ABSTRACT.

Entomological Investigations on the Spike Disease of Sandal

THE LIFE-HISTORY AND MORPHOLOGY OF SARIMA NIGROCLYPEATA, MEL.

(11) FULGORIDAE (HOMOPT.).

Sarima nigroclypeata Mel., is one of the commonest Fulgoridae found on sandal, *Santalum album*, and feeds on seven other plants. When the attack of this species on sandal is prolonged and severe, its foliage is entirely shed, young plants and shoots are killed within a short time and the vitality of the tree is reduced. *S. nigroclypeata* is partly responsible for causing thin crowns and the general stag-headedness prevalent in sandal forests. Under laboratory conditions mass feeding on young sandal plants resulted in a reduced and clustered condition of leaves. The adult life is over three months and the female has a long oviposition period. Eggs are laid on surface of bark of shoots and there are five nymphal stages. The average time taken to complete development from egg to adult is 121 days. There are three generations in a year and the generations overlap. Most of the transformations of the different stages take place within 17-23 days at mean temperature varying from 68°F—87°F at Denkanikota, N. Salem, Madras. This species is active throughout the year in sandal forests of Madras, Coorg and Mysore. All the instars are described and a table is given for the identification of the nymphs. Observations on the development and morphology of eyes, antenna legs, anal brushes, and male genitalia have been made. This species is considered to be a probable vector of the spike disease of sandal.

INDIAN FOREST RECORDS

Vol. XVIII] 1932 [Part VIII

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (11).

THE LIFE-HISTORY AND MORPHOLOGY OF SARIMA NIGROCLYPEATA, MEL.

Fulgoridae (Homopt.).

BY

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INTRODUCTORY.

This paper embodies in part the results of an investigation conducted in North Salem, North Coorg, and Vellore forest divisions, on the entomology of the spike disease of sandal (*Santalum album*), taken up by the writer under the direction of the Forest Entomologist.

The Indian Fulgoridae have been very scantly studied, and with the exception of Misra's work (8) on the sugarcane leaf-hopper, *Pyrilla aberrans*, Kirby, we know very little about the life-history and bionomics of the Fulgoridae of India. From an economic stand point the Fulgoridae must be counted injurious, as all the species so far known, are dependent upon growing plants for their food. Besides being pests of agricultural crops, fulgorids are incriminated in the transmission of various virus diseases.

Indian investigators regard the spike disease of sandal as due to a virus. If the virus of spike disease is insect-borne, a permissible hypothesis is, that the vector is one of the dominant insects of sandal. With regard to the efficiency of the various groups of insects as vectors of virus diseases, Smith (*12*; *p. 317-318*) writes 'apart from three rather doubtful cases, biting insects (Coleoptera and Orthoptera) seem to be concerned in the dissemination of only three plant viruses, while all the rest are transmitted by sucking insects. Then, as regards sucking insects, in the Thysanoptera there appears to be only one authentic case of virus transmission by thrips with four others in which the connection is not definitely proved.' He further states 'considering the aphididae, these are found to be responsible for the transmission of no less than twenty-seven plant viruses, in which twenty-three species of Aphis are concerned. The Aphididae then are undoubtedly the most efficient insect vectors of plant viruses'. 'Next in efficiency come the Jassidae including Fulgoridae with seven viruses.'

Studies on bionomics, distribution, incidence, and morphology of sandal insects restrict the consideration of the probable vectors of Spike disease to nineteen species of Homoptera, belonging to the families Aphididae, Jassidae, Fulgoridae and Cicadidae; to three species of Curculionidae, to three species of Thysanoptera (thrips); and to one species of Acarina (red spider).

Most of the life-history studies were made during February, 1930, to December, 1931, in the field at Denkanikota, in Hosur Taluk of the Salem district. From January, 1932, work was started in the Insectary provided by the Indian Institute of Science, Bangalore. Transmission experiments were also conducted with some of the selected probable vectors during the 1931-32 season (April to March), and the results obtained will form the subject of a separate paper.

1. SYSTEMATIC POSITION.

Melichar (*6*) has classified the sub-family Issidae into three groups, CALISCELIDAE, HEMISPHAERIDAE, and ISSIDAE, and the third group Issidae is further divided into three sub-groups (*a*) HYSTEROPTERINAE, (*b*) ISSINAE, (*c*) THIONINAE. The genus *Sarima* belongs to the sub-group Thioninae.

2. ECONOMIC STATUS.

This is one of the very common species of Fulgoridae found feeding on both healthy and spiked sandal trees in North Salem, Coorg, and Vellore forest districts of the Madras Presidency, and in the State forest areas lying between Hunsur and Fraserpet, belonging to the Mysore Durbar. No previous record on the bionomics of this species is available. During the course of field work and insectary experiments, it was discovered that the combined feeding of twenty-four adults and nymphs of *Sarima nigroclypeata*, caused the shedding of the entire foliage and the dying-back of the twigs and young shoots of a sandal branch in two months. A suppressed sandal plant at Jawalagiri under sleeve-experiments, was found dead within three months, due to the action of mass feeding by this species. *S. nigroclypeata* is injurious to sandal both as adult and nymph.

As a consequence of the abnormal drain of sap from the plant, this species when feeding on sandal foliage and shoots checks the growth, and if its attack is prolonged and severe the foliage may be shed entirely, the young shoots may be killed back and thus the vitality of the tree reduced. The new flush that comes up after complete leaf-shedding caused by *S. nigroclypeata*, has been observed in certain cases to be short and clustered, but this condition lasts for two to three months only. Like *Petalocephala nigrilinea Walk*, and others this is one of the species responsible for causing the general condition of stagheadedness (*14*) in sandal, seen in the sandal forests of South India.

3. DISTRIBUTION.

Lanouli, Matheran, Bombay; (Melichar). Aiyur, Dasempatti Daverbetta, Hoganackal, Jawalagiri, Muttur, Nognoor, Uduparani, North-Salem Forest Division; Kottur-yelagiri, Vellore Forest Division; Madras; Fraserpet, North Coorg Forest Division; Chamundi Hill, Hunsur, Koppa, Periyapatna, Mysore; (Forest Research Institute).

4. FOOD PLANTS.

This species has been observed to feed and breed on the following plants:—*Albizzia amara, Dodonæa viscosa, Erythroxylon monogynum, Lantana camara, Pterolobium indicum, Santalum album, Scutia indica, Webera corymbosa.*

BIOLOGY.

5. Technique for the study of life-history.

Considerable difficulty was experienced at first, in rearing the sandal fulgorids, in the building which served as insectary at Denkanikota. After many trials the following method was found to be satisfactory.

These insects did quite well inside tubes of $6'' \times 1''$, the open end of which was covered with a small piece of muslin. A small succulent sandal shoot with one or two leaves, was introduced inside the tube as food. Owing to the condensation of moisture on the inside of the tube, due to the drying up of the shoot, the food was changed every alternate day during September to January, and daily during other months of the year. No difficulty was experienced in dislodging the insects from the shoots or leaves. A slight shake brought them on to the sides of the tube, after which the old shoot was removed and the insects were carefully transferred to a clean tube with a fresh sandal shoot. Rearing inside tubes had the advantage that the insects could be examined with a hand lens without disturbing them much. Later sleeves $15'' \times 9''$ and cellophane cages, $14''$ in length and $5''$ in diameter, supported on thin wire frame, covering a nine-inch-high sandal seedling grown from seed in a pot were used. The diameter of the cage was smaller than the diameter of the pot, and the space between the cage and the rim of the pot was utilised for watering the sandal plant, which did quite well. As the moulted skins are left sticking to the stem, or leaf, or are found on the ground, observations could be easily made and accurate records maintained, without disturbing the insects in any way. In this method, the disturbance caused by the first method in the removal of the various stage nymphs from one tube to another, was avoided. As a check on the work in the laboratory, observations were recorded in the forest. Eggs, nymphs, and adults were sleeved on numerous sandal shoots at Aiyur, Denkanikota and Jawalagiri and their development watched at frequent but definite intervals.

