Symposium on the Malaria Problem in India.

Malaria is not only a disease of major public health importance in India, but it is also one that presents innumerable problems of local and scientific interest for investigation and research. The entomologist, the protozoologist, the pharmacologist, the sanitarian and the public health engineer are all interested in one or other of its diverse problems and specialists all over India are studying these with a view to elucidating them. It was, therefore, considered desirable to collect together workers representing the various specializations from different parts of the country and to afford them an opportunity to present their researches and the special problems encountered by them, so as to elicit a discussion that would be helpful and profitable to the country in general and to the malariologists in particular. The National Institute of Sciences of India undertook to organize such a symposium in Calcutta and appointed Dr. R. B. Lal to be the Convener. Reputed malariologists from different parts of India were invited to attend the symposium. Thanks to the ready response of the workers and their employers there was a good and representative gathering. The meetings were held for two days on the 27th and 28th August, 1937, at the All-India Institute of Hygiene and Public Health, Calcutta, under the joint presidency of Prof. M. N. Saha, F.R.S., and Col. R. N. Chopra, C.I.E., I.M.S., on the first and of Sir U. N. Brahmachari on the second day. In all 28 papers were read.[1] They may be classified under the following heads :—

(I) Treatment, (II) Epidemiology, (III) Irrigation and Malaria, (IV) Immunity, (V) Control, (VI) Malarial Engineering, (VII) Entomology, (VIII) Protozoology, (IX) Ichthyology.

I.

1. Col. Chopra opened the session by discussing the relative value of various anti-malarial drugs such as cinchona alkaloids and the new synthetics employed for the treatment and prevention of malaria. He drew special attention to a new German synthetic drug cilionol which, though still in the experimental stage, promises to become a very useful addition to the drugs already in use, because of the fact that it can be safely used for mass treatment.

In connection with Col. Chopra's paper Dr. P. Neogi (Calcutta) said that before the introduction of cinchona preparations in India several vegetable drugs containing bitter principles were being used very extensively for counteracting malaria. The Indian *Kaviraj* professes to cure malaria and other

[1] For a list of the papers, see pp. 142, 143.

kinds of fever with pills containing these. He asked Col. Chopra if he had investigated the composition of any of these pills and the nature of the bitter principles in them. If not, he suggested that they may be investigated as he believed that they certainly possessed anti-malarial properties.

The synthetic anti-malarials possessed distinct advantage over quinine and other alkaloids inasmuch as the latter produced cinchonism, in some persons, even in medicinal doses.

2. Dr. K. V. Krishnan (Calcutta) said that his detailed investigations on the biochemical changes taking place in the blood of hæmoglobinuric and non-hæmoglobinuric monkeys during the different stages of the disease, with special reference to those chemical constituents that were known to be associated with the phenomenon of hæmolysis, such as cholesterol, inorganic and organic phosphorus and glucose had brought out the fact that in the pre-hæmoglobinuric stage the following changes were conspicuous: (*a*) a fall in glucose and a rise in inorganic phosphorus; (*b*) a rise in cholesterol esters, and a fall in total cholesterol in a fair number of cases and a marked fall in free cholesterol in all cases; and (*c*) a rise in organic phosphorus. Somewhat similar results were also obtained in human cases of blackwater fever. From these findings it was concluded that the phenomenon of hæmoglobinuria both in man and in monkeys was determined by the manner in which the host reacted to the stimulus of malarial infection. The production of the hæmolytic agent, as well as the conditions that favour its action, seem to be the result of altered metabolism due principally to liver injury. Whatever the true nature of the hæmolysin may be, it is clear that its action is definitely inhibited by excess of *free cholesterol*. So in the treatment and prevention of blackwater fever the aim should be: (1) to prevent liver injury, (2) to correct the consequent alterations in fat metabolism; (3) to stimulate the cholesterologenetic centres in a manner such that the synthesis and mobilization of free cholesterol will keep pace with the increased demand; and (4) to stimulate the reticulo-endothelial system so that phagocytosis and the cholesterol stores of the body may be maintained. Preliminary studies showed that all these could be accomplished to a certain extent by injections of glucose, ascorbic acid and cortin.

In connection with Dr. K. V. Krishnan's paper Dr. S. C. Seal wished to be enlightened on the following points:—

(1) What was the effect of the injection of 'cortin' and ascorbic acid on the free cholesterol content in monkeys suffering from hæmoglobinuria? Was it definitely increased?

(2) Has any attempt been made to burn out or prevent relative or actual increase of ester-cholesterol which is directly or indirectly associated with the production of hæmolysis by any process?

Dr. Krishnan replying said that there was a definite indication of the ratio between free and ester-cholesterol being brought back to normal after the use

of cortin and ascorbic acid. Regarding the other question he said that he had tried substances like glutathione for the purpose but had failed to obtain any beneficial results.

Mr. N. K. Iyengar said that Dr. Krishnan had tried the injection of choline hydrochloride without success in the treatment of blackwater fever. Recent experiments showed that choline was first decomposed to betaine which prevented storage of fat. It was likely that this decomposition to betaine was rendered difficult in cases of blackwater fever. He suggested direct feeding of betaine in small quantities in cases of blackwater fever.

Dr. Krishnan replied that he was aware about the decomposition of choline to betaine and that he had also tried betaine but without success. He, however, had obtained good results by the use of a combination of choline hydrochloride and quinine in the treatment of monkey hæmoglobinuria. Thus the suggestion that the mechanism of conversion of choline to betaine was at fault was untenable.

3. Dr. Dikshit being absent his paper was taken as read. The main points of his paper may be summarized as follows :—

His experimental observations show that plasmoquine is liable to affect most systems of the body especially the cardio-vascular and the digestive systems. Cardiac irregularities are produced by intravenous injection of the drug and therefore this method of administration should be avoided. The liver seems to be the organ which is very often affected by toxic symptoms seen after clinical use of the drug. The action on the reproductive system, however, does not appear to be harmful, and there is some evidence to believe that even large doses fail to interrupt the course of a normal pregnancy. The fact that a combination of quinine and plasmoquine antagonizes the stimulant effect of both on the isolated uterus is interesting from a clinical point of view for such a combination has proved useful in the treatment of malaria.

(1) Toxicity tests on protozoa and bacteria show that plasmoquine is not toxic.

(2) Plasmoquine has no antipyretic action of its own, but in combination with quinine it lowers temperature quicker than quinine alone.

(3) The cardio-vascular system is depressed by small doses of plasmoquine. Larger doses produce cardiac irregularity.

(4) The gastro-intestinal motility is depressed and toxic doses produce fatty degeneration of the liver.

(5) The contractions of the isolated human or animal uterus are increased by low concentrations of plasmoquine and decreased by high concentrations.

(6) Contractions of the intact animal uterus are not affected by administration of therapeutic doses of plasmoquine given over a period of five days.

(7) Therapeutic or even toxic doses of plasmoquine given to pregnant guinea-pigs do not produce abortion.

4. Col. Chopra said that he had treated six patients of neurosyphilis by parenteral administration of *P. knowlesi*. Although no beneficial effect was noted on the patients' nerve condition, he arrived at the following conclusions:—

(*a*) The monkey malaria parasite can be safely given to human beings.
(*b*) They are particularly suitable for the treatment of aged and debilitated cases.
(*c*) As monkeys do not suffer from syphilis there is no risk of giving this infection to man by using their blood.
(*d*) These parasites can be maintained in the laboratory with great ease.
(*e*) The infection in humans has a tendency to spontaneous recovery.
(*f*) Sometimes when after infection the fever is high it can be controlled easily by atebrin or quinine.

