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THE CAUVERY RIVER ECOSYSTEM AND THE PATTERNS OF ITS FISH DISTRIBUTION*

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ABSTRACT

An investigation of the fish resources of the Cauvery river system in S. India, has revealed the occurrance of 142 species of fishes. The river by virtue of its natural physiography is divisible into three zones : mountainous, plateau and plains. Each zone is characterised by diverse ecological features which is reflected in the composition of the fish fauna also. The faunal distribution is analysed and the causative factors of the patterns are discussed.

INTRODUCTION

Cauvery, Krishna and Godavary rivers in Southern India constitute the three major perennial drainages of the Deccan plateau. The Mahanadi though it can also be stated to belong to the peninsular drainage system, differs significantly from the other three in that it does not originate in the Western Ghats. These three rivers are the very subsistence for the agricultural and economic prosperity of the southern states, Andhra Pradesh, Karnataka and Tamil Nadu. It is no wonder as such, that the waters of these rivers have been utilised to the maximum possible extent for irrigation and hydroelectric purposes. Of these, the Cauvery is perhaps the best tapped river system. The aquatic faunal resources of these three river systems show a remarkable pattern, each having its own peculiar fish species. In recent years a number of exotic and indigenous species have been introduced and transplanted into these rivers, competing with the existing species and affecting the natural faunal balance and ecosystem. Many weirs, anaicuts, dams have been constructed disturbing the continuity of distribution of a large number of economically valuable species. Further, so far there has been no consolidated account of the fish fauna of any of these rivers as is the one available for the Ganga by Hamilton (1822).

THE CAUVERY RIVER

The Cauvery is physically perhaps, the most remarkable river of the Peninsula. Though not large as compared to the other two south Indian rivers the Krishna and Godavary, or the North Indian Ganga, it is about 850 km long and draining about 89,600 km^2. It is considered India's fourth largest river and

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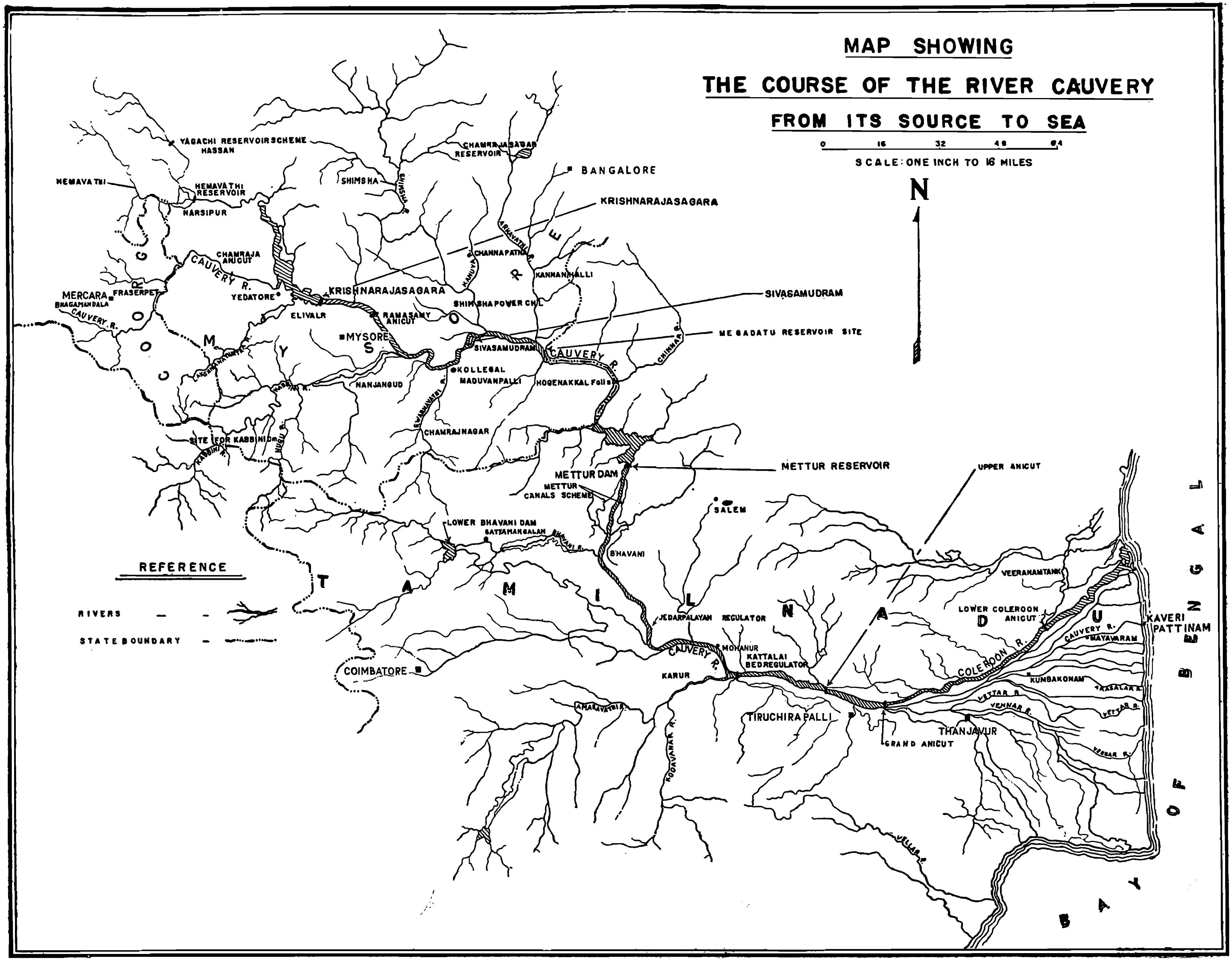

MAP SHOWING
THE COURSE OF THE RIVER CAUVERY
FROM ITS SOURCE TO SEA
0 16 32 48 64
SCALE: ONE INCH TO 16 MILES
N
REFERENCE
RIVERS
STATE BOUNDARY
YAGACHI RESERVOIR SCHEME
HASSAN
HEMAVATHI
HEMAVATHI RESERVOIR
NARSIPUR
SHIMSHA
CHAMRAJASAGAR RESERVOIR
BANGALORE
KRISHNARAJASAGARA
CHAMRAJA ANICUT
CAUVERY R.
MERCARA
FRASERPET
BHAGAMANDALA
YEDATORE
KRISHNARAJASAGARA
ELIVALR
RAMASAMY ANICUT
CHANNAPATNA
KANNANHALLI
SHIMSHA POWER CHL
SIVASAMUDRAM
MEGADATU RESERVOIR SITE
MYSORE
SIVASAMUDRAM
CAUVERY R.
CHINNAR R.
KOLLEGAL
MADUVANPALLI
HOGENAKKAL Falls
NANJANGUD
KABINI R.
CHAMRAJNAGAR
SITE FOR KABBINI
METTUR RESERVOIR
METTUR DAM
METTUR CANALS SCHEME
UPPER ANICUT
SALEM
LOWER BHAVANI DAM
SATYAMANGALAM
BHAVANI R.
BHAVANI
VEERANAMTANK
T A M I L N A D U
M Y S O R E
C O O R G
LOWER COLEROON ANICUT
KAVERI PATTINAM
JEDARPALAYAM REGULATOR
MOHANUR
KATTALAI BEDREGULATOR
CAUVERY R.
MAYAVARAM
COLEROON R.
COIMBATORE
KARUR
KUMBAKONAM
AMARAVATHI R.
TIRUCHIRAPALLI
VETTAR R.
VENNAR R.
THANJAVUR
GRAND ANICUT
NOYYAL R.
VELLAR R.
BAY OF BENGAL

Tamil Nadu's biggest and almost the very life line of that state. It takes its origin at the Brahmagiri hills in the Sahayadri range in Western Ghats at Coorg, Karnataka state at an elevation of *ca* 1355 m (5149 ft.) alt. (12°25'N, 75°34'E) and joining the Bay of Bengal at Kaveripattinam in Tamil Nadu. At its origin at Talaicauvery it is a small channel, religiously supposed to be emanating from a perennial spring (Pl. II, Fig. 1). It runs through a deep gorge of thick evergreen jungle for about 19 km in a narrow channel of hardly 3 metres (Pl. II, Fig. 2) width up to Bhagamandala, where it meets its first tributary the Kannige, which again is a shallow narrow stream. Upto the Krishna Raja Sagar Dam near Mysore it is simply a rocky mountain stream at most places shallow or moderately deep with a swift run off. The Krishna Raja Sagar Dam is the first man-made barrier in its course. Just below this, above the confluence of Shimsha, the river crossess the 2,000 ft. contour at Sivasamudram island on either side of which it branches off in a succession of falls and rapids to a total drop of about 85 metres. "Below this island the river plunges through a succession of wild gorges, with right angle bends conforming to the NW/SE and SW/NE stresses of the plateau edge. The Hogenaikal falls with a drop of about 18 metres (70 ft.) may be taken as the end of its plateau course" (Spate, 1957). Some 50 km. above Hogenaikal at "Pannandu Chakravani" (12 whirl pools) where after a fall of *ca* 30 ft. strong vertices are formed during floods in a succession of deep rock pools ; Mekatadu (the Goat's leap) is also here : these act as effective barriers to fish movement and dispersal to upstream areas. The second manmade barrier is placed in the narrow gorge west of Salem at Mettur. Below Mettur, the Cauvery enters its plains course. At Grand Anaicut near Tiruchirapalli the third and the last but the oldest of the three man-made barrier is built across the river.

ZONATION

Conforming to the geographical features discussed sbove, the river can be broadly divided into the following three zones :

1. The stretch of the river from its origin up to Shivasamudram.—*Mountainous course.*

2. The stretch below Shivasamudram up to Hogenaikal. —*Plateau course.*

3. The stretch below Hogenaikal up to its confluence with the Bay of Bengal.—*Plains course.*

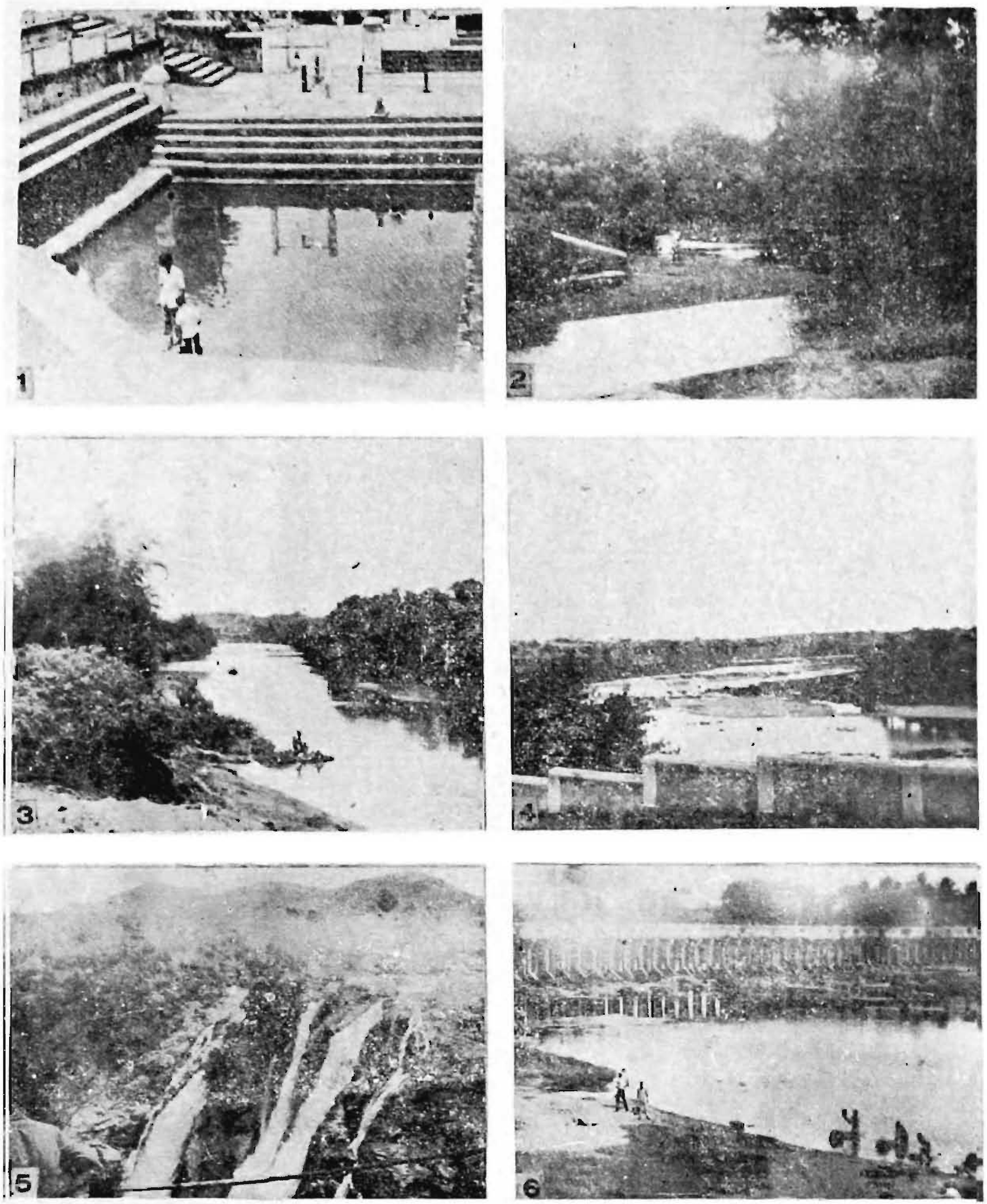
Each one of these zones is characterised by attendant geological features. In the mountainous course the river flows through steep gradients in narrow channels over rocky and boulderous beds. The second zone has the river flowing along less steep gradient, over a pebbly bottom, fitted as if to the natural geological contour. The last zone is characterised by the river meandering leisurely through broad deltaic areas gathering silt and sand to join finally the Bay of Bengal at Kaveripattinam.

FISH FAUNA AND THEIR DISTRIBUTIONAL PATTERN

It is a remarkable fact that the fish fauna inhabiting the entire Cauvery system is influenced by the ecological and geographical parameters discussed above. The zonation thus marked is also justified by the fish distribution though species widely distributed are not of any consideration.

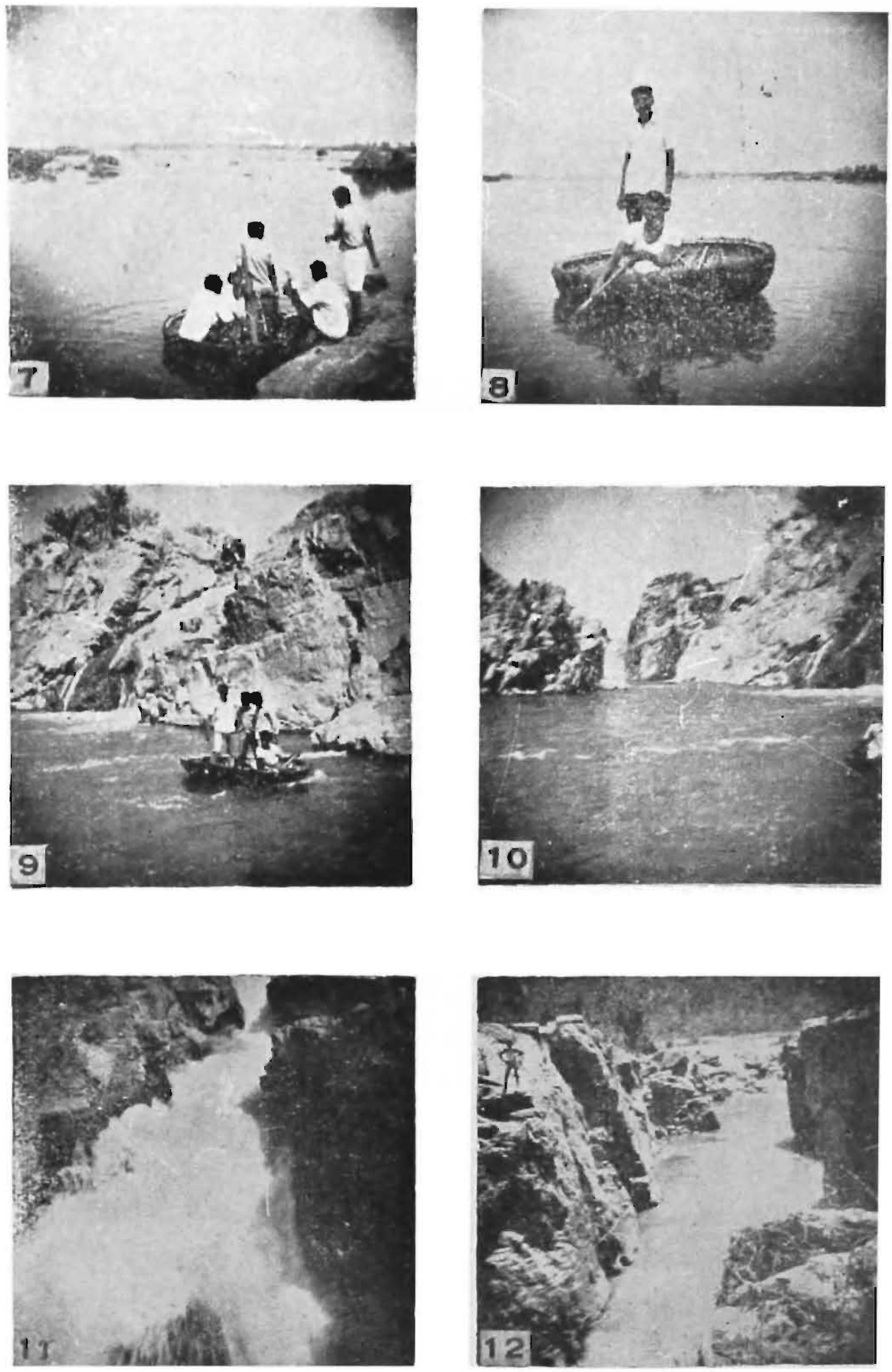
ZONE I.—This zone is characterised by impoverished fish fauna as is naturally to be expected. Till the river reaches somewhat

PLATE II



1. The origin of the River Cauvery at Talaicauvery. The small channel emanates from this perennial spring.
2. Downstream view of River Cauvery as it emerges from the gorge at Bhagamandala before its confluence with R. Kannige.
3. Upstream view of River Cauvery at Kudige.
4. Upstream view of River Hemavathy at Holenarsipur. 5. Sivasamudram falls.
6. Downstream view of River Cauvery at Srirangapatnam below road bridge.

JAYARAM PLATE III



7. & 8. View of River Cauvery at Jedarpalayam.
9 to 12. Cauvery river and falls at Hogenaikal.

plain territory near Bhagamandala and further down near Kudige (Pl. II, Fig. 3), the channel is not very wide for sustenance of any prime fish of quality. Mostly Cobitid fishes of the genera *Noemacheilus*, *Lepidocephalus*, small *Puntius* species such as *ticto*, *sophore*, *conchonius* which are generally well acclaimatized to varying conditions of stream are found. These very rarely grow to a size beyond eight inches. Catfishes such as *Mystus vittatus* are also occasionally obtained. *Barilius barila*, *Salmostoma boopsis*, *Danio aequipinnatus*, *Rasbora daniconius*, *Esomus danricus* are all again common species of little value.

However, after the river emerges out of the gorge and runs down to slightly less elevated terrain at Kudige, wher Harangi river meets, at Ramanathapura where a fish sanctuary exists, and at Holenarsipur where Hemavathi river joins (Pl. II, Fig. 4), the pattern changes. The river is wider, but still flowing over rocky boulderous surfaces and forming deep rock pools. The fish species also change accordingly. *Notopterus notopterus*, *Glossogobius giuris*, *Tor khudree*, *Tilapia mossambica*, *Cirrhinus reba*, *Anguila bengalensis* which are all species of larger size (up to 18 to 20 inches in length) and which requires shallow to moderately deep waters are obtained.

Krishna Raja Sagar Dam, the first major obstruction in the free flow of the river at 19 Km west of Mysore City impounds the river to a water spread area of 54 sq miles and with a depth of 124.80 ft at full level. The basic physiographic structure and zonal characteristic of the river bed continues to remain rocky and boulderous. The reservoir is stocked with artificially introduced exotic species such as the Chinese carp, Mirror Carp, etc., which are obtained in large sizes. As a follow up of such availability of large sized fishes predators like *Wallago attu* are also seen. This feature is maintained up to Srirangapatnam 19 km north of Mysore where the river is more placid (Pl. II, Fig. 6). Common fishes like *Puntius carnaticus*, *Puntius sarana*, *Mystus punctatus*, *Mastacembelus* species which are all medium sized make their appearance. An important tributary of the Cauvery is the Kabbini which abounds in fish life. In terms of variety and quality the Kabbini contributes a large share of fish to the Cauvery system. The terrain the Kabbini flows is akin to the main Cauvery but the volume of water and width of the river is more and perhaps is the reason for the rich fish life. *Puntius narayani* was obtained in this zone which is endemic here.

ZONE II : The Shivasamudram Falls (Fig.5) of the Cauvery is a major distributional barrier for many fish species. The river flowing at an altitude of 620 metres falls 85 metres to form a large cascade or sheet of water quarter or half mile in width when in full floods. Near about the falls the stream with innumerable rock pools harbour many hill stream fishes such as *Garra*, *Balitora*, *Tor khudree*, etc. Below the falls up to Hogenaikal the river flows fast over pebbles and rocks with thick forest cover along its banks following the contour of the land. Here a large number of carps such as *Puntius kolus*, *Puntius carnaticus* and catfishes like *Aorichthys seenghala*, *Silonia childreni*, (over 24 inches in length) *Mystus armatus*, *Mystus menoda* (about 10 inches in length) are caught. Many fishermen from Tamil Nadu poach in this area because of availability of large sized fishes in this zone. The river assumes the characteristics of a meandering stream at Kollegal but the basic features of the substratum remain unchanged. This zone is also remarkable for the occurrance of *Osteocheilus thomassi* a primitive Cyprinid fish whose closest ally lives in Thailand and Malaya. *Silurus berdmorei wynaadensis* is a catfish which again shows a noteworthy discontinuity in distribution as *Osteocheilus*. This zone is thus remarkable for its fish fauna and appears to be a transitory area between the purely hilly terrain of the river to its plains course after Hogenaikal.

ZONE III : Hogenaikal in Tamil Nadu is another landmark in the course of the Cauvery. The river cuts across gorges and drops about 18 metres (Pl. III, Figs. 9-12) (70 ft) to follow a run along the plains. The height of these falls has however been reduced by the formation of the Mettur reservoir whose water spread reaches this area more particularly during the monsoon season. Fishes are now able to ascend the falls, such as *Catla*. However up to Bhavani and Jedarpalayam the bed is still with pebbles, rocks and with occasional rock pools. The Mettur Dam at Mettur is the second impediment in the course of the river. The dam impounds an area of 59.25 sq miles in water spread and is 150 ft deep at full level. Though the Dam is an insurmountable barrier, the surplus discharge channel called the Ellis Channel, with easy gradient has assisted in the passage of fish to above the dam. However, some are washed down with injuries. The fauna changes considerably. *Catla catla* though introduced, *Puntius dobsoni*, *Puntius kolus*, *Puntius dubius*, *Labeo kontius*, *Labeo ariza*, *Labeo calbasu*, *Aorichthys seenghala*, *Silonia childreni*, *Pangasius pangasius*, *Cirrhinus cirrhosa*—all economically valuable fish and which grow to considerable size (over 36 inches in length) begin to occur. Beyond Jedarpalayam it is a wide river (Pl. III, Figs. 7,8) branching off Coleroon at Upper Anaicut and assuming the form a deltaic river. Below the Grand Anaicut, smaller fishes such as *Cirrhinus reba*, *Danio*, *Esomus*, *Rasbora* occur. This is the zone where Hilsa also once had its run, though it is a rare phenomenon now. Five km. north of Tranquebar from Mayurum onwards, the Cauvery becomes one of the three regulated streams the whole of its waters having been utilized for irrigation. It is an insignificant stream when it joins the sea at Kaveripattinam.

DISCUSSION

Division of a river into distinct biological zones, each with a characteristic fish fauna is not new. Huet (1959) divided the European streams into four distinct zones based on fish distribution. Tropical river systems fall more or less on similar lines, the zonation being distinguished by fish fauna, nature of bottom, gradient, current velocity etc. The distributional pattern that emerge indicate that the Cauvery can be divided into three such zones as detailed. Of the three zones the last zone or the plains course is undoubtedly economically valuable not only in terms of its deltaic nature and utility of water for irrigation and agricultural purposes, but also in terms of fish life. About 60% of the fish fauna of the entire Cauvery basin is found here. The major natural barrier, Sivasamudram likewise divides the ecological face of the river into distinct areas which is also reflected by the fish life the river holds. Raj (1941) analysed this problem in detail and pointed out that whereas the Hogenaikal or Mettur Dam do not act as a barrier for the dispersal of fishes, Sivasamudram falls has prevented many fishes such *Cirrhina cirrhosa*, *A. aor*, *A. seenghala*, *Labeo fimbriatus* from colonising the upper reaches. There is a distinct transition in the fish fauna from the first zone to the last zone as evidenced by the abundance and availability of fish of quality and of different sizes. The area of the river between Shivasamudram and Hogenaikal looks promising for better exploitation, since ecologically it is least disturbed.

Acknowledgement

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QUALITATIVE AND QUANTITATIVE COMPOSITION OF ORIBATEI IN GANGETIC DELTA OF WEST BENGAL IN RELATION TO EDAPHIC FACTORS

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ABSTRACT

The present work deals with the results of synecological study involving influence of edaphic factors like temperature, moisture, organic carbon, pH, electrical conductivity and available phosphate on soil dwelling oribatid mites extracted by modified Macfadyen expedition funnel at Bakkhali, 24-Parganas, West Bengal.

A total number of 72 soil samples were collected at monthly interval over a period of two consecutive years (January, 1977 to December, 1978). Altogether 707 individuals were extracted belonging to seven genera, viz. *Scheloribates, Lamellobates, Haplochthonius, oppia, Hoplophorella, Hoplophthiracarus* and *Heptacarus.* Among these *Scheloribates* was dominant comprising 38.75% of total population. Season wise analysis of Oribatei showed two peaks, namely in May and November when the factors like moisture and organic carbon content of soil also obtained their respective maximum concentration. Oribatid nymphs were counted only as the total number and maximum was found in May.

The regression, correlation and analysis of variance study was done between different soil factors and oribatid population and their interrelationship are discussed.

INTRODUCTION

Little attention has been paid to the qualitative and quantitative ecology of soil oribatid fauna of Indian subcontinent and no study has hitherto been made of the soil oribatid in gangetic delta of West Bengal. However, of late in India, Bhattacharya (1974), Choudhuri and Banerjee (1975, 1977), Bhattacharya and Raychaudhuri (1977) and Bhattacharya, Joy and Joy (1978) have studied the oribatid population of alluvial and laterite soil. Luxton (1967), Weigmann (1971, 1973) and Polderman (1974) investigated the distribution pattern of oribatids in salt marshes and inland saline areas.

The results of a study of the oribatid fauna of deltaic soil at Bakkhali, 24-Parganas with special reference to different soil factors, are presented in this paper.

SITE DESCRIPTION AND METHODS

The study was carried out in a large uncultivated area which is situated in the extreme south of 24-Parganas and Bay of Bengal is washing its southern part. The area was covered with herbs, shrubs and trees, viz. *Acanthus illicifolius* Linn. (Acanthaceae) ; *Alstonia scholaris* Br. (Apocynaceae) ; *Tylophora* sp. (Asclepiadaceae) ; *Caesalpinia nuga* Ait, *Tamarix dioica* Roxb. (Caesalpinieae) ; *Fimbristylis schoenoides* Vahl. (Cyperaceae) ; *Excoecaria agallocha* Linn., *Mallotus repandus* Nuell. (Euphorbiaceae) ; *Cynodon dactylon* Pers., *Echinochloa colona* Link. (Gramineae) ; *Thespesia populnea* Corr. (Malvaceae) ; *Azadirachta indica* A. Juss. (Meliaceae) ; *Phoenix sylvestris* Roxb. (Palmae) and *Solanum trilobatum* Linn. (Solanaceae). The area also contained debris of fallen leaves and dried twigs from the plants stated above.

For this study three plots, each 5 metre square were selected. Altogether 72 soil samples were drawn from a depth of 5 cm at monthly interval over a period of two consecutive years (from January, 1977 to December, 1978). Soil samples were drawn by stainless steel samplers having 5 cm depth and 17.36 sq cm surface area and these were inverted and placed in an expedition funnel apparatus (Macfadyen, 1953). Soil factors studied were temperature, moisture, organic carbon, pH, electrical conductivity and available phosphate. A colorimetric method for phosphate and an oven-drying method for moisture determination as described by Dowdeswell (1959) were followed. The organic carbon content was estimated by Walkley and Black (1934) method and the pH was determined from soil described by Piper (1942). The electrical conductivity and temperature were measured by electrical conductivity bridge and conductivity cell and soil thermometer respectively.

Observations

Edaphic factors : Soils of these plots are alluvial in nature, grey in colour and loamy in texture. Soil temperature varied from 21.43°c to 37.33°c in January and April respectively. Values of soil moisture, organic carbon, pH, electrical conductivity and available phosphate ranged between 10.1% to 19.55%, 0. 53% to 1.21%, 7.1 to 8.1, 1.04 mmohs/cm to 11.08 mmohs/cm and 18.75 ppm to 35.42 ppm respectively. Comparatively maximum amount of moisture and organic carbon was recorded during May and November in both the years of observation. Other soil factors showed a trend of fluctuation regarding maximum and minimum values. Mean values of soil factors (Table 1) revealed more or less identical edaphic characteristics of plots concerned. Mechanical analysis of soil samples showed more or less equal proportion of sand and silt (Table 2).

Oribatid population : The relative abundance of population was obtained (Table 1) in May and November when soil factors like moisture and organic carbon attained comparatively greater concentration. Altogether 7 genera of oribatid mites were obtained such as *Scheloribates*, *Lamellobates*, *Haplochthonius*, *Oppia*, *Hoplophorella*, *Hoplophthiracarus* and *Heptacarus* (Table 2). Among these *Scheloribates* was dominant representing two species, viz. *Scheloribates rakhali* Sanyal (in press) and *Scheloribates bhadurii* Sanyal (in press) comprising 38.75% of total population. *Lamellobates palustris* Hammer, 1958 came next to *Scheloribates* having 23.90% of total population. *Hoplophorella scapellata* Aoki, 1965 and *Hoplophorella sundarbanensis* Sanyal (in press) came next to *Lamellobates* having 11.03% of total population. The fourth, fifth, sixth and seventh genera/species in order of dominance were *Haplochthonius intermedius* Chakrabarty, Bhaduri and Raychaudhuri, 1977, *Oppia yodai* Aoki, 1965 and *O. orientalis* Sanyal (in press), *Heptacarus supertrichus* Piffl, 1966 and *Hoplophthiracarus siamensis* Aoki, 1965 comprising 5.94%, 2.69%, 1.27% and 0.57% respectively. Oribatid nymphs were counted as the percen-

TABLE 1. Showing oribatid population and mean value of soil factors in different months.

	1977							1978						
Month	Oribatid (Mean)	Tempera -ture (Oc)	Moisture (%)	Organic carbon (%)	pH	E. Ce. (mmohs/ cm)	Avail-able phosp-hate (ppm)	Oribatid (Mean)	Temper-ature (Oc)	Moisture (%)	Organic carbon (%)	pH	E. Ce. (mmohs/ Cm)	Avail-able phosp-hate (ppm)
Jan.	5	21.43	11.00	0.77	7.30	8.10	33.33	4	22.16	10.10	0.69	7.60	7.47	35.42
Feb.	9	25.90	12.00	1.10	7.20	7.00	31.25	7	28.66	10.95	0.70	7.10	6.09	33.33
Mar.	10	31.26	11.43	1.15	7.30	6.85	27.08	11	33.20	11.00	1.02	7.50	5.26	27.08
Apr.	9	30.83	15.60	0.90	7.50	5.57	27.08	10	37.33	10.50	0.53	7.35	4.57	24.10
May	15	33.83	16.65	1.19	7.10	3.10	31.25	18	35.00	19.00	1.14	7.15	5.26	27.08
Jun.	12	29.93	12.83	0.95	7.50	8.21	24.10	13	34.00	13.10	1.02	7.12	11.08	22.92
Jul.	8	32.00	11.00	0.84	7.85	1.76	24.10	8	32.66	18.30	0.67	7.95	1.30	20.83
Aug.	7	31.50	10.78	0.65	7.70	1.04	22.92	9	31.00	12.50	0.55	8.10	1.13	18.75
Sep.	10	31.13	12.00	0.60	7.85	2.88	18.75	10	33.66	12.20	0.65	7.45	2.46	18.75
Oct.	11	30.83	14.50	0.92	7.80	3.77	18.75	11	28.66	13.00	0.67	7.30	3.87	20.83
Nov.	13	30.76	17.95	1.21	7.40	1.99	22.92	15	28.33	19.55	0.77	7.15	3.60	22.92
Dec.	6	22.50	10.10	0.81	7.70	3.55	29.17	7	21.50	11.00	0.59	7.60	4.84	27.08

TABLE 2. Showing mechanical analysis of soil.

Sand (%)	Silt (%)	Clay (%)	Texture class
39.64	39.80	20.56	Loam

tage of total number (Table 3) because of difficulty in proper taxonomic diagnosis and comprised 15.85% of total oribatid population.