6. Habits.

The first stage nymph on hatching, moves up and down for a short time over the shoot of sandal, and then selects a spot on the new leaves or on leaf bud; punctures the surface tissue, and begins to suck sap. Third, fourth, fifth stage nymphs, and adults suck sap

from both green and suberised shoots; while the first and second stage nymphs feed on the fresh flush of leaves and sprouting leaf buds very rarely on green shoots. Just the tip of the rostrum is inserted inside plant tissues while feeding, the rostrum penetrating at an acute angle. When leaves are not available, the younger nymphs die. The punctures made on shoot and leaf are very minute, almost imperceptible to the naked eye. Adults and nymphs feed on both healthy and spiked sandal, are delicate creatures, and are very active in their movements. They jump about from shoot to shoot, and plant to plant, and when approached move away quickly to the opposite side of a shoot or leaf. When alarmed the adults jump to a height of three feet, and the nymphs about eighteen inches. The flight of the adult is not strong, but it can fly short distances to reach adjoining plants. Adults and older nymphs rest on shoots, while younger nymphs rest on leaves and succulent shoots. The nymphs are provided with a pair of anal brushes, consisting of a number of wax bristles, which are banded black and white. They spread out these brushes fanwise, more particularly when they are about to moult. During the repeated process of spreading, the anal brushes wear out, break, drop off, and only short stumps projecting from the apex of the abdomen are left after a time. The nymphs have also the habit of carrying the anal brushes right over the back, and moving them sideways apparently to scare and drive away an approaching enemy. The products of digestion is a sweet transparent liquid, which is excreted in the form of a fine spray, with the apex of the abdomen tilted upwards. The honeydew occasionally accumulates on surfaces of leaves and shoots in small lumps. When freshly deposited the honeydew imparts a shining appearance to leaves and shoots, which subsequently become sooty black owing to the growth of a mould. This species is not gregarious.

7. COPULATION.

Copulation takes place end to end, the heads of the male and female being away from each other and lasts for two to three hours during the day time. In some cases the period of copulation was found to exceed this time. The female after copulation, wanders over the plant to select a proper site for laying eggs, and the male either remains on the plant or jumps off to another plant. Copulation begins within ten days after the last moult, but may be delayed for more than a fortnight.

8. Oviposition.

The female begins to oviposit within a week of copulation and oviposition is followed by further mating. In captivity *Sarima nigroclypeata* lays eggs by instalments, and the interval between two successive instalments varies from five to seven days. Examination records of sleeved shoots in the forest indicate, that mating and oviposition goes on all round the year; so that females of the older generation may be evipositing, when adults of a new brood are emerging from the last moult.

9. Site of Oviposition.

The female oviposits on the bark of shoots, at the axil of leaf and shoot, on the petiole of the leaf, on old and new leaf flush, and also on sprouting leaf buds. The eggs are never deposited inside plant tissue. The eggs are laid singly, rarely in clusters of three or four, distributed all over the branch, and are struck on the surface with a secretion.

10. Incubation.

The egg when freshly laid is dull white in color, which gradually becomes pale yellow on the seventh day. The color of the egg changes to mixed pink and yellow on the tenth day, and finally attains a light pink color throughout on the fourteenth day. When about to hatch the pink embryo can be distinctly seen inside the egg shell. The body occupies just three quarters the length of the egg with two dark red spots, the future eyes of the first stage nymph at the cephalic end; the abdominal segments are clearly defined, and the long legs are seen sticking out at the sides.

11. Duration of Incubation Period.

The shortest time taken for the eggs to hatch was seventeen days in April and June at a mean temperature of 80°F—82°F, while the longest time was of twenty-five days in February—March at a mean temperature of 74°F. The average of nineteen records is of 21·4 days and the mode is of 23 days at a temperature of 68°—82°F, in practically all the months of the year.

12. Hatching.

The nymph emerges by making a slit at the side of the egg with the help of the third legs, which are provided with toothed tro-

chanters. By rubbing the toothed trochanters against the chorion of the egg from within, a meso-metasternal suture is first made, and is further widened by the spines on the tibia and tarsus of the third legs. The first to come out from the egg are the head and rostrum. By moving laterally and also backwards and forwards, the yolk skin or membrane enclosing these parts, is gradually pushed down the abdomen and the legs till the body is entirely free.

13. DIFFERENT STAGES IN THE LIFE-HISTORY.

The nymph undergoes five moults during an average period of one hundred days and then becomes adult. Collecting on any day of the year on sandal plant, with yield almost all the stages of this species. The time spent in the different stages during the different months of the year is given below.

First Nymphal Stage.

The shortest time taken to moult from the first to the second nymphal stage was fifteen days in June at a mean temperature of 80°F, while the longest time was twenty-four days in January at a mean temperature of 70°F.

One nymph moulted in sixteen days in March at a mean temperature of 76°F, while three transformed in seventeen days during April, June, and July, at mean temperatures of 85°F, 80°F and 78°F respectively. Four individuals moulted in eighteen days at mean temperatures of 80°F, 78°F, 77°F, 70°F during June, July, September and December; and four moulted in nineteen days during February, July, August and December at mean temperatures of 74°F, 78°F, 79°F and 70°F. Four individuals moulted in twenty days during August, October and December at mean temperatures of 79°F, 77°F, 70°F; two moulted in twenty-one days in January, and August, at mean temperatures of 68°F and 79°F; while three moulted in twenty-two days during January, February, and December at mean temperatures of 68°F, 69°F, and 70°F.

The average time of twenty-three records is 19·2 days, and the mode is 18 to 20 days, at mean temperature varying between 70°F to 80°F, in practically all months of the year.

Second Nymphal Stage.

The shortest time taken to transform from the second to third nymphal stage, was fourteen days during February—March, at a

mean temperature of 78°F; and the longest time was twenty-four days during December—January, at a mean temperature of 69°F.

Twenty-four individuals, took fifteen to twenty-three days to moult from the second to third stage, at mean temperature varying between 69°F—86°F. The average time of twenty-six records is 19·4 days, and the mode is 19 days, at mean temperature varying between 69°F—86°F, in practically all months of the year.

Third Nymphal Stage.

The shortest time taken to moult from the third to fourth nymphal stage, was sixteen days during April—May, at mean temperature of 82°F—85°F; while the longest time was twenty-three days during March and September, at mean temperature of 75°F and 77°F.

Twenty-two individuals, took seventeen to twenty-two days to transform, at mean temperature varying between 68°F—85°F. The average time of twenty-nine records is 19·9 days, and the mode is 20 days, at mean temperature varying between 68°F—79°F, in six out of twelve months of the year.

Fourth Nymphal Stage.

The shortest time taken to moult from the fourth to fifth nymphal stage, was eighteen days during April—May, at a mean temperature of 86°F; while the longest time was twenty-three days during February, at a mean temperature of 73°F.

Twenty-four individuals, took nineteen to twenty-two days to transform, at mean temperature varying between 70°F—87°F. The average time of twenty-eight records is 20·7 days, while the mode is 20 days, at mean temperature varying between 71°F—86°F, in practically all months of the year.

