TRANSACTIONS

OF THE

SOCIETY OF TROPICAL MEDICINE AND HYGIENE.

JULY, 1914.

VOLUME VII. Nos. 7 and 8.

Proceedings of a Meeting of the Society on Friday, June 19th, 1914.

SURGEON-GENERAL

SIR R. HAVELOCK CHARLES, G.C.V.O., I.M.S.(R.), *President*, in the Chair.

MOSQUITO WORK IN CEYLON.

BY

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Three years ago the Government of India, having in view the risk that the opening of the Panama Canal might be followed by the introduction of yellow fever into Asia, initiated a series of enquiries and investigations with the object of devising timely measures to guard against any threatened outbreak of that disease. Their example was followed by the Governments of several British Colonies, and in January, 1913, after my return from a study of yellow fever in Central and South America, I was engaged by the Government of Ceylon to make a *Stegomyia* survey of her seaports, to study malaria in certain parts of the island, and to assist in training a body of men who would afterwards be employed as sanitary inspectors in her municipalities. Our work was an

application of the principles of what is termed the "new hygiene," of which research is the starting point, the basis, and the guide, and we are hopeful that it has justified itself by shewing that measures and arrangements based upon such research are more simple, more economical, and more effective than those recommended in the absence of the detailed knowledge which it alone can supply.

This evening I can, of course, deal with only one of the various issues with which we were occupied, and I have selected for chief notice the mosquito problem in the great seaport of Colombo, because that is a matter not only of local but of international concern.

When I arrived in Ceylon I found that some progress had already been made towards obtaining information regarding the mosquitoes of the colony, and that in Colombo three overseers and six coolies had been engaged in practical anti-mosquito work for some months. My primary duty was to study mosquitoes of the *Stegomyia* genus, which contains the species *fasciata*, the carrier of yellow fever; but as the work already begun shewed that the authorities were prepared to grant facilities for measures to control other kinds of mosquitoes, it was clearly advisable that my enquiry should be as comprehensive as possible. And this was the more desirable for the reasons that up to that time it had not been possible to deal with the subject except in a superficial way, as a relatively unimportant item in the sanitary policy of the town, and because it was felt that there was great uncertainty even of the names of the mosquitoes that were prevalent, very little information regarding their life-histories and habits, and almost none regarding the usefulness of the arrangements that had up to that time been adopted. I need scarcely remind you that although in the early years of anti-mosquito work it was usually taught that all species of mosquitoes have, in general, the same habits and mode of life, and that operations based on that assumption should be prosecuted without special enquiry, those who have devoted serious attention to the subject now hold that anti-mosquito work, upon which public money is to be expended, must be preceded and accompanied by research, with a view to ascertain at least:

1st—The names of the species that are dangerous and of those that are troublesome.

2nd—The distribution and prevalence of each of those species separately.

3rd—The life-history and habits of each.

4th—The practical methods which, in view of the knowledge collected under these headings, will be most likely to bring about a reduction of the different species.

In the absence of definite and complete information upon these subjects, it would not be possible to deal satisfactorily with the mosquito pest in Colombo, or any other large city, and for that reason they are the subjects with which we were occupied in our enquiry.

I shall take these headings in order in the following brief summary of the results of our year's work.

First, then, as to

THE NUMBER AND NAMES OF THE SPECIES.

From Colombo alone we collected no fewer than 52 different species of mosquitoes, of which 5 belong to the genus *Stegomyia*, 5 to the closely similar genus, *Ochlerotatus*, 8 to the genus *Culex*, and 8 to the genus *Anopheles*, the remainder coming in no fewer than 18 genera, whose names are rather difficult to pronounce. About 17 of the 52 species are sufficiently prevalent as to be a source of annoyance or danger to the inhabitants of Colombo, and they include 4 of the genera *Stegomyia* and *Ochlerotatus*, 6 of the genus *Culex* and 3 of the genus *Anopheles*. The names of the troublesome species in the *Stegomyia* genus are *fasciata* (the yellow fever carrier), *scutellaris*, *W. alba* and *sugens*.