Population fluctuation : Variations in oribatid population with time are shown in Fig. 1. The Faunal size as a whole obtained from different sampling sites showed variations at different times of the year during the whole sampling period. The total population showed two peaks, one in May-June (Pre-Monsoon months) and the other in November (Winter month). The fall of population peak was found in December-January (winter months). Seasonal change in the number of oribatid nymphs is shown in Fig. 2. The number raised maximum in the month of May and again in November. Population fluctuation of dominant species of oribatid is shown in

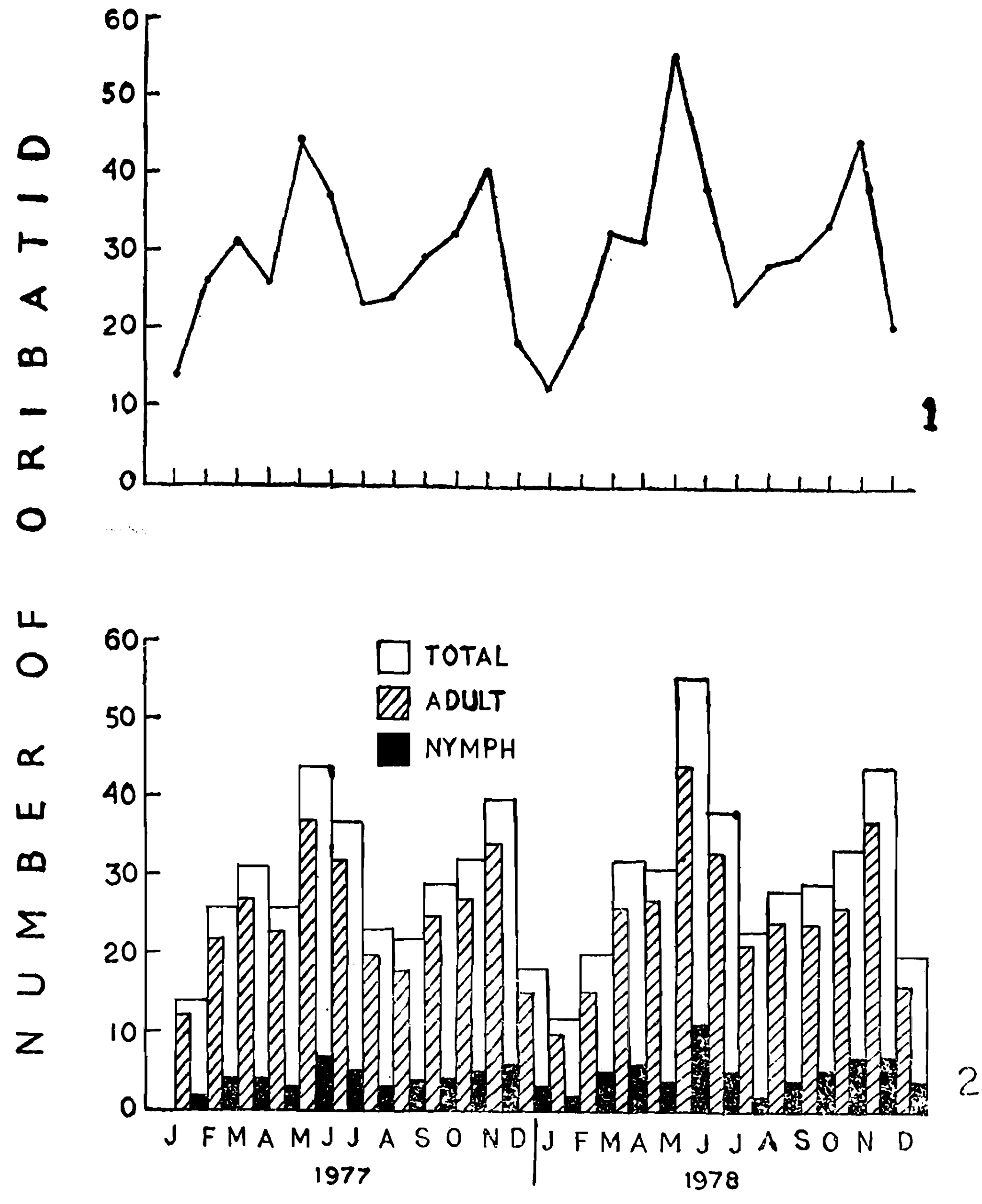

Fig. 1. Seasonal fluctuation of total oribatid mite population.

Fig. 2. Seasonal fluctuation of total, adult and nymphal population of oribatid mite.

Fig. 3. All the species showed maximum population in May and a second peak in November except *Hoplophorella scapellata* which showed the peak in April. Figure 4 showed the monthly changes in faunal structure.

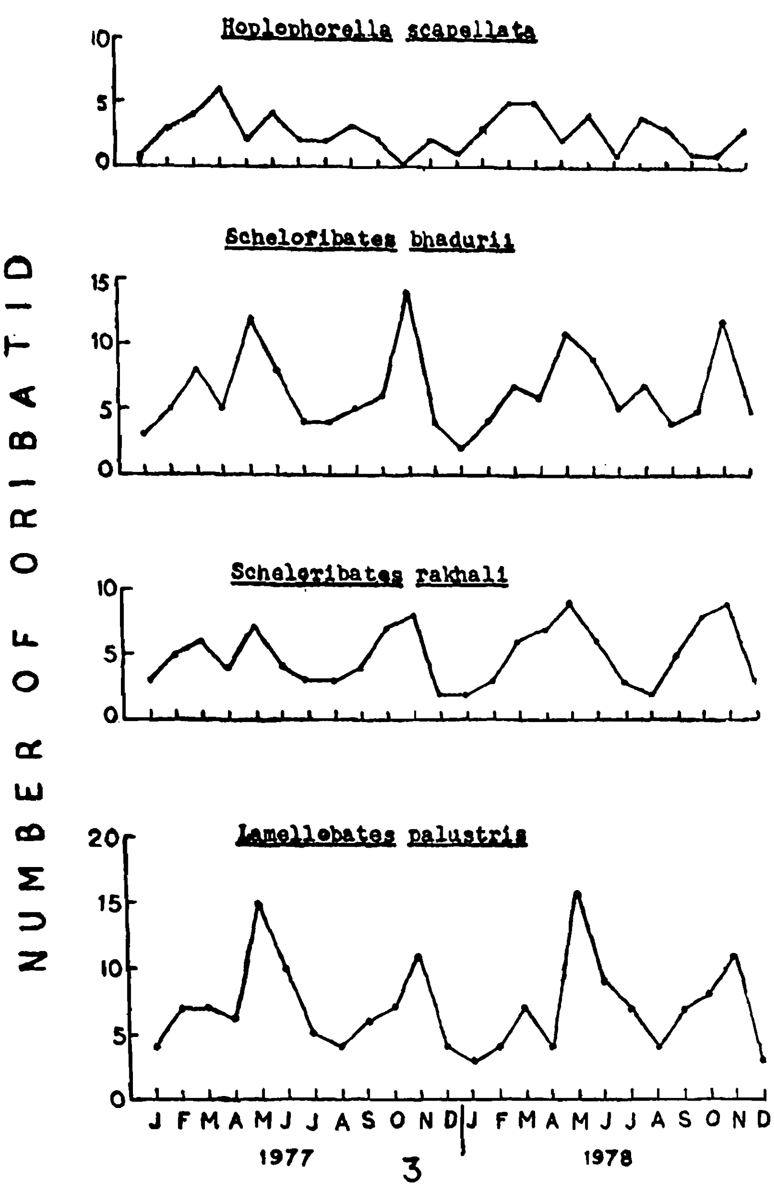

Fig. 3. Seasonal fluctuation of dominant species of oribatid mite.

of the six variables (soil factors) considered here. The correlation coefficient data as mentioned in the Table 4 indicated of the six variables, viz. temperature, moisture and organic carbon were significant and positively correlated with the oribatid population. The pH appeared to show significant negative

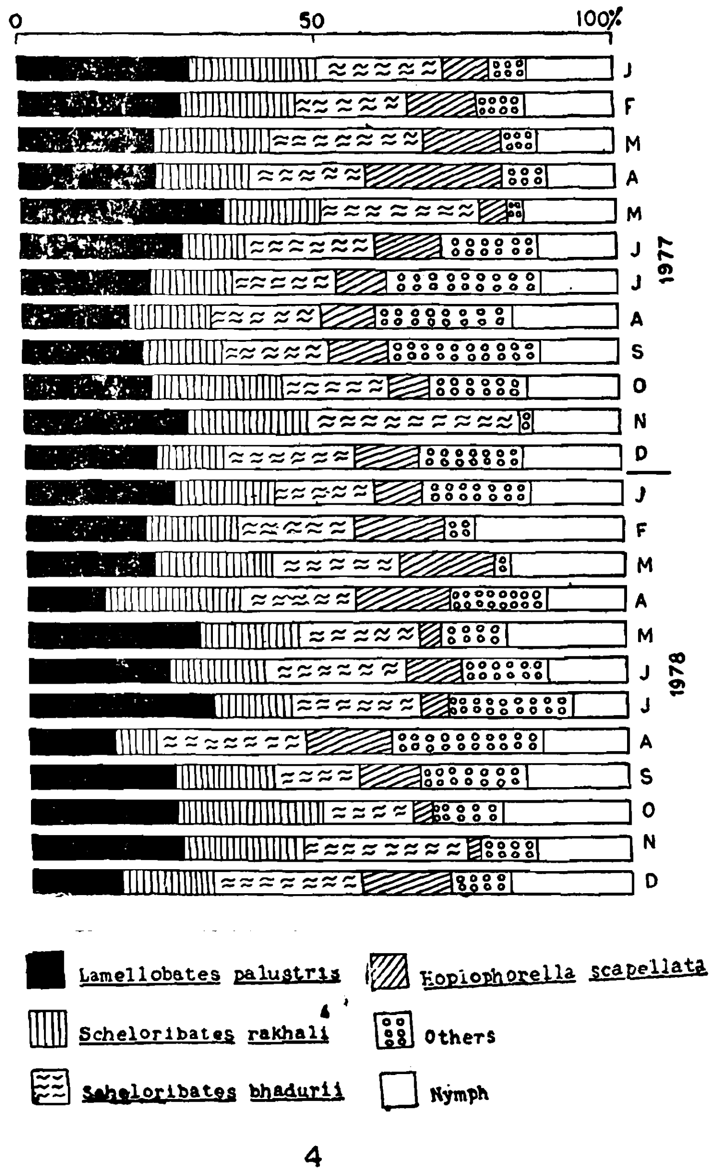

Fig. 4. Change in percentage of dominant oribatid species and nymphs for each month.

Correlation between oribatid population and soil factors : The data involving soil factors and the densities of oribatid population were subjected to the statistical analysis to find out possible regressions, correlations and dependence of mean number of oribatid (Y) on each correlation with the oribatid population where as no significant association with electrical conductivity and available phosphate was observed.

The regression lines were obtained by pulling together the data for the two years.

The combined regression lines drawn along with the respective scattered diagram are shown in the Figs. 5-8.

The analysis of variance study (Table 5) showed that there was a difference between sampling years and between months of a sampling year and the seasonal pattern or monthly variation was significantly constant in both the years.

moisture and organic carbon attained their maximum concentration. The increased population with increased moisture and organic carbon content of soil was reported by Macfadyen (1952), Madge (1964), Loots and Ryke (1966), Fujikawa (1970) and Choudhuri and Banerjee (1977). It may be assumed from the present study that higher pH inhibited the population increase and the negative correlation between pH and oribatid population recorded in the study was supported by Karppinen (1955) and Bhattacharya and Raychaudhuri (1977). It may reasonably be postulated that the oribatid species were capable of withstanding a wide range of temperature. From insignificant correlation between oribatid population and two other soil factors like soil salinity and phosphate it might be suggested that these two factors may not exert sufficient influence on faunal make up but these in combination with other edaphic factors may contribute to the population fluctuation. It may also be assumed from the study that most of the oribatid mites are salt tolerant and able to withstand the higher amount of salt in soil (Weigmann, 1971).

It may be that the biotic and abiotic factors considered here and also those components not analysed in this study collectively contribute to the population fluctuation of

TABLE 5. Showing analysis of variance.

	Year	Month	Error	Total
Degree of freedom	1	11	11	23
Sum of squares	2.66	240.83	10.34	253.83
Mean square	2.66	21.89	0.94	
Frequency	2.8297	23.2872**		

** Significant at 1% level.

DISCUSSION

The population peaks in pre-monsoon and autumn as observed in the present study followed the observations made by Riha (1951), Macfadyen (1952), Sheals (1957), Chiba et al. (1975) and others. Absence of definite winter and autumn peak was reported from gangetic alluvial soils of West Bengal by Choudhuri and Banerjee (1977). This pattern of fluctuation appeared to be a bit different from the works of Wallwork (1959, 1972), Madge (1965a, 1965b) and Usher (1975) who observed a winter maxima. The consideration of climatic and edaphic factors as well as population fluctuation of oribatid fauna leads to the conclusion that high amount of rainfall during May (early monsoon is observed in deltaic region) sets up favourable conditions for the upward migration of soil oribatid and eclosion of juveniles from eggs as peak population of nymph is found during May when factors like

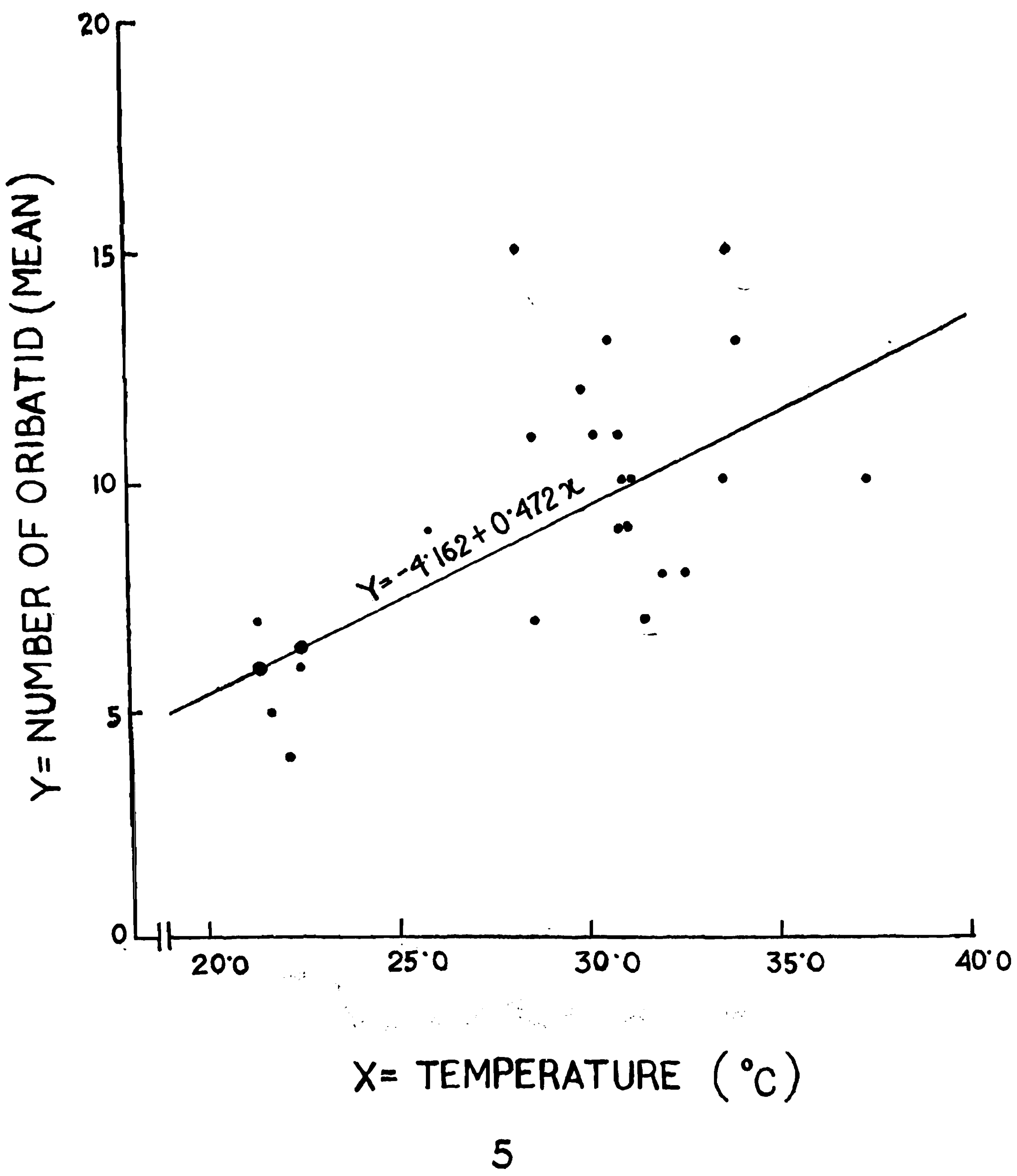

Fig. 5. Regression line with scattered diagram of Oribatei on temperature (°c).

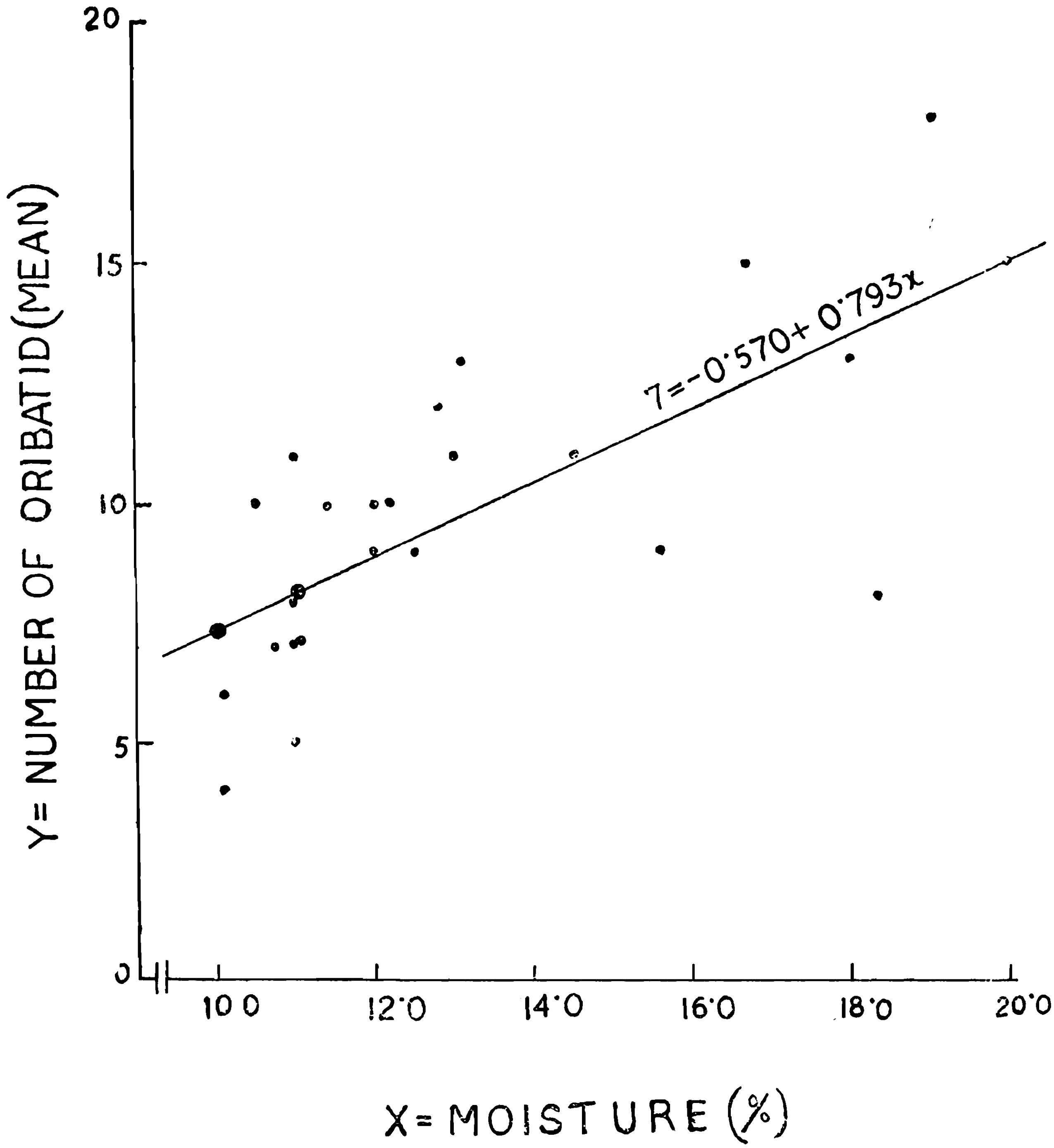

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Fig. 6. Regression line with scattered diagram of Oribatei on moisture (%).

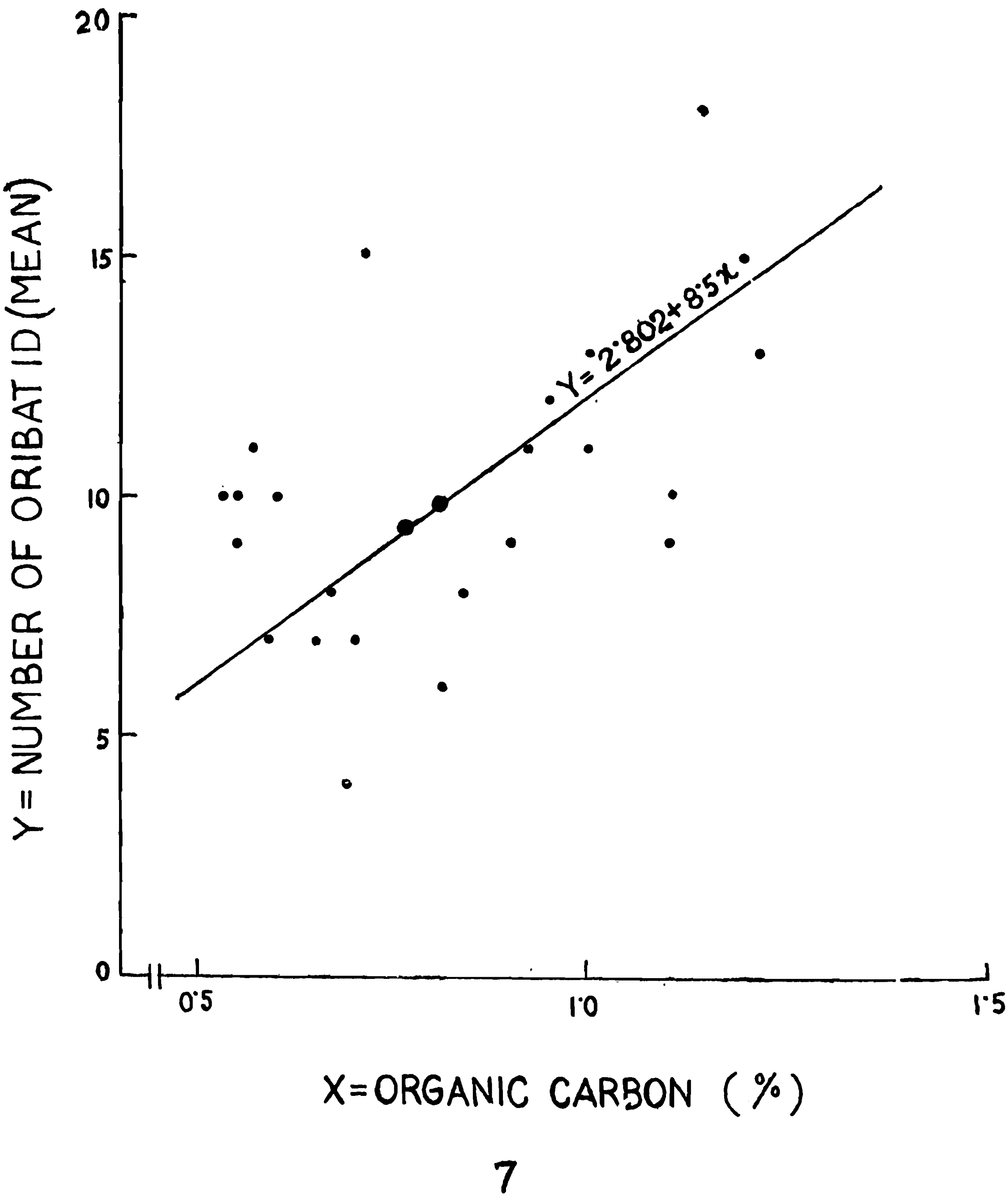

Fig. 7. Regression line with scattered diagram of Oribatei on organic matter (%).

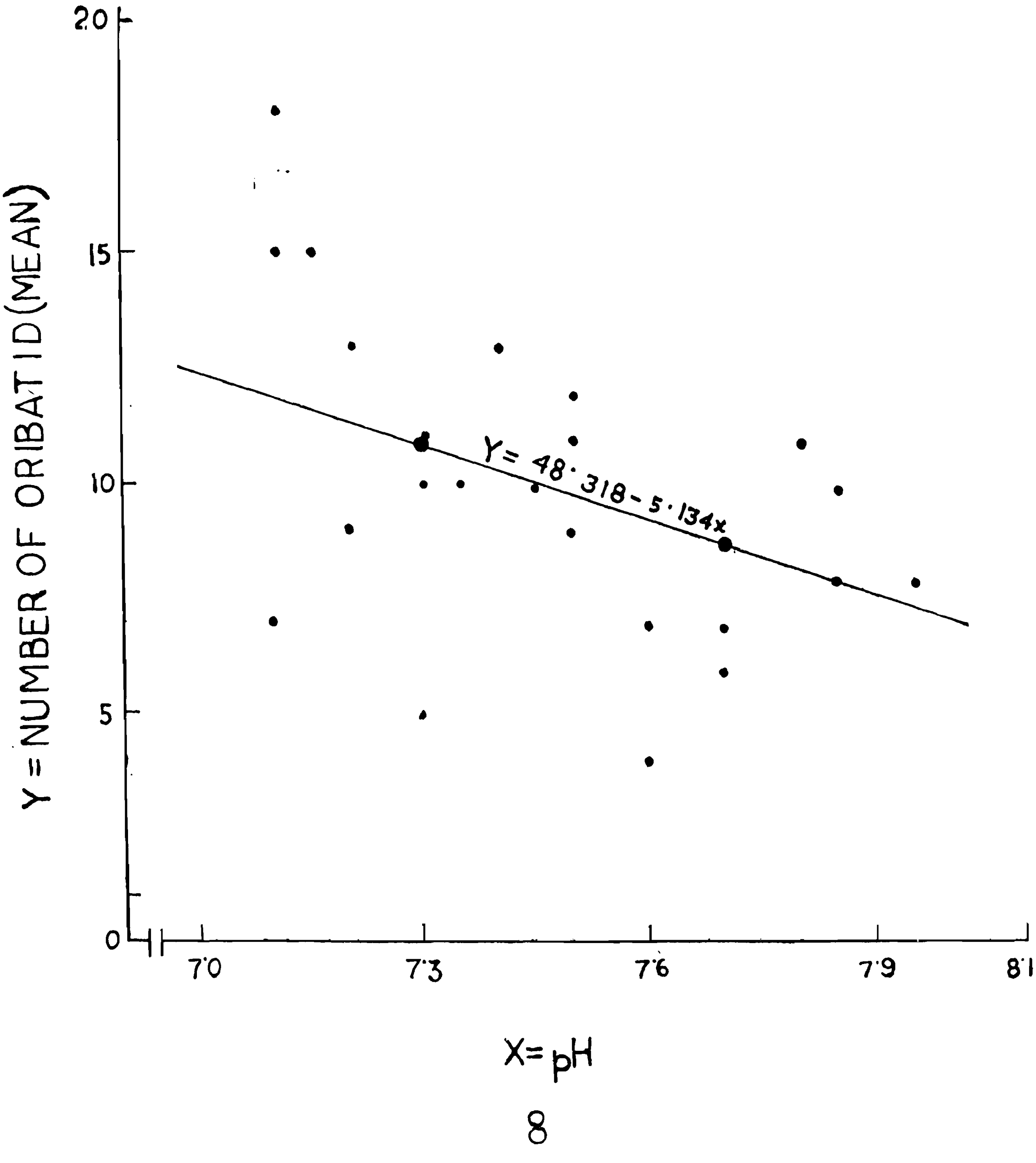

Fig. 8. Regression line with scattered diagram of Oribatei on pH.

oribatid mites in the deltaic soil of West Bengal.

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ECOLOGY OF GRASSHOPPERS IN TWO GRASSLANDS OF WEST BENGAL IN-RELATION TO SOME PHYSICAL FACTORS

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ABSTRACT

This observation presents the results of distribution of grasshoppers in two grasslands of West Bengal during the period from May—December, 1979. Higher population of grasshoppers were observed in Botanics grassland (72.7%). The number of species occured from both the sites were also varied (16 species from Bethuadohari and 9 species from Botanics).

Fluctuations of pupulation per month showed two Peaks one in October and other in August at Botanics grassland and during August and September at Bethuadohari. Monthly fluctuations of Male, Female and nymph showed that female population was nil during July-August from both the sites and maximum nymph yielded in August.

A regression and correlation-coefficient analysis was done between physical factors and abundance of grasshoppers and their inter-relationships are discussed.

INTRODUCTION

Workers like Isely (1937), Cantrall (1943), Merton (1959), Roonwal (1976), Uvarov (1977) and Dwivedi (1977) have studied the qualitative and quantitative ecology of Orthopteran population in different parts of the world. However, the grasshopper population in the grassland of West Bengal has not been studied so far. These grasshoppers are of great economic importance as most of them are either pests or potential pests of different crops of West Bengal. Therefore, their time of emergence as hoppers and the time when they become adults may help us to forecast their outbreaks in West Bengal. For this, the present observations dealing with the effect of temperature and relative humidity on the population of grasshoppers and their distribution in two different grasslands of West Bengal has been discussed.

MATERIALS AND METHODS

During the survey period random-sampling was carried out once in a month from both the plots during the period from May 1979 to December 1979. Catchcount method (Andrewartha 1970) was employed for collecting the grasshoppers from the field. Temperature and relative humidity were recorded by a mercury thermometer (with stainless steel coverings) and a dial hygrometer respectively.

LOCATION AND CHARACTERISTICS OF SAMPLING SITES

Two sites were selected. One at Bethuadahari Grassland (75 m×60 m) is located near Bethuadahari reserve forest area in Nadia district. The other at the Botanics Grassland (55 m×45 m), is located at the Botanics Garden in Howrah district. These sites, though about 95 km apart, contained more or less the same ecological conditions, except some differences in vegetations, e.g. the grass *Dichanthium annulatum* Stap. is present only at the Bethuadohari site. Soils of these sites were alluvium, grey in colour and clay-loam in texture.

Results

A comparison of total number of grasshoppers collected from both the sites shows that the Botanics grasslands yielded the higher number (72.7%) of the total individuals collected than the Bethuadohari grassland (27.3%), although the number of species occurring in Bethuadohari was higher (16 species) Botanics grasslands, (9 species). In the monthly fluctuations of total population of grasshoppers obtained from both the plots, two clear peaks occured in the Botanics grassland one in October and other in August and in the Bethuadohari grassland in August and September (Fig. 1).

The faunal composition is given in Table 1. Altogether 18 species occured from both the

TABLE 1. Characteristics of two grasslands.

	Bethuadahari grassland	Botanics grassland
Mean Temperature (oC)		
Air	31.81	33.03
Soil	30.44	31.75
Mean relative humidity (%)	77.13	71.5
Vegetations : (grasses and sedges)	*Sporobolus diander* Beauv. *Arundinella* sp. *Dichanthium annulatum* Stapf. *Eragrostis brachyphylla* Stapf. *Digitaria marginata* Linn. *D. royleana*	*Sporobolus diander* Beauv., *Arundinella* sp. *Eragrostis brachyphylla* Stapf. *Commelina obliqua* Ham., *Vernonia cenerea* Less., *Panicum* sp., *Echinochloa colonum* (Lin.) Link., *Digitaria idscendens*, *Cynodon dactylon* Pers., *Eupatorium odoratum* Linn., *Digitaria marginata* Lin and *D. royleana*.
Grasshoppers :	*Aiolopus thalassinus tamulus* (Fabr.) *Spathosternum prasiniferum prasiniferum* (Walk.) *Phlaeoba infumata* Brunner *Oxya fuscovittata* (Marschall), *O. hyla hyla* Serv., *Atractomorpha crenulata* (Fabr.), *Trilophidia annulata* (Thumb.), *Aulacobothrus luteipes* Walk., *Aulacobothrus* sp., *Acrida exaltata* (Walk.), *Chorthippus indus* Uvarov, *Acrotylus humbertianus* Saussure, *Tristria pulvinata* (Uvarov), *Hieroglyphus banian* (F.), *Leva cruciata* Bolivar, *Gelastorrhinus semipictus* (Walk.)	*Aiolopus thalassinus tamulus* (Fabr.), *Spathosternum pr. prasiniferum* (Walk.) *Epistaurus sinetyi* Bolivar, *Phlaeoba infumata* Brunner, *Oxya fuscovittata* (Marschall), *O. hyla hyla* Serv., *Atractomorpha crenulata* (F.), *Gesonula punctifrons* (Stal), *Tristria pulvinata* (Uvarov)

sites of which 7 are predominant and occur from both the sites except *Aulacobothrus luteipes* which occured only in the Bethuadohari grassland. Monthly fluctuations of the sexes, nymphs and total population of these predominant species are given in figures 2 and 3. It is clear that the predominant species are much more frequent in the Botanics glassland than in Bethuadohari. The maximum and minimum population of each of these species are variable.