Fifth Nymphal Stage.

The shortest time taken to moult from the fifth nymphal stage to the adult hopper, was nineteen days in the month of May, at a mean temperature of 86°F; and the longest time was twenty-four days during August—September, at a mean temperature of 78°F.

Twenty-two individuals, took twenty to twenty-three days to transform, at mean temperature varying between 69°F—86°F. The average time of twenty-five records is 21 days, while the mode

is also 21 days, at mean temperature varying between 69°F—83°F, in practically all months of the year.

14. MOULTING OF NYMPHS.

When about to moult, a fine rupture appears from the vertex to the base of the metanotum. The head of the emerging nymph or adult is pushed out first, and the moulted skin previously covering the head and thorax occupies a ventral position. The emerging nymph or adult slowly crawls out, and the moulted skin is always left attached to the undersurface of leaves or on bark of shoots by the legs. The whole process of moulting from one stage to another occupies thirty minutes.

15. RECENTLY MOULTED ADULT.

In a particular case on the 13th March 1931, a freshly transformed *S. nigroclypeata* adult was closely watched, and the following observations were recorded with regard to its coloration and development:—

8-30 A.M.—The fresh adult is whitish in color; eyes reddish; wings white; abdomen elongated, with light pink streaks between eyes, at middle of pro-and meso-notum, at base and sides of metanotum, and on first abdominal segment. Wings about a quarter of the length of the body; legs and rostrum whitish.

8-45 A.M.—Wings whitish, and have grown to three-quarters of the length of body. The abdominal segments have contracted.

8-50 A.M.—Wings still whitish, but have expanded, and covered the abdomen, leaving only the sixth and seventh segments exposed.

9 A.M.—Wings as long as the abdomen, darkish white; venation of tegmena distinct; pink rings visible in between abdominal segments; eyes dark.

9-25 A.M.—Spines on eyes become visible; rostrum brown at base; femur and tibia darkish at places.

9-35 A.M.—Wings have become darkish with spots.

9-50 A.M.—The hopper has assumed its yellowish brown coloration with dark brown speckling, legs yellowish with dark brown stripes.

16. LIFE OF ADULT.

In nature the imago of *Sarima nigroclypeata*, should have a maximum life of three to three and a half months throughout the year. In captivity inside sleeves, and in insectary cages, six records of adult life have been made between January and November, with a range of 93 to 107 days.

17. FECUNDITY AND SEX RATIO.

The female hopper lays eleven to twelve eggs at a time up to a total of 124. Counts in the overies have not been made. The sex ratio based on reared colonies is 1 : 1.

18. DURATION OF LIFE-CYCLE.

The following table summarizes the time variation in the stages of the life-cycle :—

Stage.	Shortest period (days).	Longest period (da .	Average period (days).
Egg	17	25	21·4
First instar	15	24	19·2
Second „	14	24	19·4
Third „	16	23	19·9
Fourth „	18	23	20·7
Fifth „	19	24	21·
Total .	99	143	121·6 days

The difference between the shortest and the longest periods from oviposition to adult is 44 days. The average is 121·6 days, and the mode is the same.

19. EFFECT OF TEMPERATURE ON DEVELOPMENT.

The difference of fourty-four days between the shortest and the longest records of the life-cycle, may possibly be due to differences in temperature. The temperature records, do not support seasonal variation in the rate of development of the different broods during the year. For example in the months of December—January at mean temperatures of 68°F—71°F, the egg takes 23 days to hatch;

in the month of March at a mean temperature of 74°F, the egg took 24—25 days to hatch; while in the month of June at a mean temperature of 82°F, the egg took 23 days to hatch. From above it is inferred, that the development is independent of the mean temperature during different months of the year. Most of the transformations of the different stages, take place within 17 to 23 days at mean temperatures varying from 68°F—87°F. This uniformity of development throughout the year, is to be expected of a species adjusted to an equable climate. *Sarima nigroclypeata* is active throughout the year.

20. NUMBER OF GENERATIONS.

Allowing a fortnight for mating and maturation of the egg, it is evident that a minimum life-cycle of 99 days, combined with an average life-cycle of 121·6 days, permit a sequence of three generations in a year. As the adults live for over three months, and the egg laying also goes on a long time, the generations overlap. Under insectary conditions three broods have actually been carried through, the first in January to April, the second in May to August, and the third in September to December.

21. BIOTIC POTENTIAL.

Assuming that the egg laying capacity of this species is 124 eggs per female, the sex ratio is 1 : 1, the number of individuals produced from one egg is one, and the number of generations per year is three, then the annual biotic potential for the species starting with a single pair is

$$(2 \times 62 \times 1)^3 = 1906624 \text{ individuals.}$$

22. SEASONAL INCIDENCE AND RELATIVE ABUNDANCE FROM QUANTITATIVE AND FIELD COLLECTIONS.

The samples of the population of sandal insects, made at regular intervals by field assistants under the writers' direction, were analysed at Dehra Dun by Mr. C. Dover. The diagrams given in Plate II are prepared from his data, and are corrected modifications of those issued on pp. 16, 17, of the 5th progress report of the Sandal Spike Working Committee, (3; pp. 16—17). Of the total of 2,048 specimens, obtained in one year's quantitative collections from the sample plots at Fraserpet, Jawalagiri, Aiyur, and Kottur;

the Aiyur plots yielded 53 per cent., Jawalagiri 40 per cent., Fraserpet 4 per cent., and Kottur 2 per cent., Pl. II, fig. 2. At Fraserpet this species is relatively most abundant in plot No. 5, which is heavily spiked, and least abundant in plot No. 6, which is healthy. At Jawalagiri *S. nigroclypeata* is more or less uniformly present in all the plots. Its relative high occurrence in spiked plots 9 and 14, in which the ground was dug up and manured, and the spiked trees were removed every month, is worthy of note. The low figure for plot 10, is due to the fact, that the plot was completely burnt by fire in April 1931, and quantitative collections were not made in the plot, for a subsequent period of about five months. At Aiyur this species is relatively more abundant in the healthy plots 16, 17, and 18, pl. II, fig. 1. Its abundance in spike plot 20, is more or less the same as in spiked plot No. 9 of Jawalagiri; and the species is fairly abundant in the heavily spiked plot 19. At Kottur, though it occurs in all the plots, this species may be considered as relatively rare. The graph for seasonal incidence, pl. II, fig. 3, shows that there is a gradual increase in abundance from April to August, followed by a decrease to November; the population increases again, but less abundantly in the cold months December and January.

During the period March 1930 to March 1931, a separate collection of 1202 *S. nigroclypeata* was made on sandal from numerous localities by sweep netting at regular intervals. Here the monthly totals do not indicate any marked seasonal variations, but adults and nymphs occur each month.

These observations on the free population confirm those made on caged individuals, namely that the species is active throughout the year.

23. Night Collections.

During the period October to December 1931, collections on sandal were made by field assistants in Denkanikota range, for one hour on alternate days at night, and out of a total of 250 specimens of Hemiptera obtained, *S. nigroclypeata* represented 11 per cent.

24. Enemies.

Sarima nigroclypeata in its nymphal and adult stages, does not suffer from the attacks of parasites and predators. Parasitism by a chalcid (?), was noted on one occasion in December 1930. No predators have been observed.

MORPHOLOGY.

