

THE DISTRIBUTION OF 'STEGOMYIA FASCIATA' IN
INDIA, WITH REMARKS ON DENGUE AND
YELLOW FEVER

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THE Government of India has for many years been fully aware of the importance of '*Stegomyia fasciata*' as a disease-carrying insect. Some years ago when, owing to the opening of the Panama Canal, it was thought that there was an increased risk of yellow fever being introduced into this country, a number of *Stegomyia* surveys were made and a great deal of useful information regarding the distribution, prevalence and habits of '*Stegomyia fasciata*' was obtained in this way. Besides being the carrier of yellow fever this mosquito is known to be the vector of dengue—a wide-spread disease in India. It is, therefore, important that measures for the control of this pest should be undertaken. The recent very important discovery with regard to monkeys and yellow fever, referred to below, has a special interest for all public health authorities and medical men in India.

I have endeavoured to collect all records of the occurrence of this mosquito in the sub-continent and wish to express my thanks to the Imperial Entomologist for sending me particulars of all specimens in the collection of the Agricultural Research Institute, Pusa, and to the Director, Zoological Survey of India, for similar information regarding specimens in the Indian Museum collection.

*The name of this mosquito has undergone several changes during recent years, and it is now more usually referred to as *Aedes aegypti* or *Aedes (Stegomyia) aegypti*. Other names by which it has been known are *Aedes (Stegomyia) argenteus* and *Stegomyia calopus*. In some Medical Journals it is still referred to as *Stegomyia fasciata* (*Brit. Med. Jour.*, April 28th, 1928, p. 723), by which name it is familiar to a large number of medical men. As this paper has been written more for the medical man than for the systematic entomologist, the more familiar name has been employed.

The distribution, as far as this is known, is given in detail, with references, at the end of this paper, and the names of all places where it is known to occur are shown on Map 1. References are also given to papers containing observations on the habits of this mosquito, and to others giving suggestions for its control. Map 2 shows the distribution, as far as can be ascertained of dengue fever in India. This map is based on one published by Megaw and Gupta in 1927 (**M. 5.**)*

'STEGOMYIA FASCIATA' AND DENGUE FEVER.

'*Stegomyia fasciata*' has been proved by experimental transmission, to be the carrier of dengue in Australia by Bancroft (**B. 2.**), and by Cleland, Bradley and MacDonald (**C. 18., C.19.**), in Texas by Chandler and Rice (**C. 15.**), and in the Philippines by Siler, Hall and Hitchens (**S. 3., S. 4.**). Experimental transmission has been attempted with other mosquitoes and success has been claimed with *Culex fatigans* by Graham (**G. 1.**) in Syria, and by Ashburn and Craig (**A. 5.**) in the Philippines, but certain other investigators have failed to confirm these findings. In Formosa Koizumi, Yamaguchi and Tonomura (**K. 1.**) made a number of experiments in 1915, but positive results were only obtained with *Aedes (Stegomyia) albopictus (Stegomyia scutellaris)* and *Armigeres obturbans*. These workers point out that as the volunteers used in the experiments were not under observation and confinement before the experiments began, the latter were not absolutely conclusive. The same remarks apply to experiments with various mosquitoes carried out by Carpenter and Sutton (**C. 2.**) in the Panama Canal zone, as the volunteer subjects were not protected at all times from the bites of other mosquitoes. Siler, Hall and Hitchens (**S. 4.**) give a full account of experimental work by earlier investigators, and a useful bibliography.

Dengue fever, as will be seen on reference to Map 2, is a widespread disease in India. Our knowledge of the exact distribution is incomplete, owing to the fact that it is often very difficult to distinguish from other 'short fevers' having somewhat similar clinical symptoms, such as sandfly fever (**B. 3., M. 4.**), and also because no specific organism has yet been isolated as a cause of the disease. The accompanying Map 2 is a modification of one published by Megaw and Gupta (**M. 5.**). The areas where dengue was reported to be unknown and those from which no information could be obtained, are left blank. In the paper by Megaw and Gupta (**M. 5.**) they say with regard to dengue 'This has a much wider distribution than that shown in the map, and one is sceptical about the reported complete absence of the disease from many districts in Bengal, Assam and Burma. The disease almost certainly occurs all over Bengal and over the greater portions of Assam, Madras, Bihar and Orissa, and the United Provinces. Dengue is exceedingly likely to be overlooked when it occurs in sporadic form in a partially protected population, so that while the positive records may be

