Paramecium caudatum*.

Some of the ciliate parasites are very interesting from the morphological point of view. The holotrichan *Ichthyophthirius multifiliis* which is parasitic in the skin of fish, the various ciliates which occur in the caecum of the horse; *Trichodina* which slowly creeps over the external surface of *Hydra* and is also found on the skin of fish; *Spirochona* known to occur on the gills of fresh-water crustacea, and *Licnophora* which is an ectoparasite of various marine animals, should all be looked for by those who have an opportunity to do so, and will very likely be found.

In conclusion, we will say a few words about the regional distribution of the ciliates that have been recorded so far from various parts of India. Following the regional divisions of India as adopted by Stephenson in his volume on Oligochaeta in the fauna of British India, the records are as follows:—

1. North-Western Territory (The drainage system of the Indus so far as comprised

in the plains of India, including the Punjab, the N.W.F.P., N. Rajputana and Sind). 85 species belonging to 50 genera.

2. Western Himalayan Region (from Hazara to borders of Nepal, including Kashmir). 27 species belonging to 18 genera.
3. North-Eastern Frontier Region (Nepal and eastwards, including Assam). 8 species belonging to 7 genera.
4. Indo-Gangetic Plain (U. P., Bihar and Bengal). 74 species belonging to 39 genera.
5. Burma (including the Andamans and Nicobars). 4 species belonging to 3 genera.
6. Main Peninsular Area (including S. Rajputana and the Central India Agency). 17 species belonging to 12 genera.
7. Southern Region (S. of latitude 15°). 80 species belonging to 31 genera, which record includes 40 species from the stomach of the ox.
8. Western Region (Goa to Cutch, the Ghats to the Sea). 30 species belonging to 26 genera.
9. Ceylon—60 species belonging to 19 genera, which record includes 41 species from the stomach of the ox.

In the present state of our knowledge, no importance can be attached to the presence or absence of any species in the specified regions. Larger number of species as recorded from certain regions is simply due to the fact that these regions have been better worked out. Further work will doubtless show the all-India distribution of most of the species.

Mining and Geological Institute of India.

THE annual general meeting of the Mining and Geological Institute of India was held on 1st February 1935 at Calcutta. In his presidential address W. H. Bates (of Burn and Co.) has surveyed the growth and development of coal trade in Bihar and Orissa for the last 30 years. In his opinion the slump in coal market is not merely due to the world-wide trade depression, but to other local causes; and he considers that the future is not so gloomy as many would like us to believe, especially in view of the possible

shortage of oil and other combustible products. The meeting was followed by the Annual Dinner with the Governor of Bengal as the chief guest. Interesting excursions were arranged to several places like Bokaro colliery, *Statesman* offices, etc. The most important work published in the *Transactions* of the year was Dr. Heron's paper on the mineral resources of Rajputana for which the author was rightly awarded the Government of India prize of Rs. 500 and a gold medal.