(*Description of the various stages Pl. 1; Figs. 1 to 15.*)

25. EGG. (Pl. 1; Fig. 1.)

Oval, depressed, rounded at both ends, with a short pedicel at the cephalic end, which is slightly narrower than the posterior end. Chorion not sculptured, but shows at certain angles fine broadly spaced furrows, which are straight on top but curved at sides. Length including pedicel 0·95—1·25 mm; breadth 0·35—0·50 mm.

First Stage Nymph.

On emergence from the egg, the nymph is of pink to crimson in color. It acquires its general pinkish-brown coloration with a whitish bloom within 48—72 hours. Eyes dark red; face, vertex, middle of thorax, and abdomen pale throughout; pro and mesonotum pale or whitish at the lateral margins; metanotum pinkish brown; abdomen basally pink, apically pinkish brown; apex of tibia, tarsus, and rostrum whitish or pale; antenna and base of rostrum pale brown to brown; legs banded brown. Sensory pits whitish or pale some surrounded by brown rim. Anal brushes white with black bands, and begin to grow within 12—24 hours of hatching. The proportion of anal brushes to the length of the body of the nymph is about 1 : 1.

Head narrower than pronotum. Vertex slightly produced in front of the eyes, rounded at the anterior margin, angularly emarginate at the posterior margin. Face a little longer than broad convex, apical and lateral margins faintly ridged with a fine central longitudinal carination, with a series of sensory pits on apical and lateral margins. Thoracic segments distinct, mesonotum longer than pronotum, metanotum about twice as long as pronotum; anterior margin of pronotum angularly produced in between the eyes, posterior margin sinuate, with a series of 8 sensory pits placed obliquely on either side of the mid dorsal carination, which runs from base of metanotum to apex of pronotum. Mesonotum with 4 sensory pits on either side of the mid dorsal ridge. Metanotum with 2 sensory pits placed obliquely on either side of the mid dorsal carination. Legs of moderate length, third pair longest. Posterior trochanter only dentate, apex of tibia and first tarsal joint of the

third leg with small brown spines, 4 on each. Anterior and intermediate legs without spines. Tarsal joints two, first joint shorter than the second in the anterior and intermediate legs but longer than the second in the posterior leg. Abdomen with seven discernible segments, first segment small, third, fourth, fifth and sixth segments, each with 2 sensory pits, on either side near lateral margins. Anal brushes come out from two small kidney-shaped white pads, situated at the sides of apparently the last abdominal segment. Each brush is composed of a bundle of white wax bristles, which increases in length with the age of the nymph, and becomes banded with black. Length 1 mm.—1·25 mm; length of anal brushes 1 mm.

Second Stage Nymph.

A freshly moulted second stage nymph is pinkish white in color, with pink spots on both dorsal margins of abdominal segments and also at base of first abdominal segment. Three pink spots situated in a triangle are seen at the apex of pronotum. The eyes are at first pink, and then turn deep red. Legs and proboscis are whitish. In mature specimens the general coloration is pinkish-brown. Vertex and face pale yellow; antenna, clypeus, and base of rostrum brown. Thorax and abdomen pale at middle; pro and mesonotum pale at lateral margins, metanotum brown with pale spots at posterior margin. Legs pale banded brown, abdomen pinkish white at base, pinkish brown at apex. The anal brushes begin to grow after 24 hours of moulting, and the proportion of the length of the brushes to the body of the nymph is about 1 : 1.

Head including eyes not as broad as pronotum. Vertex subpentangular, about twice as broad as long, slightly produced in front of the eyes, with a fine central carinate line. Face as in the first stage nymph, slightly ampliated, sinuate before clypeus. Clypeus short, robust. Pronotum shorter than mesonotum, transversely smaller than the following two segments, sinuate at base, anterior margin angularly produced in between the eyes, a faint median carination present, with 9 sensory pits placed obliquely on either side of the median ridge. Mesonotum faintly tricarinate at middle, with 4 sensory pits on either side of the carinations. Metanotum with a faint median carination, sinuate anteriorly, posterior margin angularly produced at sides about twice as long as pronotum, with 2 sensory pits placed obliquely on either side. Apex of tibia and first tarsal joint of the third leg with small brown spines, 5 on each.

The anterior pairs of legs without spines. Legs and tarsal joints as in the first stage nymph. Abdomen broad at base, tapering posteriorly, first abdominal segment transversely smaller than the second segment. Third, fourth, fifth and sixth abdominal segments, each with 2 sensory pits, on either side near lateral margins. The abdomen is mildly ridged mid-dorsally in the male which is smaller than the female. Anal pads larger than those of first stage nymph. Anal brushes as in the first stage nymph but with more numerous bristles. Length 1·5 mm—1·75 mm; length of anal brushes 1·75 mm; greatest breadth over thorax on the metanotum 0·85 mm; breadth between the eyes 0·65 mm.

Third Stage Nymph. (Pl. 1; Fig. 2.)

General colour pinkish brown. Vertex, face, clypeus at base, middle of thorax and abdomen dorsally, apex of rostrum pale or pale yellow. Femora, tibiæ and tarsii darkish, banded. Compound eyes dark red, with a thin white film. Antenna, clypeus, and base of rostrum brown. Pro and mesonotum pale at lateral margins, metanotum with pale spots. Abdomen whitish pink brown, basally whitish pink, apically pinkish brown above, with pale brown patches on the third, fourth and fifth segments beneath. The anal brushes and the bands on them are most conspicuous in this stage. The ratio of the length of the anal brushes to the length of the body of the nymph is about 1·5: 1.

Head, vertex, face, clypeus, pro-meso and metanotum, as in second stage nymph. The faint mid dorsal carination on the pronotum is continued over the meso and metanotum. The angularly produced anterior margin of the pronotum is slightly raised and ampliated. Pronotum with 12, mesonotum with 8, and metanotum with 4 sensory pits placed on either side of the medio-dorso-longitudinal carination. Legs and tarsal joints as in the second stage nymph. Apex of tibia and first tarsal joint of the posterior leg with 5 brown spines on each. Abdominal segments as in the second stage nymph. Second abdominal segment with 1 sensory pit, third, fourth, fifth and sixth abdominal segment each with 3 sensory pits on either side near anterio-lateral margins. Anal pads larger than those of the second stage nymph. Anal brushes as in second stage nymph but with more numerous bristles. Length 1·80 mm.—2·25 mm; length of anal brushes 2·75 mm.—3·5 mm; breadth over thorax on the metanotum 1·25 mm; breadth between eyes ·9 mm.

Fourth Stage Nymph.

Similar in coloration to third stage nymph but more dark brown. Vertex, pro-meso and metathorax, brown, mottled. Abdomen light brown, with transverse pink bands in between segments, more brown apically. First abdominal segment castaneous at the extreme lateral margins. Sixth abdominal segment with a castaneous spot at middle of the posterior margin. Face brown, speckled; clypeus at base pale. Femur, tibia, and tarsus pale, banded brown. Eyes dark red. Antenna, clypeus, and base of rostrum dark brown. The proportion of the length of the anal brushes to the length of the body of the nymph is above 1 : 1.