* The letters and numbers in brackets refer to the list of references given at the end of this paper.

accepted as being fairly trustworthy, the negative reports cannot be admitted as reliable evidence of the absence of the disease. The relationship between sandfly fever and dengue has been a difficult problem; it was hoped that the combined experience of the civil surgeons of India would throw some light on this point, but the replies for the most part are vague.'

Dengue appears to be epidemic in some of the chief ports, places where '*Stegomyia fasciata*' is known to abound. From 1921 to 1925 outbreaks of dengue occurred every year amongst British or Indian troops, or both, at Calcutta, Rangoon, and Madras (P. 3. to P. 7.), and rather less commonly at Bombay and Karachi. There was a steady rise in the number of admissions to hospital, diagnosed as dengue, amongst European and Indian troops, from 1920 with a total of 746 cases, to 1924 with a total of 1,701 cases (P. 2. to P. 6.). These returns include Aden, where Dive (D. 1.), says that the seasonal incidence of the disease corresponds with that of '*Stegomyia fasciata*.' The disease there is epidemic from April to July amongst troops arriving during the previous winter, whilst a further epidemic occurs in September, in some years, amongst non-immune troops.

Although dengue is not a very serious or fatal disease, its occurrence in epidemic form means loss of efficiency and probably increased susceptibility to other diseases by lowering the general standard of health. It seems important, therefore, that precautions should be taken against its occurrence. In military cantonments and barracks the reduction of the mosquito carrier should not be a difficult matter. The control of the breeding places, which are nearly always in or near human habitations, should be easy in such areas where disciplined action can be taken.

E. H. Ross (R. 2.) stated that dengue was eradicated from Port Said by vigorous anti-mosquito measures.

Some remarks on methods of control are given further on in this paper.

'*STEGOMYIA FASCIATA*' AND YELLOW FEVER.

A very important discovery regarding yellow fever has recently been made. Stokes, Bauer and Hudson (S. 6., S. 7.) have found that the common Indian brown monkey, *Macacus rhesus*, is very susceptible to yellow fever, and that the Indian crown monkey, *M. sinicus*, is also susceptible in a moderate degree. These findings have been confirmed by Mathis, Sellards and Laigret (M. 3.) and by Sellards and Hindle (S. 1.). When it is realised that the combined distribution of these two monkeys covers practically the whole of India from the Himalayas to Cape Comerin (*vide* Map 1), it will be seen that should yellow fever ever appear in India there will be a new and important factor, in connection with the spread of the disease, to be dealt with. As everyone in India knows such monkeys are often numerous on the outskirts of even the largest cities, and are commoner in and about towns. The probability of the infection passing to them, in the event of the disease being introduced into this country, and of a dangerous reservoir of infection being thus created, would appear to be great. The stamping

out of such an infection would be a serious problem, as, apart from other difficulties, the *bandar log* are regarded as sacred animals in many parts of India.

Balfour (**B. 1.**) once drew attention to a popular belief in Trinidad that outbreaks of yellow fever were preceded by considerable mortality amongst the red howler monkeys of the island.

The chance that yellow fever will ever appear in India seems to be remote, but in these days of increasingly rapid communications, the risk cannot be entirely lost sight of.

Some years ago the possibility of the introduction of the disease was thoroughly investigated (**J. 1., A. 4.**). A number of *Stegomyia* surveys were made, and, with a view to selecting suitable sights for quarantine stations, surveys were also made of the Calcutta dock area (**A. 2.**), Bombay harbour (**C. 17.**), and other places.