II.

5. Dr. R. B. Lal (Calcutta) gave an account of the methods of forecasting malaria which had been in use for over 16 years in the Punjab. He discussed the principles underlying the methods of forecasting and invited discussion as to whether those methods could not be profitably developed to suit the varying conditions in different provinces of India. If this could be done, the administrative officers, being forewarned, could concentrate their attention to specific areas where epidemics of malaria were likely to develop in particular years. He then discussed the following factors actually made use of in Gill's method of forecast for the Punjab :—

(*a*) The spleen rate of school children taken all over the province in the month of June.
(*b*) The rainfall figures to obtain an idea of the strength of the monsoon.
(*c*) Economic condition.
(*d*) Epidemic figure for each *thana* or town obtained by dividing the fever mortality for October by the average fever mortality for the months of April, May, June and July.
(*e*) The epidemic potential factor or the coefficient of variation of malaria deaths.
(*f*) The co-efficient of correlation between rainfall and fever deaths for the month of October for the district.

In connection with Dr. R. B. Lal's paper Mr. Senior-White stated that Punjab had given a 16 years' lead to other provinces in this respect. Forecasting in his opinion had been of great value. He could not understand why the other provinces did not adopt it. Will not the staff of the Malarial Survey do it for the provinces subject to epidemics ?

Prof. J. N. Mukherjee (Calcutta) asked how far the forecasts agreed with the actual incidence of epidemics in each district.

The President enquired if the periodical epidemics showed any correspondence with the sun-spots.

In his reply Dr. Lal said that while there was a fair amount of agreement between the forecast and the actual happenings, he believed that the method in use at present was capable of improvement to a considerable extent. His main difficulty was with regard to the assumption that the autumnal deaths were necessarily due to malaria because he was not convinced that sufficient evidence in support of that assumption had ever been set out.

The sun-spot cycles exhibited 11 years' periodicity. Sixteen years, during which the subject had been studied, was too short a period for studying the correspondence between sun-spot cycle and periodicity of malaria incidence. However, a correspondence between the two events might be expected because malaria epidemics in the Punjab were markedly influenced by the amount of rainfall which in turn had been correlated with sun-spot cycles.

6. Dr. A. C. Banerjea (Lucknow) discussed the essential factors responsible for urban malaria in the United Provinces. He classified them as follows :—

1. *Natural causes :*
   (*a*) Due to urban areas growing in the midst of malarious zones as in the Tarai and foot-hill regions.
   (*b*) Due to drying up of rivers on which cities are situated or due to change in the course of rivers.

2. *Man-made malaria :*
   (*a*) Due to proximity to irrigation canals and wet crops, viz. sugarcane and rice.
   (*b*) Due to defective railway systems interfering with natural drainage or creating fresh breeding grounds, viz. burrow-pits, excavations, etc.
   (*c*) Due to ill-developed cities.
   (*d*) Due to breeding in wells.
   (*e*) Due to proximity to big lime and brick kilns and excavations.
   (*f*) Due to lack of co-ordination between different bodies responsible for urban sanitation.
   (*g*) Due to domestic causes.
   (*h*) Due to ill-developed industrial centres in urban areas.

He further stated that urban malaria in the United Provinces was mostly endemic and periodical fulminant epidemics like those in the Punjab were practically unknown. The two seasonal rises were in spring and autumn. One was due to benign tertian infection and the other to malignant tertian infection. The principal carrier mosquitoes incriminated were *A. culicifacies* and *A. stephensi*.

Urban malaria to a very large extent was man-made and could be reduced by sound sanitation, by co-ordinated activities on the part of the different

departments concerned and by enforcement of suitable anti-malarial bye-laws. In a campaign against urban malaria, the investigation and anti-malarial measures should not only be confined to the area itself but to at least one mile area all round the territorial limits of the urban areas.

In connection with Dr. A. C. Banerjea's paper Mr. Senior-White (Calcutta) enquired what the writer meant by the term 'incriminated'. No records of *A. culicifacies* having been found infected in the areas investigated by Dr. Banerjea were known to him. If Dr. Banerjea found the species infected this information has not been published.

Dr. Banerjea replied that the term 'incriminated' was used because the insect was found infected on dissection. This information had been recorded in his reports.

Referring to the breeding of mosquitoes in connection with sugar-cane cultivation Dr. Ananthasamy Rao enquired whether the carrier species were bred in the irrigation channels or in the actual cane plots. He also sought information regarding the system of irrigation adopted and enquired whether it was continuous or intermittent.

7. Mr. M. O. T. Iyengar (Calcutta) said that many species of Anopheles were specialized in regard to their breeding habitats and were adapted to breed in certain types of breeding places. Their distribution would, therefore, be determined by the availability of the type of breeding place suitable for the particular species. Consequently, in a country with different topographical regions, the anopheline fauna shows considerable variation. The species responsible for the transmission of malaria would also differ in the respective regions and the problems connected with the control of malaria would therefore differ with the areas concerned.

The province of Bengal, which extends from the Himalayas to the sea, includes different types of country: the mountains, the foot-hill region, the dry undulating area, the deltaic area and the mangrove area.

Studies in these regions have brought out the interesting fact that the operations of man have increased the facilities for the breeding of the harmful species of *Anopheles*. In the virgin state, it is probable that the incidence of malaria was comparatively low. In many of the regions, the high incidence of malaria is largely the result of human operations. The occurrence of malaria in the submontane regions is probably largely due to the extensive forest clearance operations for the purpose of tea and rice cultivation. The clearance of the forests have eliminated the harmless species of *Anopheles* and have offered facilities for the intensive breeding of the harmful species. In the pastural region with little or no malaria, the localized foci are the results of attempts to alter the natural conditions, as for example, creating terraced plots for rice cultivation, colliery operations, impounding of rivers and the digging of wells for water supply. In the deltaic area, the construction of embankments to prevent the flooding of the land by rivers in flood or by the tides largely contribute to the establishment of endemic conditions. In the

estuarine area, the clearing of the forests and the prevention of tidal flushing are responsible for the establishment of malaria endemicity through intensive breeding of *A. ludlowi*. In most of the cases these results are due to interference with natural conditions without due precautions being taken against the natural consequences of such interference.

8. Dr. G. C. Chatterjee (Calcutta) said that it was generally accepted that agriculture in a general way would tend to diminish malaria, but that cultivation of rice, to the exclusion of other agricultural products, might increase malaria incidence. Therefore, balanced agriculture was a pressing need of the province. The production of fodder crops for feeding cows, which are useful in many other ways, is highly desirable. This will also tend to improve the humus content of the soil on which fertility depends and will lead to improvement of public health. Cultivation all the year round will tend to nullify, to a great extent, the scorching effect of the tropical sun. It will also tend to lessen the scouring action of the floods during the rainy season which tend to produce soil erosion. These in turn remove the top dressing of land.