Spathosternum prasiniferum prasiniferum (Walk.) is the most predominant species (24.37%) in both the plots combined. *Aulacobothrus luteipes* Walk. (23.53%) is the most

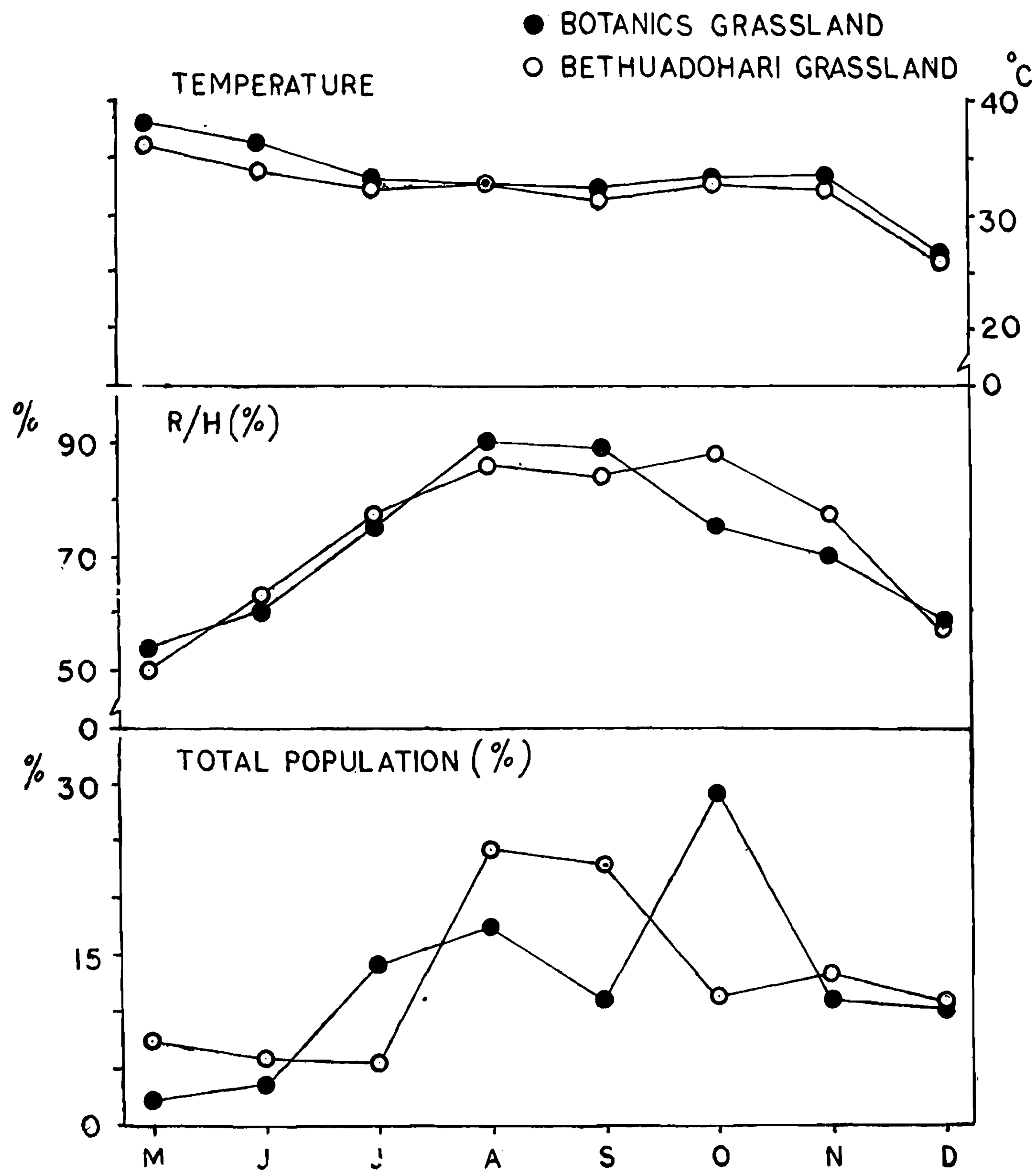

Fig. 1. Showing fluctuations of total population of grasshoppers, relative humidity and temperature in two grasslands.

dominant species in the Bethuadohari grassland. *Spathosternum* shows two peaks (in August and November) and minimum number in June in Bethuadohari grassland. In the Botanics grasslands the maximum occurs in August and October and the minimum in May. Similarly, the majority of species shows two peaks (Fig. 2 and 3). Male, female and nymph population of each species also fluctuate from one month to another. Male (2.36%), female (1.79%) and nymph (6.18%) shows the highest peak during the month of November, May, and August respectively in the Bethuadohari grassland. The corresponding highest percentage of male (2.96%) ; female (4.08%) and nymph (5.05%) occur during August, November and August respectively in the Botanics grassland. The female population is completely absent during July and August in both in fields. When the total male, female and nymph population of both sites are considered, it is seen that nymphs constitute the major portion of the total population (32.94%), then comes males (26.23%) ; and minimum population is that of female (13.54%) (Table 2).

From figure 1 it is clear that in both the sites the lowest population is associated with the low relative humidity, higher air and soil temperature during May, but the highest population in Bethuadohari is associated with high relative humidity (92%) and moderate air and soil temperature in August. Corresponding higher population in the Botanics grassland in October when the relative humidity (74.1%), and air and soil temperatures are moderate. This higher peak may be due to sudden large catch of *Spathosternum* and *Oxya* in this month.

An attempt has been made to find out the relationship between the population of grasshoppers and the physical factors and also between some other parameters considered in this study. For this correlation coefficients and regression equations were done. From Table 3, it is clear that only the relative humidity shows a positive correlations (Column 3, Table 3) with the total populations and individual species populations, but even this is not significant. The other two factors (air and soil temperatures) show a negetive corrélation. Column 4 of Table 3 shows the regression values of above parameters. The correlation between the population of two grasslands shows a positive insignificant relationship. The population of male and female shows a

TABLE 2. Showing monthly fluctuations of adult Male, Female and Nymphal populations in two grasslands (in percentage).

	Bethuadohari grassland			*Botanics grassland*		
Months	Male	Female	Nymph	Male	Female	Nymph
M	—	1.77	0.21	0.43	0.43	0.43
J	1.07	0.48	—	0.75	0.43	0.43
J	0.54	—	0.91	1.88	—	4.62
A	0.38	—	6.18	2.96	—	5.05
S	0.7	0.48	5.00	1.61	0.38	3.01
O	1.13	1.72	0.21	1.83	4.08	1.99
N	2.36	0.7	0.51	2.53	1.72	0.64
D	0.97	0.05	1.88	1.72	1.29	1.83

positive correlation (significant at 5% level), but the correlation between adult and nymph population is negetive and not significant. When relationship in between the species are calculated it is seen that there exists a positive correlation between them but this is not significant except between *Spathosternum* and *Oxya* and between *Spathosternum* and *Atractomorpha*, which shows positive correlation and significant at 5% level. The impact of relative humidity, air and soil temperature on male, female and nymph population shows that the relative humidity is positively correlated with the male and nymph population

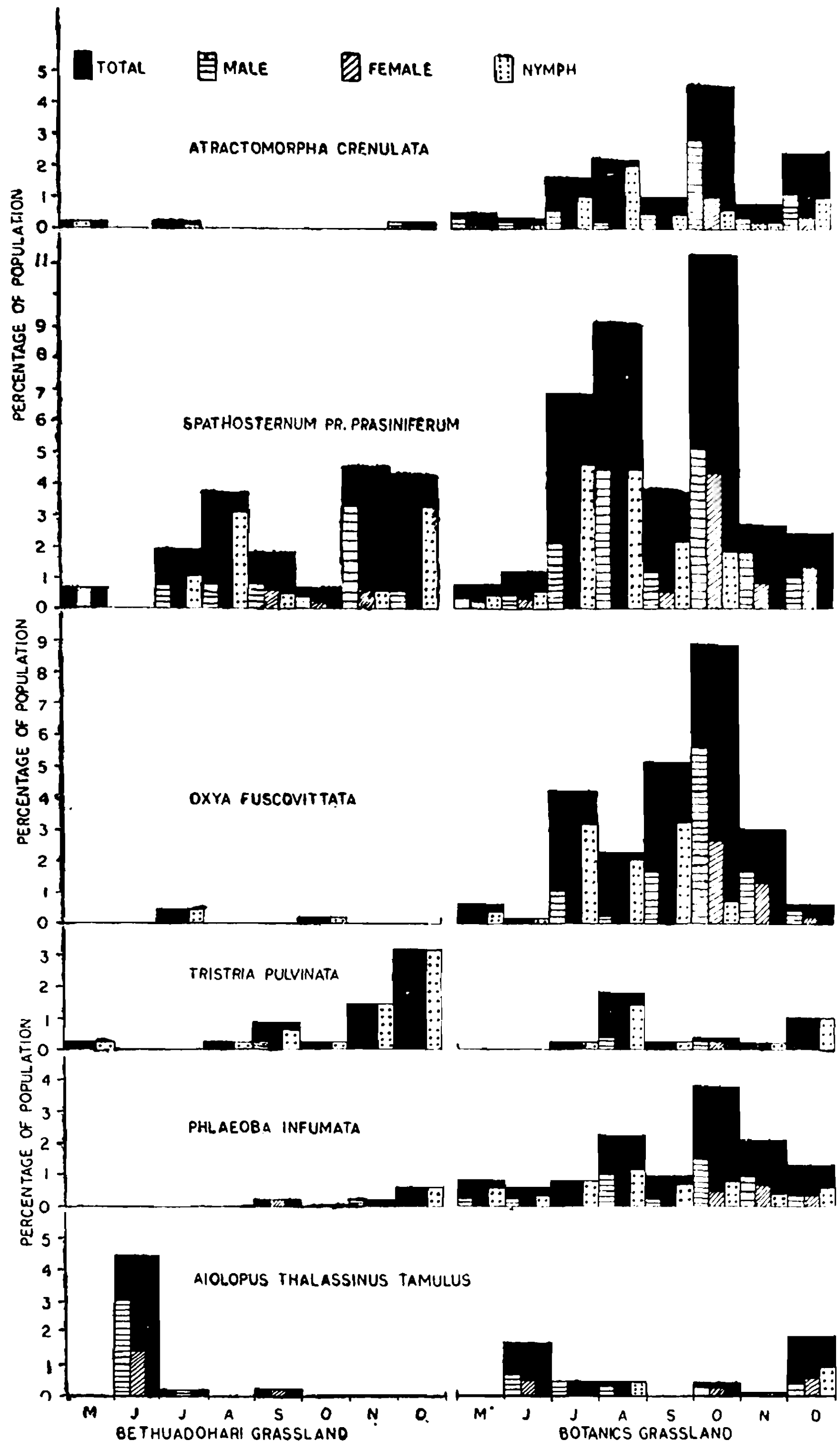

Fig. 2. Showing fluctuations of dominant grasshopper species per month in two grasslands.

and other two factors like air and soil temperature are negetively correlated. In case of female population relative humidity and soil temperature are negetively correlated and air temperature is positively correlated. This relationship is unique in case of female population in this study.

Discussion

The present investigation is a part of a long term project on the ecology of grasshoppers and on ecological energetics in some grasslands of West Bengal.

The present observation exhibits two peaks during August and September in one site

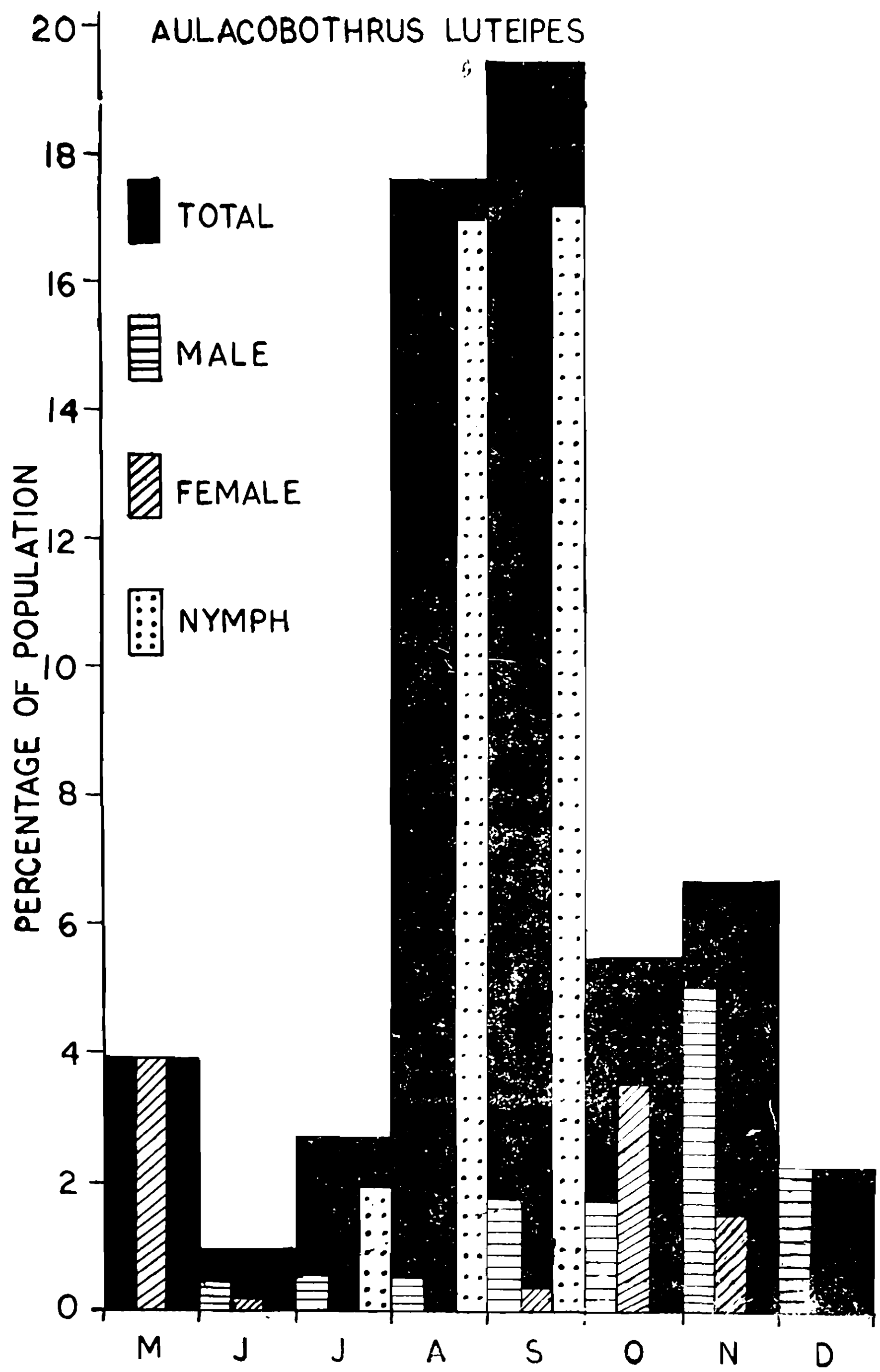

Fig. 3. Showing fluctuations of *Aulacobothrus luteipes* per month in Bethuadohari grassland.

TABLE 8. Showing relationship between grasshoppers population and different parameters.

Parameters	Mean	'r' value	Regression equation Y=a+bx
Bethuadohari Reserve Forest	57.25		
Y : *Total population*			
Air temp.	31.75	−0.2	Y=32.9−0.02 x
Soil temp.	30.44	0.27	Y=28.15+0.04 x
Relative humidity	77.13	0.38	Y=13.01+1.12 x
Y : *Aulacobothrus* sp.	37.5		
Air temp.	31.75	0.05	Y=31.75+0.004 x
Soil temp.	30.44	−0.05	Y=30.82−0.01 x
R/H	77.13	0.5	Y=69.25+0.21 x
Y : *Spathosternum* sp.	10.75		
Air tem.	31.75	—0.68	Y=28.85−0.27 x
Soil temp.	26.38	—0.2	Y=25.84−0.05 x
R/H	65.88	0.58	Y=61.02+1.98 x
BG/Botanics			
Y : *Total population*	101.75		
Air temp.	32.96	—0.29	Y=33.98−0.01 x
Soil temp.	31.81	—0.03	Y=34.86−0.03 x
R/H	71.5	0.29	Y=57.25+0.14 x
Y : *Atractomorpha* sp.	14.25		
Air temp.	32.96	—0.45	Y=30.96−0.14 x
Soil temp.	31.81	—0.61	Y=28.25−0.25 x
R/H	71.5	0.08	Y=69.93+0.11 x
Y : *Oxya* sp.	26.13		
Air temp.	32.96	−0.08	Y=37.93−0.01 x
Soil temp.	31.81	−0.19	Y=32.86−0.04 x
R/H	71.5	0.49	Y=63.66+0.3 x
Y : *Phlaeoba* sp.	13.88		
Air temp.	32.96	−0.25	Y=34.76−0.13 x
Soil temp.	31.81	−0.19	Y=33.2−1 x
R/H	71.5	0.44	Y=60.95+0.76 x
Y : *Spathosternum* sp.	38.75		
Air temp.	32.96	−0.18	Y=33.74−0.02 x
Soil temp.	31.81	−0.31	Y=33.75−0.05 x
R/H	71.5	0.43	Y=63.36+0.21 x
Correlation between population of two sites			
Y : No. of specimen in Bethuadohari grassland	63.5		
No. of specimen in Botanical Garden Grassland	105.5	0.22	Y=70+0.56 x

TABLE 8. *Concluded.*

Parameters	Mean	'r' value	Regression equation Y=a+bx
Correlation between Male & female			
Y : Total no. of male	61.00		
Total no. of female	31.00	0.78	Y=—6.21+0.61 x
Correlation between Adult and Nymph Population			
Y : Total no. of adult	98.38		
Total no. of Nymph	75.68	—0.17	Y=59.89−0.16 x
Correlation between Aulacobothrus sp. and *Spathosternum* sp. & others			
Y : Total no. of *Aulocobothrus* sp.	37.5		
Total *Spathosternum* sp. population	38.75	0.17	Y=27.87+0.29 x
Total *Phlaeoba* population	13.88	0.11	Y=12.75+0.03 x
Total *Oxya* sy. population	26.13	0.21	Y=20.88+0.14 x
Total Atractomorpha sp. population	14.25	0.03	Y=13.12+0.01 x
Correlation between Spathosternum sp. with others			
Y : Total no. of *Spathosternum* sp.	38.75		
Total no. of *Phlaeoba* sp.	13.88	0.29	Y=11.94+0.05 x
Total no. of *Oxya* sp.	26.13	0.77	Y= −3.17+0.77 x
Total no. of *Atractomorpha* sp.	14.25	0.78	Y=2.62+0.3 x
Correlation between Male population and physical factors			
Y : No. of Male	61.13		
Air temp.	32.45	—0.2	Y=44.46—0.02 x
Soil temp.	31.09	—0.48	Y=34.15—0.05 x
R/H	74.31	0.39	Y=66.36+0.13 x
Correlation between Female population and physical factors			
Y : No. of Female	31.5		
Air temp.	32.45	0.1	Y=32.13+0.01 x
Soil temp.	31.13	—0.01	
R/H	74.31	—0.14	Y=76.2—0.06 x
Correlation between Nymph population and Physical factors			
Y : No. of Nymph	76.63		
Air temp.	32.45	—0.3	Y=31.68—0.01 x
Soil temp.	31.13	—0.27	Y=32.69—0.02 x
R/H	74.31	0.44	Y=67.41+0.09 x

* Significant at 5% level

and August and October in other site. It agrees with the observation of Dwivedi (1977) where he also obtained in a grassland of Madhya Pradesh early August and late September peaks. Littlevariation in the second plot may be due to climatological and vegetational differences of the two places. From the present study it is clear that the female population does not tolerate excessive humidity as is evidenced from Table 3. All the female population disappeared from both the field during July and August when, maximum relative humidity was present in the atmosphere. This inference is also supported by Statistical analysis (Table 3). Vegetation exerts a greater role in the distribution of grasshoppers. It is seen from the present investigations that *Aulacobothrus luteipes* is associated only with the grass *Dichanthium annulatum* (Table 1). It agrees with the observations of Bailey and Mukherjee (1976) in the case of *Melanoplus bivittatus*.

Dwivedi (1977) observed that the population density and climatic factors like temperature and relative humidity show a significant correlations. But in the present study these parameters are not statistically significant. The cause of this differences can not be explained at present unless more data are obtained. But it is clear that temperature and relative humidity exerts a notable influence upon the limits of population as is evidenced from Table 3.

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GALLS OF PEMPHIGINAE (HOMOPTERA : APHIDOIDEA) IN THE INDIAN REGION WITH DESCRIPTION OF A NEW SPECIES

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ABSTRACT

The present paper provides an account of gall aphids and aphid galls of the subfamily Pemphiginae in the Indian region. Moreover, host association, gall record and biological knowledge of such species in the region have also been included. A new gall forming species, *Kaltenbachiella carpinicola* infesting *Carpinus* sp, is described in this paper. A total of 27 species including 8 newly recorded one under this subfamily are known to produce galls in the area.

INTRODUCTION

Aphid galls are anatomically and histologically complex, formed mostly on the primary host-plants, in the course of heteroecious life cycle and association with true galls is regarded to be of primitive origin. Aphid galls may be covering galls, pouch galls, krebs galls and leaf fold or roll galls (Mani 1964). Amongst the members of Aphididae, species belonging to Pemphiginae are well known as gall makers ; of these, many species migrate to secondary hosts to complete the cycle (Table 1) while some may either become autoecious on primary host or may become restricted to a paracycle on secondary host and the situation in Indian region cleary indicates prevalence of the second condition ; out of more than 60 Pemphigids under 3 tribes known from Indian region, about 27 species are known to form galls. Many of these Pemphigid galls from Indian region have been described by Buckton (1896, 1897), Keiffer (1908), Das (1918), Gulamullah (1941), Mani (1973) and Habib and Ghani (1970) ; galls for eight species are reported here for the first time. So far, no key for identification of aphid species by their galls in the region is available. Several collection trips to Northwest and to Northeast India and Sikkim by the authors have enabled to prepare a key to the aphid species basing on the plant galls. The collection data for many of these species would indicate period of occurrence, while for the others, information have been incorporated from published literature, TABLE—1

Host Association of Pemphiginae

		Primary Host	Secondary Host
I.	Tribe	Pemphigini	[mostly known from primary host in the region]
	Sub Tribe	Pemphigina	
		Populus (Galls)	Dicot Plants (Roots)
	Sub Tribe	Prociphilina	
		Dicot Plants (Galls)	Conifers (Roots)
II.	Tribe	Eriosomatini	[mostly known from secondary hosts in the region]
		Ulmus (Galls)	Rosaceae
		Carpinus (Galls)	Graminae
III.	Tribe	Fordini	[mostly known from secondary hosts in the region]
		Pistacea (Galls)	Graminae
		Rhus	
		Ailanthus (Galls)	?
		Toona ciliata (Galls)	? Graminae

TABLE—2

Aphid species on Poplar Galls

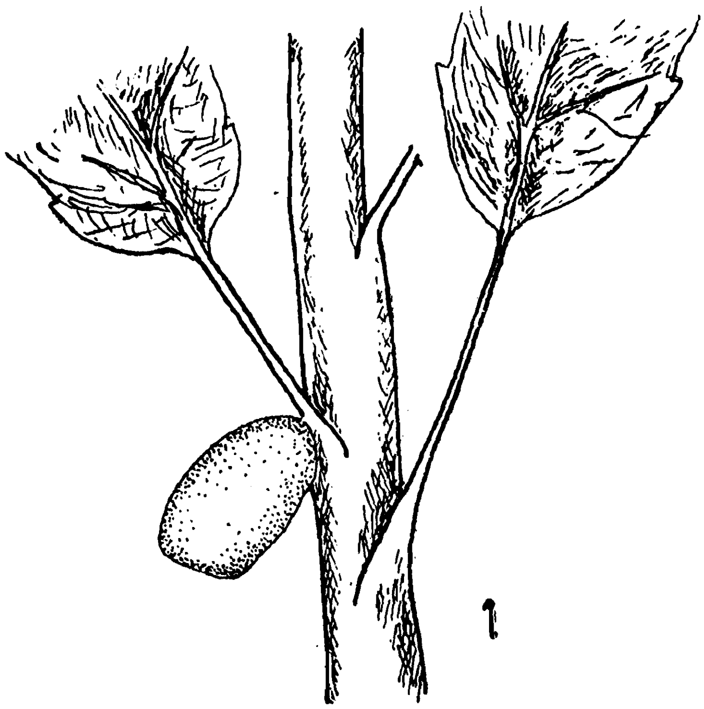
	Aphid species		Host Plant	First record
1.	*Epipemphigus imaicus* (Cholodkovsky) :	:	*Populus ciliata*	(Cholodkovsky, 1912)
2.	*Pemphigus immunis* Buckton	:	*Populus nigra*	(Buckton, 1897)
3.	*Pemphigus mordvilkoi* Cholodkovsky	:	*Populus ciliata*	(Cholodkovsky, 1912)
4.	*Pemphigus nainitalensis* Cholodkovsky	:	*Populus ciliata*	(Cholodkovsky, 1912)
5.	*Pemphigus napaeus* Buckton	:	*Populus euphratica*	(Buckton, 1897)
6.	*Pemphigus siphunculatus* Hille Ris Lambers	:	*Populus ciliata*	(Hille Ris Lambers, 1973)
7.	*Pemphigus indicus* Keiffer	:	Host indet	(Keiffer, 1908)
8.	*Pemphigus spyrotheceae* Passerini	:	*Populus nigra*	(Mathur & Sinch, 1959)
9.	*Pemphigus ignotus* Habib & Ghani	:	*Populus ciliata*	(Habib & Ghani 1970)
10.	*Pemphigus venosus* Habib & Ghani	:	*Populus ciliata*	(Habib & Ghani, 1975)
11.	*Pemphigus vesicarius* Passerini	:	*Populus* sp.	(Gulamullah, 1941)
12.	*Pemphigus* sp.	:	*Populus ciliata*	(New Record)

Galls and Aphids

1. Tribe **Pemphigini**

A. On **Populus** spp.

Four species of Poplars, *alba*, *ciliata*, *euphratica* and *nigra* grow in the Himalaya (Indo-Pakistan region), but 6 of the 12 Pemphigids species (Table 2) are known to form galls only on *Populus ciliata*, which is known to prevent soil erosion and is also used for match-industry (Habib & Ghani 1970). Further report of occurence of four of these Poplar-aphids, after their first record of incidence,



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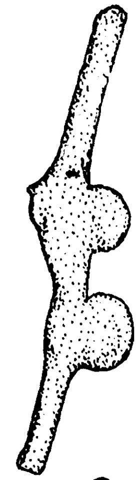

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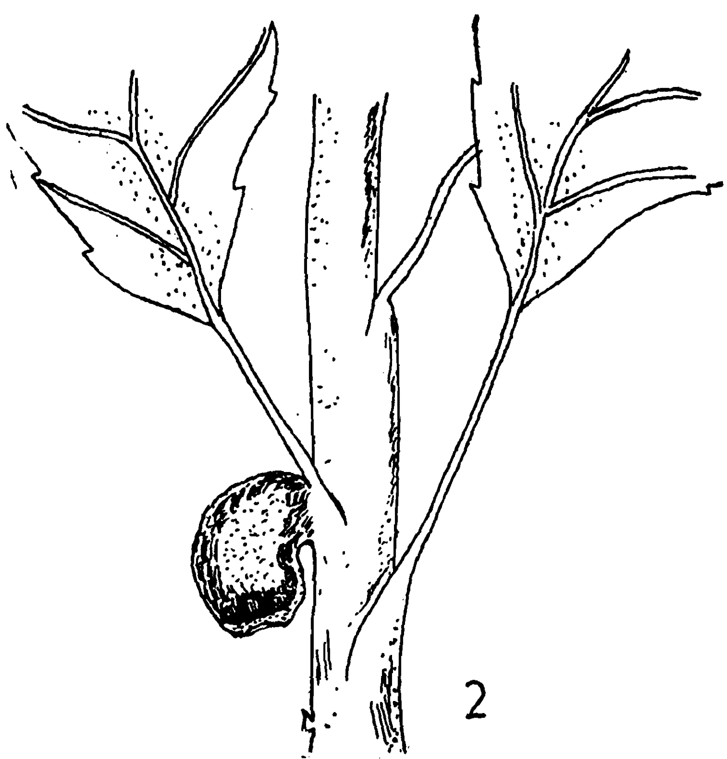

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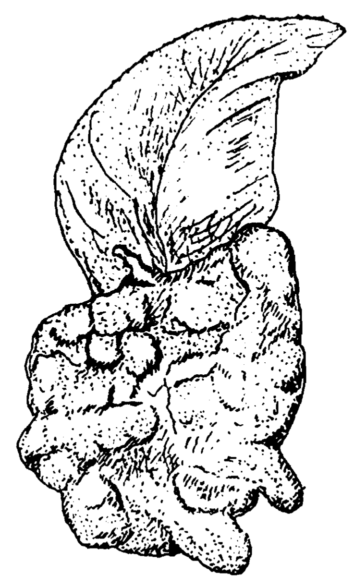

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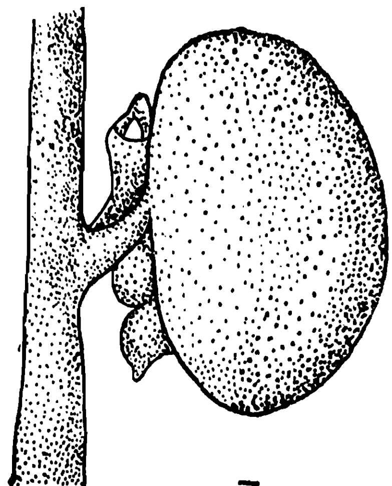
Fig. 1. Stem gall of *Pemphigus napeus* on *Populus* sp.

Fig. 2. Stem gall of *Pemphigus mordvilkoi* on *Populus* sp.

Fig. 3. Stem gall of *Pemphigus naintalensis* on *Populus* sp.

Fig. 6. Leaf gall of *Pemphigus indicus* on unidentified plant

is lacking (4, 7, 8, 11) and two species have only been recently recorded in Pakistan region (9,10) ; of these two, *venosus* is reported to form galls on twigs and branches (like *napaeus*, *mordvilkoi*, *nainitalensis* and *siphunculatus*) and *ignotus* is reported to form leaf-galls, as in the cases of most of the other pemphigids. The key includes 6 of the



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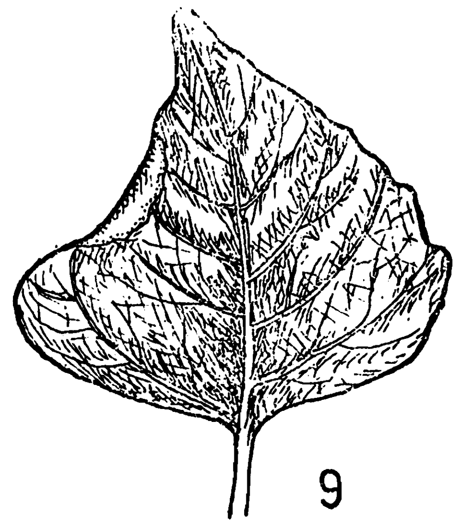

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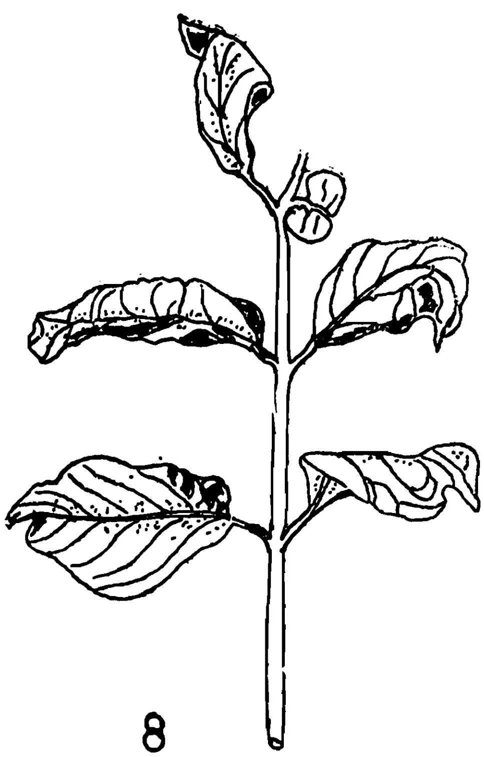

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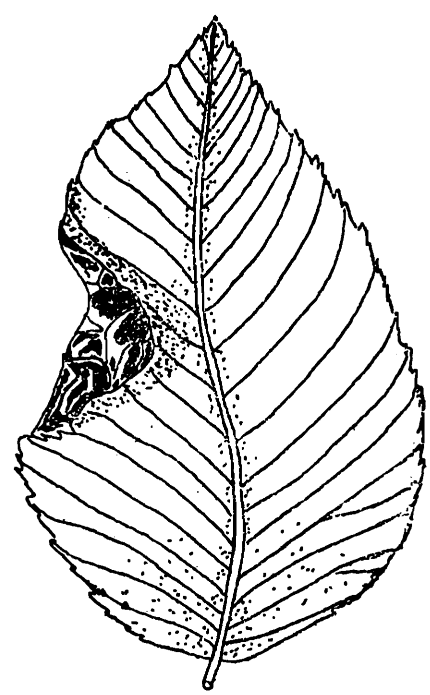

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Fig. 7. Leaf gall of *Pemphigus immunis* on *Populus* sp.