Owing to the vigorous methods adopted in America during recent years (**R. 1.**) in the control of yellow fever, the disease has disappeared from a number of areas where it was formerly epidemic or endemic, and has been largely reduced in others. The risk of the disease being introduced into India from the east is therefore less than it was some years ago. No authenticated cases have ever been reported from Hongkong, Singapore or the Dutch East Indies. An interesting point in this connection is the rarity of '*Stegomyia fasciata*' in Hongkong (**H. 3., J. 1., M. 1., S. 2.**) although this port is in direct communication with others where this mosquito is common (**S. 5.**).

Apart from the considerations mentioned above, there is always the possibility that yellow fever may appear in East Africa and be conveyed to India from there. Mombasa is in direct communication by sea with Bombay without an intermediate port of call, the passage takes from 10 to 12 days only, and is in latitudes favourable to the survival of '*Stegomyia fasciata*.'

HABITS OF '*STEGOMYIA FASCIATA*.'

'*Stegomyia fasciata*' is a man-hunting and day-biting mosquito and occurs in greatest numbers in the most densely populated parts of cities and towns. There is overwhelming evidence that the race of this mosquito found in India prefers artificial breeding places in or near human habitations, and that it seldom lays its eggs in any natural collections of water. In Calcutta it has seldom been found breeding further than about 20 yards from houses.

There are some thousands of records of actual situations in which the larvæ have been found. The most usual are earthenware chatties and other receptacles used for storing water in houses, barrels, tubs, anti-formicas and flower vases. Tins and disused domestic articles which may be left lying about in compounds are also favourite places.

Adults and larvæ are frequently to be found on ships (**A. 3.**) (especially when lying in docks or harbours), launches, country boats, and 'flats' used as landing stages on Indian rivers, the larvæ occurring in bilge water, collections of rain water, and in barrels and tanks used for storing drinking water (**B. 4., M. 2.**)

As regards wells Horne (**H. 4., H. 5.**) found larvæ in 40 per cent of those examined in Madras in July 1913, but at Tuticorin larvæ were found in one well only, out of 229 examined. In an extensive survey of the seaports of Burma, under the direction of Lalor (**L. 1.**), when larvæ were found in more than 1,300 separate breeding places, none were found in wells. They were also reported to be absent from wells in Colombo, Ceylon, where a mosquito survey was carried on for one year (**J. 3., J. 4., J. 5.**).

Larvæ have been found very occasionally in tree-holes and hollow bamboos, but this is unusual and happens only when such breeding places are close to human habitations, as far as observations have been made in India. During the last seven years I have collected many thousands of mosquito larvæ from tree-holes and bamboo stumps, in various parts of India and have never reared any specimens of '*Stegomyia fasciata*' from these. The only natural collection of water in which I have ever found the larvæ was a pool of rain water on a rock at Karwar. In its breeding habits the Indian race of this mosquito differs from that found in West Africa according to recent observations made there. Dunn (**D. 2., D. 3., D. 4.**) has found that this mosquito prefers to lay its eggs in hollow bamboos rather than in tins. The eggs and larvæ have been found in 'test bamboo pots' 500 yards from habitations. Adults have also been bred frequently from larvæ found in tree-holes. In one instance, 1,141 specimens were bred from 26.9 per cent of the tree-holes searched, some of the trees being 350 yards from the nearest house. It has been stated that in East Africa collections of water in the tops of palm tree are favoured by '*Stegomyia fasciata*' and that it is the predominating species breeding in these situations (**H. 1.**). Doubt has, however, been expressed with regard to these observations as Lester (**L. 4.**), some years later was unable to obtain larvæ in any numbers from such situations.

The race of this mosquito found in America appears to agree with the Indian one in breeding habits. Howard (**H. 6.**) has written an account of the 'yellow fever mosquito' and gives details of the kinds of breeding places selected by it in various parts of the Americas.

It may be mentioned that where extremely intensive anti-*Stegomyia* measures have been carried out, '*Stegomyia fasciata*' has sometimes been found breeding by compulsion in very unusual situations (**C. 1.**).

RACES OF '*STEGOMYIA FASCIATA*.'

