

MORE ON HILL MALARIA

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It has recently (1935) been suggested by the senior writer that the spring epidemic of malaria in the lower Himalayan hills was spontaneous, and different from that at Calcutta where it was only due to relapses, because of the local differences in the physical conditions, of which the temperature was the most important factor.

Another possible explanation, however, not then taken into consideration, was that human infection in the hills was acquired during autumn just as in Calcutta but did not appear till spring, as has been reported to happen in Holland.

With this possibility in view anophelines infected in Calcutta during the recent autumnal infective season were transported by us to the lower Himalayan hills and the behaviour of the Plasmodia watched. *A. stephensi* was used as one now knows that its infective rate in Calcutta is at this season very considerable and would afford a good datum line for the observations in the hills.

The result of these have been that while the anopheline was becoming infected in Calcutta, when used as a strict control, at a rate of 58.5 per cent*, in the hills the rate was about 6 per cent. Further the evidence adduced below will show that under more 'natural' conditions than obtained during our observations autumn infection in the mosquito in the hills probably does not take place at all. The spring epidemic† of

*This rate would doubtless have been greater if two of our batches of mosquitoes had not been fed about 24 hours after a course of plasmochin which had not eradicated the gametocytes, but which doubtless affected their viability.

†Steps are now being taken to ascertain the spring rate of infection in the mosquito in the hills.

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My thanks are due to Major R. Linton, I.M.S., Superintendent, Medical School, Dacca, for allowing me to publish this case note and also to Dr. P. Chakravarty, M.B., D.M.R.E., radiologist, for sending the case to me for investigation.

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malaria in the lower hills of the Himalayas is therefore not to be considered as a manifestation of autumn inoculation as it is in Holland, and is a *de tempore* phenomenon, the reverse of the state of affairs in that country.

The schedule below the report shows the detailed observations. In detail it will be seen that only 3 out of 49 mosquitoes taken to the hills, dissected and examined after 10 days had the glands infected with sporozoites and it is significant that these 3 were included in 2 batches (nos. 1 and 2 in the schedule, Table I) that had been kept, except for 2 days‡, after arrival, in a closed room on the south side of a laboratory on which the sun beat down and which was otherwise kept warm by a charcoal fire; the resultant temperature being as shown in Table II where it is contrasted with the temperature at which the other batches, which showed no gland infection at all, were kept, in a room open day and night.

As the required material was not available in the hills the mosquitoes had to be infected in Calcutta§, but this was an advantage in that infection was putatively established in the mosquitoes at the same rate as if they had remained in Calcutta and so one may conclude that it was afterwards that the infection was killed under the conditions of carrying on the observations.

It had been anticipated that if this event should take place, the degenerating parasite would be revealed by 'black spores' in the gut, but, in the sequel, whereas in Calcutta 32.5 per cent of the mosquitoes showed the developing plasmodia as zygotes or oöcysts in the gut wall, in the hills only 1 specimen, or say 2 per cent, showed black spores, so that the balance of the putative gut infection was entirely lost.

Then it was thought possible that the normal infection inseminated in Calcutta might under the conditions in the hills only be arrested and that, on restoring favourable conditions to the mosquito, the infection would forthwith manifest itself. With this in view, 28 of the mosquitoes were, after a greater or less interval, returned to Calcutta and then after another period of from 1 to 5 days examined for parasites. In one of these 28 mosquitoes infection of the glands was seen, while of 24 mosquitoes that remained in the hills all the time 2 developed infection. There was thus no proof that the infection had merely remained in abeyance in the hills.

‡On these 2 days the minimum temperature was 57°F. and the maximum 77°F.

§Some little time had to elapse before they arrived in the hills, the mosquitoes after being fed being usually either despatched the same night to the hills by post or taken by some guardian by train. Batch 1 was exceptional in remaining in Calcutta an extra 24 hours. The journey through the plains takes about 12 hours.