Next to ascertaining the names of the dangerous and troublesome species, the subject of our second heading, namely—

PREVALENCE AND DISTRIBUTION

is of paramount importance, as being the only satisfactory basis on which to gauge the effect of measures. But you are doubtless aware that the task of making enumerations and estimations of mosquitoes is difficult. In Colombo it was especially so, because (1) the number of species to be studied was large, (2) the problem of local distribution was in general one of differences in the relative abundance, rather than in the kinds, of mosquitoes present in various areas, and (3) the various species differed widely in their habits, especially in the fact that while some were locally bred others swarmed into the town from long distances.

Of the various methods available for studying distribution and prevalence, we find that, in our experience, the systematic enumeration of adults collected either by hand catching in test tubes or in specially devised traps is the best, and, although our staff was too small for a complete enquiry of this kind, we were able to satisfy ourselves that the method is practicable, and a great advance upon the usual practice of basing estimates upon an enumeration of breeding places. We devise our traps and method of setting them in accordance with the varying habits of the different species, and I will now give you a description of one of the traps that we have found most successful. It consists of a rectangular wood framework, 5ft. long, 3ft. deep and 3ft. broad, closed with mosquito netting, one end of the trap being a door on hinges. We place these traps on the ground in the shady corner of a garden, and cover them with sacking and a thick tarpaulin, so that the interior is dark and cool. Two or three pots of plants are put inside each trap and several near the door, which is left partly open. We set the traps over night, and the next morning, about nine o'clock, we send beaters through the vegetation in the neighbourhood of the traps, and we burn straw torches in all the surrounding buildings so as to drive the mosquitoes into the open air. The result is that most of them quickly find their way into the traps, which appear to them to be very attractive and cool resting-places. After completing the disturbance of vegetation and the smoking of surrounding buildings we close the door of the trap, and collect and count the imprisoned mosquitoes.

I am now able to put before you the following tabular statement of the number of adult mosquitoes caught daily for some time in one of these traps placed in a garden in the Fort Ward of Colombo.

The trap was 5 feet long, 3 feet broad and 3 feet high, the entrance door being 2½ feet square, and was placed near some outbuildings in a shady corner of the walled garden of Queen's House. This will give an idea of the great numbers of mosquitoes present in the area :—

TABLE I.

Date.	Number of adults caught in the trap.	Remarks.
20-11-13	200	
21-11-13	160	
22-11-13	369	
23-11-13	35	Heavy rain and wind. No sun.
24-11-13	101	
25-11-13	180	
26-11-13	250	
27-11-13	503	
28-11-13	650	
29-11-13	25	Heavy rain. No sun.
30-11-13	10	Heavy rain and wind.
1-12-13	499	
2-12-13	102	
3-12-13	304	
4-12-13	826	
5-12-13	256	
6-12-13	350	
15-12-13	204	
16-12-13	368	
17-12-13	94	
18-12-13	141	
19-12-13	200	
20-12-13	130	
In the same trap placed in the compound of the Grand Oriental Hotel the following numbers were caught:—		
7-12-13	170	
8-12-13	350	
9-12-13	581	
10-12-13	319	
11-12-13	305	
12-12-13	200	

The average of the figures is 280 per day, but you will see that on several occasions it was more than 500, and on one occasion 826. We ascertained that if we had a trap for every house garden in Colombo we could catch about the same number in each, and from the figures that we have obtained we surmise that there were $7\frac{1}{2}$ millions mosquitoes in the houses of Colombo on the 20th November, $11\frac{1}{2}$ millions on the 3rd December, and more than 30 millions a few days later.

Our trap for *Anopheles* is of a different kind. It is a movable mosquito-proof hut, each wall of which is provided with a special trap similar to those used so successfully on the Panama Canal. The traps appear to the mosquitoes to be windows through which the hut can be entered. A man sleeps in the hut, and each morning we count the mosquitoes that have been caught in the special traps.