Fig. 8. Leaf gall of *Prociphilus alnifoliae caryae* on *Lonicera* sp.

Fig. 9. Leaf gall of *Thecabius affinis* on *Ranunculus* sp.

Fig. 10. Leaf gall of *Eriosoma ulmi* on *Ulmuz* sp.

first seven species besides an unidentified *Pemphigus*, (no description of gall of *siphunculatus* is available) and excludes last 4 species, because of lack of sufficient report (8, 11 from Afghanisthan) or description (9, 10 from Pakistan); however detailed description of galls of *spyrothecae* Passerini, and *vesicarius* Passerini are available in Roberti (1938).

Galls on **Populus** spp.

1. Closed galls, on stem. ... 2

   On leaves. ... 4

2. Roundish or irregular, sessile, shining green, variegated with yellow or brown spots, distinctly veined, 25-75 mm, on *P. ciliata, P. nigra*; Darkot Pass in N. W. Himalaya (Fig. 1). ... *Pemphigus napaeus* Buckton.

   Galls never veined as above ... 3

3. Subspherical or pyriform, sessile, usually, solitary, yellow or yellowish green, smooth walled, 10-30 mm in diameter with a large gall chamber. On *P. ciliata*; Kumaon Himalaya to Kashmir (Fig. 2). ... *Pemphigus mordvilkoi* Cholodkovsky

   Subspherical, smooth, small, sessile, lateral, 1-2 per branch, 5-7 mm in diameter, much smaller than of *mordvilkoi* on *P. ciliata*; N. W. Himalaya (Fig. 3). ... *Pemphigus nainitalensis* Cholodkovsky

4. On dorsal surface, at leaf base, reddish green, cystolith patterned. On *Populus ciliata* (Fig. 4). ... *Pemphigus* sp.

   Never on leaf base as above ... 5

5. Elongated finger like, reddish green, on dorsal surface of leaf, near midrib or on margin, chamber opens ventrally through a minute pore. On *P. ciliata*; Northwest Himalaya and Sikkim (Fig. 5) ... *Epipemphigus imaicus* (Cholodkovsky).

   Never finger shaped as above; very large sac like or pyriform gall on branches, hard, smooth, with ostiole at apex, and corrugated at the edges; 25-50 mm long. On *P. euphratica*; Kashmir Himalaya (Fig. 7) ... *Pemphigus immunis* Buckton

B. On **Lonicera** sp.

Gall formed by folding of entire leaf blade, forming, somewhat elliptical, irregular shaped structure. On *Lonicera quinquelocularis*; Himachal Pradesh, (Fig. 8) ... *Prociphilus alnifolliae caryae* Baker & Davidson

C. On **Syringa** sp.

Gall hypophyllous, formed by simple leaf folding, appearing as a closed, marginal, tubular structure. On *Syringa emodi*; Uttar Pradesh ... *Prociphilus xylostei* (de Geer)

D. On **Rananculus** sp.

Simple hypophylous (rarely epiphyllous) leaf folding to form a closed tubular marginal gall; Uttar Pradesh (Fig. 9) ... *Thecabius affinis* (Kltb.)

E. On unidentified Plant

Irregular globose, lobed, with rugose surface, thick walled, with a large gall cavity, Eastern Himalaya (Fig. 6) ... *Pemphigus indicus* Keiffer

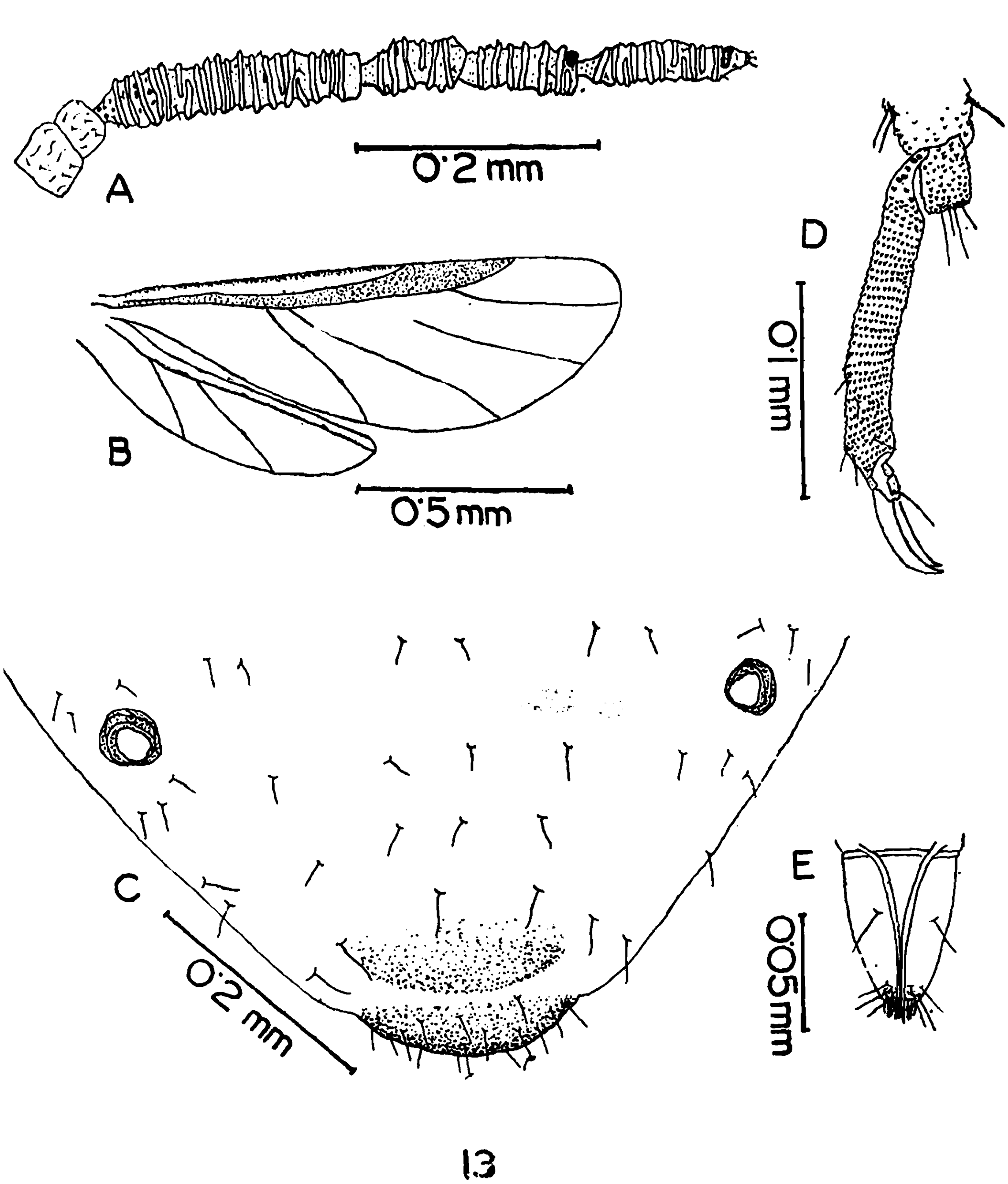


Fig. 13. *Kaltenbechiella carpinicola* sp. nov., alate viviparous female ; A. antenna, B. wings, C. posterior part of abdomen, D. second joint of hind tarsus, E. ultimate rostral segment.

II. Tribe **Eriosomatini**

A. On **Ulmus** spp.

Four species of *Ulmus* are known to grow in Indian region between 1700-2000 m. of which *Ulmus villosa* and *wallichiana* appear to be more common. Eight species of Eriosomatini (of Pemphiginae) (Table 3) are known to form galls on *Ulmus* in the region, of which five have been keyed below ; of the remaining species, no description of galls of *S. indica* Hille Ris Lambers and *T. polychaeta* Hille Ris Lambers is available ; galls of *lanuginosum* have been described from Europe by Hartig (1841).

Galls on **Ulmus** spp.

1. Simple leaf gall, without complex architecture, with a folding to form a closed tubular marginal hypophyllous structure. On *Ulmus montana* ; N. W. India. ... *Eriosoma phoenax* Mordvilko

   Leaf gall, with complex architecture ... 2

2. Gall twisted, spiral, formed of leaf folding or epiphyllous 3

   Gall bladder like ... 5

3. Large, epiphyllous, of various shape, ovoid, clavate, sometimes laterally compressed and lop sided with a short narrow neck, rugose, reddish brown, pubescent on inner wall ; On *Ulmus* sp. Afghanistan ... *Eriosoma lanuginosum* (Hartig)

   Galls spiral, twisted, never as above ... 4

4. Elliptical hard spiral gall with an elongate slit like opening on one side ; leaf margin ventrally folded. On *Ulmus wallichiana* ; N. W. India (Fig. 10) ... *Eriosoma ulmi* (Linnaeus)

   Gall with pouch or chamber, wall of which twisted clockwise and fringed to form a screwed—tubular gall ; on *Ulmus* sp., N. W. India (Fig. 11) ... *Eriosoma kashmiricum* L. K. Ghosh *et al.*

5. Reddish, conical bladder like, solitary, on dorsal leaf surface, on *Ulmus* sp. ; Kashmir (Fig. 10). ... *Tetraneura ulmi* Linnaeus

   Epiphyllous, conical, short, bladder like, greenish not less than 4-5 on single leaf, on *Ulmus* sp. ; Uttar Pradesh (Fig. 12) ... *Tetraneura nigriabdominalis* (Sasaki)

B. On **Carpinus** sp.

A new aphid species of *Kaltenbachiella* viz. *Kaltenbachiella carpinicola* sp. nov. has been collected from open galls on leaf blades, appearing as swollen cup-shaped pouch or cavity, surrounded by thick leaf tissue. Description of the new species is given below.

Fig. 14. Leaf gall of *Baizongia pistaciae* on *Pistacia* sp.

Kaltenbachiella carpinicola sp. nov. (Fig. 13)

Alate viviparous female : Body 2.23-2.55 mm. long with 0.89-1.24 mm. as maximum

TABLE—3

Aphid species in *Ulmus* Galls

	Aphid species		Host Plant	First Record
1.	*Eriosoma* (*Schizoneura*) *kashmiricum* L. K. Ghosh et. al.	—	*Ulmus* sp.	(L. K. Ghosh et. al. 1976)
2.	*Eriosoma lanuginosum* (Harting)	—	*Ulmus* sp.	(Gulamullah, 1941)
3.	*Eriosomae* (S.) *phaenax* Mordvilko	—	*Ulmus montana*	(New record)
4.	*Eriosoma* (S.) *ulmi* Linnaeus	—	*Ulmus wallichiana*	(New record)
5.	*Schizoneurella indica* H. R. L.	—	*Ulmus villosa*	(H. R. L. 1973)
6.	*Tetraneura* (*Tetraneurella*) *nigriadominalis* (Sasaki)	—	*Ulmus* sp,	(New record)
7.	*Tetraneura* (*Tetraneurella*) *polychaetn* H. R. L.	—	*Ulmus villosa*	(H. R. L. 1970)
8.	*Tetraneura* (*Tetraneura*) *ulmi* (Linnaeus)	—	*Ulmus* sp.	(New record)

width. Head brown to blackish brown; vertex slightly rugose with many scattered wax pores and with 4 pairs of short hairs and a single hair placed laterad, with acute to acuminate apices, longest one about 11-14 μ long and about 0.50-0.66 times as long as the basal diameter of the antennal segment III; dorsal median suture present on posterior half of the head; lateral and median frontal prominance not developed. Eyes with indistinct occular tubercles, median ocellus not viewed from the dorsal side. Antennae 6 segmented, brown to blackish brown, about 0.36-0.42 times as long as the body; segments I and II each with 4 short, pointed hairs; hairs on the flagellum sparse, acute, longest one on segment III about 7-11 μ and 0.45-0.50 times as long as the basal diameter of the segment; secondary rhinaria non-ciliated, annular, nearly encircling the width of the segments; segment III with 20-29, IV with 7-10, V with 10-13 and VI with 15-17 secondary rhinaria; primary rhinaria ciliated; processus terminalis about 0.14-0.18 times as long as the base of segment VI. Ultimate rostral segment about 0.54-0.62 times as long as the second segment of hind tarsus, bearing 2-4 accessory hairs. Thorax blackish brown and with scattered wax pores particularly on mesothoracic lobes. Abdomen pale brown, tergum membranous, dorsal hairs thin with acuminate apices, mostly arranged in rows, anterior tergite with 10-12 hairs, usually with 1 pair of spinal, 1 pair of pleural, and 2-3 pair of marginals, longest hair on anterior tergites about 0.22-30 μ long and about 1.0-1.5 times as long as the basal diameter of antennal segment III; 7th tergite with 8-10 hairs and 8th with 6 hairs, longest one about 26-30 μ and 29-33 μ long and about 1.3-1.6 times and 1.3-1.7 times as long as the basal diameter of antennal segment III, respectively. Siphunculi black, sclerotized, ring like, about 0.029-0.044 mm in diameter. Cauda semilunar with 12-14 hairs. Subanal plate sclerotised slightly indented with 29-31 hairs. Subgenital plate with about 24 pairs of hairs in 2-3 rows on posterior margin. Ventral hairs stouter than dorsal hairs. Legs brown, femora stout scabrous, femoral hairs short and pointed, tibiae with long and fine hairs, longest hair on hind tibiae 23-26 μ long, 0.58-0.66 times

Measurements in mm :

Specimen No.	Length	Width	Antena	Antennal segments III	IV	V	VI	urs.	ht_2
1.	2.23	1.07	0.95	0.34	0.11	0.16	(0.16+ 0.03)	0.09	0.16
2.	2.33	1.13	0.93	0.35	0.11	0.13	(0.16+ 0.03)	0.09	0.16
3.	2.20	1.08	0.93	0.34	0.11	0.14	(0.16+ 0.03)	0.09	0.16
4.	2.34	0.89	0.96	0.35	0.12	0.16	(0.17+ 0.03)	0.09	0.15

(1. Holotype, 2-4, Paratypes, alate viviparae female, from *Carpinus* sp. Trijuginarayan, UTTAR PRADESH, INDIA, 5. 6. 1978. Coll. *D. K. Bhattacharya*).

as long as the diameter at the middle of hind tibiae ; tarsi and anterior most portion of tibiae spinulose, spinules on tarsi arranged in rows. First tarsal segments with 4, 4, 5. Empodial hairs 23-30 μ long, 0.63-0.69 times as long as the claws. Forewing with media simple, veins little dusky.

Type material : *Holotype* ; alate viviparous female from *Carpinus* sp. Trijuginarayan, INDIA : UTTAR PRADESH, 5. 6. 1978 (Coll. *D. Bhattacharya*).

Paratypes : 13 alate viviparous females and 3 alatoid nymphs, collection data as in the holotype.

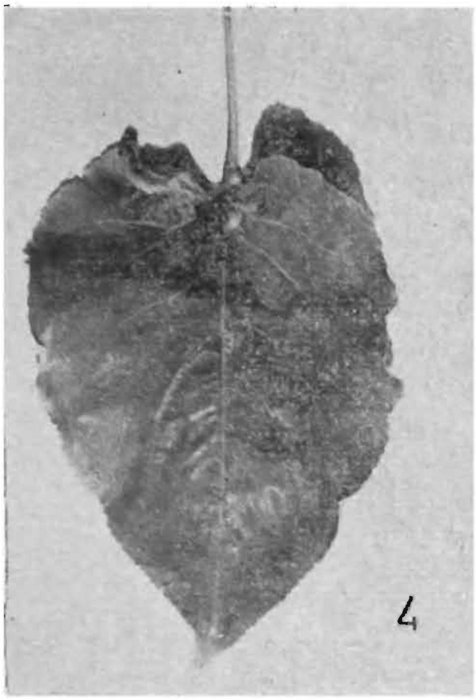
Remarks : Four valid species of *Kaltenbachiella* Schoutedon 1906, are now recognised, viz. *elshotriae* (Shinji) from Japan and Sri Lanka, *japonica* Matsumura from Japan, *pallida* (Haliday) from Holoarctic region and Africa, *ulmifusa* (Walsh & Riley) from U.S.A. The typical life cycle (e.g. *pallida*) involves alternation between galls of *Ulmus* spp., and roots of Labiatae but some like *japonica* Matsumura and perhaps also *elshotriae* (Shinji) complete their life cycle on *Ulmus* and *Elshotzia*. The present collection from *Carpinus*, where these insects form galls, indicate the existence of yet another species, completely different in its host-association, from all other known species. The species, seems closest to North American *ulmifusa* but differs in much larger size of body, in ratio of body to antenna, ultimate rostral segment to second joint of hind tarsus and in having more number of secondary rhinaria etc.

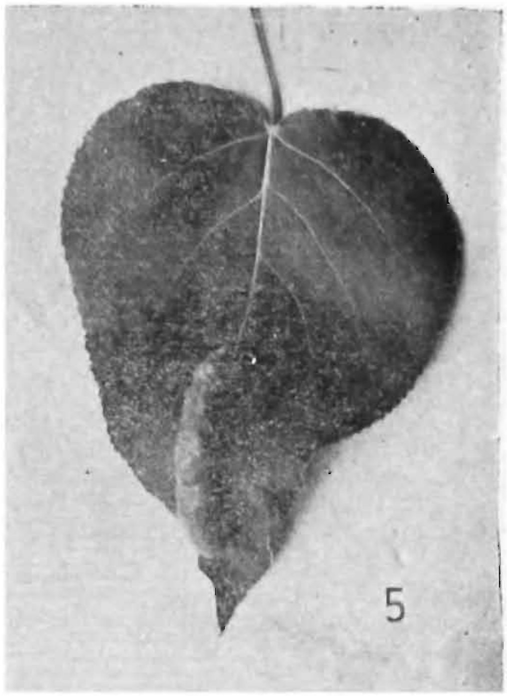
The type materials are deposited in the Department of Zoology, University of Kalyani, except 4 paratypes which are with Fauna Unit, Zoological Survey of India, Calcutta.

III. Tribe **Fordini**

E. On **Pistacia** (Das 1918)

Elongate horn shaped, pod like leaf gall, may be twisted, straight or curved, green or pink, old galls remaining often on trees ; may often be very long and contains hundreds of aphids, N. W. India (Fig. 14). ...





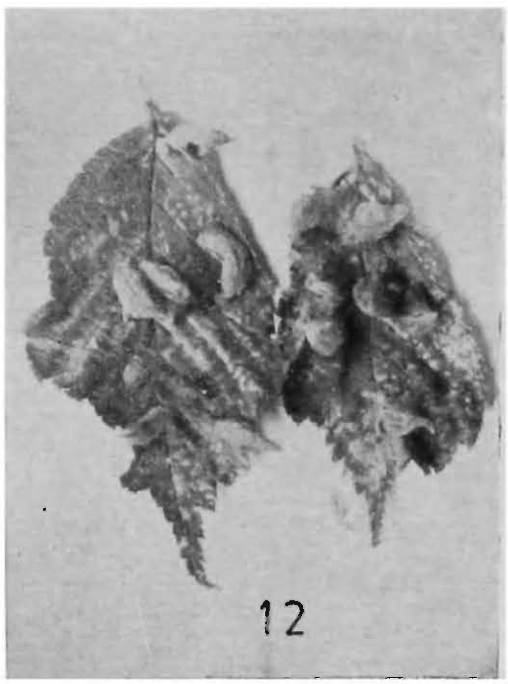


Fig. 4. Leaf gall of *Pemphigus* sp. on *Populus* sp.

Fig. 5. Leaf gall of *Epipemohigus imaicus* on *Populus* sp.

Fig. 11. Leaf gall of *Eriosoma kashmiricum* on *Ulmus* sp.

Fig. 12. Leaf gall of *Tetraneura nigriabdominalis* on *Ulmus* sp.

... *Baizongia pistaciae* (Linnaeus).

F. On **Ailanthus glandulosus** (Chowdhury *et al.*)

Petiole gall, elongate without specific shape with a single cavity. Himachal Pradesh...... *Kaburagia aillanthi* Chowdhury *et al.*

G. On **Toona ciliata** (new record)

Epiphyllous, leaf-folding, covering, brick-red, elliptical, pouch· gall on the margin of leaf blade. Uttar Pradesh...*Forda orientalis* George

MATERIAL EXAMINED FROM GALLS

1.	*Baizonga pistaciaie* Linnaeus	: 8 alatae and nymphs, INDIA : U. P. : Dhakuri, 25. x .1970. Coll. *S. Chakrabarti.*
2.	*Eriosoma ulmi* Riley	: 3 apterae, 4 alatae and nymphs ; INDIA : KASHMIR ; 22.v.1979. Coll. *D. K. Bhattacharya.*
3.	*Eriosoma kashmiricum* L. K. Ghosh *et al.*	: One aptera, many alatae and nymphs, INDIA : U. P. ; Ghangaria, 10. vi. 1978. Coll. *S. Chakrabarti.*
4.	*Eriosoma phoenax* Mordvilko	: Many apterae, 5 alatae and nymphs, INDIA : U. P. ; Bhowali, 24. v. 1969. Coll. *S. Chakrabarti.*
5.	*Epipemphigus imaicus* Chelodkovsky	: Many apterae, alatae and nymphs, INDIA : U. P. ; Mussoorie, 20. vi. 1975 Coll. *S. Chakrabarti* ; 21. vi. 1976 ; Coll. S. P. Maity ; HIMACHAL PRADESH ; Simla, 16. v. 1979. Coll. *D. K. Bhattacharya.*
6.	*Forda orientalis* George	: Many apterae, 7 alatae and nymphs, INDIA : U. P. ; New Forest, Dehradun, 21. vi. 1976, Mussorie, 23. vi. 1976. Coll. *S. Chakrabarti.*
7.	*Kaburagia ailanthi* Chowdhury *et al.*	: 4 alatae and nymphs, INDIA ; U. P. ; Sundardonga valley, 18.x. 1970. Coll. *A. N. Chowdhuri.*
8.	*Kaltenbechiella carpinicola* sp. nov.	: 6 alatae, INDIA : U. P. ; Trijuginarayan, 5. vi. 1978. Coll. *D. K. Bhattacharya.*
9.	*Pemphigus mordvilkoi* Cholodkovsky	: Many apterae, alatae and nymphs, INDIA : U. P. ; Mussooree, 21. vi. 1976. 16, x. 1976, 19. x. 1976. Coll. *S. P. Maity.*
10.	*Pemphigus* sp.	: 2 apterae and nymphs, INDIA ; U. P. ; Ghangaria, 10. vi. 1978. Coll. *S. Chakrabarti,* Lanka 8. vi, 1980, Coll. *D. k. Bhattacharya.*
11.	*Prociphilus alnifoliae caryae* Baker & Davidson	: A alatae and nymphs, INDIA : HIMACAL PRADESH Simla, 13. v. 1979. Coll. *S. P. Maity.*
12.	*Prociphilus xylostei* (de Geer)	: Meny apterae and 10 alatae and nymphs, INDIA : U. P. ; Ghangaria, 13. vi. 1978. Coll. *D..K. Bhattacharya.*
13.	*Tetraneura ulmi* Linnaeus	: Many apterae, 4 alatae and nymphs, INDIA : KASHMIR, 22. v. 1979. Coll. *D. K. Bhattacharya.*
14.	*Tetraneura nioriabdominails* (Sasaki)	: 2 apterae and nymphs, INDIA ; U. P. ; Ghangaria, 10. vi. 1978. Coll. *D. K. Bhattacharya.*
15.	*Thecabius affinis* Kaltenbaci	: 5 apterae and nymphs, INDIA ; U. P. ; Kedarnath, 3. vi. 1978. Coll. *S. Chakrabarti.*

DISCUSSION

Schoutedon (1905) described a new genus and a species *Ceratopemphigus zehntneri*, from 'large foliate galls on undetermined shrubs', and opined that the 'shrub is possibly *Pistacia*'. Howard (1922) and Mani (1948) quoted from Schoutedon (op. cit.) ; Doncaster (1956) redescribed the species from another plant, *Brunfelsia uniflora* and did not mention any thing about the galls. It is known that members of Pemphiginae have Poplar (Pemphigina) or Conifers (Prociphilina) as Primary host and have never been reported from *Pistacia* ; as such leaf gall on undetermined plant may not belong to *Pistacia* ; in case, *Brunfelia* is recorded as secondary host, the genus and species could clearly be more closely correlated with *Prociphilus* (which has an array of primary hosts), as Doncaster (op. cit.) has already shown it taxonomically. But the question remains about the identity of the plant on which foliage gall were found.

Mani (1973) in his pioneering work on 'Plant Galls of India', listed four galls caused by unidentified aphids on *Ulmus wallichiana* (Gall No. 493), *Ulmus luevigata* (Gall 591), *Populus nigra* (Gall 590) and *Populus ciliata* (Gall 592) : All these must have been formed by some Pemphigids as no other aphid would form gall on Elms and Poplars ; the gall 493 may belong to a *Tetraneura* species, while gall 591 appear to be formed by *Schizoneura* species ; Mani, (op. cit.) also mentions a gall, i.e., 112, to be formed by *Schizoneura campestris* but no such species is known in Aphididae and this may refer to *Eriosoma* (*S.*) *ulmi*. Gall 590 on *P. nigra* and 592 on *P. ciliata* appear to be formed by some *Pemphigus* species (as it is, only two species *Pemphigus immunis* Buckton and *Pemphigus spyrotheceae* Passerini, are known from *P. nigra* and at least 6 spp. are known from *P. ciliata*, (see Table 1).

It may be mentioned that *Dasia aedificator* (p. 320, Mani) on *Pistacia integerrima* and unknown aphid on *Pistacia khinjuk*, should both refer to *Baizongia pistaciae* (Linnaeus), as the galls described therein could only be formed by this aphid species.

Two galls on Rosaceae (Gall 422, 417) formed by unidentified aphids have been reported by Mani (op. cit.) which may be caused by some *Schizoneura* species (as secondary host) or even by *Brachycaudus* or some *Myzus* species, as often members these genera show preference for Rosaceaeus hosts.

The present paper outlines several aspects which need further investigation. Records of galls appear to be very few and from restricted collections localities ; as most of the plant species occurs in wide spread areas of temperate climate in North-west India, it is most likely that a more extensive survey of aphid-galls may reveal a better picture of occurrence of these galls and aphid species. This may also help to locate primary host of many of the other species, which have so far been reported only from secondary hosts ; new records of at least 8 species from plant-galls in this paper through recent surveys is notworthy. Biological knowledge of many pemphigid species in the region remain far from complete and correlation of material from both primary (wherever existent) and secondary host could only solve the problem.

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A NEW GENUS AND A NEW SPECIES OF FLYING SQUIRREL (MAMMALIA : RODENTIA : SCIURIDAE) FROM NORTHEASTERN INDIA

By

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ABSTRACT

A new genus and a new species of flying squirrel (Rodentia : Sciuridae) from Namdapha, Tirap District, Arunachal Pradesh, India, a proposed Biosphere Reserve in northeastern India, have been described.

This new genus is distinguished by having a combination of characters found in several seperate genera and, so far known, is monotypic. The type species, also a new taxon, is characterized by its gorgeous red, white and gray colours on the dorsum and the ventrum being largely white.

INTRODUCTION

Recently, in course of a faunistic survey in Namdapha, Tirap District, Arunachal Pradesh, a proposed Biosphere Reserve area, during March-May 1981, a team headed by Dr. Shyamrup Biswas, Zoologist of the Zoological Survey of India, collected a unique flying squirrel. After critical examination, it was found to be an undescribed form belonging to a hitherto undescribed genus.

Since it will take some time to work out and report upon the entire collection, opportunity is taken to describe the new genus and the new species of this flying squirrel in the present communication.

All measurements are expressed in millimetres unless otherwise stated. Cranial measurements are taken after Ellerman (1963). Names of colours with initial capital letters are after Ridgway (1912).

SYSTEMATIC ACCOUNTS

Order RODENTIA

Family SCIURIDAE

Subfamily PETAURISTINAE

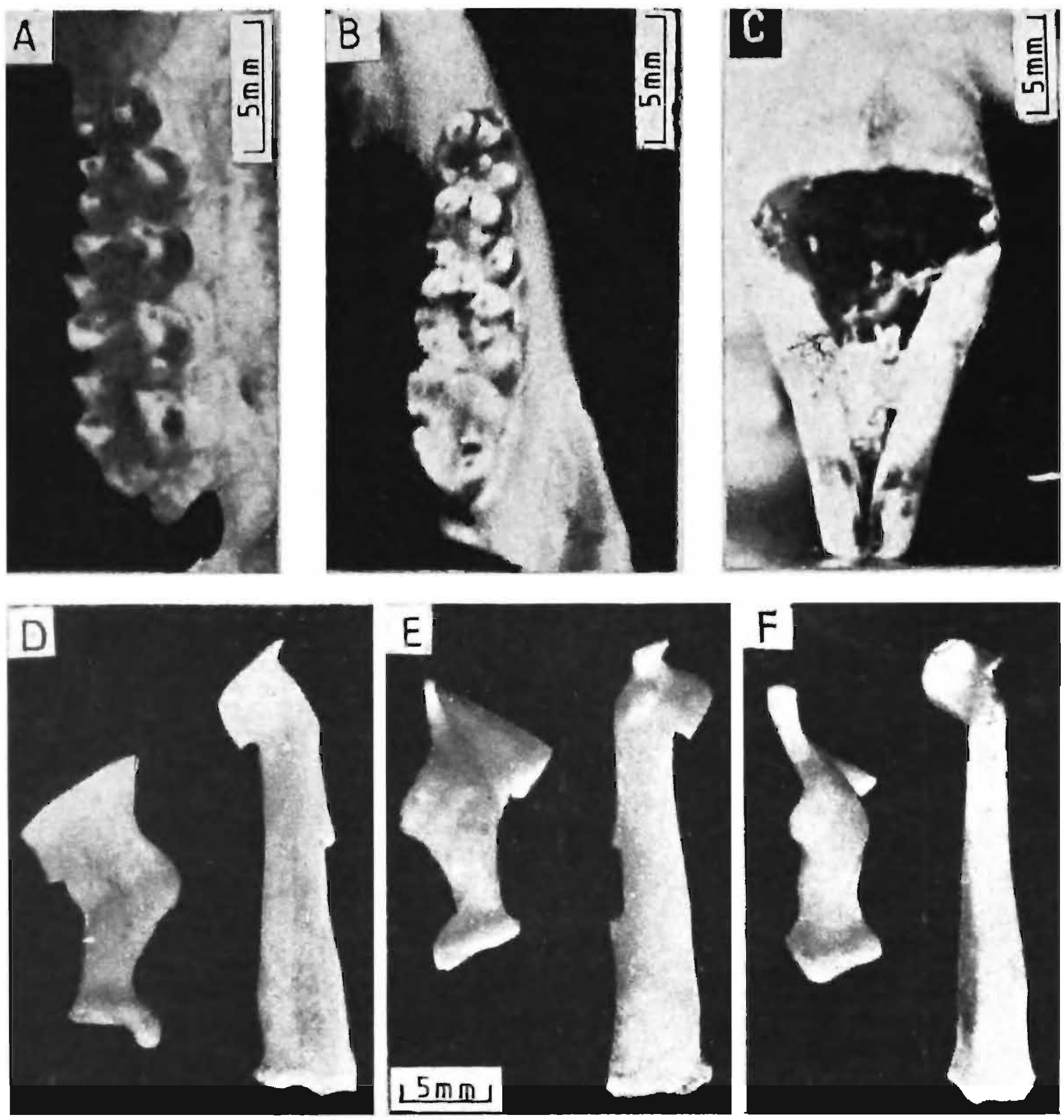
Genus **Biswamoyopterus***, new genus

DESCRIPTION

Size large, total length 1010 mm, head and body being 405 mm. Has a distinct interfemoral membrane connecting the basal one third of the tail. The tail is cylindrical, not distichous. Pelage thick, soft and gorgeously coloured on the dorsum, the vetrum being largely white. Each ear conch; apparently denuded, has tufts of long hairs at the base, one at the anterior margin, one at the posterior margin and another on the dorsal part.

Cranially, it is characterized by large orbit, very large bulla, relatively shorter palate

* The generic name has been derived in honour of Dr. Biswamoy Biswas, Joint Director (Retired), Zoological Survey of India, who has been my mentor since last twenty years.