Head, vertex, face, and clypeus as in the third stage nymph. Pronotum smaller than mesonotum or metanotum. The mediodorso-longitudinal carination runs from vertex to base of metanotum. The angularly produced anterior margin of the pronotum slightly elevated and ampliated. Pronotum with 15 sensory pits, placed obliquely on either side of the median ridge. Mesonotum tricarinate with 8 sensory pits, 5 near middle and 3 on tegminal region, on either side. Metanotum with 6 sensory pits in two groups of 3 each, on either side of the median carination, one group near middle and the second on tegminal region. Tegmina on meso- and metanotum present, but small and inconspicuous. Legs and tarsal joints as in the third stage nymph. Apex of tibia, and first tarsal joint of the posterior leg, with 6 black spines on each. Abdominal segments as in the third stage nymph. Second abdominal segment with 2 sensory pits, third, and fourth abdominal segments each with 4, and fifth, and sixth segments each with 3 sensory pits on either side near anterio-lateral margins. Abdomen mildly ridged mid dorsally in the male which is smaller than the female. Anal brush pads, larger than those of the third stage nymph. Anal brushes as in third stage nymph but with more numerous bristles. Length 2 mm.—2·5 mm; length of anal brushes 2 mm.—2·25 mm; breadth over thorax on the metanotum 1·5 mm; breadth between eyes 1 mm.

Fifth Stage Nymph.

General coloration, pale pinkish dark brown or black. Eyes dark red with a whitish film. Vertex, face, pro—and mesonotum, and first four abdominal segments over a greater area, pale with dark brown or black mottling. Pronotum with brown spots;

mesonotum pale at middle, and at anterio-lateral area; metanotum dark brown or black, with large pale spots. Two oblique pale lines on the metanotum, on either side of the median ridge, reach as far as the mesonotal carinations. Apices of tegmina, apical three abdominal segments, clypeus except at base, base of rostrum, and antenna dark brown or black. Abdomen in between segments pinkish above, with a pair of large dark brown or black patches on the third, fourth and fifth segments, beneath. Legs banded dark brown or black. Tegmen dark brown or black, conspicuous with pale, and brown or black striations. The wax bristles composing the anal brushes are most numerous in this instar, and the proportion of the length of the anal brushes to the length of the body of the nymph is about 1·5 : 1.

Head including eyes narrower than pronotum. Vertex subpentangular, its base angularly emarginate, with a fine carinate line, twice as broad as long, slightly produced in front of the eyes. Face slightly ampliated, sensory pits at apex and sides, sinuate before clypeus, with one central and two curved marginal carinations which meet at apex. Clypeus short, robust, shining. Antenna dark brown, second joint longer and stouter than the first, globose, with a number of fine sensory pits and hairs. Basal aristal knob minute globose. Pronotum transversely smaller than the following two segments, sinuate at base, anterior margin slightly ampliated, and angularly produced in between the eyes, with 18 sensory pits placed obliquely on either side of the median carination. Mesonotum tricarinate angularly produced posteriorly at sides, with 11 sensory pits on either side, 5 near middle in one group and 6 distributed over the tegminal region. Metonotum sinuate anteriorly, angularly produced at sides posteriorly, with 3 sensory pits placed in one group near middle on either side of the median ridge. Tegmina conspicuous. Posterior legs longest with the trochanters dentate. Apex of tibia, first and second tarsal joints with small black spines, the number of spines being 7-8 at apex of tibia, 7-10 at apex of first tarsal joint and 1-3 on the second tarsal joint. Tarsal joints two in the anterior and intermediate legs, but three in the posterior leg. Abdominal segments as in the fourth stage nymph. Second segment with 3 sensory pits; third, fourth, and fifth segments each with 4 sensory pits, and the sixth segment with 3 sensory pits, on either side near apical margins. Abdomen mildly ridged in the male which is smaller than the female. Anal brush pads, larger than those of the fourth stage nymph. Anal brushes

as in the fourth stage nymph but with more numerous bristles. External genital organs dark brown or black. Length 2·75 mm.—4·5 mm; length of anal brushes 5 mm.—6·75 mm; breadth over thorax on the metanotum 2·5 mm; breadth between eyes 1·5 mm.

26. Adult.* (Pl. 1; Fig. 3.)

'Vertex twice as broad as long, surface deepened in the middle, with white grainy middle line. Face somewhat less long than the maximum breadth, tapering between eyes on sides, surfaces rounded to clypeus flat, sprinkled with deep brown, with three obvious carinations, bounded with each other in the middle of upper margin of face, the lateral carinations are close against the sides of the face, the middle carination runs through the length of face upto clypeus. Clypeus with the exception of a small yellowish-white base; black, glossy, and not keeled. Pronotum and mesonotum brown or black spotted, the later with three obvious longitudinal carinations. Tegmen longish, narrower at the apical end, brownish yellow, sometimes irregularly black spotted. At the apical end both the radial veins run closely towards each other. From the root branches a shorter nerve joins in a loop with the outer radial nerve. Wing smoky brown. Underside pale yellow, sometimes with dark longitudinal markings and on either side are present a row of black dots. Legs pale yellow, fumur with brown longitudinal stripes, on the tips of tibia are seen small dark dots ♂ ♀ length 5 mm.'

The male is smaller than the female. In twelve specimens of males and females selected out of a large number of specimens, the length from apex of vertex to the apex of tegmina, varied from 4 mm. to 4·5 mm., the average being 4·2 mm. in the case of the male; and from 4·75 mm. to 5·5 mm., with an average of 5 mm., in the case of female.

27. Development of Antennae and Presence of Sensory Pits and Hairs on the Second Antennal Joint.

In the first instar the second joint of the antenna is robust, globose, studded with minute projections, being longer and broader than the first joint; which is small, plain and annular. At the apex of the second joint is seen a knob, the aristal knob, with two

(* Footnote.—Description translated from Monographie der Issiden by Melichar.)

fine hairs, and minute tubercles, lateral to which arises the seta, Pl. 1; Fig. 5. In the second instar, both the second joint, and the antennal knob, are spinulate or are studded with black minute projections, with few olfactory spots on the second joint. At one side of the antennal knob, are seen two long hairs, with few small tubercles probably sensory in function; and on the opposite side is seen a small pointed tubercle outside which the antennal seta arises. In the third instar, the second joint with few small, olfactory pits, is also longer and broader than the first. Both the second joint, and the antennal knob, are studded with black minute projections or blunt spines, with small spines and hairs at apex. The large hairs on the aristal knob seen in the second instar are also present and the seta arises from the knob laterally. In the fourth instar, the second joint is with small olfactory pits, minute spines, and hairs, all over, more so at apex. The antennal knob is small, globular, studded with minute spines, and the seta arises laterally. In the fifth instar, the second joint is spinulate with a number of stout, pointed, transparent setae. A series of large sensory foveæ are seen on the second joint each with 5-7 thin triangular pointed projections at the outer edge. Antennal knob with sensory pits, fine hairs, and minute tubercles, at apex. In the adult stage, Pl. 1; Fig. 6, the second joint is spinulate also, with a number of stout, transparent, pointed setæ, amongst which are present a number of large olfactory pits; each with 7-10 thin triangular pointed projections at the outer edge. Antennal knob small, smaller than that of the nymphs, globose without hairs, but with sensory pits and minute tubercles. The seta arises laterally.

28. DEVELOPMENT OF LEG AND PRESENCE OF TACTILE HAIRS.

TROCHANTER: The trochanter of the posterior leg in all the nymphal stages, is dentate at the inner margin, Pl. 1; Fig. 9; which is not seen in the anterior and intermediate legs, nor in any of the legs of the adult.

FEMUR: In the first and second stage nymphs, the femur of the anterior and intermediate leg, is studded with small setæ and hairs. In the third and fourth stage nymphs, the femur of the first and second leg, is studded with small whitish pointed spines, besides setæ and hairs. In the fifth stage nymph, small pointed brownish spines are present in double row on the fumur of the first and second leg, besides the setæ and hairs. The fumur of the posterior leg, is studded with small fine spiculæ in the first four instars, and with

small setæ in the fifth instar. In the adult stage the femur of the anterior, intermediate and posterior leg, is similar to that of the fifth stage nymph.