For estimating the prevalence and distribution of *Stegomyia fasciata*, we have made extensive use of test breeding pots. In March, 1913, during our preliminary investigation by that method, we distributed over the town 168 pots of this kind, of which 14 per cent. became infected with *Stegomyia fasciata* within 48 hours and 42 per cent. within 120 hours.

As regards estimations by enumeration of breeding places, we followed the well-known plan of making monthly house to house inspections in selected areas in each ward of the town. We call the percentage of dwellings in which larvæ are found the larval index for dwellings, and we work out these figures for all mosquitoes and for *Stegomyia fasciata*. In Colombo the index for all mosquitoes is usually about 25, and for *Stegomyia fasciata* about 16. These figures, however, certainly under-estimate the real prevalence, for as regards all mosquitoes the figure refers to the locally bred species only, and as regards *fasciata* and other household and urban species it is the case that in ordinary routine house to house inspections there is no time to do more than examine the more obvious and easily accessible collections of water. For example, there is no time to make a complete examination of all the roof gutters of the houses, and no time to make a thorough search for holes in the trunks and branches of every tree in the compounds. From the following statement you will at once realise that to make

TABLE II.—BLOCK B.: FLOWER ROAD.

FIRST INVESTIGATION 7-6-13 AND FOLLOWING DATES.

Name of the House.	Potential breeding places.	Actual breeding places.
Collingwood	154	9
The Zea	744	42
Garden No. 4	201	15
,, ,, 5	327	23
House, No. 1,665	64	1
,, C.H. Pate	130	6
Garden No. 7	539	8
House No. 8	24	2
Mr. Duncan's Bungalow	265	19
Garden No. 8	892	50
House No. 9A	241	4
,, ,, 9B	434	20
Garden No. 10	526	16
,, ,, 10B	2,486	32
Clare	908	38
Areas	7,935	285

a complete examination of that kind in a fairly large house (which often contains from 20 to 40 or 50 actual breeding places) will occupy a hard worker at least three or four hours, and it is obvious that, if so much time were given to each house, a considerable staff might take two years or more to cover the town. Nevertheless it is true that unless these complete examinations are carried out an accurate measure of the prevalence of breeding places cannot be obtained. This is clearly seen in the tabular statement printed below.

TABLE III.

	Section of Fort Ward.	Section of Maradana.	Section of Slave Island.	Section of Cinnamon Gardens.
Larval index for houses as obtained by ordinary routine inspections	35·1	17·0	13·0	85·4
The same obtained by the complete investigations preparatory to anti-mosquito operations	55·5	35·5	18·0	100·0
Number of actual breeding places found in 100 houses at the ordinary routine inspections	103	38	23	394
The same found at the complete investigations	340	90	42	1833

I now pass on to our third heading, namely—

THE LIFE HISTORY AND HABITS OF THE DIFFERENT SPECIES,

but lack of time necessitates my making many omissions under this section, and in particular I shall omit all our rather numerous observations upon breeding places.

Our findings upon this and other topics of the subject shew clearly how necessary it is to study each species separately. Such a study has led us to arrange the mosquitoes of Colombo in the following broad groups based upon habits :—

A. Urban Mosquitoes—

Group 1.—The strictly household species.

Group 2.—Other urban species.

B. Rural Mosquitoes—

Group 3.—The strictly sylvan species.
Group 4.—The migrating species.
Group 5.—The species with peculiar or unexpected habits.

I will recount very briefly a few details regarding the habits of the mosquitoes in each of these groups.

Group 1.—The strictly household mosquitoes live in intimate association with man and his dwellings, and their habits have become very closely adapted to his mode of life. They may be described as being almost entirely parasitic on man alone. Their whole life is spent within or in the immediate vicinity of the house in or near which they were born, and their breeding places are of a particular kind found in the environment of human beings only. Their habits have become very fixed and definite and they can only very slightly adapt themselves to changed conditions. *Stegomyia fasciata* is the best example of this group.