TABLE I
showing attempted infection in the hills of *A. stephensi* by *Plasmodia*

Date of feeding mosquitoes	Number fed	Species of <i>Plasmodium</i>	Dissection between	Number dissected	Gland infection		Gut infection						REMARKS			
							showing living forms only		showing 'black spores' only		showing living forms or 'black spores'					
					No.	%	No.	%	No.	%	No.	%				
1935																
30-10	..	5	M. T.	6 and 39 days.	5	2	40.0	0	0.0	0	0.0	0	0.0	0	0.0	1 showed infection 30th day, 1 on 39th day after having been taken back to Calcutta and kept here 2 to 3 days.
Batch 1.				20 and 39 days.	3	2	67.0									
Control	..	9	..	13 and 17 days.	9	9	100.0	3	33.3	0	0.0	3	33.3			
31-10	..	9	M. T.	4 and 39 days.	9	1	11.0	0	0.0	1	11.0	1	11.0	1	11.0	3 returned to Calcutta for 4 to 5 days, none becoming infected.
Batch 2.				13 and 39 days.	6	1	16.67									
Control	..	8	..	13 and 16 days.	8	8	100.0	2	25.0	..	..	2	25.0			
10-11	..	6	B. T.	25 and 27 days.	6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	(After plasmochin course up to 9th.) 2 returned to Calcutta (1 to 2 days).
Batch 3.				13 and 16 days.	5	2	40.0	4	80.0	..	..	4	80.0			
Control	..	5	..													
10-11	..	8	M. T.	10 and 28 days.	8	0	0.0	1	12.5	0	0.0	1	12½	1	12½	After plasmochin course. 4 returned to Calcutta (2 to 3 days).
Batch 4.				13 and 15 days.	20	10	50.0	6	33.3	..	..	6	33½			
Control	..	20	..													
21-11	..	4	B. T.	14 and 17 days.	4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2 returned to Calcutta (2 to 3 days).
Batch 5.				13 and 14 days.	4	3	75.0	1	25.0	..	..	1	25.0			
Control	..	4	..													
16-12	..	20	Q. T.	24 and 27 days.	20	0	0.0	0	..	0	..	0	0.0	0	0.0	16 returned to Calcutta on 3rd January.
Batch 6.				19 and 33 days.	20	7	35.0	5	25.0	0	..	5	25.0			
Control	..	20	..													
Total including early dissections.	early	..	..	..	52	3	5.9	..	..	..	..	..	..	..	..
Total excluding early dissections.	early	..	..	..	47	3	6.1	..	..	..	..	2	3.9			
Controls	..	..	..	..	66	39	58.5	..	..	..	..	21	32.5			

It therefore appears justifiable to say that malarial infection is not possible at all under the conditions prevailing during autumn in the hills.

The development of the insect on the other hand goes on during the cold weather. Larvæ and pupæ were caught in the Balasun river bed; larvæ pupated when kept in the open at Ambootia (3,000 feet); and larvæ and pupæ were

the hills there is practically no autumnal malaria is that the physical conditions debar infection in the mosquito. People can therefore go without mosquito nets with impunity at this season.

Acknowledgments are due to Mr. O'Brien Webb, Manager of Ambootia Tea Estate, for so kindly giving us the hospitality of his administration, as well as privately, for the conduct of this enquiry. They are also due to

TABLE II

The temperature at which each batch of mosquitoes was kept

Batch	Conditions 1935 Nov.-Dec.	Rate of gland infection,* per cent	Time in Calcutta †	DAILY MAXIMUM		DAILY MINIMUM		DAILY MEAN		
				Range	Average	Range	Average	Range	Average	
1	1st to 11th south room closed. 11th to 13th opened. 13th to 14th closed.	33.3	30th and 31st October.	68 to 80	75.5	59 to 65	62.0	64	72.5	68.5
2	ditto	16.7	31st October	68 to 80	75.5	59 to 65	62.0	64	72.5	68.5
3	11th to 13th south room opened. 13th to 4th north room opened.	0.0	13th p.m.	60 to 65	63.0	..	54.6	54.5	62	59.0
4	11th to 13th south room opened. 13th to 4th north room opened.	0.0	13th p.m.	60 to 65	63.0	..	54.6	54.5	62	59.0
5	in open north room.	0.0		60 to 64	62.4	49 to 58	53.7	54.5	59.5	58.3
6	ditto	0.0		54 to 60	58.0	46 to 49	47.0	50	54.5	52.5

* after 10 days.

† does not include any time spent in Calcutta after being returned there. See also footnote §, page 267.

found all along the Teesta valley and up the Kalimpong cart road to 5,000 feet. It is impossible however to say how the production compared with that at other seasons.

Then not only are the mosquitoes breeding out, but they bite at this season, as has been observed by us (Strickland, 1935).

It can be concluded then that the reason why at about the altitude of 2,500 to 4,000 feet in

the very efficient assistant medical officer of the estate, Dr. K. B. Chakraberty, who has also been of the greatest help, and to Mr. T. C. Biswas who was in charge of the laboratory arrangements which he carried through with energy and efficiency.

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