Mention has been made above of the differences in breeding habits between the races of '*Stegomyia fasciata*' found in West Africa and India. Legendre (**L. 3.**) has put forward a theory that there are two forms of this mosquito, one studied by him in Indo-China, Madagascar, Syria, etc., with a slim pale coloured larva and slender adult, which he calls the Oceano-Indian race; the other form, with a large blackish larva and thick-set adult, is found in French West Africa, and is called by him the African-American race. He suggests that whereas the latter transmits yellow fever, the former possibly does not. Now that a susceptible laboratory animal has been discovered (**S. 6., S. 7., M. 3., B. 5.**) it should not

be difficult to test this theory, and, in order to assist in any such experiments, eggs of the Indian race are being sent this season to London and West Africa.

It is certain that the races of this mosquito found in Australia, the Philippine Islands, and the southern part of North America, are able to transmit dengue, successful experiments having been carried out in these countries, as mentioned in a previous paragraph.

In connection with Legendre's theory it may be pointed out that '*Stegomyia fasciata*,' at least as regards the adult stage, is often very variable in size and markings. Hill (**H. 2.**) has recorded the occurrence of two forms in Australia, one small and dark, the other larger and lighter. Larvæ and pupæ of the former were found in a tin 600 yards from the nearest house. From these five generations were bred and at the same time a similar number of generations of the larger and lighter form were bred for comparison. It was found that the light form 'bred true' whilst the dark form produced, after the first generation, a proportion of both forms and some intermediates. On another occasion, a number of larvæ were obtained from a tree-hole about 70 yards distant from the nearest dwelling. In this case the males were of average size but the females were lighter and unusually large. This record of Hill's of the larvæ having been found in a tree-hole is, I believe, the only one of its kind from Australia.

Indian specimens vary a good deal in size and in the colour of the mesonotal scales, they are however seldom as pale as individuals from Mesopotamia and Aden. In some of the latter the scales on the mesonotum lying between the curved white lines are light brown or yellowish and the pair of submedian yellow lines is obliterated. One female from Ambala, Punjab, in the Central Malaria Bureau collection, is of this form.

Some remarkable variations have been described from West Africa by Connal (**C. 21.**).

NOTES ON THE CONTROL OF '*STEGOMYIA FASCIATA*' IN MILITARY CANTONMENTS AND BARRACKS FOR THE PREVENTION OF DENGUE.

The problem of the control of '*Stegomyia fasciata*' in cities, towns, dock areas and harbours of India has been thoroughly investigated and recommendations have been made by Christophers (**C. 16.**), and James (**J. 2., J. 5.**). The titles of other papers dealing with this subject, both as regards India and elsewhere, will be found in the list of references under the following numbers:—**C. 20., C. 22., H. 6., and S. 4.** I do not propose to repeat these recommendations in full but a few notes may be useful to officers commanding military stations and medical officers in charge of troops, from the point of view of the prevention of dengue.

The control of '*Stegomyia fasciata*' is best accomplished by the systematic destruction of the larvæ, and by the reduction of the number of breeding places. As mentioned in a previous section of this paper, the larvæ breed almost exclusively in artificial and domestic collections of water. All useless artificial collections of water should be eliminated as far as possible, i.e., tins, broken pots, jars or bottles,

old domestic utensils, etc., which may collect water in the rains, should be buried. Fire buckets, anti-formicas, jars used for storing water or cooling soda water, flower vases, rain water barrels or tubs, cement cisterns, etc., should be examined once a week, emptied where possible, and all mosquito larvæ destroyed. Wells may also be examined but larvæ of '*Stegomyia fasciata*' are not usually found in these except in Madras. Tins or earthenware pots containing water may be kept in suitable situations, preferably in dark corners, as traps, and the larvæ destroyed regularly once a week. Defective gutters, blocked pipes, faulty drains, etc., which may hold water and form breeding places, should be cleared or repaired.

Men suffering from dengue should be protected from the bites of '*Stegomyia fasciata*' during the 'infective period' (the first three days of the attack) by being kept in bed and under a mosquito net *day and night*. Although the mosquito carrier usually bites during the day, it will also attack man during the evening and at night. It would be a wise precaution to treat suspected cases in the same way, as soon as discovered, as this would reduce the risk of fresh mosquitoes becoming infected. During an epidemic, everyone, including the ward orderlies and patients, should co-operate in destroying adult mosquitoes by 'swatting' and spraying, and by using mosquito nets not only at night but when resting during the day.