In Bengal, from time immemorial, a system of irrigation of lands around excavated tanks or bunded reservoirs is extensively prevalent. This system is seen in Burdwan, Midnapore, Bankura and other districts, but not to the same extent in districts like Khulna, Jessore, Dacca, where there are a large number of rivers. It is, however, getting out of use, due to the constant migration of the people to towns, and to the tanks becoming the joint property of several members of a family and thereby getting neglected. It is, however, still in force in several places and can be made use of for the improvement of agriculture as well as for the prevention of malaria.

Recently a large number of small co-operative irrigation societies have been formed in Bankura and Birbhum districts for utilizing these tanks for irrigation purposes. The system has thus been given a new lease of life. If by some means or other, propaganda can be done for enlarging the scope of this scheme lasting good to the country is bound to result. Cultivation should include some type or other of fodder plants and leguminous crops. The people should be made to understand that milk along with fish is the greatest protective food ; and these should be made available for all at a cheap price. When this is done it will automatically solve the malaria problem of the province.

9. Due to the absence of Prof. de Mello, his paper was taken as read. The points of interest in the paper may be summarized as below :—

The highly malarious regions in Portuguese India are Novas Conquistas in Goa, Pragana in Daman, the town of Diu and certain villages of Brancavara in Diu. The three important anopheline carriers of malaria are *A. listoni*, *A. culicifacies* and *A. stephensi*. The chief anti-malarial measure practised is the treatment of infected persons and carriers. Plasmoquine and atebrin have been tried with great benefit. Mass treatment with quinine-plasmoquine

during pre-epidemic periods has given encouraging results. The use of atebrin-musonate in the treatment has proved valuable. In rural areas it has not been possible to conduct any anti-larval campaigns.

III.

10. Dr. Sweet (Bangalore) stated that there were three types of irrigation systems in Mysore State. One type involved a small area under a local tank. It was usually not malarious. A second type covered a larger area under a bigger and more permanent tank. This was frequently malarious. The third type was an extensive riverine system which was invariably malarious. The riverine system not only produced an initial epidemic of malaria at its commencement, as demonstrated by the history of events following the opening of the Irwin Canal system in June, 1932, but also created highly endemic conditions. The three types of irrigation seemed to differ in (1) the length of main and subsidiary channels ; (2) the amount of water used ; and (3) the season of the year in which water was available. In these three differences, possibilities for the control of malaria exist, especially in the strict control of the amount of water supplied and its use. Lack of drainage is a defect common to all types but, due to expense, it does not seem likely that this aspect of the prevention and control of malaria in new and existing irrigation systems will receive the attention it deserves until the profit motive is largely removed from consideration.

In connection with Dr. Sweet's paper Dr. K. V. Krishnan (Calcutta) in endorsing the views expressed by Dr. Sweet on irrigation and malaria referred to his study of a severe outbreak of malaria in Mopad in the Nellore district of the Madras Presidency in 1925, which had arisen as a result of the introduction of irrigation. The Mopad area prior to the introduction of irrigation was a dry tract of country with only about 10 per cent spleen rate. After irrigation was introduced in 1921, the spleen rate rose to over 50 per cent and, on account of the severity of malaria, agriculturists had to abandon their land and leave the area. Investigations showed that the most important factor that contributed towards the increase of malaria was water-logging of the whole area, resulting from the excessive supply of water and poor drainage. The Government was anxious to sell as much water as possible and the ryots wanted all the water they could get for raising at least two crops of rice. He was, therefore, of the opinion that unless water supply is restricted to the actual needs and financial considerations are not over-emphasized, malaria was bound to arise shortly after the introduction of irrigation schemes in dry tracts of country. He wished to emphasize the importance of the views presented by Dr. Sweet and stated that even if proper drainage could not be effected, restriction of the amount of water supplied plus control of the type of crops raised could reduce malaria to a considerable extent. The mere consideration of immediate financial gain appeared to him a short-sighted policy.

11. Dr. Masillamani (Madras) said that the irrigation systems in the Madras Presidency varied from place to place. He classified them as follows :—

(*a*) Canal irrigation.
(*b*) Rain and river-fed irrigation tanks.
(*c*) Irrigation from springs and hill streams.
(*d*) Lift irrigation from wells in the beds of streams.
(*e*) Irrigation from field wells.
(*f*) Irrigation or watering from pits.

In the case of wells, there was a limited supply and no stagnation or continuous flow of water. Wells in the beds of streams got flushed out during floods. No malaria was associated with this type of irrigation.

In the case of pits in casuarina and cocoanut plantations, they were abandoned after the plants grew to a certain height. These provided prolific breeding grounds for *A. culicifacies*.

Part of the foot-hill malaria in the Presidency was due to irrigation from springs and streams. In the plains malaria was associated with canal irrigation and tank irrigation though it was not so in every instance. The main factors seem to be the ill-kept canals and uncared for field channels. In the seepages from the canals, in the burrow-pits by their side and in the grass-grown edges *A. culicifacies* find suitable breeding places. The field channels rather than the method of irrigation followed or the kind of crop raised are of the greatest importance. The water-logging conditions produced outside the fields, as in the case of sugar-cane and paddy cultivation, are also important, but the semi-stagnation of water in the fields themselves is not of much significance except perhaps in the very early stages of cultivation of paddy. In dry irrigated areas, it is the seepages from canals and the canals themselves that are responsible more than the field channels.

The many factors associated with irrigation malaria and the precise scope of their influence are not fully known. There are several kinds of water sources, the importance or otherwise of which has not yet been scientifically determined. There is also the possibility that malaria in irrigated areas is only a passing phenomenon. The endemicity in many places is often very low. We are not justified in blaming the engineer for his errors of omission and commission. Drainage schemes are usually utopian, larvicide schemes are make-shift arrangements, and abolition of paddy fields and breaching of tanks are merciless steps. Prevention of percolation, regulation of flow, alteration in supply, maintenance of channels—these are methods in which the engineer should be interested and to these attention should be mainly directed.

In connection with Dr. S. G. Masillamani's paper Dr. K. V. Krishnan (Calcutta) said that it was generally believed that irrigation schemes if properly introduced in deltaic areas helped to reduce greatly the incidence of malaria. Dr. Bentley and others were great advocates of this view. The increase in

malaria in certain parts of Bengal had been attributed by them to the gradual decadence of the old irrigation system and people here often quote the excellent results obtained through the introduction of irrigation in the Godavery, Krishna and Kavery deltas. He wanted to ask Dr. Masillamani whether he had made a comparative study of the influence of irrigation on malaria in deltaic and non-deltaic areas in the Madras Presidency and whether there were any differences, and if so what they were. He also requested Dr. Masillamani to tell him how far his findings corroborated or contradicted Dr. Bentley's views with regard to the beneficial results of irrigation in deltaic areas.

IV.

12. Dr. Krishnan (Calcutta) said that the course of *P. knowlesi* infection varied greatly in different species of monkeys. Ordinarily in the *Silenus rhesus* it causes an acute fatal infection, while in *S. irus* and *S. radiatus* it produces a low grade, non-fatal infection. From the splenectomy experiments conducted by him the following conclusions were drawn :—

(*a*) In splenectomized animals the differences due to natural species immunity completely vanishes ; all three species suffer alike from acute and rapidly fatal infection.

(*b*) The natural resistance of monkeys to the human plasmodium is not influenced by splenectomy.

(*c*) If splenectomy is done during the latent period of infection a severe relapse follows.