A. Upper tooth row (right side) of the Holotype of *Biswamoyopterus biswasi* Saha.

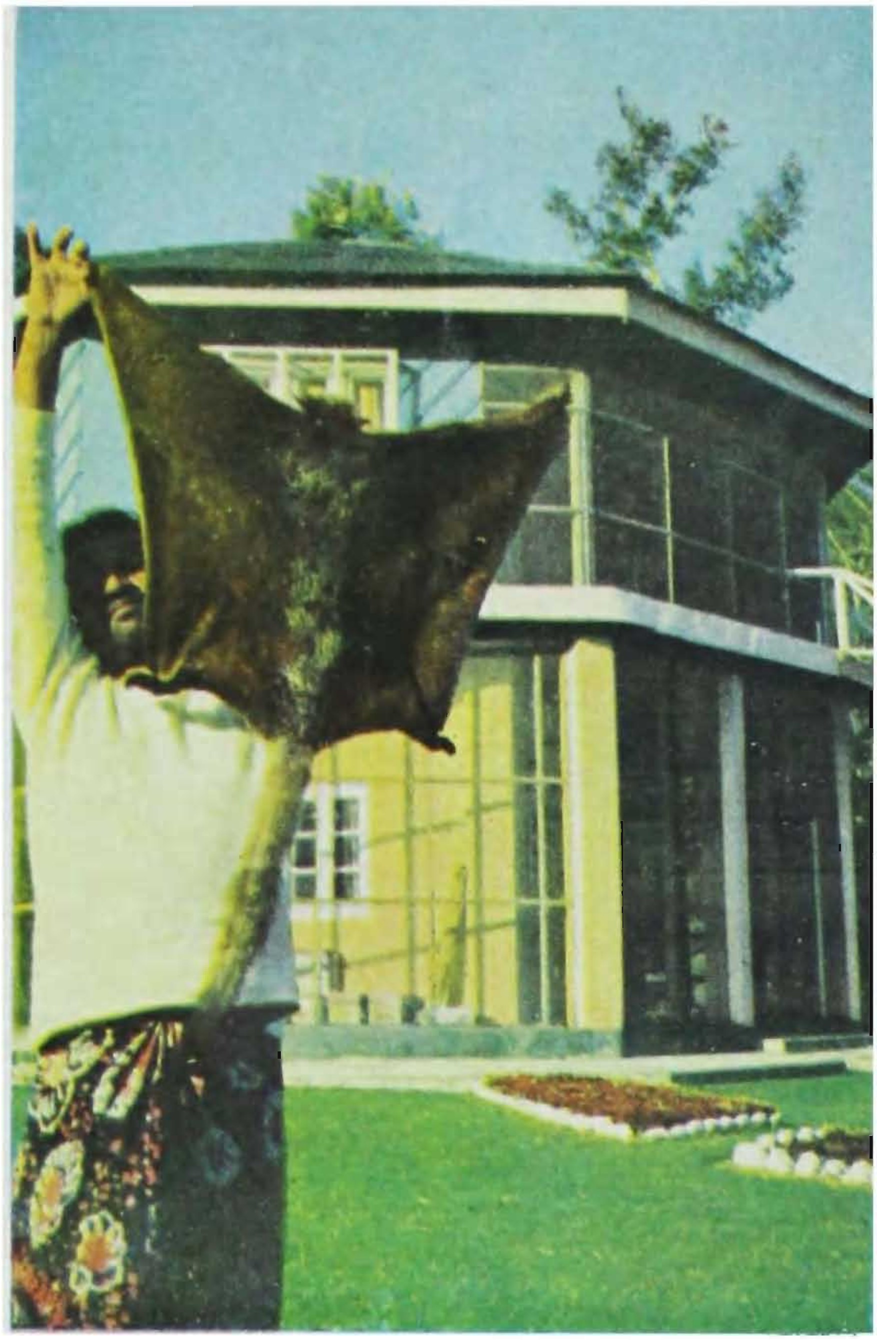
B. Lower tooth row (right side) of the same.

C. Upper incisors (in front view) of the same to show the unpigmented enamel although patchily stained and very feebly grooved inner margin of each tooth.

D. Baculum of the Holotype of *Biswamoyopterus biswasi* Saha (left) compared with that of *Petaurista candidulus* Wroughton (right) in dorsal view.

E. The same in ventral view.

F. The same in lateral view (right side).



Dorsum of the Holotype of *Biswamoyopterus biswasi* Saha
(the dead animal before skinning).

Dorsum of the Holotype of *Biswamoyopterus biswasi* Saha
(the dead animal before skinning).

Close up of the head region to show the ear tufts of Holotype of *Biswamoyopterus biswasi* Saha (the dead animal before skinning).

ending in line with the tooth row, deeply notched frontal depression, wider zygomatic width, and the zygomatic spring and muzzel giving an overall acute triangular outline to the skull in dorsal profile.

In dentition, it is characterized by the following features. The incisors are not pigmented with red although the white enamel is patchily stained with dark brown, and the upper incisors are feebly grooved on the inner margin (Plate V, Fig. C). Cheek teeth are brachydont but simplified and strongly cuspidate, lacking wrinkles and sculptures on enamel. Each molariform tooth is subtriangular in outline with the blunt apex on the lingual side. Both the upper premolars are functional. Pm^3 occupies the middle of the internal half of the tooth row. On the upper series Pm^4 is the largest tooth with three strong cusps, well seperated from each other, are placed on the labial side and one strong cusp on the lingual side ; another small cusp is present in the middle of the posterior transverse ridge. M^1 and M^2 are with two prominent cusps on the labial side and two on the lingual side, of which the postero-internal cusp is lowest ; another feeble cusp is present on the posterior transverse ridge. M^3 strongly built and has a deep central valley with one major cusp on either side of it placed anteriorly ; the margin of the tooth is sharply laminated, more prominently so on the posterior part. The transverse ridges on the molariform teeth are obliquely placed connecting the posterior cusp of the labial side with the anterior cusp of the lingual side. The lower M_3 is, however, the largest tooth in the combined upper and lower series. The lower molariform teeth are rhomboid in outline (Plate V, Fig. A, B).

The baculum is strongly built ; apex hollowed and spatulated but is very short in length. The proximal part has a short but robust shaft and the distal apical part large, flattened and curved into a very wide spout, without any accessory structures (Plate V, Fig. D, E, F).

Discussion

The new genus exhibits a combination of characters that are present in several distinct genera and are of much taxonomic values. In external features, it resembles the giant flying squirrels of the genus *Petaurista* Link, 1795, in its large size, cylindrical and non-distichous tail, and by the presence of a well developed interfemoral membrane. These characters are also found in *Aeretes* Allen, 1940 and *Aeromys* Robinson & Kloss, 1915. But, the present genus differs from those three genera by detailed taxonomic characters, externally by the presence of ear tufts and in dentition. Ear tufts are also found in *Belomys* Thomas, 1908 and *Trogopterus* Heude, 1898 but these two genera do not have any interfemoral membrane and their tail is not cylindrical but distichous.

In dentition, the new genus has the unique feature of its incisors being not pigmented with red as they are in all other known flying squirrels. The cheek teeth are brachydont but much simplified and strongly cuspidate. Enamel of the cheek teeth is not wrinkled or sculptured as found in the giant flying squirrels, specially, *Petaurista*. Simplified molariform teeth retained much of the basic *Sciurus*-type pattern, similar to *Hylopetes* Thomas, 1908 and *Aeromys*, but differ from them by upper Pm^4 being larger than M^1 as found in *Belomys* and *Trogopterus*. It differs from the last two genera who have complicated cheek teeth with much wrinkles and folds on enamel and also by other details.

The baculum of the new genus, at the first glance, appears similar to that of *Belomys* but the nature of curvature of the apical spatulate hook and absence of accessory structure it differs from that in *Belomys*.

This new genus like *Aeromys*, abridges the giant flying squirrels and the smaller flying squirrels. To the former by presence of inter-femoral membrane and non-distichous, cylindrical tail and with the latter by much simplified brachydont molariform teeth retaining much of the basic *Sciurus*-type pattern and also by presence of ear tufts as found in some smaller flying squirrels.

The new genus *Biswamoyopterus* Saha, so far known, is monotypic and represented by the type species which is also a new species described below.

Biswamoyopterus biswasi*, new species

DESCRIPTION

Colouration : body above, in general, Morocco Red grizzled with white, a conspicuous blob of Pale Violet Gray present on the top of crown ; patagium glossy Mehgony Red ; particoloured tail beyond interfemoral membrane proximally Pale Smoky Gray, changing distally to Vinaceous Rufous, then to Hay's Russet and finally to Clove Brown near tip, the proximal gray part is also washed with red ; muzzle mostly Vinaceous Rufous changing to a broad ring of Mehgony Red around eyes ; a narrow black line forms the nasal bridge ; hands and feet darker than body ; ear tuft on posterior margin silvery white but that of anterior margin basally white and changing to Morocco Red distally, some all silvery white hairs are also mixed up with those bicoloured hairs, tufts on dorsal base of the ear Morocco Red and extending to middle of the neck from each side ; neck region otherwise coloured Mehgony Red ; some silvery white hairs are scattered over forehead and cheeks ; forehead is washed with red because of the hairs of that region being faintly tipped with red ; lower cheeks mixed gray and white. Body below is white with hairs having Pearly Gray bases ; patagium below washed with faint Orange-Rufous ; interfemoral membrane with a band of Pale Morocco Red near margin, the margin is also grizzled with gray and white, more so near tail root ; underarm Mehgony Red, intensified distally ; underfeet Morocco Red near ankles ; a black line running from each side of propatagium extends to wrist and margin of the palm, this also extending over dorsal side of manus, particularly to fingers ; margins of soles of feet black ; lateral margin of patagium and scrotal sac Vinaceous Slate grizzled with silvery white ; distal end of scrotal sac adorned with long hairs which are tipped Vinaceous Rufous ; chin dusky with a spot of Clove Brown below lower lip. (Plate VI, Figs. A, B).

Each hair on dorsum is banded with gray basally and red distally, but pattern is different in different region. Each body hair is coloured Vinaceous Slate and Smoky Gray on basal onethird and red on remaining part. White hairs that produce grizzled effect are basally gray, middle part white and finely tipped with black. Haris on loin and outer part of patagium Orange Cinnamon on base and red on distal part. Underwool coloured intense

* The species name has been derived after the collector of the Holotype, Dr. Shyamrup Biswas, Zoologist, Zoological Survey of India, the Leader of the Namdapha Expedition, 1981.

cinnamon. Each hair on proximal twothird of tail banded by various shades of colours from base to tip and arranged in the following manner : Vinaceous Slate (20%), Pale Smoky Gray (next 40%), Orange Cinnamon (15%), Vinaceous Rufous (10%) and the remaining free end (5%) being Hay's Russet to Clove Brown ; in similar fashion, each hair on distal onethird of tail Orange Cinnamon (10%), Pale Smoky Gray (next 30%), Orange Cinnamon again (5%) and the rest (55%) grading from Hay's Russet to Clove Brown. Intensity of gray on tail decreases with the increase of russet and brown from proximal to distal region.

Cranial features are characterized by the following : very large orbit (33.9% of occipitonasal length), bulla enlarged and inflated (21.4%), large palatal foramina (8.84%), foramen magnum much enlarged, frontal depression very deeply notched, zygomatic arch much wide (65.6%), interparietal well demarcated, fronto-parietal ridge strong anteriorly and confluent with posterior rim of postorbital process, the latter is more flat and broad, transverse flank of squamosal that contributes to zygomatic arch is flat, broad and convex anteriorly, occipital plane much convex, peroccipital process very short and closely inclined to tympanic bulla, the latter being very large and approaching each other anteriorly resulting narrowed anterior part of basioccipital and posterior part of basisphenoid, intermaxillary foramen conspicuously large.

Short and robust baculum has a dumbbell-shaped twisted proximal shaft and widely expanded and upturned distal apical part, the latter is very broad and curved, and projecting from the left hand side like a spout of jug ; apical part is subequal to shaft in length.

Type Material : *Holotype* one male ; skin, skull and baculum, deposited in the National Zoological Collection, Zoological Survey of India, Calcutta, Z.S.I. Reg. No. 20705, collected by Shyamrup Biswas on 27 Apr. 1981.

Type Locality : Deban, (alt. *c*. 350 metre), 26 km east of Miao, Namdapha, Tirap District, Arunachal Pradesh, India.

Measurements of the Holotype : External : head and body 405, tail 605, hindfoot 78 (with claws 83), ear 46, greatest patagial expanse 760, interfemoral membrane connects 186 of tail length from root.

Cranial : occipitonasal 72.4, condylobasal 70.1, palate 34.7, diastema 15.7, palatal foramina 6.4, bulla 15.5, upper tooth row 15.5, nasal 20.9, orbit 24.6, frontal length 28.6, least interorbital width 19, greatest zygomatic width 47.5 ; upper teeth : Pm^3 2.4, Pm^4 4.4, M^1 3.6, M^2 3.6, M^3 3.4 ; lower teeth : Pm_4 2.9, M_1 3.4, M_2 3.4, M_3 4.4.

Baculum : total length 16.7, shaft length 11.5, width of apical hook 6.8.

Discussion

This new species, which may be called the Namdapha Flying Squirrel, is a beautifully coloured animal with gorgeous fur. In brilliance of coat colour, it approximates to some species of the genus *Petaurista*, specially to *Petaurista taylori* Thomas.

The Holotype was collected at early hours of evening (at 20.15 hrs) from a lofty Nahar tree (*Mesua ferrea*). Another species of flying squirrel, namely, *Petaurista candidulus* Wroughton, fairly common in that terrain, was also found foraging near by. The range of this new species, so far known, is only in the catchment area of the Noa Dihing River, particularly on the western slope of the Patkai Range in Namdapha area. Its extraordinary characters as well as its range of distribution are of important acadēmic interest, particularly in regard to its bearing on the phylogeny of flying squirrels and zoogeography of the region.

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FURTHER STUDY ON THE ASPECTS OF POPULATION FLUCTUATIONS OF PHLEBOTOMID SANDFLIES (DIPTERA : PHLEBOTOMIDAE) IN NORTH BIHAR

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ABSTRACT

This paper deals with the continued study of numerical fluctuation of populations of phlebotomid sandflies of Darbhanga, Sitamarhi, Samastipur and Muzaffarpur districts of North Bihar for two more years, i.e., from November 1979 to September 1981. A total number of 14,587 flies belonging to *Phlebotomus argentipes* Annandale and Brunetti, *Phlebotomus papatasi* Scopoli and *Sergentomyia babu* (Annandale) were collected, the increase and decrease of their populations are discussed in relation to abiotic factors, and the cause for the spurt in population is also discussed.

INTRODUCTION

In the earlier paper (1981), I had given in detail the significance of the study, a brief description of the nature of the terrain along with a map showing the collection localities, an account of the different kinds of houses of North Bihar, the mode of collection of phlebotomid sandflies, a graphical representation of the flies collected, their seasonal abundance for one year, etc. The present paper deals with the continuation of this study for two more years, i.e., from November 1979 to September 1981, and regular bimonthly collections of flies were made per man hour from all the same eleven localities —three each from Muzaffarpur (Chapralasgiripur, Sipahapur and Pirocha), Sitamarhi (Gotbavadevpur, Sakanbavadevpur and Thumma) and Samastipur (Tajpur, Adharpur and Shambu Patti) districts and two from Darbhanga (Derhar and Khansi Simidi) district.

RESULTS

A total number of 14,587 flies belonging to *Phlebotomus papatasi* Scopoli, *P. argentipes* Annandale and Brunetti and *Sergentomyia babu* (Annandale) were collected from Darbhanga, Sitamarhi, Samastipur and Muzaffarpur districts (Table I-VIII). It can be seen from the tables that as in the first year *P. papatasi* is the predominant species followed by *S. babu* and *P. argentipes*. In cases of *P. papatasi* and *S. babu* the females outnumbered the males whereas in *P. argentipes* both sexes are almost equal in number (total number of females 256, total number of males 250). However, in the first year study (1978-79) in the case of *P. argentipes* it was observed that the females were lesser (48) than the males (82). Overall analysis shows that the total population contains 87.34% *P. papatasi*, 2.43% *P. argentipes* and 10.23% *S. babu* in 1979-80, and 84.88% *P. papatasi*, 4.44% *P. argentipes* and 10.68% *S. babu* in 1980-81, the only notable

TABLE I.—*Phlebotomid sandflies collected per man hour from indoors in Darbhanga District from November 1979 to September 1980 along with climatological data*

	Nov. 79			*Jan. 80*			*March 80*			*May 80*			*July 80*			*Sept. 80*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	33	81	114	1	—	1	22	68	90	83	138	221	187	322	509	147	309	456	1391	82.36
P. argentipes	7	8,	15	—	—	—	3	—	3	—	—	—	4	2	6	12	21	33	57	3.37
S. babu	12	23	35	1	1	2	10	13	23	24	26	50	38	56	94	15	22	37	241	14.27
Grand total	52	112	164	2	1	3	35	81	116	107	164	271	229	380	609	174	352	526	1689	100.00
Temp. Mean maxi °C		29.7			23.6			32.2			35.0			33.6			32.6			
Temp. Mean mini °C		18.7			12.5			19.8			26.1			27.9			27.1			
Mean monthly rainfall (mm)		2.6			0.1			0.8			4.8			13.8			5.5			
Mean monthly humidity (%) at 17.30		70.4			70.4			52.8			63.8			82.7			81.3			
Mean wind velocity (Km. p. h) at 08.30		0.0			0.3			0.8			2.7			1.4			1.3			

TABLE II.—*Phlebotomid sandflies collected per manhour from indoors in Darbhanga District from November 1980 to September 1981 along with climatological data*

	Nov. 80			*Jan. 81*			*March 81*			*May 81*			*July 81*			*Sept. 81*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	16	52	68	—	—	—	18	25	43	67	140	207	184	306	490	162	317	479	1287	71.86
P. argentipes	46	70	116	—	—	—	22	13	35	6	14	20	15	11	26	5	—	5	202	11.28
S. babu	7	12	19	—	—	—	26	37	63	21	41	62	43	68	111	19	28	47	302	16.86
Grand total	69	134	203	—	—	—	66	75	141	94	195	289	242	385	627	186	345	531	1791	100.00
Temp. mean maxi °C		26.5			16.7			27.3			33.8			28.5			29.8			
Temp. mean mini °C		20.0			8.6			18.7			24.6			25.6			25.6			
Mean monthly rainfall (mm)		0.0			0.6			1.2			1.7			20.2			7.1			
Mean monthly humidity (%) at 17.30		63.3			72.8			45.3			62.1			81.9			78.2			
Mean wind velocity (Km. p. h) at 08.30		0.0			0.3			1.3			2.0			1.8			3.3			

TABLE III.—*Phlebotomid sandflies collected per man hour from indoors in Sitamarhi District from November 1979 to September 1980 along with climatological data*

Name of species	*Nov. 79* M	F	T	*Jan. 80* M	F	T	*March 80* M	F	T	*May 80* M	F	T	*July 80* M	F	T	*Sept. 80* M	F	T	Total	% of the grand total
P. papatasi	65	160	225	—	—	—	152	142	294	198	294	492	382	473	855	276	364	640	2506	87.26
P. argentipes	2	1	3	—	—	—	1	3	4	1	2	3	3	1	4	14	17	31	45	1.57
S. babu	16	19	35	—	—	—	27	32	59	27	33	60	36	78	114	22	31	53	321	11.18
Grand total	83	180	263	—	—	—	180	177	357	226	329	555	421	552	973	312	412	724	2872	100.01
Temp. mean maxi °C		29.7			23.6			32.2			35.0			33.6			32.3			
Temp. mean mini °C		18.7			12.5			19.8			26.1			27.9			27.1			
Mean monthly rainfall (mm)		2.6			0.1			0.8			4.8			13.8			5.5			
Mean monthly humidity (%) at 17.30		70.4			70.4			52.8			63.8			82.7			81.3			
Mean wind velocity (Km. p. h) at 08.30		0.0			0.3			0.8			2.7			1.4			1.3			

TABLE IV.—*Phlebotomid sandflies collected per man hour from indoors in Sitamarhi District from November 1980 to September 1981 along with climatological data*

Name of species	*Nov. 80* M	F	T	*Jan. 80* M	F	T	*March 81* M	F	T	*May 81* M	F	T	*July 81* M	F	T	*Sept. 81* M	F	T	Total	% of the grand total
P. papatasi	45	115	160	—	—	—	105	91	196	217	291	508	407	529	936	338	474	812	2612	86.49
P. argentipes	3	3	6	—	—	—	9	7	16	7	7	14	21	14	35	4	1	5	76	2.52
S. babu	28	41	69	—	1	1	29	34	63	20	26	46	35	59	94	22	37	59	332	10.99
Grand total	76	159	235	—	1	1	143	132	275	244	324	568	463	602	1065	364	512	876	3020	100.00
Temp. mean maxi °C		26.5			16.7			27.3			33.8			28.5			29.8			
Temp. mean mini °C		20.0			8.6			18.7			24.6			25.6			25.6			
Mean monthly rainfall (MM)		0.0			0.6			1.2			1.7			20.2			7.1			
Mean monthly humidity (%) at 17.30		63.3			72.8			45.3			62.8			81.9			78.2			
Mean wind velocity (Km. p. h) at 08.30		0.0			0.3			1.3			2.0			1.8			3.3			

TABLE V.—*Phlebotomid sandflies collected per man hour from indoors in Samastipur District from November 1979 to September 1980 along with climatological data*

	Nov. 79			*Jan. 80*			*March 80*			*May 80*			*July 80*			*Sept. 80*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	22	37	59	—	—	—	11	19	30	43	52	95	76	133	209	78	124	202	595	81.84
P. argentipes	2	4	6	—	—	—	5	3	8	2	11	13	6	8	14	9	9	18	59	8.12
S. babu	2	3	5	—	—	—	4	6	10	7	7	14	12	16	28	3	13	16	73	10.04
Grand total	26	44	70	—	—	—	20	28	48	52	70	122	94	157	251	90	146	236	727	100.00
Temp. mean maxi °C	29.3			23.0			31.2			34.6			32.3			32.7				
Temp. mean mini °C	17.9			8.9			14.7			21.5			25.5			25.2				
Mean monthly rainfall (mm)	2.9			0.1			0.5			2.7			15.4			5.7				
Mean monthly humidity (%) at 17.30	79.7			69.7			47.9			73.6			83.4			79.9				
Mean wind velocity (Km. p. h) at 08.30	0.6			1.3			2.4			3.6			2.5			2.5				

TABLE VI.—*Phlebotomid sandflies collected per man hour from indoors in Samastipur District from November 1980 to September 1981 along with climatological data*

	Nov. 80			*Jan. 81*			*March 81*			*May 81*			*July 81*			*Sept. 81*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	29	54	83	—	—	—	14	27	41	37	49	86	88	163	251	91	148	239	700	85.89
P. argentipes	3	4	7	—	—	—	2	1	3	—	—	—	9	7	16	8	3	11	37	4.54
S. babu	—	4	4	—	—	—	2	8	10	7	4	11	9	21	30	7	16	23	78	9.57
Grand total	32	62	94	—	—	—	18	36	54	44	53	97	106	191	297	106	167	273	815	100.00
Temp. mean maxi °C	31.4			22.3			28.6			35.0			33.2			33.5				
Temp. mean mini °C	21.9			10.2			17.0			23.1			27.3			28.5				
Mean monthly rainfall (mm)	0.0			0.8			1.3			1.8			17.5			6.5				
Mean monthly humidity (%) at 17.30	71.6			75.1			48.9			61.3			83.8			81.3				
Mean wind velocity (Km. p. h) at 08.30	0.4			1.4			1.9			3.3			2.5			5.8				

TABLE VII.—*Phlebotomid sandflies collected per man hour from indoors in Muzaffarpur District from November 1979 to September 1980 along with climatological data*

	Nov. 79			*Jan. 80*			*March 80*			*May 80*			*July 80*			*Sept. 80*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	63	92	155	1	—	1	47	91	138	105	156	261	228	385	613	192	296	488	1656	94.57
P. argentipes	—	—	—	—	—	—	2	—	2	—	2	2	1	1	2	3	1	4	10	0.57
S. babu	3	5	8	—	2	2	4	7	11	9	11	20	13	20	33	3	8	11	85	4.85
Grand total	66	97	163	1	2	3	53	98	151	114	169	283	242	406	648	198	305	503	1751	99.99
Temp. mean maxi °C	29.3			23.0			31.2			34.6			32.3			32.7				
Temp. mean mini °C	17.9			8.9			14.7			21.5			25.5			25.2				
Mean monthly rainfall (mm.)	2.9			0.1			0.5			2.7			15.4			5.7				
Mean monthly humidity (%) at 17.30	79.7			69.7			47.9			73.6			83.4			79.9				
Mean wind velocity (Km. p. h) at 08.30	0.6			1.3			2.4			3.6			2.5			2.5				

TABLE VIII.—*Phlebotomid sandflies collected per man hour from indoors in Muzaffarpur District from November 1980 to September 1981 along with climatological data*

	Nov. 80			*Jan. 80*			*March 81*			*May 81*			*July 81*			*Sept. 81*				% of the
Name of species	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	Total	grand total
P. papatasi	80	135	215	—	—	—	73	126	199	143	201	344	224	356	580	173	297	470	1808	94.07
P. argentipes	—	—	—	—	—	—	5	1	6	1	—	1	4	3	7	3	3	6	20	1.04
S. babu	5	11	16	—	—	—	11	4	15	7	12	19	11	19	30	6	8	14	94	4.89
Grand total	85	146	231	—	—	—	89	131	220	151	213	364	239	378	617	182	308	490	1922	100.00
Temp. mean maxi °C	31.4			22.3			28.6			35.0			33.2			33.5				
Temp. mean mini °C	21.9			10.2			17.0			23.1			27.3			28.5				
Mean monthly rainfall (mm)	0.0			0.8			1.3			1.8			17.5			6.5				
Mean monthly humidity (%) at 17.30	71.6			75.1			48.9			61.3			83.8			81.3				
Mean wind velocity (Km. p. h) at 08.30	0.4			1.4			1.9			3.3			2.5			5.8				

TABLE IX.—*Relationship between sandflies and variables (temperature, rainfall and humidity)*

	Correlation coefficient between number of sandflies and variables	Regression line of number of sandflies (Y) on variables (X) Y=a+bx
	Darbhanga District	
P. papatasi		
Temperature	0.6131**	Y = −601.16+31.43 x
Humidity	0.7942*	Y = −641.39+12.94 x
S. babu		
Rainfall	0.8423*	Y=28.38+4.16 x
	Samastipur District	
P. papatasi		
Temperature	0.8084*	Y = −463.64+21.75 x
Rainfall	0.8193*	Y=63.91+11.73 x
Humidity	0.7777*	Y = −215.53+4.85 x
P. argentipes		
Temperature	0.7421*	Y = −19.63+1.12 x
Rainfall	0.6293**	Y=7.85+0.50 x
Humidity	0.6599**	Y = −5.94+0.23 x
S. babu		
Temperature	0.6576**	Y = −36.13+1.88 x
Rainfall	0.9179*	Y=8.61+1.28 x
	Sitamarhi District	
P. papatasi		
Humidity	0.6353**	Y = −1548.89+32.92 x
	Muzaffarpur District	
P. papatasi		
Temperature	0.8643*	Y = −685.76+38.20 x
Rainfall	0.8621*	Y=169.76+28.73 x
S. babu		
Temperature	0.6886**	Y = −20.40+1.4 x
Rainfall	0.8284*	Y=9.39+1.28 x

*Significant at 1% level.
**Significant at 5% level.

variation being the increase in the population of *P. argentipes* in the third year of the study.

Relationship between sandfly population and climatological factors: Data pertaining to climatological factors and population density of sandflies were subjected to statistical analysis for finding out regression correlation and dependence of the number of sandflies (Y) on each variable (temperature, rainfall and humidity) considered here (Table IX).

It has been found that in Darbhanga district the population of *P. papatasi* has shown significant correlation with temperature and humidity, and *S. babu* with rainfall; in Samastipur district the population of *P. papatasi* and *P. argentipes* with temperature, rainfall and humidity, and *S. babu* with temperature and rainfall; in Sitamarhi *P. papatasi* with humidity; and in Muzaffarpur *P. papatasi* and *S. babu* with temperature and rainfall.

Regression line were obtained by pooling together the data obtained during two years. The combined regression lines drawn along with respective scattered diagrams are shown in figures 5-20.

Seasonal Abundance

The incidence of sandflies is similar to that of first year study, in extreme winter the flies are practically absent and their peak season in monsoon, i.e., from July to October. In summer the population is comparatively lower than in the monsoon. The number of flies caught per man hour varies from 0 in January to 437 in July 1981. As in the first year, sandfly activity is maximum in Sitamarhi district.

Discussion

The pattern of seasonal abundance of *P. papatasi*, *P. argentipes* and *S. babu* for two years is similar to that of the first year. As pointed out in my earlier paper (1981), it is to be ascertained whether *P. argentipes* or *P. papatasi* is the vector of kala-azar in North Bihar or both of them are vectors side by side.

The application of insecticides was slowed down by the beginning of 1980 due to the decrease in the number of cases of kala-azar, consequent to which there is a sudden increase in the fly activity. There is 30.47% increase in the number of flies in the second year and only a slight increase (7.23%) in the third year from the preceding year thus showing that the fly activity is more or less steady in the absence of systematic application of insecticides. Consequent to the spurt in fly activity we are sitting on a 'live volcano' which can erupt at any moment causing another outbreak of the dreaded kala-azar.

Additional Observations

It has been found that the flies prefer moderately dirty of shabby corners to the extremely dirty or clean corners of the rooms. It may be due to the thick cobweb (on the contrary a little cobweb helps their resting) or a thick coat of dust present in the dirty corners which makes their resting difficult as they get entangled in the cobweb or their body gets covered with dust. Similarly the flies detest the extremely clean corners of the rooms, the reason of which is difficult to understand, perhaps it may be due to their difficulty in resting for longer periods on smooth surfaces.

Sandflies have been found hanging on the cobweb, which the collector may mistake for dead ones. When disturbed they dart and hang themselves again in cobweb, if available. While using the aspirator, if it is not sucked in with force, often the flies cling on to the surface and may escape as soon as the suction is over.

As mentioned in the earlier paper, flies are seldom found in brick-walled houses. Curiously enough, on two occasions from this type of houses also considerable number of flies have been collected during the peak season. The favourite resting places of the flies are the dark corners of mud-walled houses, but in a few cases they have been found to occur in abundance in open rooms with three or even two walls. Generally the flies are scarce or absent in cooking rooms because of the heat and smoke but exceptio-

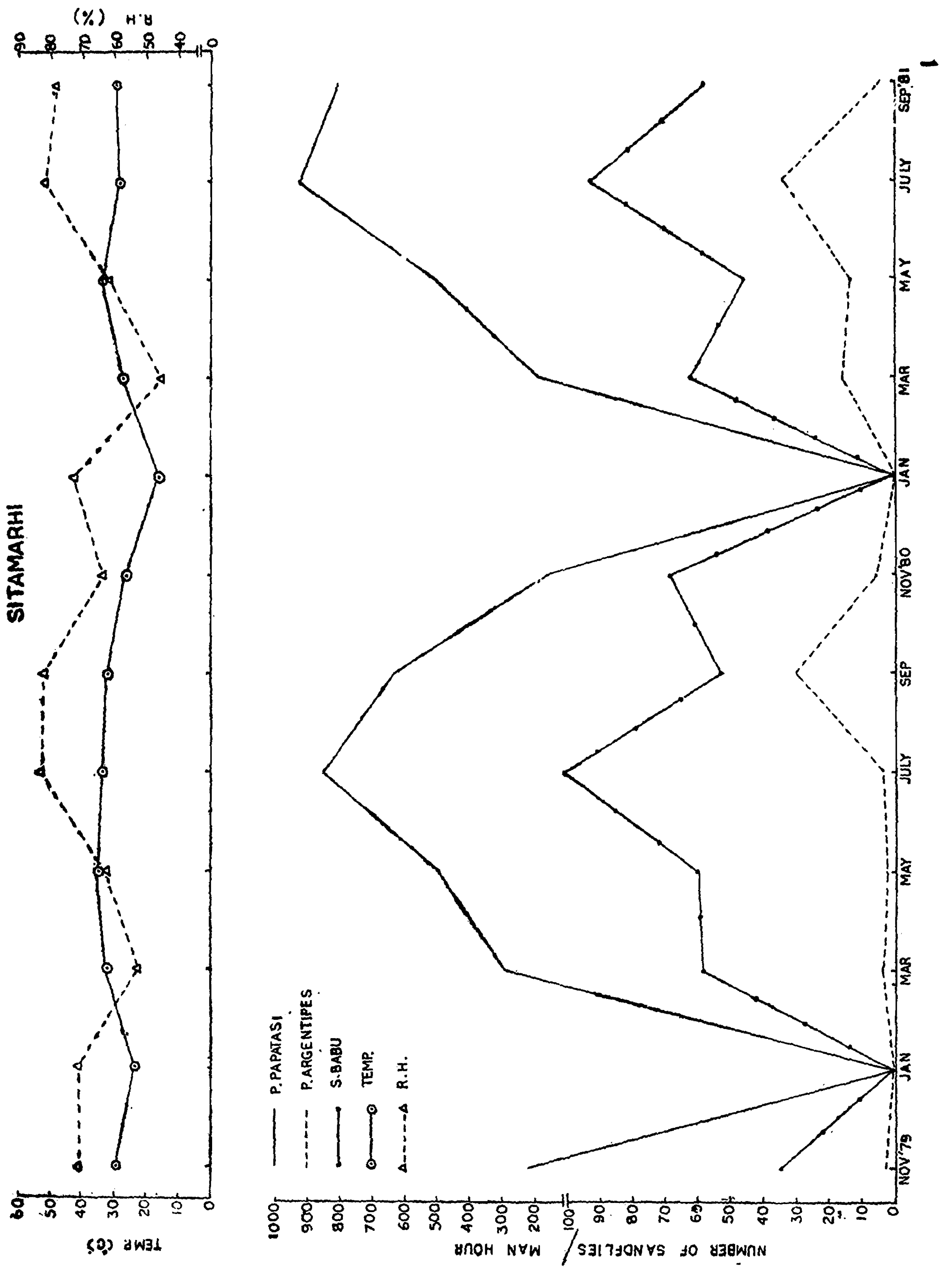

Fig. 1. Bimonthly fluctuation of sandfly population in relation to temperature and relative humidity in Darbhanga District.

nally in the peak periods they may be seen on the walls opposite to hearth, even while the cooking is on.