Group 2.—The remaining urban mosquitoes are not strictly household insects, and not so dependent on man as those of the first group. They feed as readily upon the blood of animals and birds as upon that of man. But they pass the whole of their life in one or other section of a city or town, seldom leaving the vicinity of the place where they were born, and being able to breed in almost any kind of collection of water that may be present there. For this reason they are more difficult to reduce by antilarval measures than are the mosquitoes of the first group, whose breeding habits are highly specialised. *Culex fatigans* is the best example of this group.

Group 3.—The strictly sylvan mosquitoes spend the whole of their life in a rural environment away from human dwellings. Most of the species in this group have never acquired the habit of feeding upon human beings, but whether they have that habit or not they never, for that purpose, visit houses. There are many species of mosquitoes in this group.

Group 4.—The migratory species, while retaining their habit of breeding in swamps and natural pools at a distance from centres of population, have the habit of flying long distances into cities and towns

for the purpose of obtaining meals of blood. Some members of this group are of great interest and importance in Colombo, especially *Culex sitiens*, *Culex vishnui*, *Culex gelidus* and various anophelines. Our observations regarding them have been made chiefly in connection with the experimental anti-mosquito campaigns of which I shall speak later. One of these campaigns was carried on continuously in a section of the Fort Ward for eight months, during the last five of which we were able to keep the area almost entirely free from *Stegomyia fasciata* and *scutellaris*, *Culex fatigans* and other mosquitoes of groups 1 and 2. But during September and October migrations of great numbers of mosquitoes of group 4 into the area occurred, the sudden and quite unexpected influx being observed also by residents who had previously discarded the use of mosquito curtains. We ascertained by continuous investigation that these mosquitoes did not breed anywhere in or near our area, but that they originated from swamps, of which the nearest was nearly a mile from the locality. Towards the end of November the flight of swarms of these mosquitoes into the area became of almost nightly occurrence.

Observations similar to those that I have just recorded have been made in various countries. In India the probability that some species migrate was mentioned, and a study of the subject was commenced, in connection with the anti-malarial operations at Mian Mir in 1901-1903. In America, in the State of New Jersey, it formed in 1902-1904 the chief subject of investigation during an enquiry carried out by the officers of the State Agricultural Experiment Station. In the Panama Canal Zone this migratory habit was first placed on record in December 1912, the observations having reference to a sudden influx of *Anopheles* at Gatun, where the numbers of adult insects increased until they were very much larger than had ever occurred previously. In April, 1912, I had an opportunity of observing similar flights or migrations of mosquitoes near Guayaquil in Ecuador. It will, of course, be recalled that such observations, if they had been recorded in the early period of anti-mosquito work, would have been met with incredulity and opposition. They can be safely recorded now because it is generally realised that the best hope of success against mosquitoes lies, not in the view that all kinds have the same habits and can be dealt with in the same way, but in a full and widely disseminated knowledge of the entirely

different characters of the various species, and in an endeavour to attack them by methods based upon that information.

Group 5.—Of the group of mosquitoes with peculiar or unexpected habits I will recount briefly part of the life history of one species in order to shew how wide may be the differences between the habits of various mosquitoes. Its name is *Harpagomyia genurostris*, and it has the very curious character of living in association with ants, and of obtaining its food from them. In Colombo it breeds in the water that collects in the folded leaves of pineapple or other similar plants. After emerging from the pupal stage, the adult insect rests on a leaf or stem of the plant, gently swaying its body from side to side. When one of the small ants, which are always to be found running up and down those stems and leaves, happens to arrive in front of the mosquito, this insect suddenly thrusts its proboscis forward so that the bulbous tip is in contact with the ant's mouth. The tip is then made to work vigorously in collecting food from the mouth of the ant, and when all has been obtained the mosquito flies upwards a few inches and hovers, while the ant runs off, apparently none the worse.

I turn now to our last heading, namely :—

THE PRACTICAL METHODS WHICH WILL BE MOST LIKELY TO BRING ABOUT A REDUCTION OF THE DIFFERENT SPECIES.

I decided that, in Colombo, the various questions in connection with this subject could best be answered by experimental anti-mosquito campaigns, and to this end we initiated, during the last eight months of our work, five such campaigns in different areas of the town.