Tibia: The tibia of the first and second leg in all the nymphal instars, and in the adult is destitute of spines Pl. 1; Fig. 11. The tibia of the anterior and intermediate leg, Pl. 1; Fig. 12, is studded with small fine hairs in the first instar, with fine spiculæ in the second instar, and with fine setæ and hairs in the third, fourth and fifth instars and also in the adult. The tibia of the posterior leg in the first instar has besides fine hairs, 4 castaneous-tipped spines at apex Pl. 1; Fig. 7. In the second instar, besides fine spiculæ, there are one spine at middle, and 5 spines at apex of the third tibia. In the third instar, besides setæ and hairs, are present one brown-tipped spine near base, one at middle, and five at apex of the third tibia. In the fourth instar are present one brown-tipped spine near base, one at middle, 6 at apex, and one spine in between the middle spine and the apical spines besides setæ and hairs. In the fifth instar besides setæ and hairs, are present 7 or 8 black-tipped spines at apex in addition to the three spines seen on the tibia of the fourth instar, Pl. 1, Fig. 8; and 8 black-tipped spines at apex with only two other spines, the basal spine being absent, in the adult.

Tarsus: The number of tarsal joints in the anterior, intermediate, and posterior legs, of the first four instars, is two. In the fifth instar, the number of tarsal joints in the first, second and third legs, is two, two, and three respectively. In the fourth and fifth instars, the first tarsal joint in the posterior leg becomes prominent, and remains so in the adult stage, in which the number of tarsal joints in all the legs becomes three. In all the nymphal instars, the first tarsal joint is much smaller than the second in the anterior and intermediate legs and longer than the second in the posterior legs. In the fifth instar, the first and the third tarsal joints are subequal, but the first joint is stouter and more prominent than the third, which is slender and bears no spines. In the adult, the third tarsal joint is longest, being longer than the first and second put together in the first and second legs; but in the third leg the first tarsal joint is longest.

The tarsal joints of the first and second legs in all the nymphal instars and in the adult, are destitute of spines.

In the nymph of the first instar, 4 brown-tipped spines are present at the apex of the first tarsal joint in the posterior leg, the

second joint is without spines. Few small tactile hairs are present on the tarsal joints of all legs. In the second instar fine tactile hairs are mostly present ventrally in all legs, more so on the third leg. At the apex of the first tarsal joint of the third leg, are seen 5 brown-tipped spines ventrally. Spines are absent on the second tarsal joint. In the third instar 5 brown-tipped spines occur at the apex of the first tarsal joint, the second tarsal joint is devoid of spines. Tactile hairs are present on both the tarsal joints of the first and second legs ventrally, but are more abundant on the tarsal joints of the third leg. In the fourth instar, tactile hairs are present on the tarsal joints of all legs as in the third instar nymph. There are 6 brown-tipped spines at the apex of the first tarsal joint but none on the second tarsal joint. In the fifth instar tactile hairs are distributed all over the first and second tarsal joints of the anterior and intermediate legs ventrally. In the posterior leg, the second tarsal joint is smallest, the third tarsal joint is less hairy than either the first or the second, on which hairs are concentrated at the apex. There are present 7-10 black-tipped spines at the apex of the first tarsal joint, and 1-3 spines on the second tarsal joint, but none on the third joint. In the adult, hairs are distributed all over the three tarsal joint of all legs, but they are more abundant ventrally. The hairs are small, pointed, and arise out of circular translucent spots. The first tarsal joint has 15 black-tipped spines at apex, the second tarsal joint only 2, while there are no spines on the third tarsal joint.

CLAWS: The tarsal joints in all nymphal stages, and in the adult, end in a pair of light to dark brown, curved and pointed claws; in between which is a bunch of small tenent hairs bent at tips, Pl. 1; Fig. 10.

29. ANAL PADS AND BRUSHES.

Nymphs of all instars have a pair of small, thick, kidney shaped, white pads, one on either side of the anal plate, from which the anal brushes develope. Each brush consists of two bundles of white, rather stiff, wax bristles; placed very close to one another. These bristles increase in number with each moult, and become banded with black at different places throughout their lengths.

The base of each bristle, is in the form of a circle or ring with an internal transparent area, bordering which are small transparent spots, the bases presumably of minute setæ; which are not discernible under low power. In between these circles are present

slightly larger transparent spots, which probably are the bases of still larger setæ. When seen under high power, these rings appear in the form of shallow cups or pits with the edges projected, round each of which are seen fifteen to seventeen very minute setæ, in the case of the nymph of the fifth instar.

The anal brushes and pads drop off with the exuvium, and fresh bristles arise in their places as the nymphs continue to feed and grow, after every moult. If the bristles forming the anal brushes, are cut off or removed intentionally in the middle of the nymphal stage, they again grow and the nymph does not appear to be in any way the worse for their removal.

The pads become larger in size with each moult. In the nymph of the first instar the number of anal bristles on each pad is seven, Pl. 1; Fig. 13, in the second instar nine, in the third twelve, in the fourth sixteen, and in the fifth instar over sixty, Pl. 1; Fig. 14. In the adult stage the anal pads entirely disappear, and no brushes are seen either in the male or in the female.

30. Growth of Anal Brushes and their Function.

The wax bristles composing the anal brushes are most numerous in the nymph of the fifth instar, and the bluish-black bands on them are most conspicuous in the third instar. In order to determine the time and rate of development of the anal brushes, a nymph of the third instar was kept under observation from 10 A.M. on the 27th February 1931. The brushes were not visible on the first day. The anal brushes when they first appear, are glistening milky white in color. On the second day only a small white stump was seen to come out. On the third day the white brushes were with two glistening bluish black bands, and had attained only half the length of the body of the nymph. On the fifth day the brushes had grown to three-quarters the length of the body of the nymph, and had three bands. On the eleventh day the brushes were one and a quarter times the length of the body of the nymph, and showed four bands. On the fourteenth day the nymph was seen to have developed five shining bluish-black bands on the brushes, which were a little less than one and a half times the length of the body of the nymph. On the sixteenth day, the brushes were found to have grown a little over one and a half times the length of the body of the nymph, and had developed seven bands. The relative position of the bands on the brushes was as follows:—The distances

between the first and third, third and fifth, and fifth and seventh band were about equal. The distances from the apex of the abdomen to the first band, and from the first to the second band were equal. The distances between the second to the third, the third to the fourth, and the fourth to the sixth were subequal. The distance between the sixth and the seventh band was longest. The distance between the fifth and the sixth band was about equal to that between the first and second. The seventh band was longest and beyond the seventh band the brushes extended for a distance equal to that between the fifth and sixth band. At 2 P.M. on the sixteenth day the anal bristles were seen reduced to mere stumps. The fragile anal brushes grow with the nymphs and after a certain stage dwindle prior to moulting. With age the brushes loose their stiffness and luster.

The exact function of the anal brushes is not understood, nor is the development of the bluish black bands on them. The object of spreading the brushes fanwise, and of carrying them over the back, may be to scare and drive away predatory and parasitic insects.