(*d*) Extirpation of the spleens of immune monkeys results in the disappearance of their acquired immunity in all cases. While in the susceptible species acquired immunity was found to be associated with the presence of residual focus of latent infection, in the resistant species (*irus* and *radiatus*) in about 50 per cent of cases, even in the absence of a residual focus of infection a high degree of acquired immunity was found to be present.

(*e*) In connection with treatment of malaria in splenectomized animals the following facts were elicited :—

(1) Larger amounts of quinine were required to cause complete disappearance of all parasites from the peripheral blood.

(2) The drug had to be administered for a much longer period.

(3) The cure rate was distinctly less.

(4) The death rate was markedly higher than in non-splenectomized monkeys.

(*f*) When animals are splenectomized prior to infection with *P. knowlesi* the incidence of hæmoglobinuria is greatly increased. In 90 to 100 per cent of splenectomized *rhesus* and in about 30 to 50 per cent of splenectomized *irus* and *radiatus* hæmoglobinuria is met with.

(*g*) Splenectomy failed to alter the course of Leishmania infection in monkeys.

From these studies it is concluded that the spleen plays a part of great importance in the resistance and cure of malaria.

In connection with Dr. Krishnan's paper Mr. N. K. Iyengar asked if the effect of splenectomy on the buffering capacity of blood had been studied. He considered this an important factor in elucidating the mechanism of resistance as it had been established that there was a relation between the buffering capacity and resistance.

Dr. Krishnan replied that as far as their studies went there was no evidence to suggest that the buffering capacity of the blood was altered after splenectomy.

13. Dr. M. N. De (Calcutta) read a paper on the pathology of the malaria spleen. He described the changes which occur in the spleen in acute and in chronic malaria. While in the former the enlargement is entirely due to the extra burden suddenly thrown upon the organ and to the concomitant vascular changes which inevitably follow such increased output of work, in the latter there is less vascularity and more cellular changes with increase in reticular fibres. The capsule instead of being thin is thick and the trabiculæ are more numerous and prominent. The typical 'ague cake' spleen is only met with in chronic malaria.

V.

14. Major Afridi (Kasauli) said that the chief causes of malaria incidence in Delhi were :—

(1) Excessive canal irrigation coupled with interference with natural drainage by railway, road, and canal embankments in the North-Western section.

(2) Annual flooding of the *bela* by the Jumna, leading to (*a*) heading up of water in the various storm-water drainage channels, and (*b*) formation of prolific breeding places as the flood recedes.

(3) Presence of vast numbers of excavations throughout the area in the form of burrow-pits alongside railways and roads, and pits in brick-fields and quarries in the ridge area.

(4) Presence of miscellaneous breeding places such as temporary water collections around hydrants, ornamental waters, non-mosquito-proof cisterns, wells and underground storm-water drainage system.

The measures enforced during the past year may be considered under two headings : (i) permanent measures, and (ii) temporary measures.

Permanent Measures.—The permanent measures have been instituted with a view to eradicating breeding places caused through faulty storm-water drains, lack of adequate drainage of low-lying tracts and over-irrigation in the area fed by the Western Jumna Canal. These measures can scarcely

be looked upon as specifically anti-malarial in nature but are designed to provide such surroundings for Delhi as could easily be controlled by the anti-malarial staff. In securing this objective the activities of the Anti-Malaria Organization have been intimately linked up with those of the Delhi Improvement Trust and sanitary improvement programmes in general. The successful conduct of these measures has been greatly facilitated by the whole-hearted co-operation of the civil and the municipal administrations and of the officers of the Central Public Works Department who have, throughout, placed all possible facilities at their disposal.

Temporary Measures.—These measures were concerned with the organization of the anti-malarial staff of the various municipalities, the provision of oil, paris-green and other larvicides, and the institution of programmes for adequate weeding, minor filling and draining of small temporary collections of water. The central organization for the measures was supplied by the Malaria Survey of India and the striking benefit of such a central control was the elimination of much overlapping of work and the baneful effects of the neglect of one sector to the detriment of the adjoining sector. The establishments for different areas have been varied to suit the demands imposed by the climatic requirements and the extent of the breeding sources.

In addition, as an experimental measure the quarters of certain isolated communities in the Delhi urban area were regularly sprayed with pyrethrum larvicide. These measures yielded very encouraging results. Similarly the practicability of spraying of paris-green by aircraft was thoroughly tested and the results have already been published (Covell & Afridi, 1937).

In connection with Major Afridi's paper Dr. Sweet said that one point which had interested him for some years was the low spleen rates in urban areas. In many city areas very low spleen rates had been reported, e.g. in Bombay, Calcutta, and Bangalore. In urban areas such low spleen rates do not mean an absence of a considerable amount of malaria. The factor which is working is possibly one of dilution which was first mentioned by Christophers. In urban areas, with many children, the chances of any single child getting repeated new infections are small and the resultant spleen rate will be low and not at all representative of the actual malaria. The parasite rate in such cases is frequently higher than the spleen rate. A method of spleen examination which might be more representative of actual conditions would be the use of POI spleens as suggested by Dr. Russell. These small spleens well up under the ribs would possibly give figures which would give a more correct idea of the actual amount of malaria in cities.

With reference to the point raised by Dr. Sweet, Dr. Row said that he had found, during an epidemic of malaria in Mysore City, against a low spleen rate in the different wards of the city, a high parasite rate ranging from 15 to 25 per cent. After 5 years of anti-malaria work in the city the spleen rates were round about 2 to 3 per cent, while in two wards the parasite rate was still round about 12 to 15 per cent. Would Major Afridi state if

A. stephensi was considered a carrier in Delhi and what percentage of wells bred this species and how the breeding was controlled ?

Mr. Iyengar said that he wished to know if there was any relation between spleen rates and density of population. In his experience Bengal towns with a fair density of population had very little malaria. He also wished to know if adult catches represented the actual incidence of adult mosquitoes in the area. There was usually very great variation in the catches from day to day and from month to month and even when there was intensive mosquito breeding in ponds, the adult catches were often small and did not reflect the extent of breeding. He further enquired about the effect of oil containing 2½ per cent cresol on fish and vegetation. Did the water get discoloured as a result of the decomposition of the vegetation ? Did the oil spread equally well in dirty as well as in clean water ?

Dr. Lal enquired whether the question of converting the low-lying *bela* area near Okhla into a lake had been considered. He also wanted to know how they proposed to deal with the Najafgarh Cut which extended to many miles and drained the shallow *jheel* and marshes of Najafgarh. By increasing the gradient they will make the level of the outlet lower than that of the river. Did they propose to put in a sump and a lift pump ?

Major Afridi replied to the various points raised in the discussion.

15. Dr. B. A. Rao (Mysore) said that one of the objections to the use of paris-green as a larvicide in anti-malaria work was that it was not hundred per cent successful as judged by the standard of larval catches. In the course of field experiments it was seen that the first and second stage larvæ remained almost untouched by paris-green. This was perhaps purely a physical defect in that the size of the particles of paris-green in common use was too big for the larva in the early stages of its growth. This handicap can effectively be controlled by spraying paris-green mixture once a week, or oftener if necessary, so as to catch these larvæ before they pupate.