In the time at my disposal I cannot pretend to give you an adequate account of these campaigns, and you must be content with a short description of one of them, and a few general remarks about the methods employed and the results attained.

First, as to methods. As everyone knows, a municipality can set about the elimination of mosquito breeding places by one of two plans, of which the first is based upon legal powers, and the second upon voluntary action. The first is the plan that has been adopted wherever anything more than a purely temporary success against domestic

mosquitoes has been attained, and as I was anxious to ascertain by practical trial whether it could be applied in Colombo, I decided very early in our campaigns to prepare an ordinance that would be suitable for dealing with all matters that appeared to be essential for the effective control of *Stegomyia fasciata* in the town. The draft of the ordinance was submitted to the Ceylon Government in March, 1913, but as it has not yet been passed by the Legislative Council, we have not been able to test its efficacy.

In the second or voluntary plan of campaign the householders and owners of land, not being legally responsible, assist in the work only in so far as they can be brought to do so by persuasion and example. A campaign of this kind is far more arduous, far more costly, causes much more annoyance and inconvenience to householders, and meets with much more opposition than a campaign based upon legal powers. It was, however, the only method that we were able to test.

It is our rule to carry out a thorough investigation of each house and compound before beginning to take measures to abolish breeding places. After several routine tours of an area the investigation work and the measures can be carried on simultaneously, but until the area has been covered several times the attempt to combine both kinds of work leads to much confusion and an ineffective result. For ensuring continuous and thorough work in the field we relied upon frequent inspections at different times each day by myself, my two Assistants (Dr. DE SILVA and Dr. ARNDT), our Sanitary Inspector and Sub-Inspectors. For journeying from area to area we had a motor car, two motor bicycles and twelve ordinary bicycles. We found that much better results were obtained when the staff allotted to an area was frequently changed, and we usually did so once a month. In addition to the check exercised by our system of frequent inspections we found it of great advantage to institute what we call "independent investigations" in the areas. For those enquiries we employed the whole of our staff, each overseer being allotted a few houses which he examined as carefully as possible. As measures supplementary to that of the elimination of breeding places we adopted the plans of placing "trap breeding places" in the areas and of catching adults by means of the traps already mentioned. We found both methods valuable.

For testing the progress and results of our campaigns we employed the following methods:—

For Larvæ.

(1) A continuous record of the number of potential and actual breeding places found in the areas at each investigation.

(2) A periodical comparison of the number of actual breeding places found inside the area, with the number found in a similar control area just outside it.

For Adults.

(3) The opinions of members of the community resident in the area dealt with as compared with the opinions of those occupying the control area.

(4) Enumerations of adult mosquitoes by hand catching and trap catching.

(5) The use of test breeding places.

Finally, as to the results attained, I will first direct your attention to some observations about larvæ and then about adults. The statement now given is an abridged table of the records of potential and actual breeding places in the Fort area. The record begins in April and ends in December. In view of the results published for other campaigns it may seem surprising that such thorough operations as we attempted did not, after a short time, make it quite impossible to find larvæ in the area. We believe, however, that our system of frequent changes of staff and of independent investigation is a great aid to the discovery of breeding places, and that a recorded inability to find larvæ after a campaign has been in progress for even a considerable time may indicate nothing more than that, while the obvious and easily accessible breeding places have been eliminated, many others, which may be inaccessible or difficult to find, are being overlooked. You will see that the column of figures, up to the end of the sixth investigation, indicates a result that appears on paper to be highly successful, and it is probable that, if we had kept the same overseers and staff in the area continuously, it would very shortly have happened that no larvæ at all would have been found. The change of staff and the institution of independent investigations shewed, however, that those early results were somewhat inaccurate and misleading, and that in anti-larval campaigns steps have to be taken to overcome the frailty of man, as well as the wiliness of the mosquito. One of our observations resulting from the

TABLE VI.

RECORD OF POTENTIAL AND ACTUAL BREEDING PLACES.—FORT WARD.