On the whole it can be summarised that the flies are found in the dark corners of the mud-walled houses. At the same time

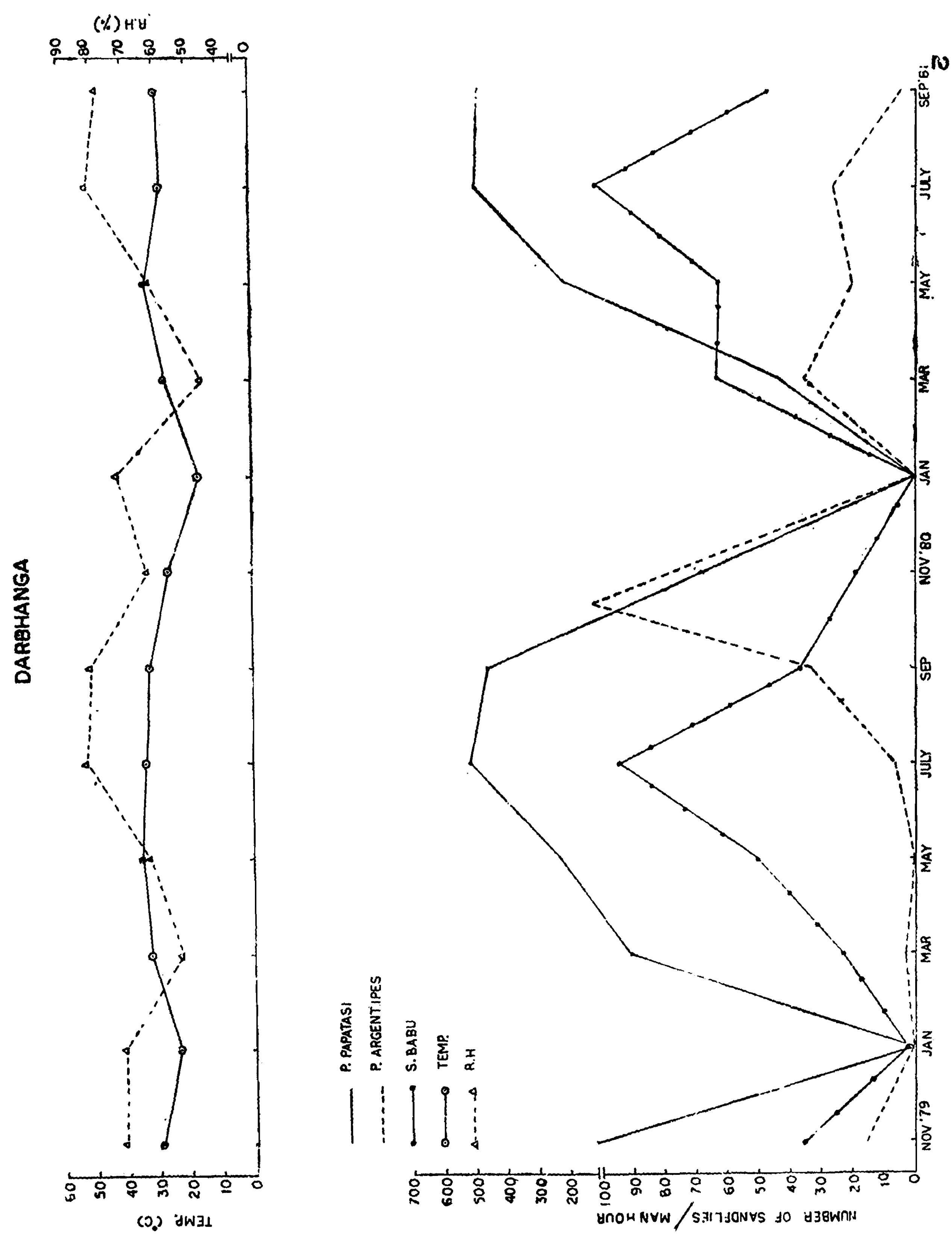

Fig. 2. Bimonthly fluctuation of sandfly population in relation to temperature and relative humidity in Sitamarhi District.

some of the microhabitats which cannot be explained are : (1) in one corner of a room the flies may be abundant whereas in the other corners only sparsely present or absent ; and (2) in houses possessing apparently similar habitats their occurrence varies from sparse to abundance.

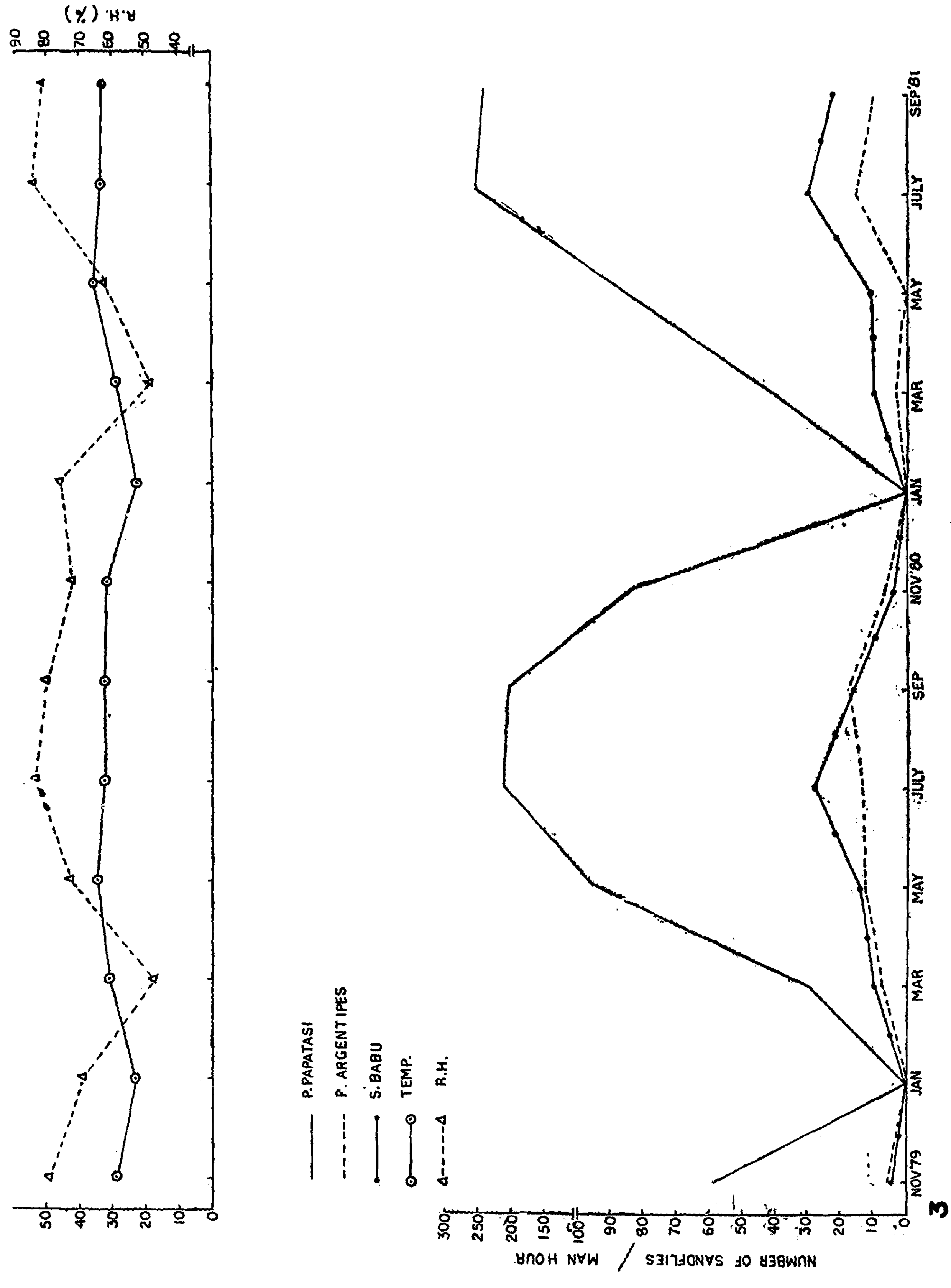

Fig. 3. Bimonthly fluctuation of sandfly population in relation to temperature and relative humidity in Samastipur District.

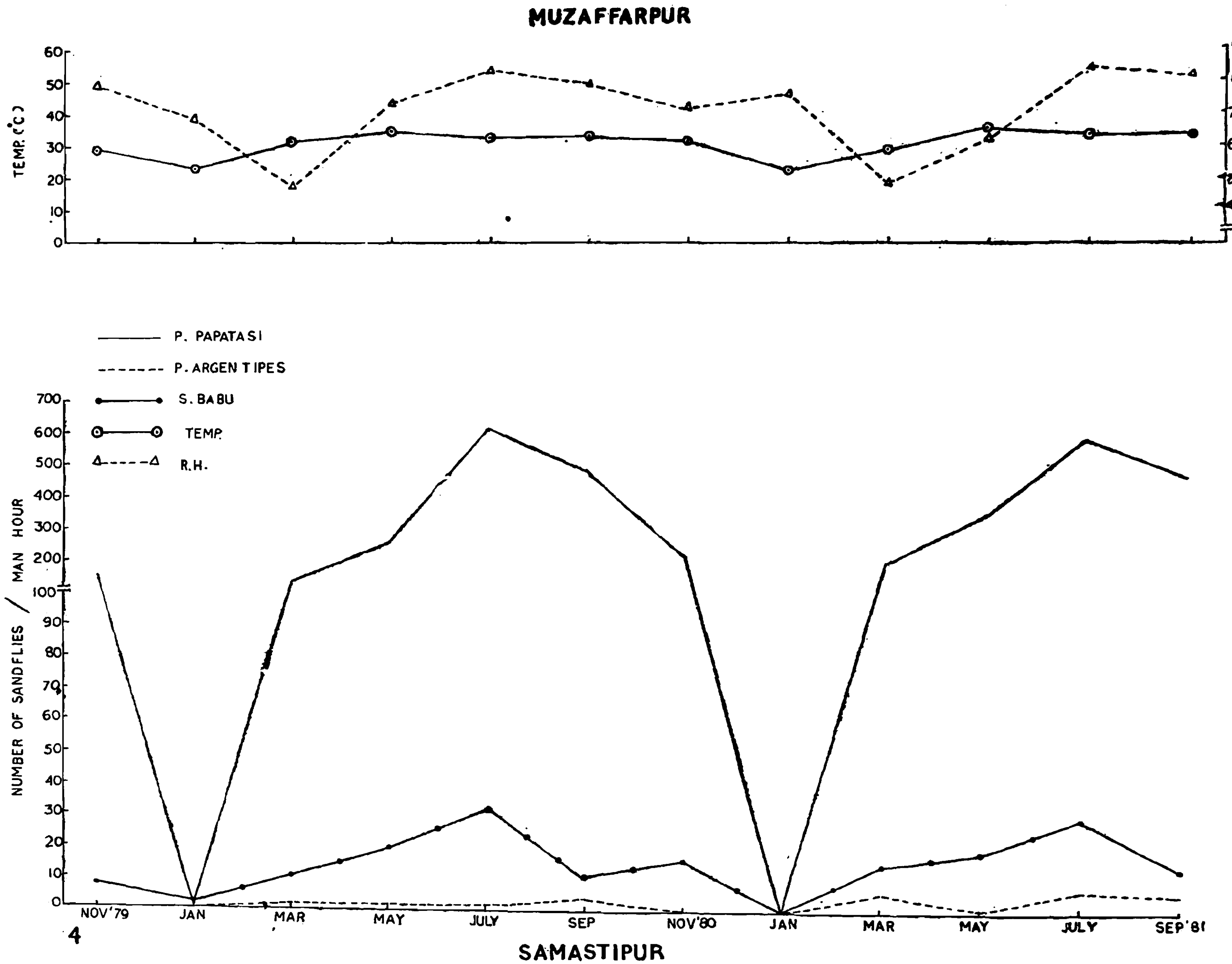

Fig. 4. Bimonthly fluctuation of sandfly population in relation to temperature and relative humidity in Muzaffarpur District.

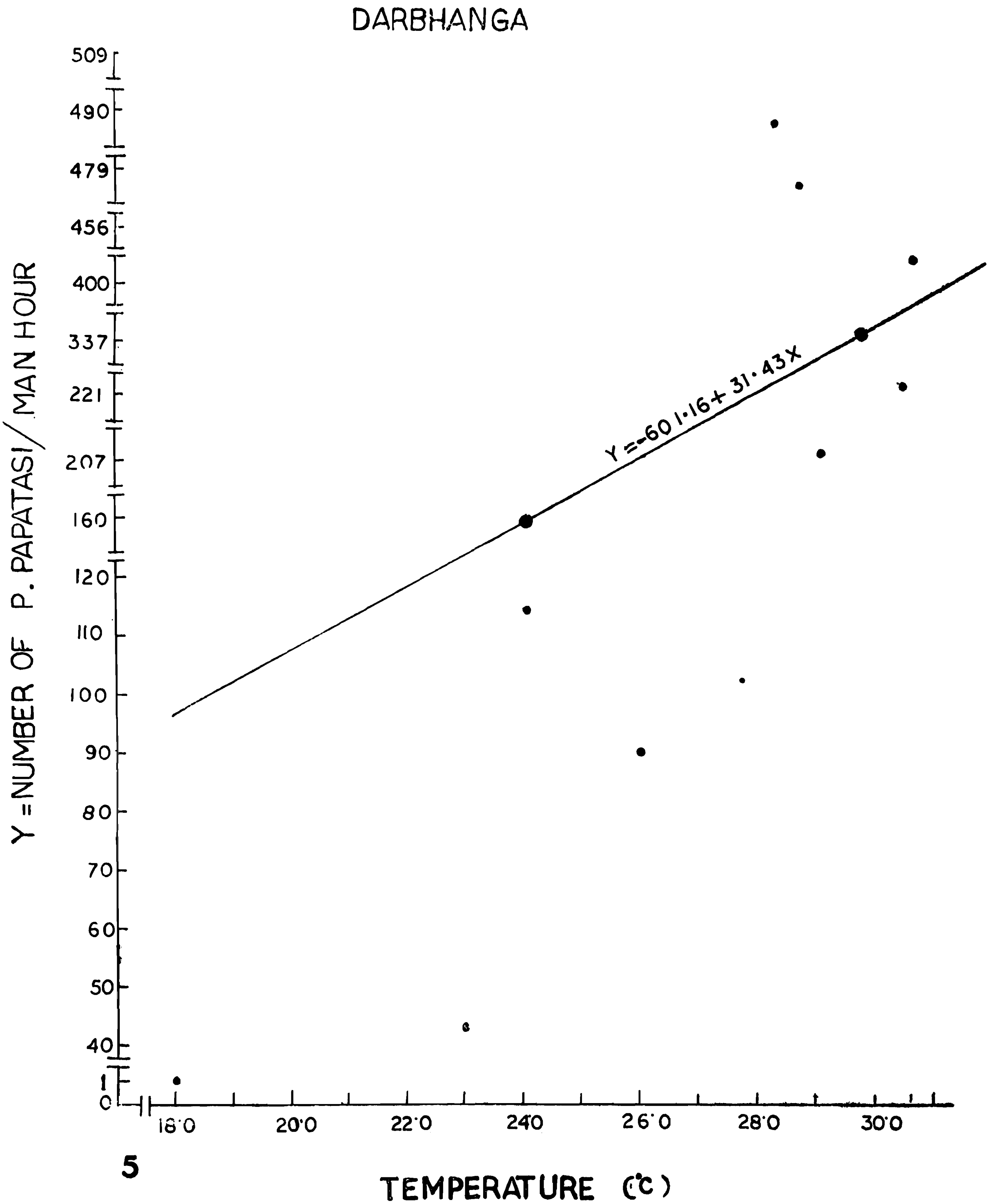

Fig. 5. Regression line with scattered diagram of *P. papatasi* (per manhour) on temperature (°C), in Darbhanga District.

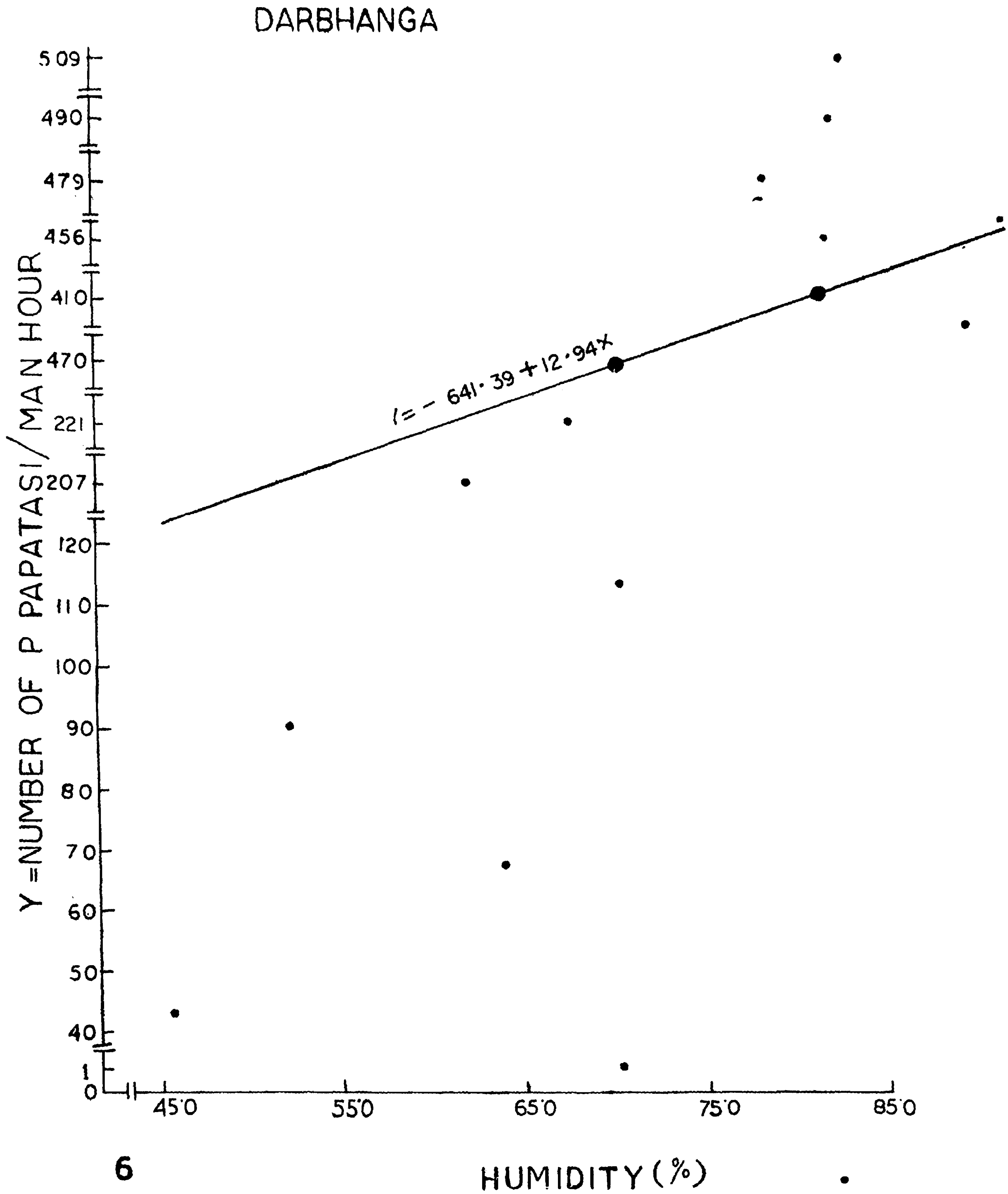

Fig. 6. Regression line with scattered diagram of *P. papatasi* (per manhour) on humidity (R/H) in Darbhanga District.

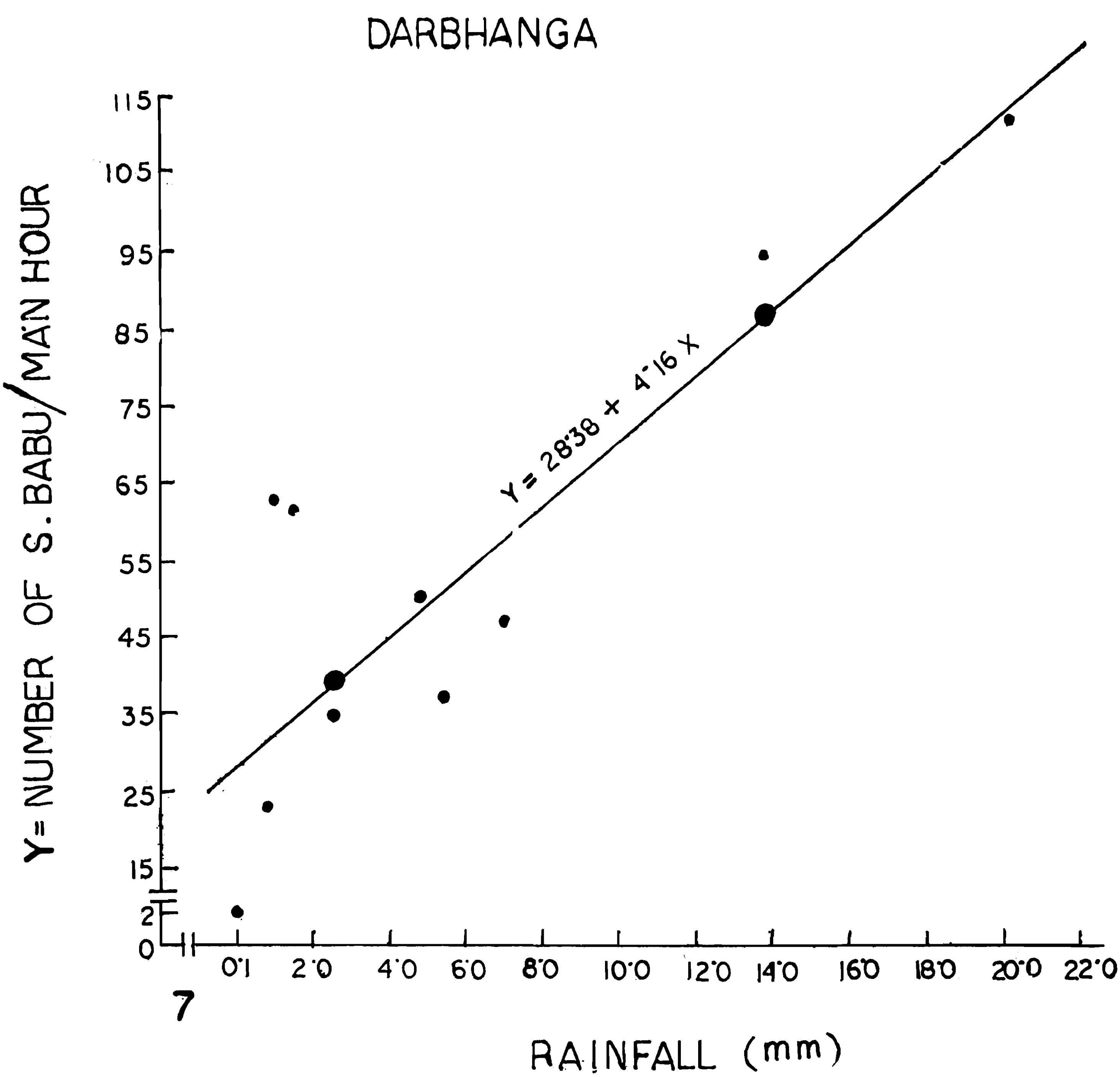

Fig. 7. Regression line with scattered diagram of *S. babu* (per manhour) on rainfall (mm) in Darbhanga District.

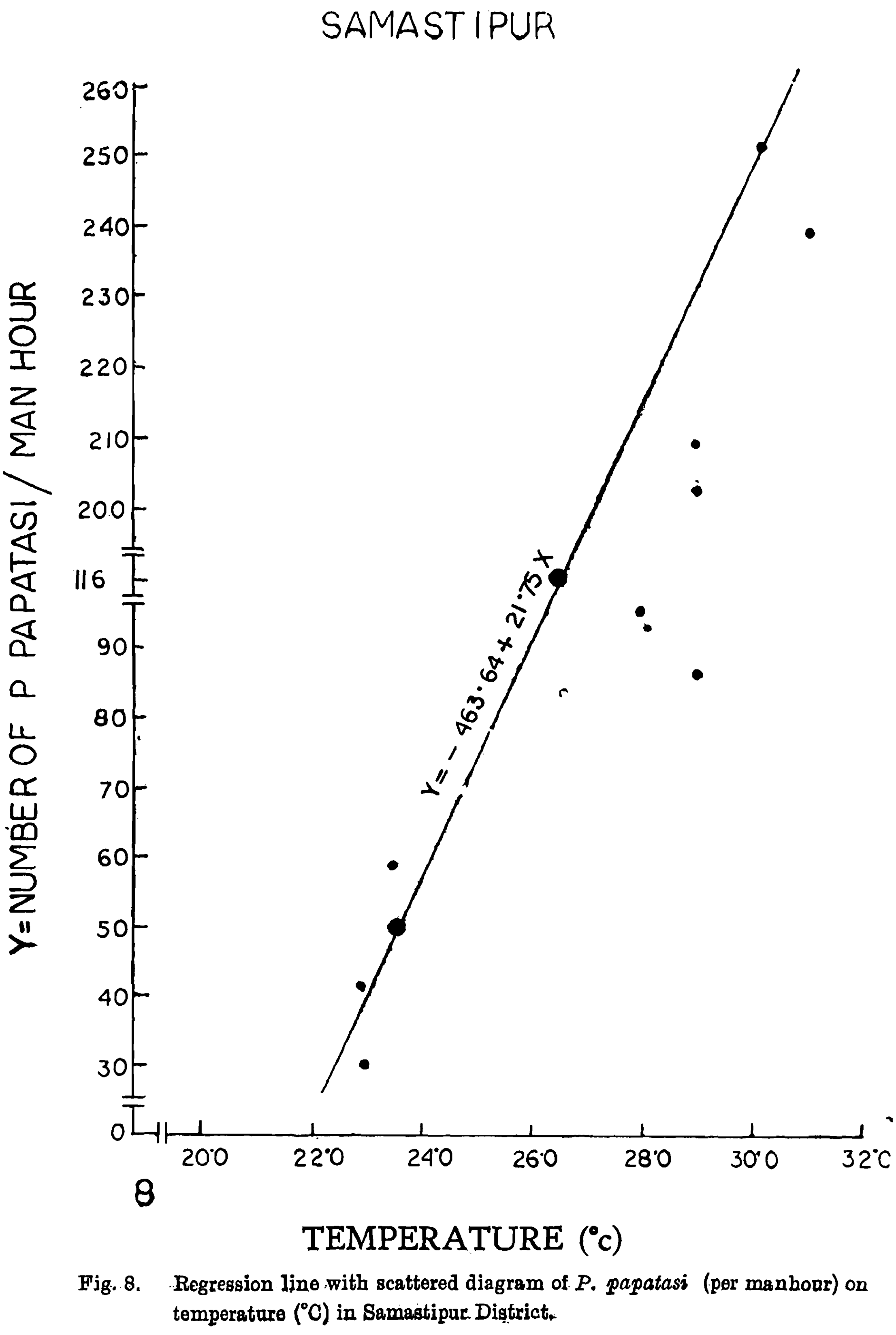

Fig. 8. Regression line with scattered diagram of *P. papatasi* (per manhour) on temperature (°C) in Samastipur District.

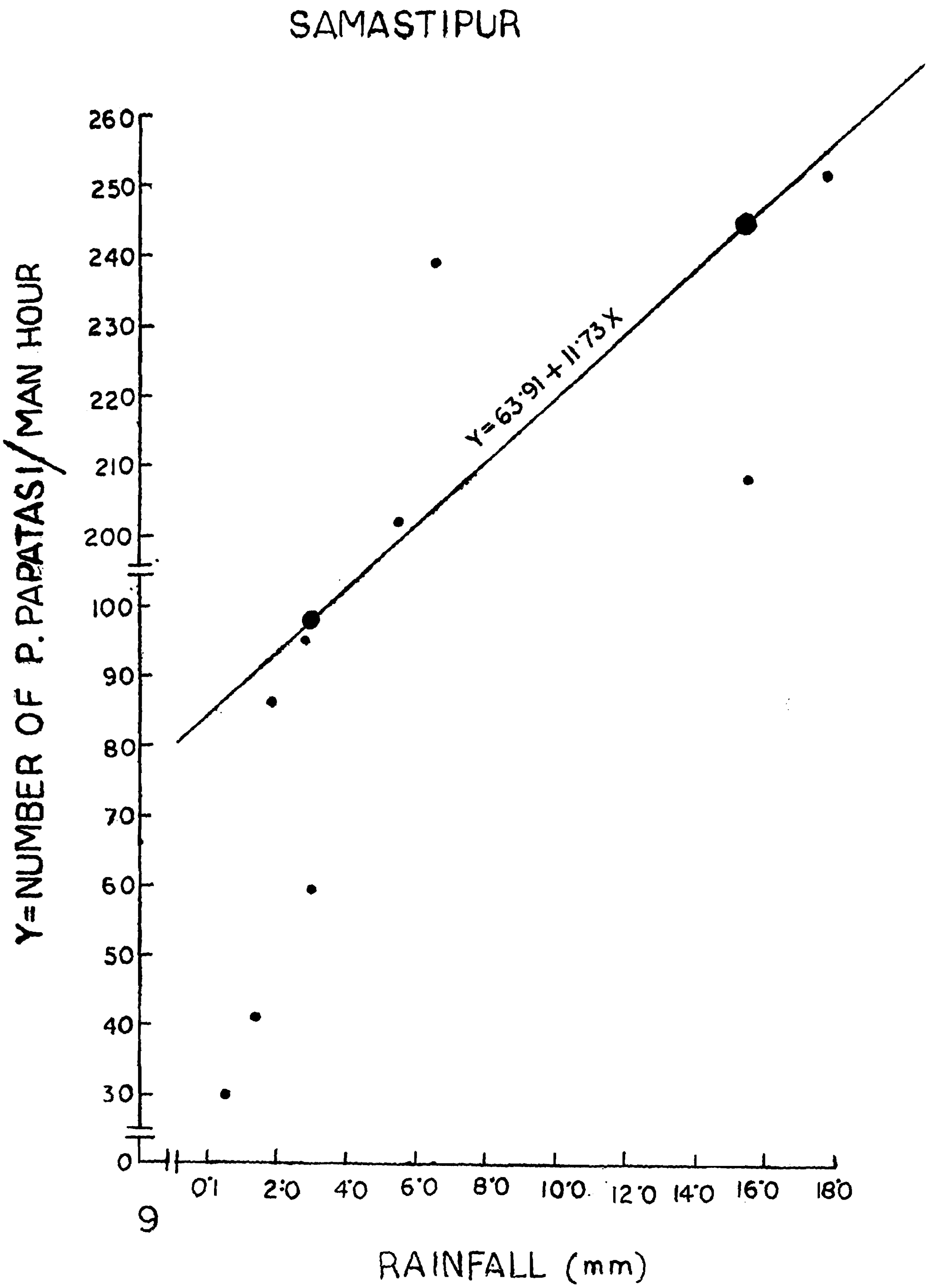

Fig. 9. Regression line with scattered diagram of *P. papatasi* (per manhour) on rainfall (mm) in Samastipur District.

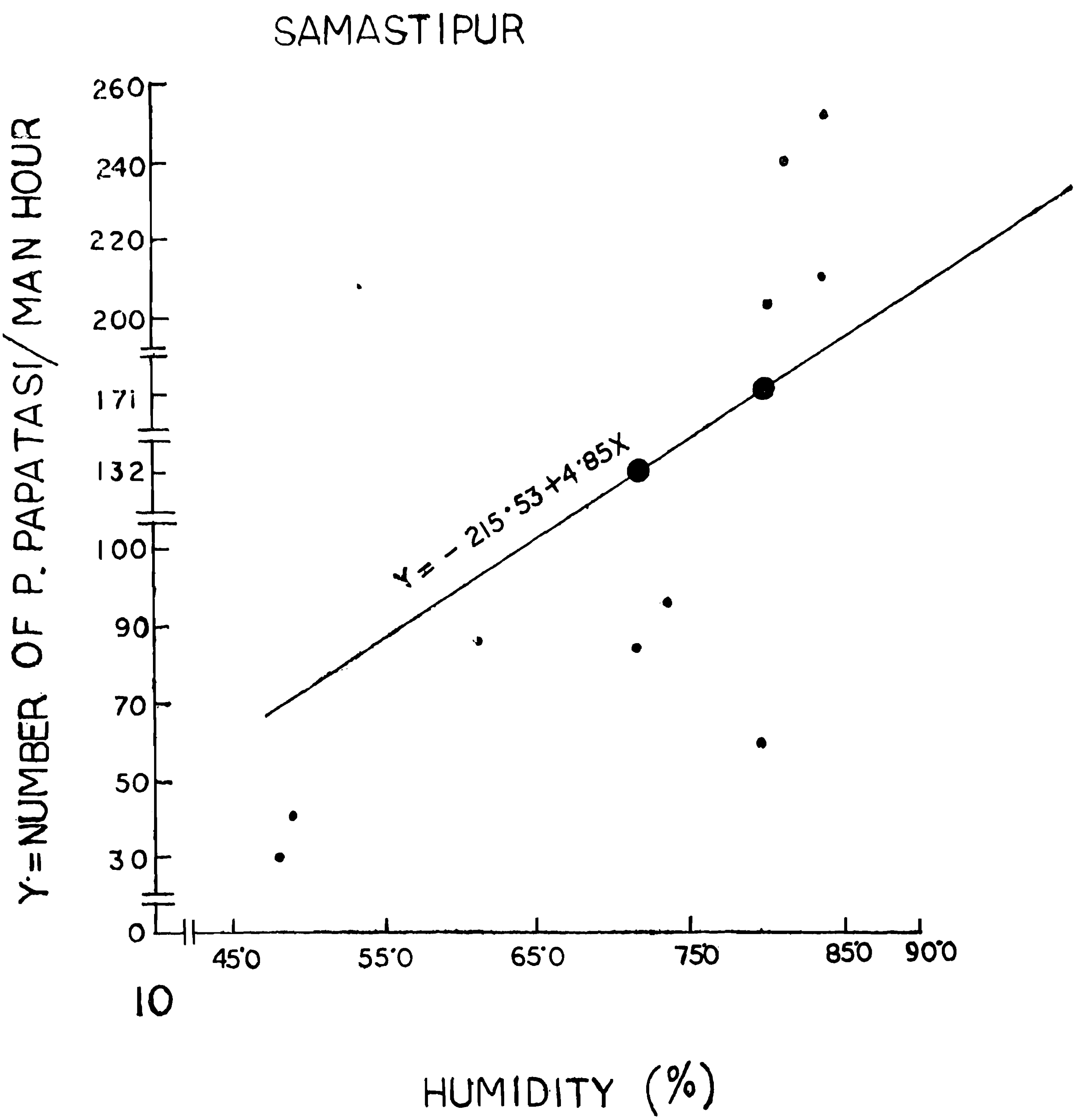

Fig. 10. Regression line with scattered diagram of *P. papatasi* (per manhour) on humidity (R/H) in Samastipur District.