THE DISTRIBUTION OF '*STEGOMYIA FASCIATA*' IN INDIA.

The distribution of '*Stegomyia fasciata*' is shown on Map 1, where it is indicated by the names of places from which specimens have been received or from which it has been recorded on reliable authority. Details are given below with references. On comparing Maps 1 and 2, it will be seen that the distribution of the mosquito corresponds fairly closely to that of dengue fever, although our knowledge of both is far from complete. The writer will be very grateful to anyone who will be kind enough to forward specimens from places not named on the map.

✓ **Burma.**—Victoria Point (A. 1.), Tenasserim (A. 1.), Mergui (A. 1.), Moulmein (L. 1.), Rangoon (A. 1., C. 5., C. 10., C. 11., G. 2., L. 1., T. 2., T. 3., Z. 1.), Bassein (L. 1.), Thayetmyo (C. 11.), Pyinmana (A. 1., C. 7.), Mandalay (C. 5., T. 2., T. 3., Z. 1.), Maymyo (C. 10., Z. 1.), Monywa (C. 5.), Katha (C. 9.), Sandoway (C. 10.), Akyab (C. 10., L. 1., G. 2.), Ross Island (Z. 1.).

✓ **Andaman Islands.**—Port Blair (A. 1., C. 12.), Mount Harriet (C. 4.).

✓ **Assam.**—Gauhati (C. 13.), Lushai Hills (T. 2., Z. 1.).

✓ **Bengal.**—Chittagong (T. 2., T. 3., Z. 1.), Chandpur (M. 2.), Narayanganj (M. 2.), Goalundo (M. 2.), Dacca (M. 2.), Calcutta (M. 2., A. 1., C. 8., G. 2., P. 1., T. 2., T. 3., Z. 1.), Siliguri (F. 1.), Khargpur (Z. 1.).

Bihar and Orissa.—Purnea (T. 2., Z. 1.), Puri (T. 2., T. 3.), Purulia (C. 12.), Pusa (A. 1.), Cuttack (C. 8.), Rajmahal (Z. 1.).

Madras Presidency.—Vizagapatam (C. 13.), Negapatam (H. 5.), Tuticorin (H. 5.), Madras (G. 2., H. 4., H. 5., T. 2., T. 3., Z. 1.). Most common

in George Town, but also plentiful in the following divisions of the city:—Tondiarpet, Perambur, Vepery, Purasawalkam, Triplicane, Mylapore, Nungambakam, Egmore, Kilpauk, and Adyar.

Mysore.—Bangalore (C. 13.).

Travancore.—Quilon (T. 1.).

Hyderabad.—Secunderabad (L. 2.).

Bombay Presidency.—Bombay (A. 1., B. 4., C. 7., G. 2.), Karwar (C. 7.), Poona (C. 8., C. 12.), Karachi (B. 4., C. 14., G. 2.).

Central Provinces.—Kamptee (C. 10., C. 11.).

United Provinces.—Lucknow (A. 1., T. 2., Z. 1.), Bareilly (A. 1.), Roorkee (A. 1.), Agra (C. 11., C. 13.), Fyzabad (C. 5.), Bhim Tal, Kumaon, 4,500 ft. (T. 2., Z. 1.), Allahabad (Z. 1.).

Delhi Province.—Delhi (G. 2.).

Punjab.—Karnal (C. 14.), Ambala (C. 9., C. 13.), Kalka (C. 3.), Lahore (C. 8.), Ferozepore (C. 10.), Dalhousie (C. 5.), Rohtak (A. 1.).

Rajputana.—Nasirabad (C. 11.), Jodhpur (C. 14.).

North-West Frontier Province.—Peshawar (C. 9., C. 12.).

Ceylon.—Colombo (J. 5., T. 1.), Trincomalee (C. 6.).