Approximate Date.	Number of the Investigation.	TOTAL FOR THE AREA.		Remarks.
		Potential.	Actual.	
30-4-13	1st	5,144	275	
	2nd	2,814	34	
	3rd	2,385	3	
	4th	2,159	16	
	5th	2,068	1	
	6th	2,014	4	
	Overseers	and Staff	changed.	
11-6-13	7th	6,762	35	The increase in potential breeding places is due to a different method of enumeration by the new staff.
	8th	6,907	12	
24-6-13	*9th*	*6,884*	*39*	"*Independent investigation.*"
	10th	5,512	40	
	11th	4,779	56	
	12th	—	—	
27-7-13	*13th*	*5,093*	*45*	"*Independent investigation.*"
	14th	4,744	19	
	15th	4,971	6	
	16th	4,808	5	
	17th	4,700	4	
	Overseers	and Staff	changed.	
16-8-13	*18th*	*4,724*	*14*	"*Independent investigation.*"
	19th	4,622	20	
	20th	5,041	15	
	21st	4,584	10	
	22nd	4,687	8	
18-9-13	*23rd*	*4,330*	*2*	"*Independent investigation.*"
	Overseers	and Staff	changed.	
24-9-13	24th	4,799	3	
	25th	4,495	2	
3-10-13	*26th*	*4,737*	*8*	"*Independent investigation.*"
	No Operations	done for	3 weeks.	
23-10-13	27th	4,849	92	Increase following absence of operations.
	28th	4,478	30	
	29th	4,422	20	
10-11-13	30th	4,602	9	
	31st	4,202	4	
22-11-13	*32nd*	*4,419*	*12*	"*Independent investigation.*"
	Overseers	and Staff	changed.	
28-11-13	33rd	4,492	7	During these weeks the migratory species *C. sitiens*, *C. vishnui*, etc., were attempting to breed in the area. The increase is due to those species.
	34th	4,411	12	
	35th	4,437	21	
23-12-13	36th	4,218	25	

institution of these precautions is of especial importance. It is that the elimination of breeding places which are easily accessible leads mosquitoes to discover places which are very difficult for ordinary human beings to find, and when found are very difficult to destroy. This clever change in the habits of mosquitoes greatly increases the difficulties of a campaign, and is one of the reasons why it is hardly possible, even for highly skilled workers, to exterminate mosquitoes, and why the brigades of voluntary untrained labour recommended in the popular books seldom effect a reduction in the number of adult mosquitoes, although they eliminate many of the more obvious breeding places. One method of overcoming that wily habit of mosquitoes is to employ the trap breeding places which I have already mentioned to you, and we have used that plan largely in our campaigns. The plan is due, I think, to the ingenuity of Mr. HOWLETT, the Imperial Entomologist in India, and you will at once realise that it contains the germ of a valuable idea which may lead to the working out of *constructive methods* of overcoming mosquitoes in place of the crude plan of indiscriminately destroying their breeding places which, until recently, has been the only practicable means at command.

After our operations had lasted some months it became plain that the amount of breeding that was going on in the area was very much less than at any previous time, and that it was very much less than occurred in our control area in which no operations were done. The table printed below indicates this clearly.

TABLE V.

(*A.*)—PERCENTAGE OF HOUSES IN WHICH LARVÆ WERE FOUND (LARVAL INDEX FOR HOUSES).

Date.	In the area.	Outside the area.
1st May	55·5	33·0
24th June	26·3	29·3
10th July	18·6	—
21st July	26·3	30·0
8th August	6·1	41·8
4th September	10·0	45·0
3rd October	3·7	41·8
20th November	11·1	42·3

(*B.*)—NUMBER OF ACTUAL BREEDING PLACES IN 100 HOUSES.