In the light of his studies, conducted over a period of eight years in the Nagenhalli area, it was possible to conclude :—

(1) That paris-green can be used effectively for controlling anopheline breeding in irrigation channels.

(2) That a one per cent mixture with a suitable inert diluent is quite an adequate strength for use as a larvicide.

In connection with Dr. B. A. Rao's paper Dr. Sweet emphasized the utility of paris-green as a larvicide in running water. He had used paris-green in irrigation channels for years in Mysore with every evidence of success. He could not say that he did not get the larval drift mentioned by Sinton. He did get the drift, but it was in large channels only and there he had to use booming and other methods mentioned by Sinton. In the smaller channels paris-green was completely effective as far as could be judged by larval dippings, adult catches and spleen and parasite rates.

16. Captain Sinha (Calcutta) said that the Bengal Public Health Department had carried out an experimental scheme in Memari Police *thana* of Burdwan district to investigate the extent to which malaria incidence could be reduced by mass treatment with plasmochin and quinine without carrying out any anti-mosquito measures.

The experiment lasted for four years from 1933 to 1937. It was observed that the malaria incidence had been reduced by more than 50 per cent, the fever index which was 16·0 in 1933-34 had come down to 4·2 in 1936-37. In the control area the index had gone down from 42·5 to 25·0 in the corresponding years. Spleen index also underwent similar reductions. In the experimental area it was reduced from 68·0 in 1933 to 21·4 in 1937, while in the control area it was reduced from 60·5 to 42·9 only. The parasite index had also been reduced in the experimental area to one quarter of what it was in 1933.

Several factors which adversely affected the results of the experiment were enumerated by him.

In connection with Captain Sinha's paper Dr. Krishnan said that the question of drug prophylaxis of malaria in rural areas in India was a very important one. Rural India watched the results of the Bengal experiment with great interest. But unfortunately the results did not come up to the expectations of many. As explained by Dr. Sinha, several factors adversely affected the success of the experiment. All that one could say at present was that the results so far obtained were not very significant although they were not altogether disappointing.

17. Dr. K. L. Chowdhury (Calcutta) said that the problem of mosquito control in Calcutta could be considered from two aspects :

(A) General problem—pertaining to the Corporation of Calcutta in the—
  (*a*) sewered area,
  (*b*) unsewered area.

(B) Special problems—pertaining to the Government of Bengal and the Local Bodies in the—
  (*a*) salt lakes,
  (*b*) areas adjoining municipalities,
  (*c*) port, railways and docks,
  (*d*) irrigation canals, the New Cut, the Circular and the Belliaghata canals,
  (*e*) maidan, Eden Garden, Government House, jails, etc., and
  (*f*) military areas : Fort, Boydguard lines, etc.

The solution of the problem in Calcutta, he said, resolved into the following measures :—

(*a*) In the sewered area :
  (1) House-inspection.
  (2) Adequate legislation like the Mosquito Ordinance.
  (3) Mosquito proofing of cisterns, oiling the street gullies, etc.

(*b*) In the unsewered areas :

(1) Vigorous anti-mosquito measures in tanks, ponds, lowlands, open drains, etc.

(2) House-inspection with the aid of adequate legislation.

(*c*) In the Salt Lake areas :

(1) Engineering schemes, such as land reclamation, cultivation, fisheries, refuse-dumping along a stretch of one mile along the eastern fringe of the city, etc.

(2) Research for chemical treatment of sewage in order to make it unsuitable for breeding *Culex fatigans*.

(3) Paris-green treatment and oiling.

(4) Amendment of the Calcutta Municipal Act of 1923 in order to enable the Corporation of Calcutta to extend anti-mosquito measures up to a mile beyond its boundaries on all sides.

(*d*) In the adjoining Municipalities :

(1) Vigorous cleansing and oiling of all surface drains, cess-pits, lowlands, etc., especially during the cold months, viz. November to March.

(*e*) In the Port and Dock areas :

(1) Regular inspection of all boats, ships, barges, etc., and taking suitable anti-mosquito measures.

(2) Suitable legislation.

In connection with Dr. K. L. Chowdhury's paper Mr. M. O. T. Iyengar (Calcutta) asked what was the present incidence of *Anopheles stephensi* breeding in cisterns in Central Calcutta. It was about 40 to 60 per cent in 1920 according to his survey made during that year.

It was necessary that the area surrounding Calcutta was also controlled as it was frequently said that all the *Culex fatigans* found in Calcutta did not breed within the city but came from outside.

Dr. Lal said that as Chairman of the Sub-Committee appointed by the Anti-mosquito Committee of the Calcutta Corporation he had an opportunity of studying the serious problem of mosquito nuisance in Calcutta. Those living in the Ballygunge area and in certain other parts of Calcutta were disturbed in their sleep every night and wondered what the city authorities were doing to exterminate this pest. As a matter of fact the anti-mosquito problem resolved itself into two parts, namely, (1) one involving major engineering schemes and the other measures requiring large funds, and (2) one which could be effectively dealt with by proper organization of available resources. It is surprising how much could be done to reduce the mosquito nuisance in this city by the proper handling of the problem. Under the present arrangements too much attention was being paid to such breeding grounds as house-cisterns which contributed a comparatively small amount

to the mosquito population but consumed large funds and even so only a few of these could be dealt with.

18. Dr. G. C. Chatterjee (Calcutta) gave an account of the different species of larvivorous fish found in Bengal and referred in particular to the following: (1) *Colisa speciosa* (*Chuno kolisa*), (2) *Haplochilus*, (3) *Panchax panchax*, (4) *Barbus ticto*, *B. sophore*, *B. conchonius*, *B. stigma*, *B. phutunio*, (5) *Esomus danricus*, (6) *Rasbora daniconius*, (7) *Amblypharyngodon mola*, (8) *Brachydanio rerio*.

He then referred to the larvivorous qualities of the fry of carps and their value in controlling mosquito larval breeding in the tanks of Bengal. In order to encourage the growth and multiplication of larvivorous fish generally, in the tanks, he recommended the cultivation of the land around the tanks enriched as much as possible by the sludge removed from the tanks. If in addition the rain water from these lands is made to drain into the tank then the fish multiply in large numbers and larval breeding is kept down to a minimum.

In connection with Dr. G. C. Chatterjee's paper Dr. Krishnan said that he had conducted field experiments in some of the Bengal villages on the utility of fish as mosquito larvæ destroyers through a grant from the Indian Research Fund Association in 1934. He was glad to note that Dr. Chatterjee had found the fry of carps extremely valuable. This was entirely in keeping with his own findings and he wished to emphasize the use of fry on a more extended scale for controlling larval breeding. This appeared to be a very useful, economical and profitable measure, under the peculiar conditions prevailing in the Bengal villages.

19. Dr. Hora (Calcutta) said that in India there was a variety of indigenous larvicidal fish belonging to the family Cyprinodontidæ, which was probably not inferior to *Gambusia*. The latter had been introduced from outside in recent years. He referred to the recent biological work of Fraser on *Panchax lineatus* (C.V.) and of Hora and Nair on *P. panchax* (Ham.). On the strength of these studies he made a plea for an intensive stimulus to pisciculture in India, as the young of practically all kinds of sluggish-water fish could feed on mosquito larvæ.

In connection with Dr. Hora's paper Dr. K. L. Chowdhury supported the views expressed by Dr. Hora regarding the value of larvivorous fish in malaria control.