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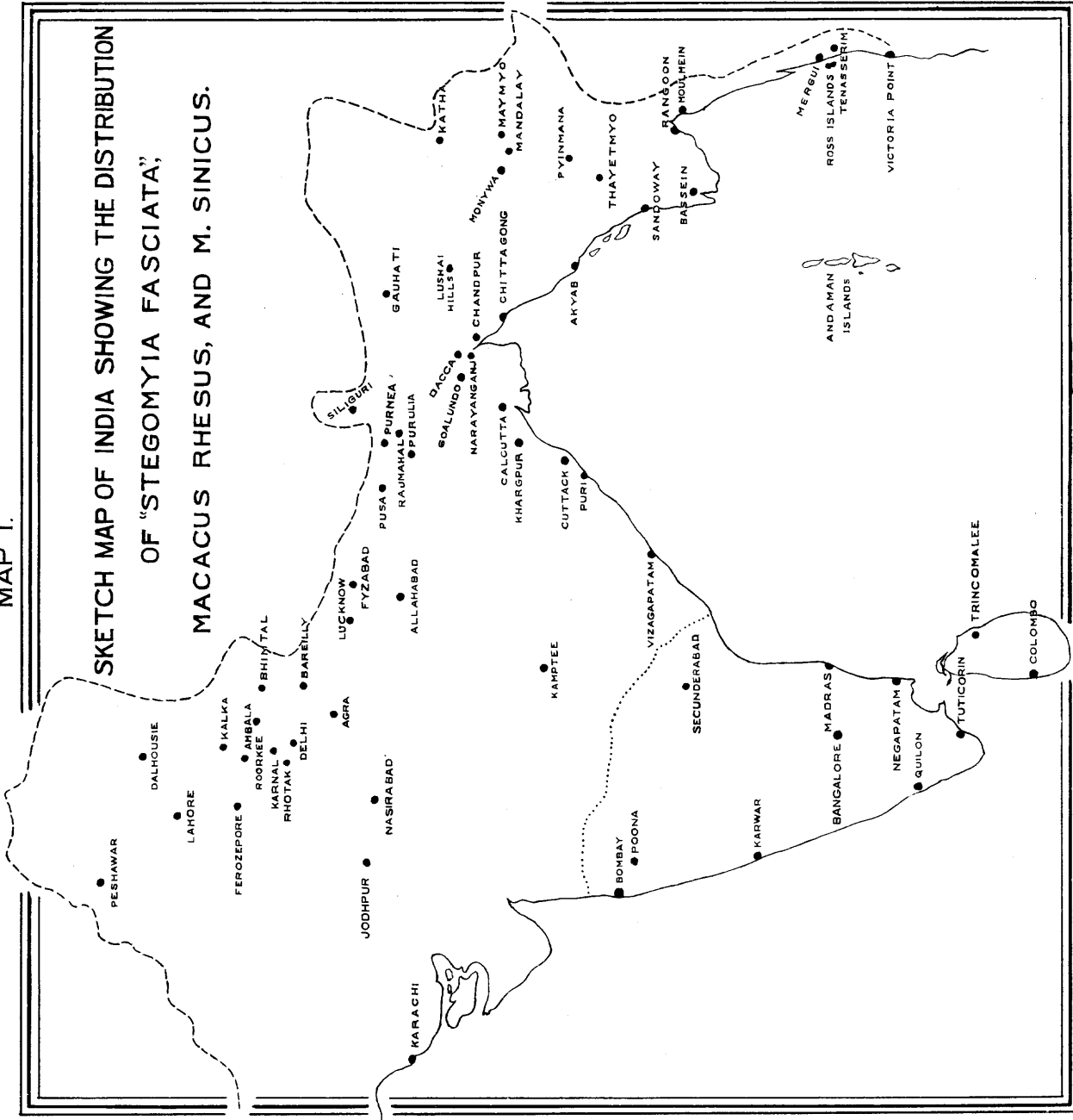
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- L. 2.** Ditto (1913) .. The Ætiological Relationships of Seven-day Fever. A Suggestion. Appendix IV to the Report quoted above (**L. 1.**). In the discussion on this paper *Stegomyia fasciata* is mentioned, by Leslie, as being 'not common' at Secunderabad.
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MAP I.