Date.	In the area.	Outside the area.
1st May	340	—
24th June	48	90
8th August	6	112
3rd October	10	158
20th November	15	246

You will see from this and the previous table that we were very successful in extirpating breeding places from the area, but of course those results do not tell us anything of the degree to which adult mosquitoes may or may not have been reduced. On that subject our results at first were disappointing, because at the end of the first six weeks, although we had eliminated by far the greater number of the breeding places in the area, and had, every six days, regularly destroyed the larvæ in all others that we could find, it was still very easy to detect in the area the presence of many adult mosquitoes of the three species, *Stegomyia fasciata*, *Stegomyia scutellaris*, and *Culex fatigans*, against which our efforts were specially directed. It was chiefly this observation that led us to introduce the system of periodically changing the staff and of carrying out independent investigations, but nearly three months passed before a very striking reduction in the number of adults became apparent. From the middle of July, however, it became quite difficult to collect any adult specimens at all, and by this and other tests we satisfied ourselves that we had effected a great reduction in their numbers. The success became even more striking during August and September, and early in the former month I received the following letter from the A.D.C. to His Excellency the Acting Governor of Ceylon:—

"The Queen's House, Colombo,
"2nd August, 1913.

"My dear Major JAMES,

"I promised to let you know the result of your campaign against the mosquitoes here. His Excellency asks me to tell you that as far as Queen's House itself is concerned they are now practically non-existent, and he is very pleased with the result of the experiment.

"Yours sincerely,
"P. BEATTIE CROZIER."

Later I received letters containing similar information as regards a number of hotels and business premises in the area, and the evidence of our success is enhanced from the fact that I received at the same time some letters from hotels and buildings *outside* the area, stating that the mosquitoes in those places were as bad as ever.

In our experience the most severe test of a reduction of adult *Stegomyia fasciata* is provided by the earthenware test or trap breeding pots that I have mentioned to you, and for this reason I consider that the following tabular statement indicates that we had really been very successful in reducing that species.

TABLE VI.

Dates.	Percentage of test pots infected.
25-7-13	41·6
30-7-13	33·3
4-8-13	33·3
30-8-13	29·1
4-9-13	17·0
9-9-13	17·0
13-9-13	12·5
18-9-13	8·1
23-9-13	4·1
30-9-13	8·1
6-10-13	4·1

Taking into consideration all our tests, we consider that we have abundantly proved that, although we have been unable entirely to extirpate *Stegomyia fasciata, Stegomyia scutellaris,* and *Culex fatigans* from the area, we have reduced them to negligible numbers, and maintained the reduction sufficiently long to make it certain that, if the arrangements are continued, the results will be permanent.

Unfortunately I have again to refer, however, to the interesting but disquieting observations regarding the migratory species of mosquitoes whose habits I have already mentioned. In August, shortly after receiving the letters previously referred to, a migration of great numbers of those mosquitoes into the Fort Ward occurred, and was observed and reported to us by several residents; but on that occasion the unusual prevalence did not last more than a few days. On the 10th of September, we again found that many adults of *Culex sitiens, Culex vishnui,*

Culex gelidus, and two or three other species, were present in the area, and at intervals throughout that month and the next, similar observations were made. During those months we carried out a number of special investigations throughout our area, our control area, and the neighbourhood generally, in the hope of finding that these species were breeding, if not actually in our area, at any rate within a reasonable distance of it. We proved, however, that that was not the case. In November the matter became serious because, although we could find no specimens of *fasciata*, *scutellaris*, or *fatigans*, the abundance of adults of the migratory species became so great that, from the point of view of the lay public, our work appeared no longer to be efficacious, and we learnt that residents were obliged again to resort to the use of curtains.

I have no time to tell you of our other four campaigns, but as regards both the urban and rural mosquitoes the results were very similar to those I have described. If I were asked to sum up the results of all our campaigns very shortly, I would say that by strictly local measures we attained a marked success in reducing the mosquitoes of groups 1 and 2 (namely, the strictly household and the remaining urban species), but that the mosquitoes of group 4 (the migratory species) will continue to be troublesome in the town at certain seasons, however thoroughly measures *confined to the town itself* are carried out. The latter fact, of course, is very unfortunate, but it cannot be too strongly urged that it should not be permitted to prevent or delay—

(a) Active measures against the household and other domestic mosquitoes, of which *Stegomyia fasciata* and *Culex fatigans* are examples.