Nuria danrica was another very good larvicidal fish. This species was found in Assam particularly during the rains.

In Calcutta good results had been obtained by carefully preserving the fish fauna, whatever they might be, and also the natural vegetation growing there.

Dr. B. Rao (Mysore) said that in Bangalore *Gambusia* was used intensively for the control of *A. stephensi* in wells. The fish together with *B. puckelli* and *B. punctatus* had been stocked in step wells in Chitaldroog district for

guinea-worm control. It was observed that all the three species thrived quite well in these wells. It was a common observation that the fish, no matter what type it was, was useless as a larvicide in the tanks where there was heavy vegetation. Cleaning the tanks of vegetation was in itself effective and in most cases additional stocking with fish was not necessary. When dealing with big areas, it was not practicable to keep the tanks clear of vegetation as the growth reappeared quickly and vigorously. The same fact had been observed in wells stocked with *Gambusia* whenever the well water was dirty, and in such cases *A. stephensi* was commonly found in association with *Gambusia*.

Mr. M. O. T. Iyengar said that he was entirely in agreement with Dr. Hora regarding the undesirability of introducing foreign fish like *Gambusia*. One should be very wary of any such attempts if one were to profit by the experience of other countries. *Gambusia* was very predaceous to the young of edible fish and fishermen in Italy and Spain were violently against the introduction of *Gambusia* as it affected fisheries adversely. We know that both *Panchax* and *Anopheles* larvæ are often found together. That is because the larvæ are afforded protection by the dense aquatic vegetation. The argument that if we clean the vegetation the mosquito larvæ would also disappear was not always true. One frequently observed ponds with very little aquatic vegetation and yet breeding *Anopheles* mosquitoes. In such cases, the introduction of *Panchax* would be most effective in controlling mosquito breeding.

VI.

20. Mr. Curry (Calcutta) said that in Bengal, owing to the economic needs of a rapidly increasing population, embankments, to prevent many of its rivers overflowing their banks, had been erected. At first the results of such action were very profitable ; crops were grown without risk of ruin by flooding, railways, roads, factories, and all other amenities and accompaniments of material and industrial progress were introduced. Later, however, the harmful effects of the policy of embankments began to be felt. When a river is embanked the silt, which is intended by Nature to be discharged on to the surrounding lands, could not escape from the river channel and was mostly deposited on the bed, thus choking the channel and causing the bed level to rise. As the bed level rises the water level also rises and, in consequence, the embankments have also to be raised to keep pace with the rise in the bed and water levels of the river. The lowlands remain at the same levels and so unhealthy swamps are formed which cannot be drained and become a menace to public health. The lands, which would normally be revitalized and moistened by river spill, become infertile and the natural system of surface drainage becomes upset. Owing to the rise in the river levels the danger of breaches in the embankments and of disastrous flooding of large areas becomes great.

The contrast between the conditions in East Bengal and Central Bengal is very striking. In the former (except in a few areas where embankments along rivers have been constructed) the countryside is subject to river spill and is fertile and populated by a virile and healthy population.

In Central Bengal where the rivers have been embanked, all the harmful effects mentioned above are evident. The rural population is declining and has become debilitated by malaria and other diseases, and agricultural prosperity has decreased.

So a beginning was made, in a small way, with flood-flushing schemes in different parts of the province. Thus the highly malarial village areas of Pingla, Naraingarh and Kola in the district of Midnapore, covering an area of 8,278 acres including 729 tanks, have been flushed with water from the Cossye and Rupnarain rivers through the Midnapore canal system, free of charge to the villages, during the flood seasons of 1932 to date.

The inhabitants there are kept under medical observation by the authorities of the Public Health Department, and the reports show a marked improvement in public health as evidenced by reduced treatment at dispensaries for malaria and other fevers and by a reduced spleen index. The results of the introduction, in 1934, of flood water (free of water tax) from the Gobra Nullah on the lands of the villages of Maidyagobindpur, Madapur, Bahadurpore, Sultanpur, and others in the Murshidabad district, were even more striking, for whole village sites which had been abandoned on account of malaria were re-occupied. Seven thousand one hundred and twenty acres were flushed and the report shows that in addition to reducing malaria the yield of the *aman* paddy crop was approximately doubled and grubs and insects like white ants were destroyed.

Encouraged by the success of the trial measures mentioned above, and acting on the suggestions put forward by the Public Health Department and by the Rural Development Commission of Bengal, an ambitious scheme has been submitted to the Local Government for flushing 3,50,000 acres in the districts of Burdwan, Hooghly and Howrah, between the Damodar and Hooghly rivers, by the flood waters of the Damodar river at a cost of Rs.273 lakhs (=£2,100,000). The salient features of the scheme include a barrage on the river Damodar near Burdwan and a network of distributing channels fitted with regulators, capable of carrying 13,160 cusecs (a discharge equal to the normal flood discharge of the Thames river at Staines), and adequate sluices for the drainage of the excess water into the river Hooghly.

In connection with Mr. Curry's paper Mr. P. Neogi observed that the districts of Hooghly, Howrah, 24-Parganas and Burdwan were the districts of Bengal which were most affected by malaria and as an inhabitant of the Hooghly district he was glad to note that a scheme of eradicating malaria by flood-flushing had been made at the cost of Rs.273 lakhs for 3,50,000 acres. The cost was not prohibitive as it was realizable. Flood-flushing or 'Bonificazione' had eradicated malaria from Italy and Panama and it should be tried exten-

sively in North and West Bengal. East Bengal on account of natural flood-flushing every year was practically free from malaria. Railway embankments were necessary evils but they must be provided with a sufficiently large number of culverts for flood-water to pass freely. Flood-water will also flush the railway burrow-pits which contained stagnant water practically throughout the year and were, therefore, fruitful and constant breeding places for malaria. Irrigation and malaria were almost synonymous terms and it is flood-flushing which could make them opposite terms.

21. Mr. Griffin (Calcutta) said that among the various ways in which man's interference with nature had caused drainage obstruction, the following might be mentioned :—

(1) Encroachments on drainage channels,—either by building over them, or too close to them—thereby confining the channel in too small a width.
(2) Obstruction of drainage channels by throwing into them rubbish, earth, or filth.
(3) By putting fishing weirs across drainage channels and failing to remove them again when the fishing is over.
(4) The construction of embankments for roads, railways, or canals, without making sufficient provision for the natural surface drainage.
(5) Paddy field terracing.
(6) Mining subsidence. The results of mining operations in many places have been known to cause the surface of the ground to cave in, with the result that water stagnates in pools and the gradients of surface channels are interfered with.

One of the experimental anti-malarial schemes carried out by the Bengal Public Health Department in 1917 was in connection with the colliery land near Raniganj. Here the land had been tumbled about by mining subsidence, and in one place there was a level swamp. The engineering work done consisted of re-grading the natural surface channels, putting in culverts where embankments were obstructing drainage, and in draining the swamp by means of network of sub-drains. These consisted of earthenware pipes, laid open-jointed in a bed of gravel and broken stone. There was a main sub-drain, and branch drains in herringbone fashion. Of course, careful levels were taken to shew that there would be a proper outlet for the main sub-drain. The drain at its outlet end was about 4 feet below ground, but there was a lower level channel into which it could discharge.