SKETCH MAP OF INDIA SHOWING THE DISTRIBUTION
OF "STEGOMYIA FASCIATA,"
MACACUS RHEBUS, AND M. SINICUS.



EXPLANATION OF MAP 1.

Sketch map showing the distribution of '*Stegomyia fasciata*,' and of the common Indian monkeys *Macacus rhesus*, and *Macacus sinicus* recently found to be susceptible to yellow fever.

The mosquito is known to occur at all the places named on the map. The distribution has not been shown by districts, as has been done in the case of dengue on Map 2, as this species is essentially a domestic one and found chiefly in cities and towns. It is probably common in a large majority of towns in India.

The distribution of *Macacus rhesus* extends from the Himalayas as far south as the dotted line drawn from a little north of Bombay to the Godavari river north of Secunderabad. Below this line *Macacus sinicus* is the common monkey of South India.

EXPLANATION OF MAP 2.

Sketch map illustrating the distribution of dengue fever in India. The disease has been reported to be common in the districts marked in black, and less common or rare in those marked with lines. Districts where dengue was reported to be unknown, or regarding which no information could be obtained, have been left blank. [The map is based on one published by Megaw and Gupta in 1927 (**M. 5.**)].

REFERENCE NUMBERS.

1. Mergui	district, Burma.	44. Cuddapam	district, Madras.
2. Tavoy	" "	45. Anantapur	" "
3. Pyapon	" "	46. Bangalore	" Mysore.
4. Maubin	" "	47. Chittoor	" Madras.
5. Hanthawaddy	" "	48. Chingleput	" "
6. "	" "	49. North Arcot	" "
7. Insein	" "	50. South Arcot	" "
8. Tharrawaddy	" "	51. Trichinopoly	" "
9. Pegu	" "	52. Coimbatore	" "
10. Toungoo	" "	53. Malabar	" "
11. Yamethin	" "	54. Tinnevely	" "
12. Meiktila	" "	55. Bombay	" Bombay.
13. Kyaukse	" "	56. Kolaba	" "
14. Mandalay	" "	57. Poona	" "
15. Sagaing	" "	58. Surat	" "
16. Lower Chindwin,	" "	59. "	" "
17. Bhamo	" "	60. W. Khandesh	" "
18. Sibsagar	" Assam.	61. E. Khandesh	" "
19. Goalpara	" "	62. Kaira	" "
20. Chittagong	" Bengal.	63. Jhalawar	" "
21. Tippera	" "	64. Karachi	" "
22. Dacca	" "	65. Khairpur	" "
23. Pabna	" "	66. Jodhpur	State, Rajputana.
24. 24-Parganas	" "	67. Mewar	" "
25. Hooghly	" "	68. Kotah	" "
26. Burdwan	" "	69. Jhalawar	" "
27. Murshidabad	" "	70. Nagpur	district, Central Provinces.
28. Dinajpur	" "	71. Chhindwara	" "
29. Manbhum	" Bihar & Orissa.	72. Jubbulpore	" "
30. Hazaribagh	" "	73. Allahabad	" United Provinces.
31. Palamau	" "	74. Bara Banki	" "
32. Gaya	" "	75. Lucknow	" "
33. Shahabad	" "	76. Sitapur	" "
34. Patna	" "	77. Agra	" "
35. Monghyr	" "	78. Delhi Province.	" "
36. Bhagalpur	" "	79. Meerut	district, "
37. Sambalpur	" "	80. Naini Tal	" "
38. Warangal	" Hyderabad.	81. Saharanpur	" "
39. Kistna	" Madras.	82. Lahore	" Punjab.
40. Atraf-i-Balda	" Hyderabad.	83. Shahpur	" "
41. Mahbubenagar	" "	84. Peshawar	" N.-W. F. P.
42. Kurnool	" Madras.	85. Dera Ghazi	" "
43. Nellore	" "		Khan district, Punjab.

MAP 2.