(b) Active investigation with a view especially to the discovery of new methods of attacking the species against which local anti-larval measures are ineffective.

I think I have now said enough to shew that in order to deal with the troublesome and dangerous pest of mosquitoes in our great Eastern seaports we must abandon the arrangements described in the popular books that we have doubtless read; we must give up the idea that great things can be accomplished by cheap and easy methods; we must set out on a new line. Even the single task of reducing *Stegomyia fasciata*

must be regarded, not as a trivial affair, but as a task of immense difficulty, only to be accomplished when the staff and materials provided are sufficient to enable a great, a long, a hard, and above all a scientific battle to be waged. I want those words to sink into your minds. The idea is still very prevalent that if a municipality spends even a little money upon mosquito destruction, by employing say three or four overseers to perambulate the town and destroy a few very obvious breeding places, some reduction of mosquitoes will result. Unfortunately this is by no means necessarily the case, and it is probably true that unless a municipality is prepared to undertake mosquito elimination thoroughly—to place it in fact in the forefront of their sanitary programme—their results will be about as satisfactory as if they had left the problem alone. In this matter half measures are futile. What is very desirable in large seaports and cities is the establishment of a special Anti-mosquito Department separate from, but working in conjunction with, the establishment of the Medical Officer of Health, and consisting of a properly qualified entomologist and a staff of thoroughly trained workers, provided with legal powers, and with liberal funds and materials for carrying on their work in an adequate manner and for testing its results in a scientific way. I am of opinion that the best policy for such a department to pursue would be one of investigation combined with experimental measures. Such a policy cannot be followed except under the direction of an officer who has previously received a thorough training in entomology, and is engaged to devote his whole time to the task. And I think the period has gone by when work of this kind should, as a general practice, be added to the multifarious duties of Medical Officers of Health. Instead, on the analogy that an enlightened municipality employs a trained bacteriologist, a trained chemical analyst, and at least three or four officers specially trained in different branches of engineering, it should employ a trained entomologist to deal with the highly specialised problems connected with the serious pest of mosquitoes and other disease-carrying insects.

Finally, the imperfect record that I have presented to you will, I hope, help us to realise that when the special department of which I have spoken is created, the public will have to be very patient with regard to results. They must not expect the mosquitoes to disappear (like they do in the popular books) as soon as the funds have been allotted

and the staff appointed. They may criticise the department if they like, for honest criticism is always helpful, but they must not break it up if its work appears at first to be almost fruitless of results. Instead, let us hope that they will applaud it when it is successful, console it when it fails, cheer it when it recovers, but above all let it battle on.

Discussion.

Dr. P. H. Bahr: I should like to congratulate Major James on his paper. I need hardly say that I admire him, not only as an entomologist but as a man, for I have had reason to thank him for his great assistance to me when I was groping my way amongst the mosquitoes of Ceylon. Anyone who has tried to work at these insects in the East will recognise the debt we owe Major James for his excellent work on the anopheline mosquitoes of India; let us hope he will produce a similar work on the mosquitoes of Ceylon. Before Major James arrived in Ceylon very little was known of the mosquitoes indigenous to that island; in fact, knowledge rested on collections made by Dr. Chalmers and Mr. Green, of Peradenija, but in many instances his terminology was out of date. Very great confusion existed, and no one was certain of the identity even of the anopheline carriers of malaria in the island. Now, thanks to Major James's work, the malaria carrier in Ceylon is well known, and a great deal of very valuable information has been collected with regard to sanitation in general, which not only applies to Ceylon, but to the whole of the tropical world, and I am sure we all have cause to feel very grateful to Major James for the work he has done.

The most practical part of the paper to my mind is Major James's insight into human nature. I think anybody who has worked at sanitation in the East and knows the character of the Sanitary Surveyor, will applaud his shrewdness in frequently changing the staff. I think we are all rather too apt to accept results, which, though plausible enough, are not based on a scientific basis, and probably statements of this nature, in popular works which he refers to, have kindled Major James's wrath.