An interesting form of sub-drain was constructed in connection with the anti-malarial scheme at the Meenglas Tea Estate in the Duars. This estate is traversed by a number of streams (*jhoras*), and there is a good natural slope from north to south. As the Anophelines were breeding along the edge of the running water, it was decided to put the streams underground by means

of sub-drains. The long distance for transport would have made earthenware pipes expensive, and as plenty of stone was available at the site, it was decided to make the sub-drains of stone. A stone bed was laid to a continuous gradient, side walls of dressed stone were built on it, and big stone slabs laid across the top,—the whole being then filled in with small stones up to the natural bed of the *jhora*. The side walls and top stones were laid without mortar so that water might find its way into the drain through the crevices of the stonework. One or two length of small drains were done with pipes, so as to make a comparison in cost. The cost of a sub-drain 9″ wide and one foot high worked out at -/7/6 per foot.

In the low-lying parts of flat country like the deltaic areas of Bengal water must lodge during the rainy season, and often,—as far as malaria is concerned,—it is found better not to attempt drainage, but to bring in river water so as to *raise* the general level and thereby reduce the amount of edge round which the mosquitoes breed, hence the ' flood-flush ' drainage schemes. Good results have been obtained by the application of this principle. In urban areas, where the surface water must be removed from the vicinity of habitations, underground sewerage systems are constructed. These, with their pumping stations are, of course, expensive. When cheap electric power is available, as in the Calcutta area, neither the capital nor running cost is high. A low level tank can be constructed or an existing tank or series of tanks can be made use of to act as a storage reservoir to receive the water from the land to be drained, and by means of a pump of moderate size and cost, the water can be pumped away at leisure. An example of this can be seen at the Jodhpur golf course, where a 4 horse-power pump deals satisfactorily with an area of 80 acres. The power required for the pump is so small because the height through which the water is lifted is only six feet.

In a deltaic area, the land near the river bank is above flood level, while further away from the river it is below flood level. It follows that there is a natural line,—roughly parallel with the river, and at a certain distance from it, such that, between the line and the river the policy of land raising and natural surface drainage should be pursued.

In connection with Mr. Griffin's paper Dr. Lal enquired if mole drainage had beed tried in Bengal.

Mr. Griffin in his reply said that mole drainage had, so far as he was aware, not been tried in Bengal and he did not think conditions were suitable for it in this province.

VII.

22. Mr. Senior-White (Calcutta) said that he had been studying the rôle of various chemical factors such as *p*H dissolved oxygen, mineral solutes and saline ammonia in connection with mosquito ecology. He had found that high dissolved oxygen content appeared to favour the use of natural waters by Anophelines, and that this was especially important in rice fields ;

but the principal discovery made was that *saline ammonia in amounts of less than* 1 *p.p.m. was inhibitory to natural water breeders*, especially Anophelines. On a previous occasion he had studied in addition to *p*H the following factors and had shown that they were of value in controlling mosquito breeding: conductivity, carbonates and albuminoid ammonia. He, therefore, recommended further studies on residual *p*H and dissolved oxygen in the hope that they will yield results of great value. Phosphates appeared to be of much less importance than they were when found in sea water; they were also worthy of further study. The conclusions formerly arrived at with regard to saline ammonia were confirmed for three vector species but not for the non-carrier *A. subpictus*. His work had since been confirmed by Beattie (1932) [1] for a Neotropical species, showing that this criterion was the only one of importance so far discovered. Whether it was applicable to all the *130* known species of the genus Anopheles was, however, quite another matter.

Mr. Senior-White also tested the 'herbage cover' method of mosquito control. He had recently found that it had great possibilities. It is a recognized method for producing excess albuminoid nitrogen in the presence of deficient oxygenation. It has long been apparent to all workers that chemical larvicides have a very limited application owing to their excessive cost, and are, in fact, quite unsuited to the vast rural tracts of this and other tropical countries. Cheaper methods will have to be evolved if anything is to be done for rural malaria generally. We now see that in adopting the above methods of malaria control we would be enriching the soil for agricultural purposes as well and this would doubly benefit the villager. We come to purely agricultural methods as our main weapon of attack, the raising of fodder crops, the stabulation of cattle, the conservation of cow-dung for manure instead of its wasteful expenditure as fuel. These are questions for the agriculturist and the economist rather than for the malariologist, who can only strengthen the hands of these professions by pointing out that the success in their immediate object will, in time, lead to the control of the 'King of Tropical Diseases'.

23. Dr. Sen (Calcutta) stated that *A. ludlowi* was migrating more and more towards human habitations year after year. This migration is helped in many places through the agency of transport either by train, country-boat, or perhaps by bus. This has been shown from the catches made at the different railway stations such as Majherhat, Sealdah, Shambazar and Howrah from time to time, as also from the lock-gates at Baghbazar and Kulti. Once transported near human habitations the species takes to new environments and establishes itself. Its great adaptability to various ranges of salinity, even to fresh water, enables it to do so. Thus in recent years the species, although normally a brackish-water breeder, has established itself in many places in what may be considered as fresh-water breeding places. This is in

[1] Buxton's (1934) analysis of this author's findings should be studied *pari passu* with the original paper.

conformity with the experience of workers in estuarine and deltaic faunas. Other factors which help the spread of this species are heavy rainfall and embankment of rivers in areas subject to tidal influence.

24. Dr. D. N. Roy (Calcutta) read a paper on the possibility of certain salt water races of *A. subpictus* acting as carriers of malaria. He said that he had found some of the adults infected in nature.

In connection with Dr. D. N. Roy's paper Dr. P. Sen said that although Dr. Roy's experiments were very interesting, one thing that struck him was that there was the possibility of his dealing with *A. sundaicus* instead of *A. subpictus*. In the larval stage it is so very difficult to distinguish between the two. As regards the natural infectivity of the species he was unable to confirm Dr. Roy's findings although he had dissected a large number of adult *A. subpictus* caught in the lake area.

Mr. M. O. T. Iyengar said that *Anopheles subpictus* was very extensively prevalent in the Salt Water lakes prior to the invasion of that area by *Anopheles ludlowi*—and yet no malaria was found anywhere in the area. The spleen rates in 83 villages in that area were practically zero.

Owing to the scarcity of cattle in the area, we ought to exclude the explanation that *A. subpictus* is zoophilic and that it is therefore not a transmitter in nature.

25. Mr. M. O. T. Iyengar said that the natural parasites of mosquitoes fell into the following groups: (1) Bacteria, (2) Fungi, (3) Protozoa, (4) Nematodes, (5) Trematodes, (6) Insects, and (7) Acarines. In this list, many of the parasites are of doubtful importance as agents checking the mosquito population. Judging from the morbidity caused in the insect-hosts and its pregnancy the following are of importance in India: (1) Coelomomyces, (2) Microsporidia and (3) Mermithidæ.

(1) *Coelomomyces.*

We have two species in India, *C. indiana* and *C. anophelesic*, both of which infest *Anopheles* larvæ and adults and cause considerable mortality. Several species of *Anopheles* have been observed to be susceptible to this infection.

(2) *Microsporidia.*

Three genera of Microsporidia were recorded by him as infesting mosquito larvæ in India, namely, *Thelohania*, *Nosema* and *Plistophora*.