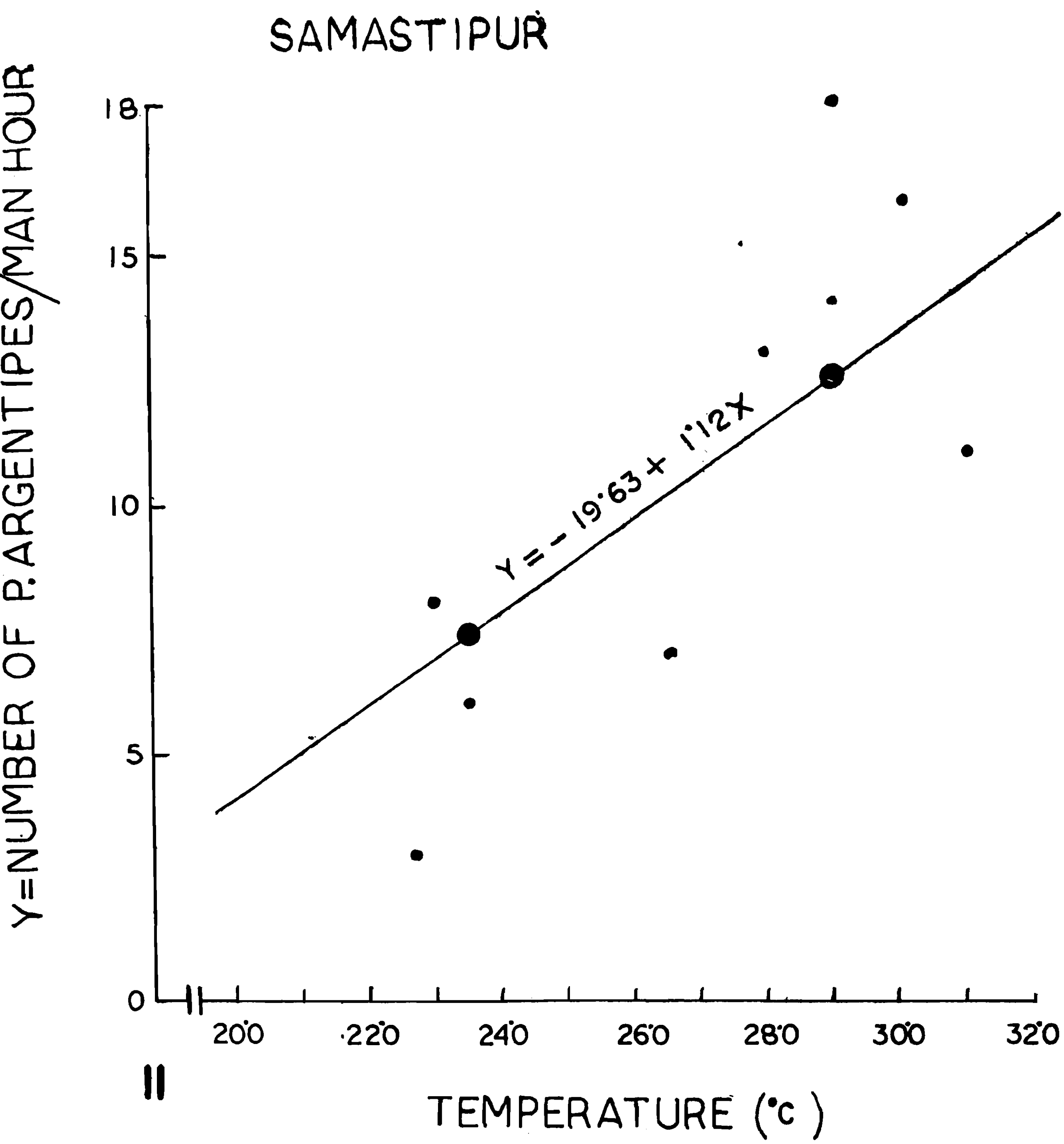

Fig. 11. Regression line with scattered diagram of *P. argentipes* (per manhour) on temperature (°C) in Samastipur District.

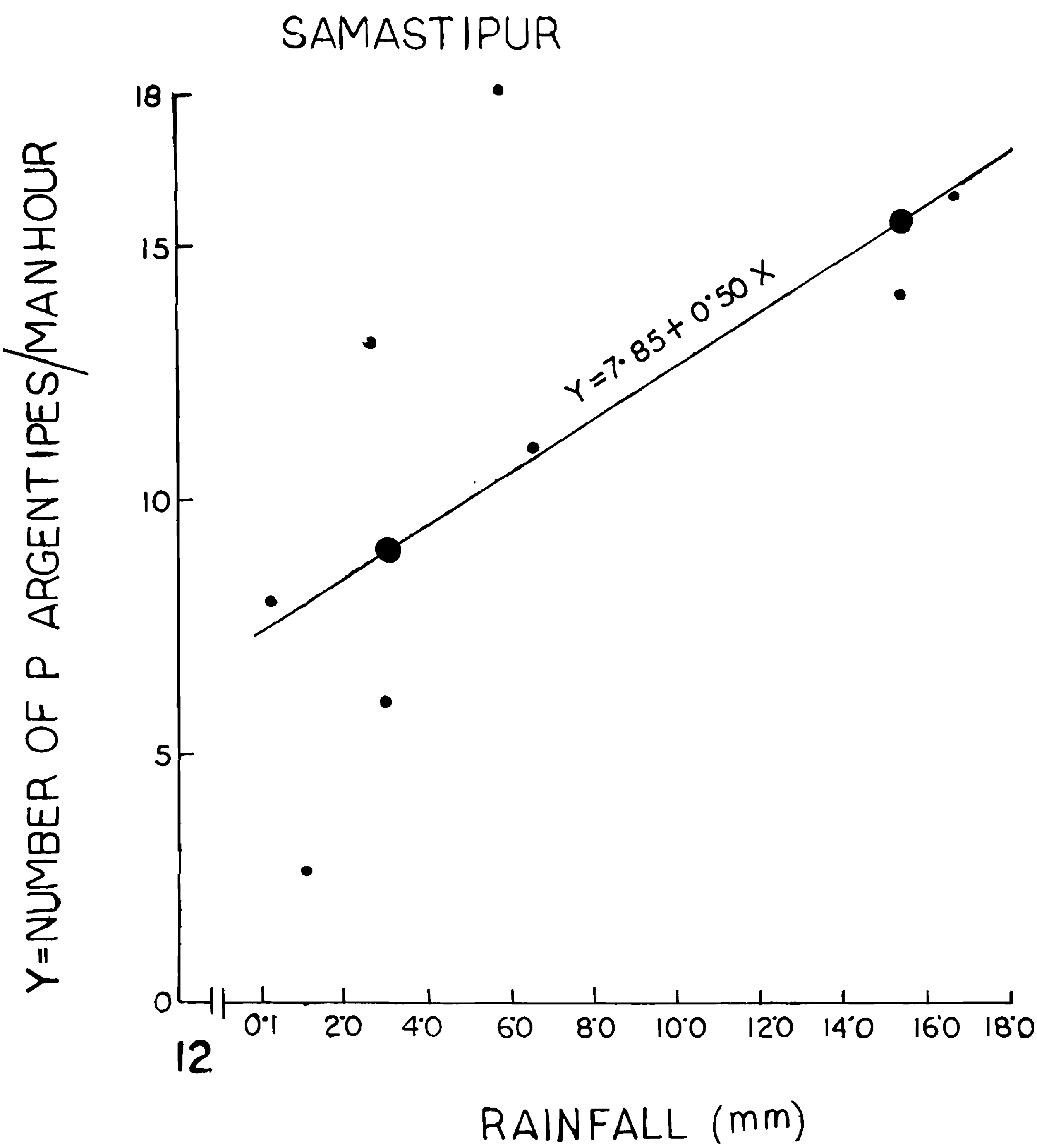

Fig. 12. Regression line with scattered diagram of *P. argentipes* (per manhour) on rainfall (mm) in Samastipur District.

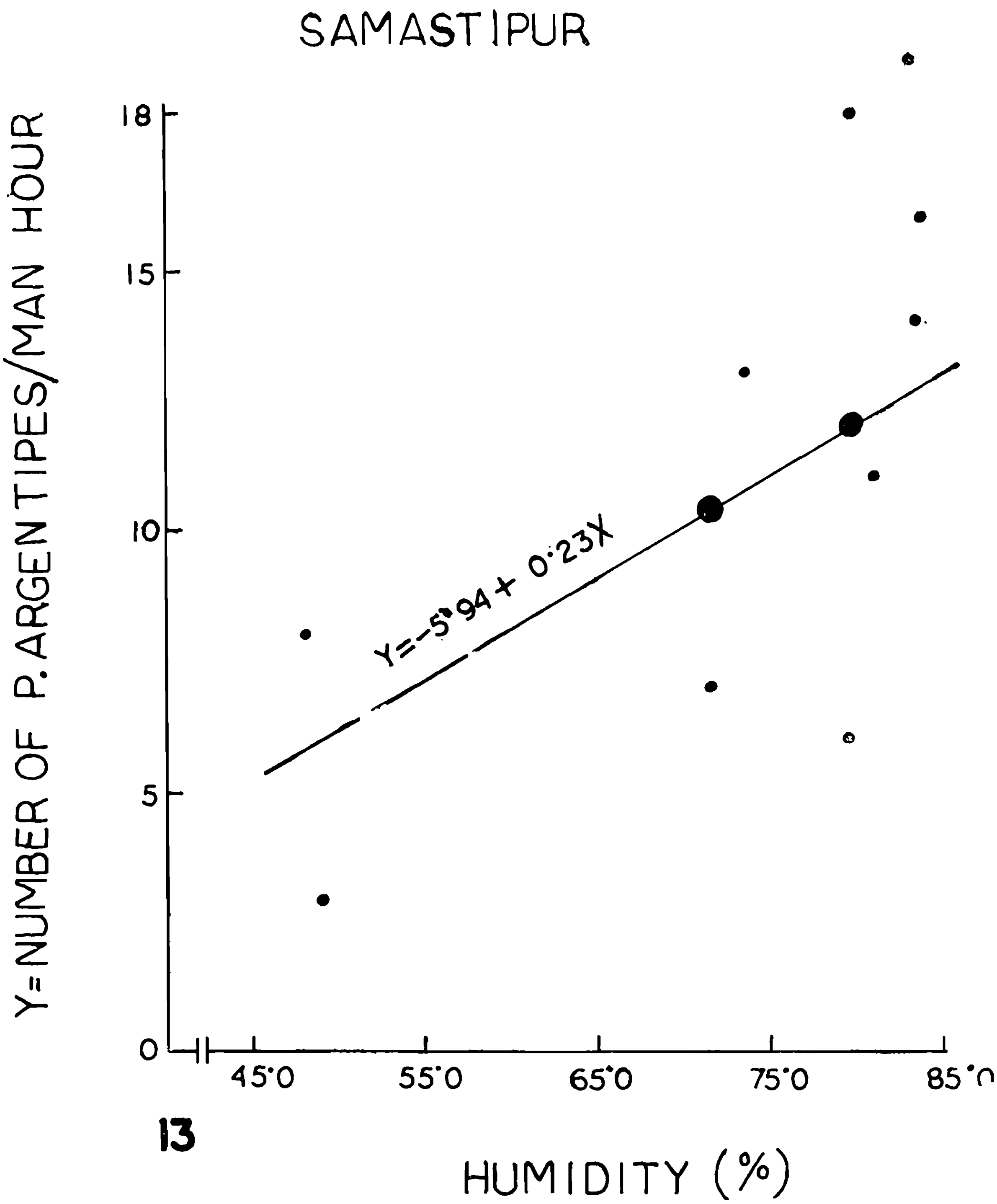

Fig. 13. Regression line with scattered diagram of *P. argentipes* (per manhour) on humidity (R/H) in Samastipur District.

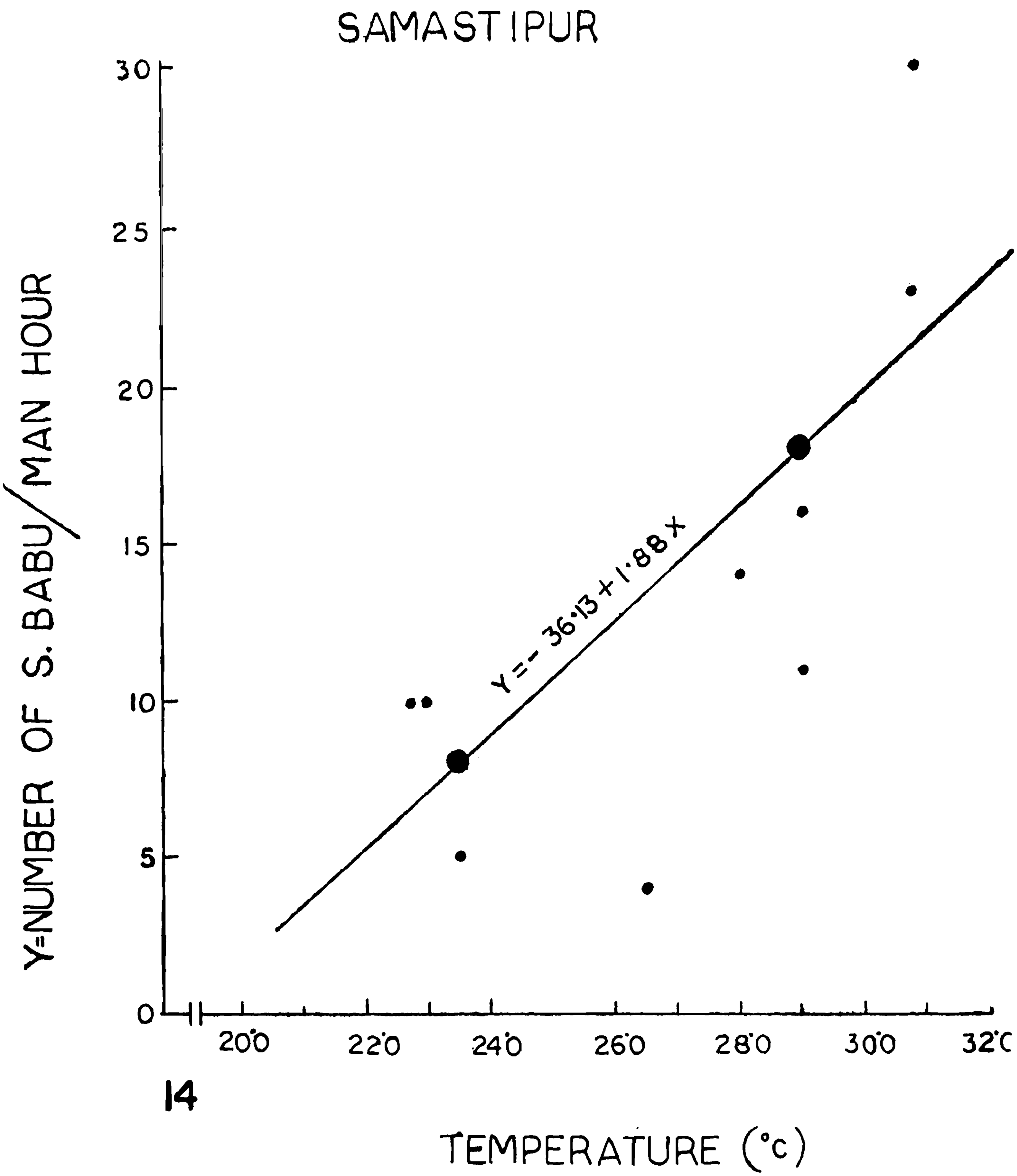

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Fig. 14. Regression line with scattered diagram of *S. babu* (per manhour) on temperature (°C) in Samastipur District.

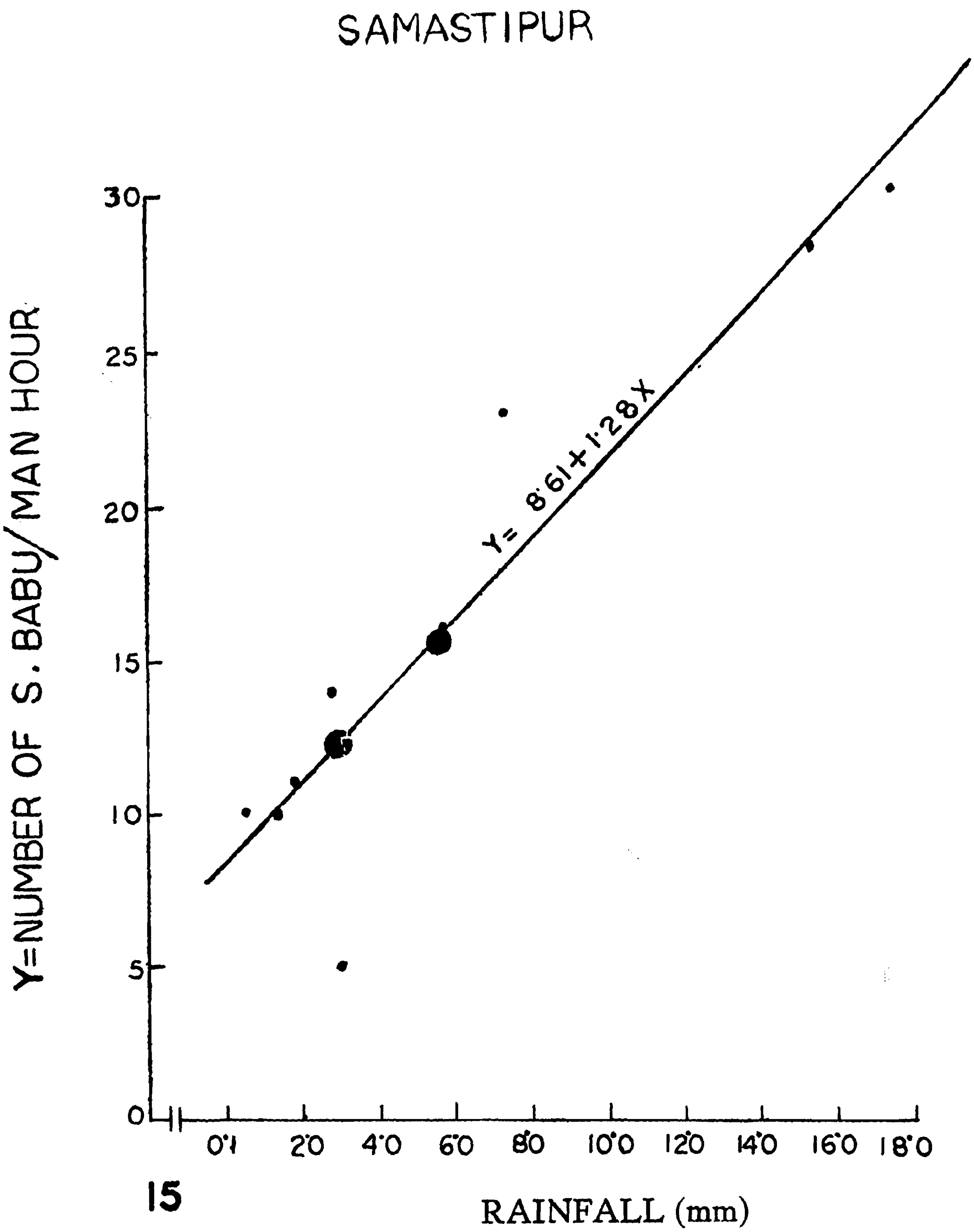

Fig. 15. Regression line with scattered diagram of *S. babu* (per manhour) on rainfall (mm) in Samastipur District.

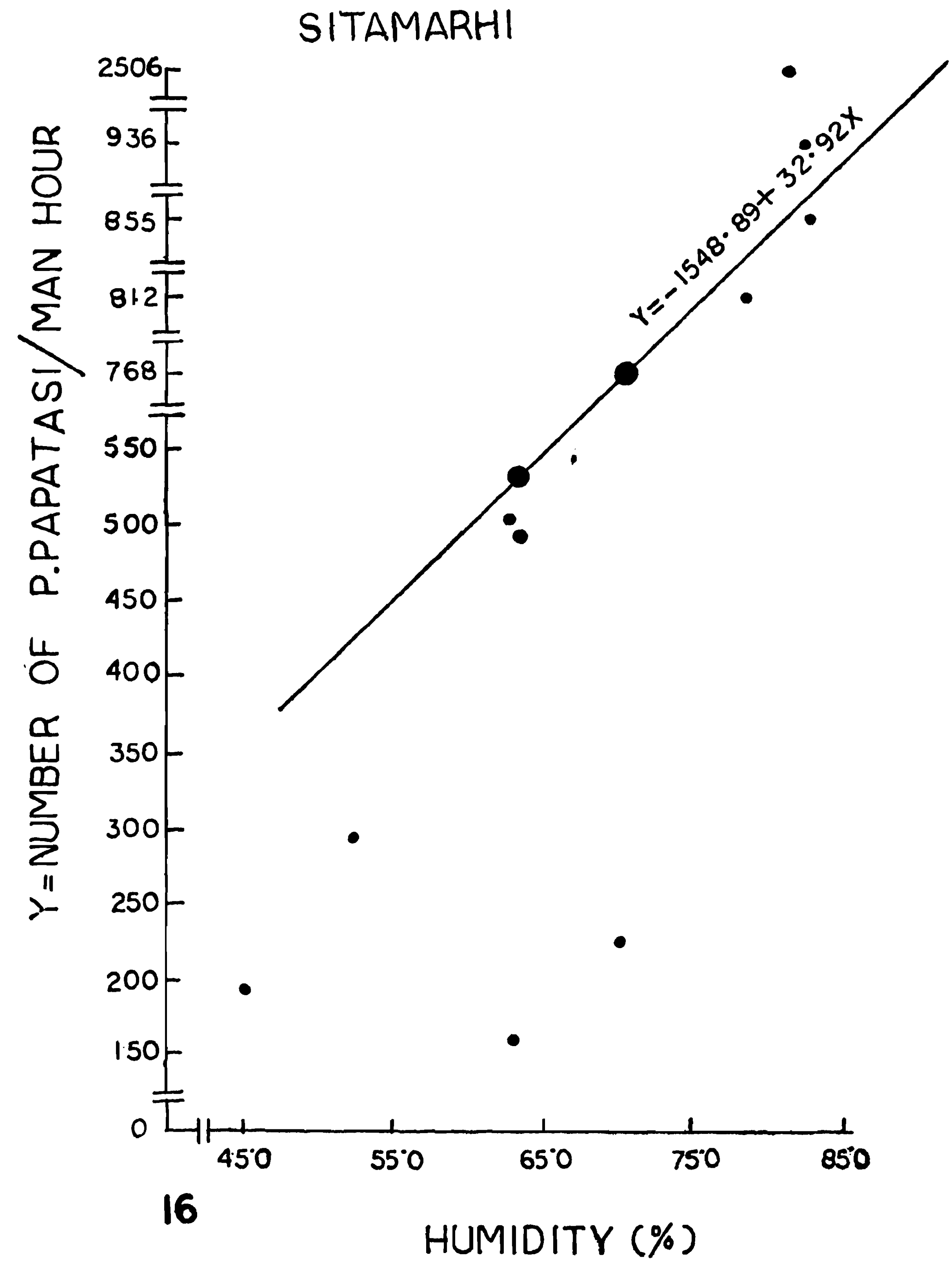

Fig. 16. Regression line with scattered diagram of *P. papatasi* (per manhour) on humidity (R/H) in Sitamarhi District.

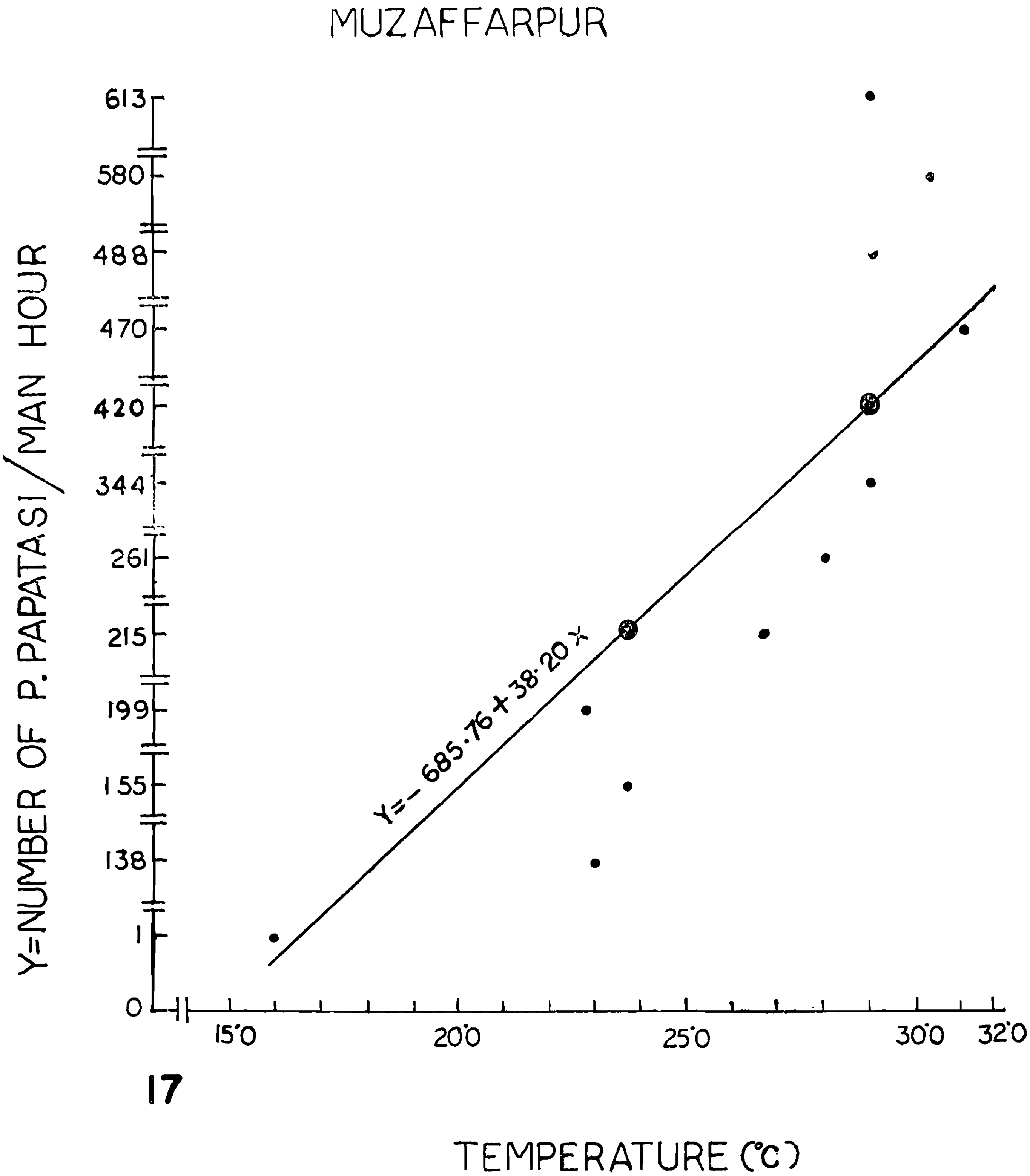

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Fig. 17. Regression line with scattered diagram of *P. papatasi* (per manhour) on temperature (°C) in Muzaffarpur District.

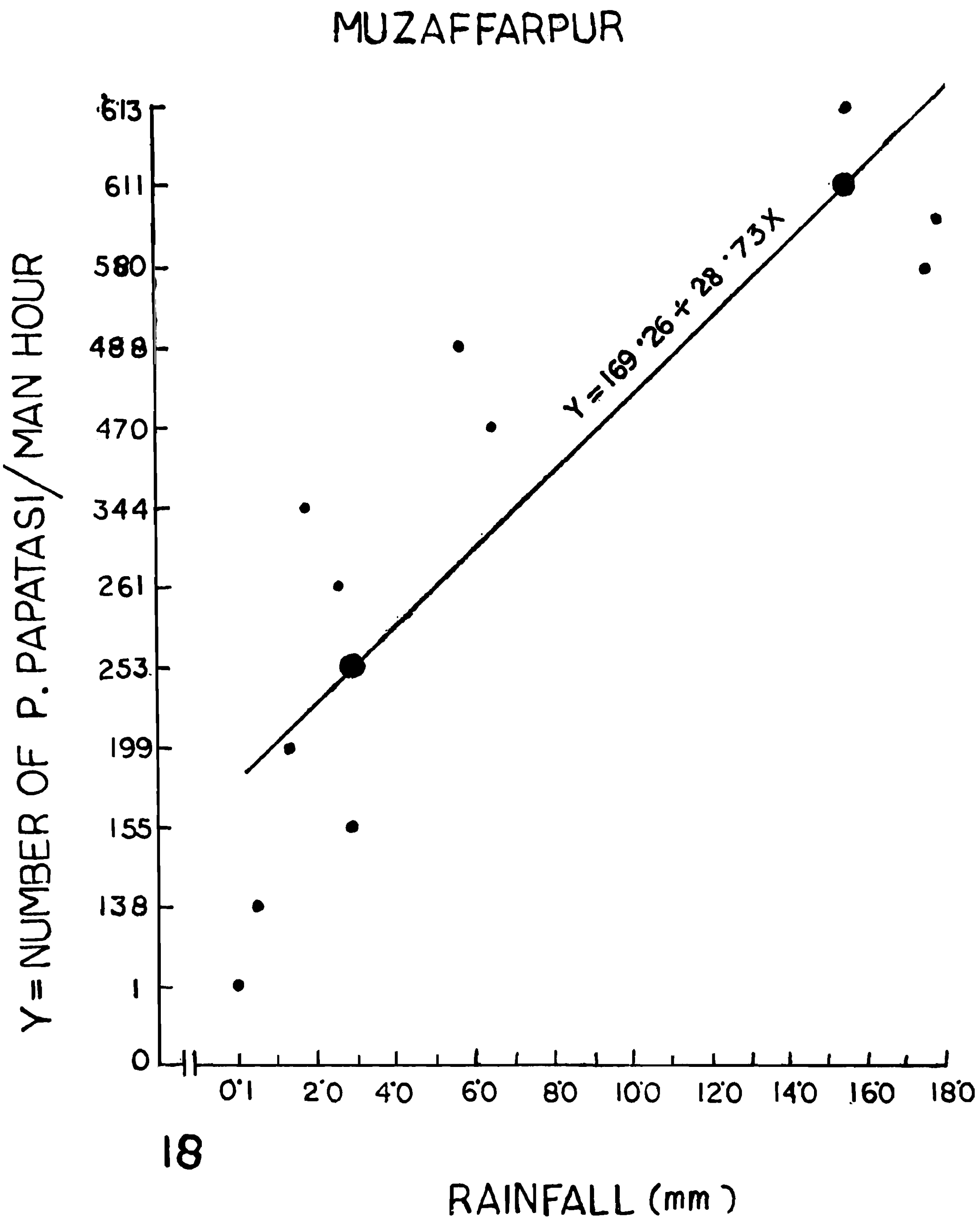

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Fig. 18. Regression line with scattered diagram of *P. papatasi* (per manhour) on rainfall (mm) in Muzaffarpur District.