31. MALE GENITALIA. (Pl. 1; Fig. 15.)

Aedegus short, phallosoma four lobed in the region of the mouth, the two dorso lateral lobes hard, pointed, each carrying small, thin, legume-shaped, appendages, pointed and curved at tip, and serrated at the outer edge. Conjunctiva appendages well developed, flattened, spinulate at the distal ends, with two pointed secondary processes. Vesica wide, and blunt at apex. Parameres broad, studded with thin spines, slightly produced at the posterio-dorsal region with a thin process before the posterio-dorsal corner, where it is slightly twisted.

32. EYES. (Pl. 1; Fig. 4.)

The surface of the compound eyes in all the nymphal stages is glabrous, but in the adult stage the eyes are studded with very minute spear shaped spines all over, except for a small area near the antennæ.

33. DISTINCTION BETWEEN NYMPHAL INSTARS.

The differences between the nymphal instars, are but for appearance and size minute, and the nymphs of the different instars cannot be separated easily without making a special study of their characteristics. The distinguishing characters lie in the number

of sensory pits on pro meso and metanotum, and also on the second to sixth abdominal segments; and in the development of spines on tibia and apices of first and second tarsal joints of the posterior leg. A reference to the following table will indicate the different stage nymphs accurately.

Part of body.	Nymphs.					Adult.
	1st Stage.	2nd Stage.	3rd Stage.	4th Stage.	5th Stage.	
Number of sensory pits on Pronotum.	8	9	12	15	18	0
Number of sensory pits on Mesonotum.	4	4	8	8	11	0
Number of sens ry pits on Metanotum.	2	2	4	6	3	0
Number of sensory pits on 1st abdominal segment.	0	0	0	0	0	0
Number of sensory pits on 2nd abdominal segment.	0	0	1	2	3	0
Number of sensory pits on 3rd abdominal segment.	2	2	3	4	4	0
Number of sensory pits on 4th abdominal segment.	2	2	3	4	4	0
Number of sensory pits on 5th abdominal segment.	2	2	3	3	4	0
Number of sensory pits on 6th abdominal segment.	2	2	3	3	3	0
Number of tarsal joints to anterior and intermediate legs.	2	2	2	2	2	3
Number of tarsal joints to posterior legs.	2	2	2	2	3	3
Number of spines on and at apex of tibia of posterior leg.	0+4	1+5	2+5	3+6	3+7 or 8	2+8
Number of spines at apex of first tarsal joint of posterior leg.	4	5	5	6	7 to 10	15
Number of spines at apex of second tarsal joint of posterior leg.	0	0	0	0	1 to 3	2

34. SUMMARY.

Sarima nigroclypeata is one of the commonest hoppers on sandal in South India, and feeds on seven different plant species besides sandal. The nymphs of the first and second instars suck sap from the new leaf flush and sprouting leaf buds; while the nymphs of the third, fourth and fifth instars, as well as the adults suck sap from shoots. As a result of abnormal drain of sap due to the feeding of a large number of nymphs and adults on the sandal tree, its vitality is reduced and growth interfered with. Under laboratory conditions, feeding causes temporary shortening and clustering of leaves on shoots. As a result of mass feeding, sandal shoots and young plants die back within a short time. *S. nigroclypeata* is considered to be one of the species responsible for causing stagheadedness generally prevalent in sandal forests. The adult life is over three months, and the female has a long oviposition period. Eggs are laid on the surface of the bark of shoots. There are five nymphal stages and the average time taken to complete development from egg to adult is 121 days. There are three generations in a year and the generations overlap. The species seem to be almost entirely free of parasites and predaceous enemies. One hundred and fifty records, of the times of development of the different stages in the life history, during different months of the year have been made. Most of the transformations of the different stages take place within 17-23 days at mean temperatures varying from 68°F—87°F. The studies were mostly conducted at Denkanikota, North Salem; where there is practically no variation in the rate of development in the different seasons. This species is active throughout the year in the sandal forests of Madras, Coorg and Mysore. All the instars are described, and a table is given for the identification of nymphs. Observations on the development and morphology of antennæ, legs, anal brushes, male genitalia, and eyes have also been made.

The data recorded in this paper, suggest that *S. nigroclypeata* is a species, capable of carrying the virus of spike disease of sandal. Experiments have therefore been undertaken, with the object of transmitting the disease by means of this insect, and the results will be published when they are concluded.

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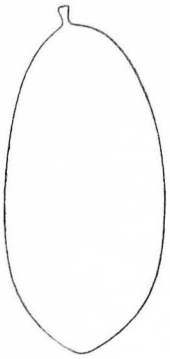
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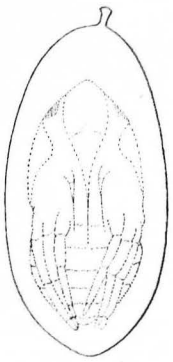
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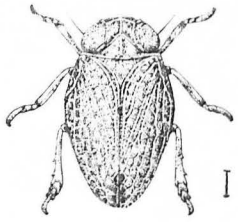

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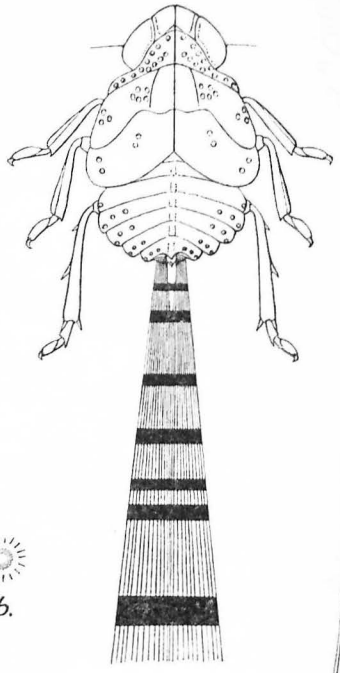
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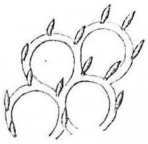
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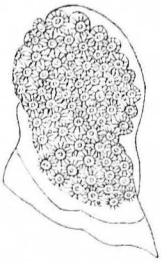
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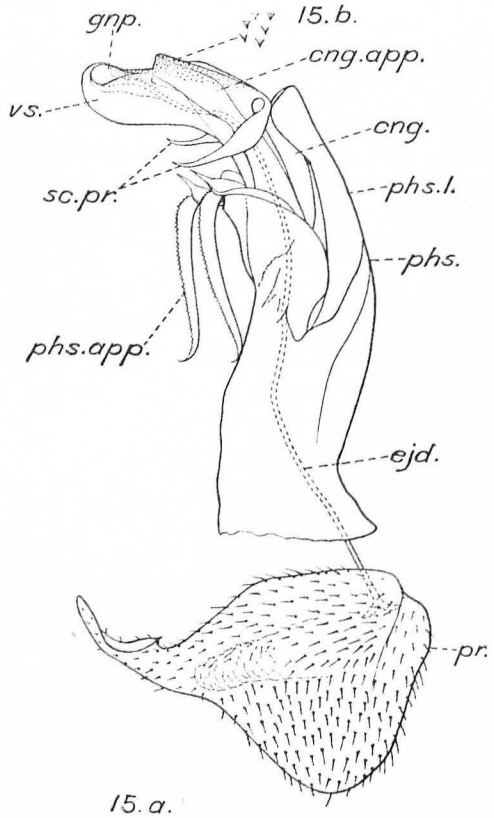

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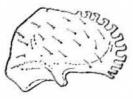
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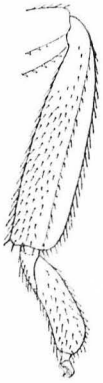
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12.

EXPLANATION OF PLATE I.

Sarima nigroclypeata, Mel.