(3) *Mermithidæ.*

These worms live in the hæmocele of the host and cause considerable mortality. The parasitic stages are the larval phases, the adults being free-living and short-lived.

These three groups comprise the parasites that play a significant rôle in the natural control of mosquitoes in India. Our knowledge of these different

parasites is admittedly meagre ; further studies are indicated in regard to their distribution, incidence, life-history and ecology. Until further information on these points is available, it would be difficult to answer the question ' Can these parasites be utilized for a biological control of mosquitoes ? '

VIII.

26. Dr. B. M. Das Gupta stated that *P. inui*, a quartan parasite occurring as a natural infection in *S. irus*, had been successfully transmitted to a human volunteer in whose blood the parasites appeared 23 days after inoculation and in whom the infection persisted for one week. The number of parasites observed in the blood of the volunteer was never high and recovery was spontaneous. Febrile symptoms were observed for three days only. The stages of the parasite encountered were rings, trophozoites and schizonts. Gametocytes were not found.

Dr. Krishnan said that Dr. Das Gupta's finding was very interesting. The host parasite specificity is usually very rigid in plasmodial infections ; but a few examples of successful cross-infection experiments are on record. This would be an additional example.

IX.

27. Dr. S. L. Hora said that he had studied the contents of the alimentary canal of a large number of specimens of *P. panchax* collected from several localities in the Ballygunge, Tollygunge, Howrah and Pulta Waterworks areas. His findings with regard to natural food of the fish confirmed those of Dr. Sen ; but he, at the same time, did not find many mosquito larvæ in the pieces of water inhabited by this fish. From experiments carried out in the field by introducing the fish in mosquito-breeding places, he concluded that *Panchax* preferred to feed on mosquito larvæ, and when their supply was almost exhausted they began to feed on other types of food, mostly insects and especially ants. These results were confirmed by laboratory experiments, in which the fish were given a mixed diet of mosquito larvæ and other types of animals, such as Chironomid larvæ, Corixiid bugs, mayfly nymphs, water mites, beetles, etc. Under these circumstances the fish showed a definite preference for mosquito larvæ. It was observed that, when kept with algæ, the fish preferred to starve rather than to feed on vegetable matter. The voracity of feeding and the intensity of digestion of the fish were also studied.

It was definitely found that *Panchax* was a very effective larvicidal fish and its use, under Indian conditions, was therefore strongly recommended.

In connection with Dr. Hora's paper Dr. Sen said that he was grateful to Dr. Hora for the confirmation of his main findings on *Panchax panchax* within such a short time of publication of his paper. He had studied at least four kinds of so-called larvicidal fishes of Bengal, *Panchax panchax, Barbus*

stigma, *Esomus danricus* and *Trichogaster fasciata* and certain other species were under investigation. He found that of all these fishes *Panchax* alone showed evidence of ingesting anopheline larvæ to the extent of 10 per cent as evinced by the analysis of stomach contents. In his experience the *Panchax* did not exhibit any preferential activity towards Anopheles larvæ. It attacked all darting objects and that explained why in aquaria in the midst of other kinds of living organisms it attacked Anopheles larvæ so vigorously. He reared the fish in the laboratory with both mosquito larvæ and ants. Not only adult ants but other strongly chitinized insects like beetles and chalcids were often found in the gut. This fish can also feed on algæ. Dr. Hora had cited Dr. Fraser's observation and opinion that the shining structure (the third eye) on the head of the fish attracted adult mosquitoes, but so far as his observations go the adult mosquitoes were attacked by the fish at the time of their emergence from the pupæ when they were in a helpless condition because some time must elapse before they could use their wings. There seemed to be some doubt about the usefulness in removing vegetation from water collections. In his experience clearance itself was a very good anti-larval measure. After the tank was cleared there was hardly any necessity of introducing fish. *Trichogaster* was also carnivorous to a certain extent, but the other two fishes studied by him, that is *Esomus* and *Barbus*, were primarily herbivorous.

Several persons took part in the discussion and at the end Dr. Hora briefly replied to the various points raised.

List of Papers.

I. Treatment.

1.	Col. R. N. Chopra ..	Present Position of Antimalarial Drug Therapy in India.
2.	Dr. K. V. Krishnan and N. G. Pai.	Bio-chemical Changes in the Blood of Monkeys developing Malarial Hæmoglobinuria and their Significance in the Aetiology and Treatment of Blackwater Fever.
3.	Dr. D. B. Dikshit ..	Pharmacology of Plasmoquine with special reference to its action in Pregnancy.
4.	Col. R. N. Chopra, B. M. Das Gupta and B. Sen.	Experimental Studies on Ape Malaria with reference to its use in Malaria Therapy in nervous conditions.

II. Epidemiology.

5.	Dr. R. B. Lal	Forecasting Epidemics of Malaria.
6.	Dr. A. C. Banerjea ..	Urban Malaria in the United Provinces.
7.	Mr. M. O. T. Iyengar ..	Topography of Land in relation to Malaria.
8.	Dr. G. C. Chatterjee ..	Malaria and its relation to Agriculture in India.*
9.	Dr. F. de Mello	Malaria in Portuguese India.*

* The papers marked with an asterisk will not be printed.

III. Irrigation and Malaria.

10.	Dr. W. C. Sweet	.. Irrigation and Malaria.
11.	Dr. S. G. Masillamani	.. Irrigation and Malaria in the Madras Presidency.*

IV. Immunity.

12.	Dr. K. V. Krishnan	.. Spleen and Resistance to Malaria and Haemoglobinuria.
13.	Dr. M. N. De ..	.. Pathology of Malarial Spleen.

V. Control.

14.	Major M. K. Afridi	.. Antimalarial Operations in Delhi.
15.	Dr. B. A. Rao ..	.. Control of Anopheline Breeding in Irrigation Channels by Paris-green.
16.	Dr. J. D. Sinha ..	.. Drug Prophylaxis in Malaria by the use of Quinine and Plasmochin in the Field.
17.	Dr. K. L. Chowdhury	.. Mosquito Control in Calcutta.*
18.	Dr. G. C. Chatterjee	.. Larvicidal Fish.*
19.	Dr. S. L. Hora ..	.. Larvicidal Fish.*

VI. Malarial Engineering.

20.	Mr. T. A. Curry ..	.. Flood and Flush Schemes in Bengal.
21.	Mr. F. C. Griffin	.. Surface and Sub-soil Drainage.

VII. Entomology.

22.	Mr. R. Senior-White	.. Physical Factors in Mosquito Ecology.
23.	Dr. P. Sen ..	.. *Anopheles ludlowi* (*A. sundaicus*) Survey in and around Calcutta.
24.	Dr. D. N. Roy ..	.. *Subpictus* as Carrier of Malaria.*
25.	Mr. M. O. T. Iyengar	.. Natural Parasites of Mosquitoes in India.

VIII. Protozoology.

26.	Dr. B. M. Das Gupta	.. Transmission of *P. inui* to Man.

IX. Ichthyology.

27.	Dr. S. L. Hora and Mr. K. K. Nair.	Observations on the Nutrition of *Panchax panchax*
28.	Dr. A. G. Fraser (communicated by Dr. Hora).	Observation on the Bionomics of *Panchax lineatus*.†

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* The papers marked with an asterisk will not be printed.

† Published in the *Journ. Bombay Nat. Hist. Soc.*, 1938.