Fig. 1. (*a*) Egg, (*b*) Egg about to hatch.

Fig. 2. Nymph, 3rd instar, showing sensory pits and anal brushes. Diagrammatic.

Fig. 3. Female hopper (dorsal).

Fig. 4. Portion of the eye of the adult hopper. Highly magnified.

Fig. 5. Sensory hair on antenna of nymph 1st instar. Highly magnified.

Fig. 6. Sensory hair and pits on antenna of female hopper. Highly magnified.

Fig. 7. (*a*) Posterior tibia and tarsus of nymph, 1st instar. (*b*) Posterior trochanter of nymph, 1st instar.

Fig. 8. Posterior tibia and tarsus of nymph, 5th instar.

Fig. 9. Posterior trochanter of nymph, 5th instar. Highly magnified.

Fig. 10. Tarsal claws with tenent hairs of nymph, 5th instar. Highly magnified.

Fig. 11. Anterior tibia and tarsus of nymph, 5th instar.

Fig. 12. Intermediate tibia and tarsus of nymph, 5th instar.

Fig. 13. Right anal pad of nymph, 1st instar. Highly magnified.

Fig. 14. (*a*) Right anal pad of nymph, 5th instar, (*b*) base of a single anal bristle, highly magnified.

Fig. 15. (*a*) Male genitalia. Cnj. Conjunctiva, Cnj.app. Conjunctiva appendage, ej. d. ejaculatory duct, gnp. gonopore, Phs. phallosoma, Phs. app. phallosoma appendage, Phs. l. phallosoma lobe, Pr. paramere, Sc. pr. Secondary process, Vs. vesica. (*b*) Spinules on conjuctiva appendage. Highly magnified.

EXPLANATION OF PLATE II.

Sarima nigroclypeata, Mel.

Fig. 1. Graph showing Relative abundance in Sample plots 1—28 Fraserpet, Jawalagiri, Aiyur and Kottur.

Fig. 2. Graph showing Relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur.

Fig. 3. Graph showing Seasonal incidence based on one year's totals.

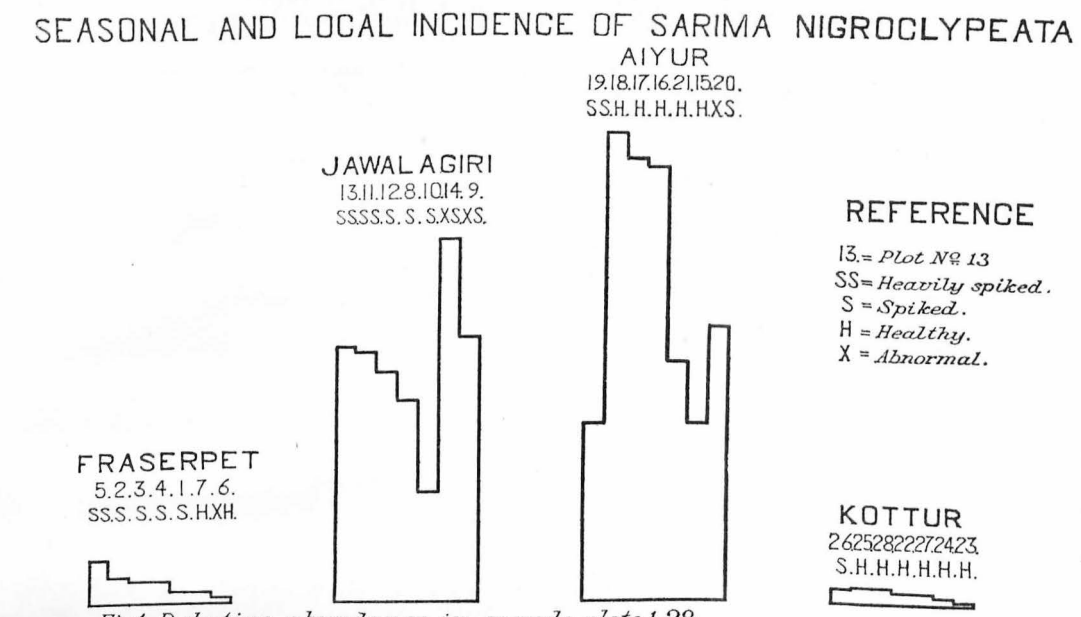

Fig.1. Relative abundance in sample plots 1-28.

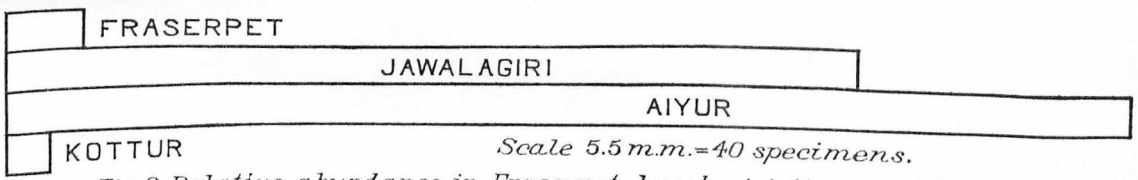

Fig. 2. Relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur.

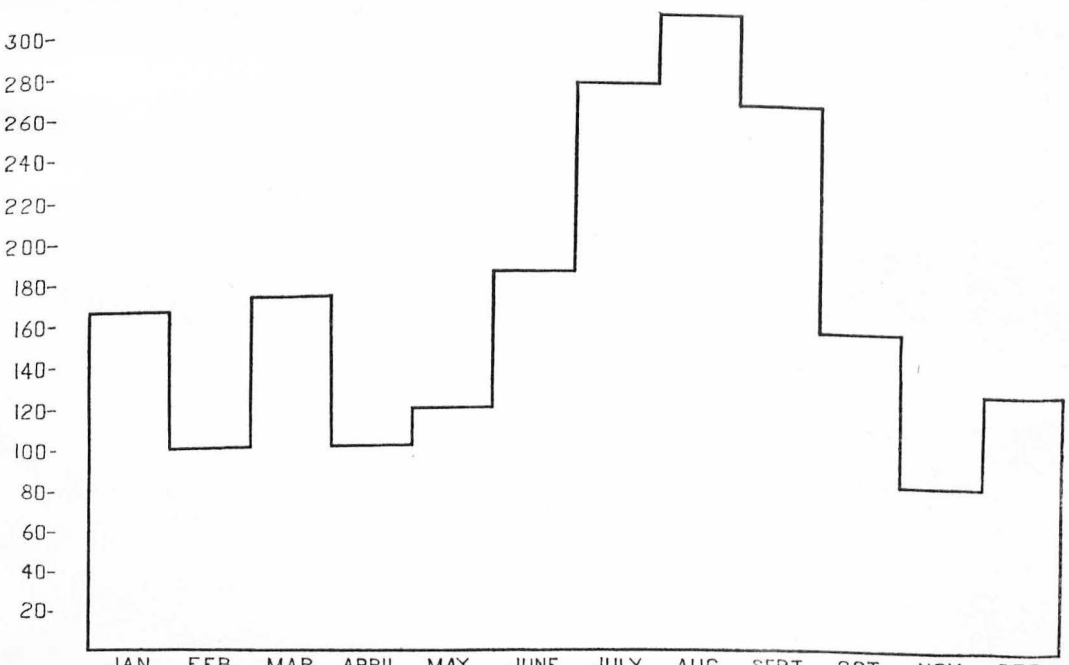

Fig. 3. Seasonal incidence based on one years totals. (Modified and corrected from Dover 1932.)