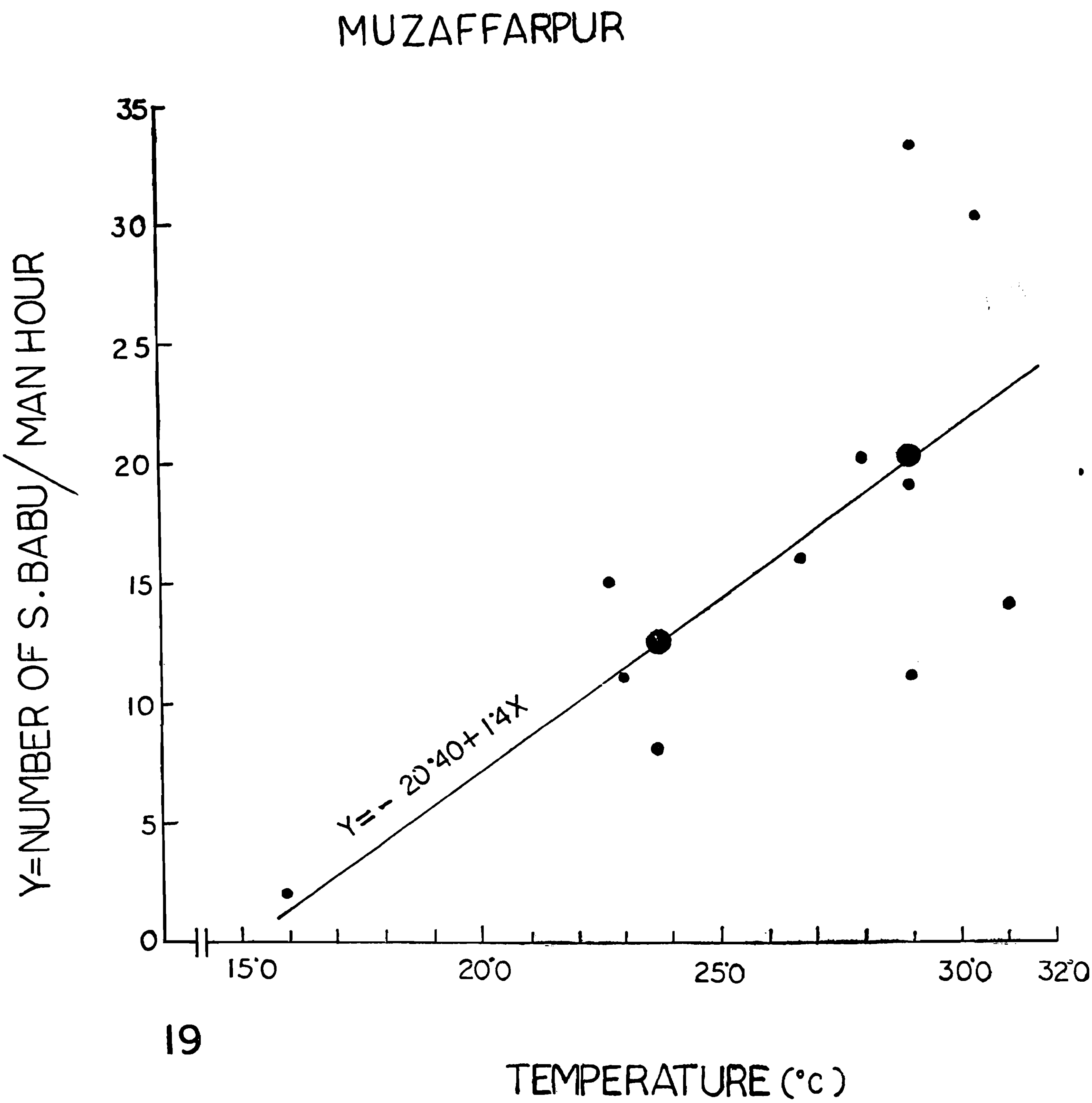

Fig. 19. Regression line with scattered diagram of *S. babu* (per manhour) on temperature (°C) in Muzaffarpur District.

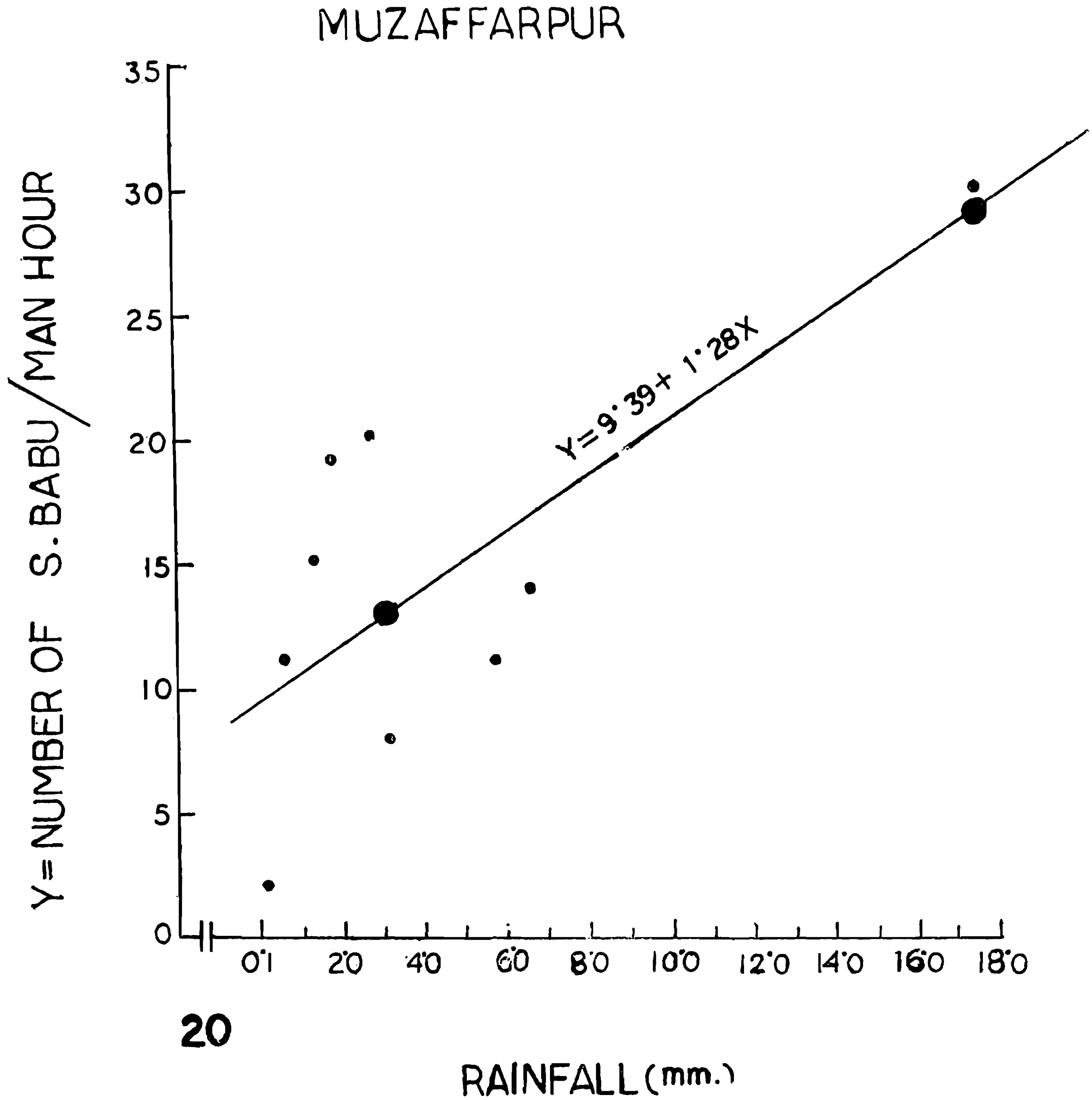

Fig. 20. Regression line with scattered diagram of *S. babu* (per manhour) on rainfall (mm) in Muzaffarpur District.

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Bull. zool. Surv. India, **4** (3) : 365-384, 1981

SOME OBSERVATIONS ON ORB-WEAVING MECHANISM OF INDIAN ARANEID SPIDERS

B. K. TIKADER AND ANIMESH BAL
Zoological Survey of India, Calcutta

ABSTRACT

Orb-weaving mechanism of Indian Araneid spiders are given with full illustrations and their two types of primary web-building operations and pattern of orb-weaving of some genera of the family Araneidae (=Argiopidae) have been discussed.

INTRODUCTION

The first thing which strikes our mind by the name of spider, is its spinning habit. Among spiders araneids are unique because of their peculiar habit to construct the orb-webs having geometrical precision. Their finished product of web is a masterpiece of their craftmanship. The webs mainly serve as trapping nets to capture their prey, often camouflage the spiders from their prey and predators. The threads of webs are nothing but the secretion of silk glands, present inside the abdomen. The silk secretion which is a kind of protein, solidifies as soon as it comes in contact with the air. The secretion of silk gland comes out from the minute microscopic spigots present on the mound of spinnerets. There are very little work on this subject in our country. Only Dugdale (1969) and Tikader (1961, 1966 and 1978) have published some observations of spiders and their biology and protective device of orb-weaving spiders from India. Levi (1978) and Kullmann (1975) have also published some observations of orb-weaving spiders from America and West Germany respectively. In this paper we have given our observations of orb-weaving technique of araneid spiders with illustrations, and also discussed the pattern of orb-weaving of different genera of spiders of the family Araneidae (=Argiopidae).

ORB-WEAVING MECHANISM

Orb-weaving spiders are of various kinds, so their modes of web-building also different to some extent. Primarily two types of operations are seen. One, the bridge line alongwith the outer frameworks are constructed first. By this way the orb-webs are either vertical or horizontal in position with the adjacent supporting objects. The other type, where after formation of bridge line a V-shaped two radii are formed from a second thread just below the upper bridge line, and the other radii alongwith outer frames are constructed. But in both the types the operations are a little bit variable according to the availability of adjacent supporting objects. After formation of all radii, the spider construct the non-viscid spiral thread from centre to periphery which later replaced by viscid spiral thread from periphery to centre.

Here the two types of web-building operations have been discussed :

In the first instance the spider *Gasteracantha mammosa* C. L. Koch (=*G. brevispina*) pays out silk from its spinnerets to the wind from at a point A until the free end of the thread gets entangled to an end B on the shrub (Fig. 1). From A the spider goes over to the point B and sticking the end firmly there. The spider then walks back and forth along the line to strengthen it by laying more silk on it. Thus the bridge line A-B is established (Fig. 2). From A the spider proceeds upto the middle of the bridge line, *i.e.*, C, from where it drops down a thread over a weed below and fixes the thread at D on the weed (Fig. 3). From this point the spider continues the thread and carrying it loose by one of its hind legs not to be entangled on the supporting weeds on which it walks, and goes over the weeds upto a stump E of the shrub where it entangles the line. Now, it climbs up along the branch from E by trailing the thread and attaches it to the point A (Figs. 4, 5). Thus D-E and E-A outer frameworks have been formed.

Then the spider crosses the bridge without any trailing thread upto B and from there it drops down on the weed below by a dragline thread and fixes it at the point F on the weed, thus B-F is formed (Fig. 6). From the point F the spider crawls down along the weed with a thread to form F-D (Fig. 7). In this way a pentagonal framework is built with the bridge line A-B and outer four boundary lines B-F, F-D, D-E, E-A, the line C-D, which passes from the middle of the bridge line C as a diameter through the centre of the entire space upto the middle of the opposite boundaries of the future web.

After this, the spider starts to construct the radial threads through a point on the already formed diameter C-D, which will be the centre or hub at the future web. In anticipation to this operation, it crawls upto a point G on D-C. At G the spider attaches a thread and trailing it loose behind proceeds upto C and from there it goes a little distance towards B and at point H entangles the line tight and makes the radius GH (Fig. 8). From H point the spider moves a few centimetres further towards B and at the point I fixes a fresh thread and trailing it loose comes back to G alongwith the radius HG and by pulling tight the thread at G the spider makes IG radius (Fig. 9).

Next, the spider spins a new thread from G and trailing the line loose descends down to D and turns towards E, at J it fixes the thread tight and thus the radial thread GJ is formed (Fig. 10). From J, the spider moves a little away towards E upto the point K, where it fixes a new thread and carrying the thread upto G via JG and attaches it to G. In this way another radial thread KG is formed.

The spider repeats the operation to construct the radial threads in pair, are laid alternately on the right and left until the required radii are formed which are sufficient to hold the future web (Fig. 11).

After completion of all radii, the spider moves to the centre of the web and gives attention to some extent to give sufficient support to the radial threads, so it spins a few turn of spiral thread immediately outside the hub. This small spiral around the hub is called attachment zone (Fig. 12), and it is, ofcourse, before the spider starts a temporary non-viscid spiral. Because of this attachment zone, the radial threads are getting the uniform tension.

Once the hub and the attachment zone are completed, the spider starts to weave a spiral from the end of the attachment zone and continuing to the periphery in an anti-clockwise direction (Fig. 13), with turns as far as the spider can stretch. The thread of this temporary spiral is coarse and non-viscid and its function is to hold the radial threads for subsequent operations.

When the temporary spiral is completed, the spider reverses its direction, rolls up the old one and puts down the new, finer and more closely interspaced viscid silk which is elastic too (Fig. 14). This viscid spiral is weaving in a clockwise direction with measured action and uniform speed. In spinning the viscid thread the spider fastens it to a radius and then moves on pulling out the thread from the spinnerets, but before the thread is fastened to another radius the spider takes hold of it with the claws of one hind leg, and straightening this leg pulls out from the spinnerets ; the spinnerets are then applied to the next radius and the thread fastened in place. After this the spider takes away its hind leg and the thread contracts to the length of the space between the two subsequent radii.

The viscid spiral does not cover entirely upto the hub but leave a space between the viscid spiral and the attachment zone called free zone (Fig. 15). By following the above mentioned modes of operation to construct the web, the final product gets a "geometrical precision" which reveals the highest achievement of the craftmanship of orb-weaving spiders (Fig. 15).

In the second instance the young *Araneus* spider starts to weave its web at the beginning of dark in the evening. At point A on a tree branch it fixes a thread and then crawls along the branch in an inverted position by trailing behind the thread carefully and attaches at the points X, Y, Z and finally at B (Fig. 16). From B the spider returns to A carrying behind a loose thread which it fixes to A. Thus an upper bridge line A-B is established (Fig.17).

Soon after this the spider drops down by a thread upto a level of a small plant below (Fig. 18) to reach to the plant the spider dangles to and fro, and as soon as it gets the plant, fixes the thread on any of the branches firmly. Through this oscillation and also with the help of wind it reaches to the plant (Fig. 19). Thus A-C is formed, and along this A-C the spider climbs back to A and then towards B upto D, the mid-point of A-B. At the point D the spider cuts the thread and attaches the spinnerets to the cut end, and makes the thread A-B longer by rotating itself. Thus a V-shaped structure of thread is formed (Fig. 20). From the bent point of V the spider drops down by a thread forming a Y and attaches the end of the thread at C (Fig. 21).

The spider then fixes a thread at C and trailing it behind and climbs upto B following the way C-D-B. At B the thread is hauled tight and fixed (Fig. 22). Thus a boundary line of the framework at future orb-web C-B is formed. From B the spider moves down a little distance towards D and fixes a thread there at E. The spider then trailing loose a thread, goes upto F via D, a little below of A where the thread is pulled tight and fixed. Thus the upper boundary line E-F is formed after removing the original bridge line A-B (Fig. 23).

From F the spider moves a few distance towards E and at G fixes a thread, and by holding it carefully not to be entangled to any pre-existing thread the spider moves upto D via F. At D the thread fixes tight. Thus the radial thread GD is formed. Then from D the spider trailing a thread upto H via C, and the thread is pulled and fixed tightly at H. In this way another spoke DH is formed (Fig. 24). The spider then moves to the point J and attaches a thread there and return to D via H to fix a thread to form the spoke JD (Fig. 25). By following the same procedure all other spokes or radial threads at the future orb-web are formed, one or two to the right alternating with one or two to the left (Fig. 26).

Next to this, the spider starts the subsequent phases to complete the orb-web, so the attachment zone and non-viscid spirals are formed after leaving the free zone as stated in the first case (Fig. 27). Then the non-viscid spiral is removed by closer meshed viscid spiral, weaving clockwise from periphery to the centre (Fig. 28). In this way the orb-web in vertical plane is constructed by *Araneus* spiders.

Different Features of a Typical Orb-Web

The bridge line (A) as in the text-fig. 29 is a line which is spun by a spider between the two supporting objects. Foundation lines (B) are outer framework lines spun subsequently after establishment of bridge line, with different supporting objects. After construction of outer framework the spider spins the radial threads (C) in the open space of the framework, each intersecting the hub or the web-centre (D). Thus after formation of the hub the spider spins a few turn of spinal thread, just adjacent to the hub, which gives more strength to the radial threads, called the attachment zone (E). At the end the spider spins the viscid, elastic spiral thread (F) from periphery to the centre in a clockwise direction by leaving an area of less width called free zone (G). The viscid spiral thread removes the non-viscid spiral thread which is spun from the centre to the periphery in an anti-clockwise direction.

Net Element or Thread

Generally large orb-weavers produce thicker threads. Within one species of spider, the diameter of the thread also changes with age. The thread thickness of an adult large orb-weaver is 0.010 mm. to 0.012 mm. per individual thread. The thread produced by *Nephila* is the strongest among spider's thread. The strong webs of *Nephila*, matted and twisted, are used by South Sea Islanders for various kinds of bags and fish nets. (Kullmann, 1975).

As a spider walks around, it usually emits a double or even quadruple thread—this is called "dragline". This dragline serves as a safety line so that in the face of danger the spider can let itself fall without loosing contact to the last attachment disk to which it can return by climbing up the thread.

The Mesh of the Orb-Webs

The mesh is the geometrical elements of the web. It is formed by the joining together the threads and knots of the close lines.

Accordingly, they are only of four kinds found in orb-webs. The Trapezoid mesh (Fig. 30) as found in general orb-webs. The Square mesh (Fig. 31) which is constructed in the sheet of the orb-web made by *Cyrtophora*. The Rectangular mesh (Fig. 32) constructed by *Nephila*, and the rest one is Irregular mesh (Fig. 33) which is also found in the hub of the orb-web of some araneids.

Net-Support

Orb-webs are suspended by one or more pairs of threads or thread bundles from objects close to it, such as grass, leaves, branches, ropes, stones and spanned between them. On one side it consists of objects found ready to hand such as grass, leaves, branches, fence wire, stones, walls etc. and on the other hand, at adjusting elements such as foundation lines and anchoring threads (Figs. 34, 35). They transmit the forces to the net supports such as branches (Fig. 36). External net supports such as blades of grass (Fig. 37) or wall or building corners (Fig. 38) are known. However, internal net supports, particularly blades of grass, may also be observed (Fig. 39). If the net supports are very elastic, as in case of very long suspension threads or very flexible grass (Fig. 40), their elastic-constructive behaviour is an essential help for trapping the prey.

SPECIAL FEATURES IN ORB-WEBS OF ARANEID SPIDERS IN DIFFERENT GENERA

The spiders of *Gasteracantha* weave some small fussy silk balls along the viscid spiral, which are afterwards entangled with debris to form rounded mass of waste products of their body size. So it is very difficult to locate the spider in exact position in the web (Fig. 41). This is also a kind of protective device. The young *Gasteracantha* may make a stabilimentum where as adults do not (Levi, 1978).

In the genera *Argiope* and *Cyclosa*, the orb-webs are commonly provided with stabilimentum. It is a zigzag ribbon like structure across the hub. It consists of large number of minute threads resembling a swathing band and spun from the small spigots of the aciniform glands.

In the webs of *Argiope*, the stabilimentum is X-marked across the hub (Fig. 42). It is always more elaborate in young than in adults. Despite its names the ribbon like white bands do not function in support of the web, so it is seen the webs of largest females often lack of stabilimentum. The stabilimentum may obscure the out-line of the spider, which does not have a retreat but hangs in the centre of the web (Levi, 1968). It is not periodically replaced as the viscid silk. Since the decorative stabilimentum is found in diverse groups, sometimes only in the webs of immature, it may have different functions in different webs (Levi, 1978).

In the orb-webs of *Cyclosa*, the stabilimentum is generally a small one, placed just above and below the hub. *Cyclosa insulana* does not spin stabilimentum in the webs but the female spider fastens her egg-sacs in a series which extends across the web from the hub to the upper margin looks like a dead twigs or debris in a row in the web. The spider hangs in the web in a small gap at the centre between the upper half and the lower half of the structure (Fig. 43). This band of egg-sacs and the spider are of the same grey colour, so it is very difficult to find out the spider in the web, *C. mulmeinensis* constructs horizontal web without any stabilimentum. The spider waits in the hub for prey and the female fastens its egg-sacs in the webs at a side.

Some orb-weavers wait away from the web in a retreat which is directly connected with the hub by thread called trap-line. This retreat is made up of leaves fastened together with silk, a little away above or a side of the web (Fig. 44). When any insect gets trapped in the web, the disturbance caused on the web is communicated to the spider waiting in the retreat, and the spider rushes to get the prey. These retreats or nests are commonly found in the spiders—*Araneus mitifica*, *Neoscona* *rumpfi*, *N. mukerjei*, *Parawixia dehaanii*, *Zygeilla* sp. etc.

Zygeilla builds the orb-web, in which characteristically one sector remains free of viscid spiral threads (Fig. 45). There is one radius leading through this open sector to the retreat of the spider as a trap-line. Their webs are renewed almost everyday.

In case of *Gea*, the orb-web occationally has a sector missing from the lower half, compare with the web of *Zygeilla* where the sector is missing from the upper half. *Gea* constructs the web close to the ground in low vegetation and not having any stabilimentum.

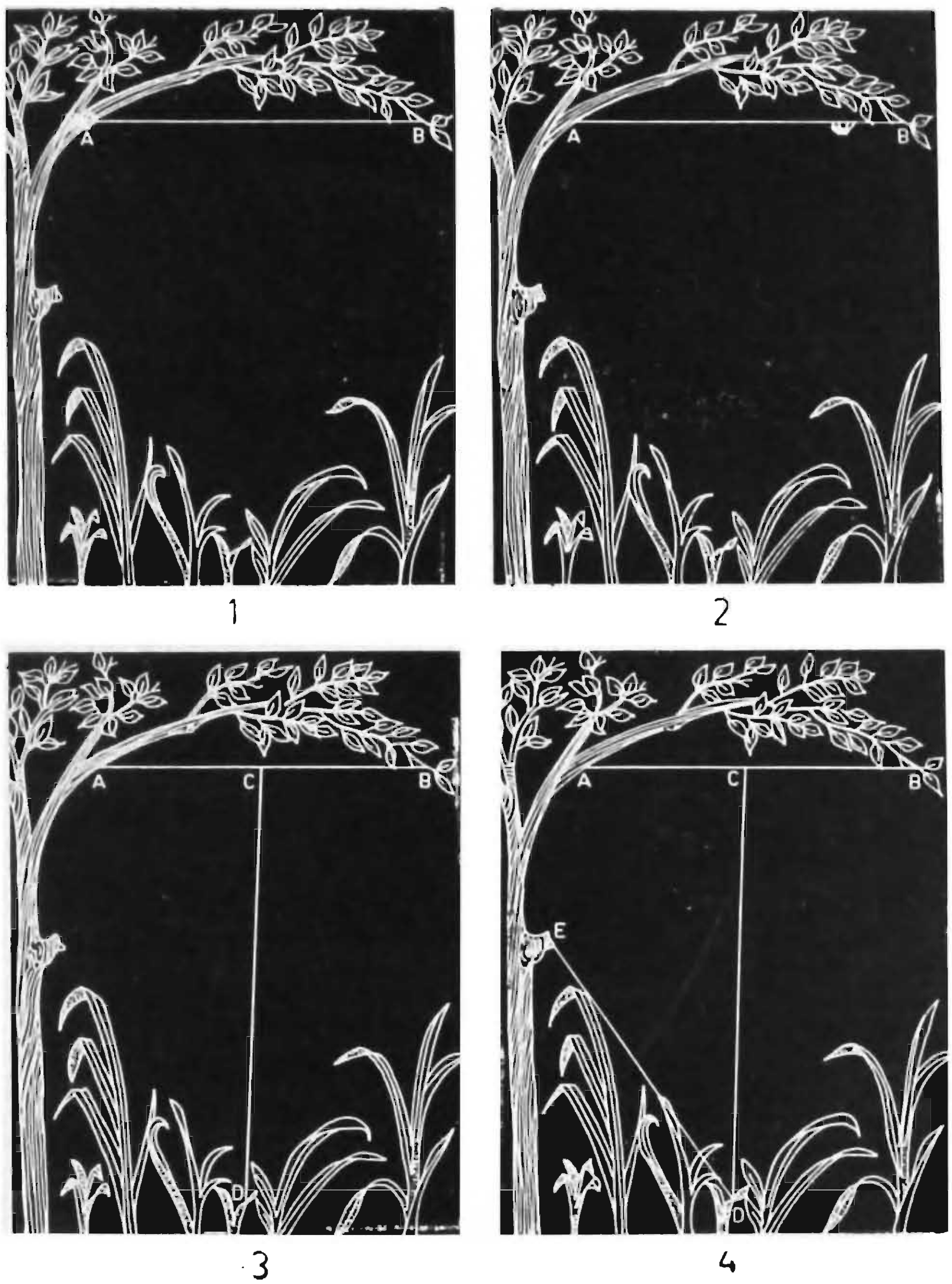
In some genera, as in *Meta*, *Leucauge*, *Gasteracantha*, the hub is open. This open hub fascilitates the spider to move from one face to the other. The hub of *Neoscona* is not fully open but crossed by only one or two threads (Fig. 46), unlike webs made by *Araneus* where the hub is meshed (Fig. 47). *Neoscona* sits in the hub with the tip of the abdomen pushed through the open space of the hub.

Leucauge builds the web in horizontal plane in low bushes during day time. Very quickly they construct their webs, which are devoid of retreats. The spider hangs at the centre upside down posture. Almost everyday they build their nets after removing the old one.

Nephila makes a huge web, nearly one metre or more in diameter, in shaded woods. The webs are different in number of respects from the others in the family. The radii are pulled out at their direct course to give a notched appearance (Fig. 48) and the viscid spiral is of yellowish in colour rather than white. The silk of *Nephila* is the strongest natural fibre known (Levi, 1968). The strong webs of *Nephila*, matted and twisted, are used by South Sea Islanders for various kinds of bags and fish nets. Unlike other orb-weavers, the *Nephila* makes use of the same web for a long period replacing only the viscid lines. The webs of young *Nephila* are complete orbs but the adults construct incomplete webs in the upper side. *N. maculata* is having an orb-web with a barrier web in the lower side.

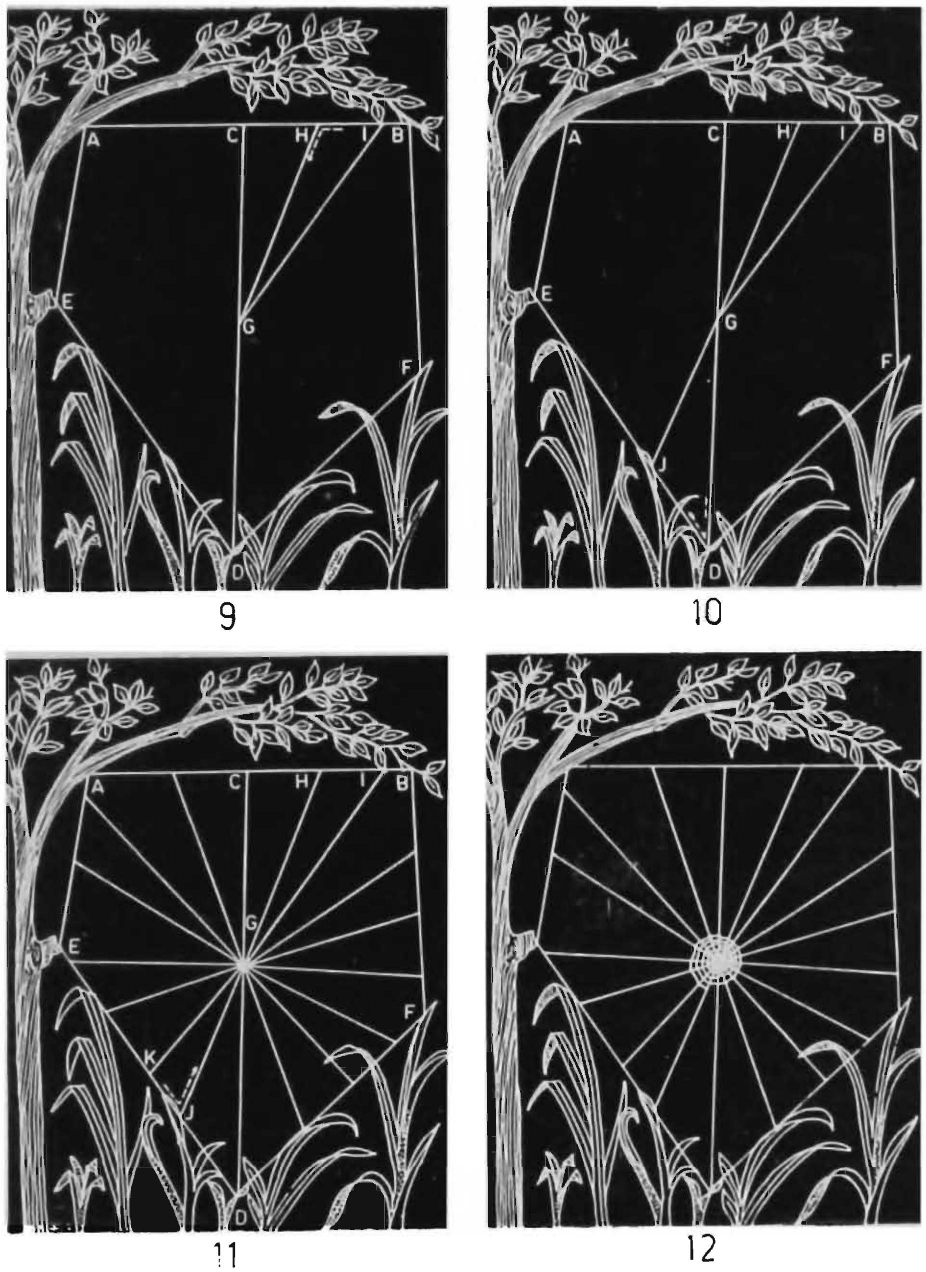
Larinia makes the orb-web in the low bushes without any retreat. It does not rest in the centre of the web but on the vegetation to the side in day time. At night it sits in the hub only.

Members of the genus *Cyrtophora* produce the most unusual webs, thus perhaps the most specialised one. They make horizontal dome shaped webs with a barrier-web above and below (Fig. 49). The webs are devoid of viscid silk which is a specialised character since sticky threads are found in almost all araneids. The mesh of the web, which takes several nights to build, is so extraordinarily small that it can be said that it is a derived character. The webs of *Cyrtophora* are the best example of highest achievement of technical masterpiece among the spiders. *C. cicatrosa*, *C. citricola*, live in large colonies that span huge areas with contiguous barrier webs. These spiders make very few catches but since new webs are not constructed frequently, little energy is spent. The moths or other insects fly against the barrier web, tumble down to the domed horizontal orb-web, and are pulled through by the spider from below the web. The threads of the orb are not viscid and thus the rain water does not affect them, so no need to replace them frequently. It is observed that *Cyrtophora* takes 4-5 nights to complete its web (Kullmann, 1975).

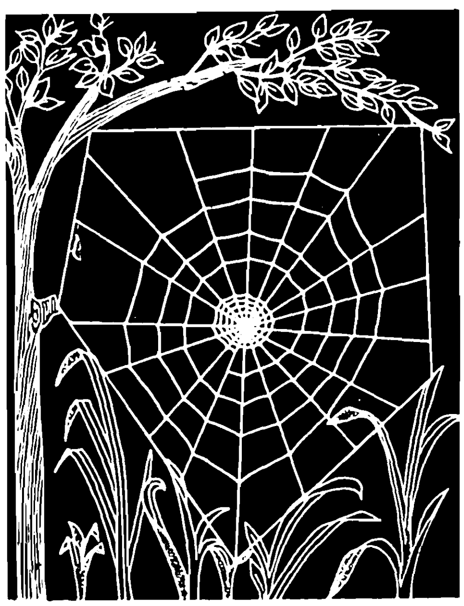


Figs. 1-4. Orb-weaving mechanism of *Gasteracantha mammosa* C. L. Koch.

Figs. 5-8. Orb-weaving mechanism of *Gasteracantha mammosa* C. L. Koch.



Figs. 9-12. Orb-weaving mechanism of *Gasteracantha mammosa* C. L. Koch.



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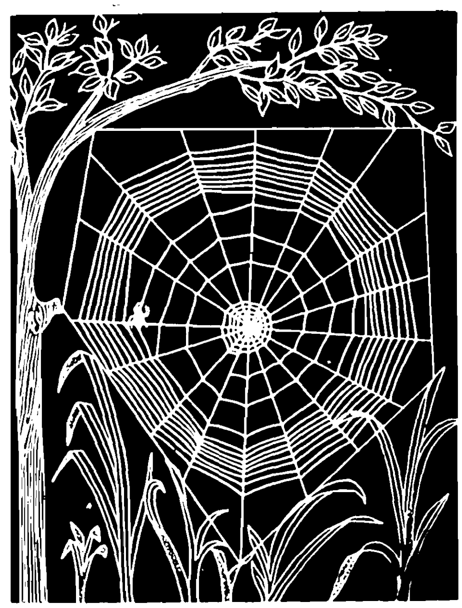

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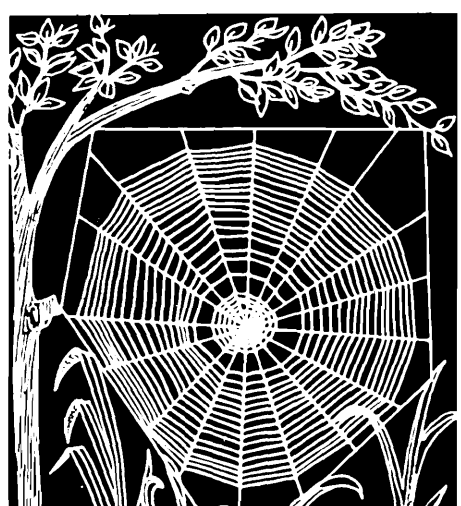

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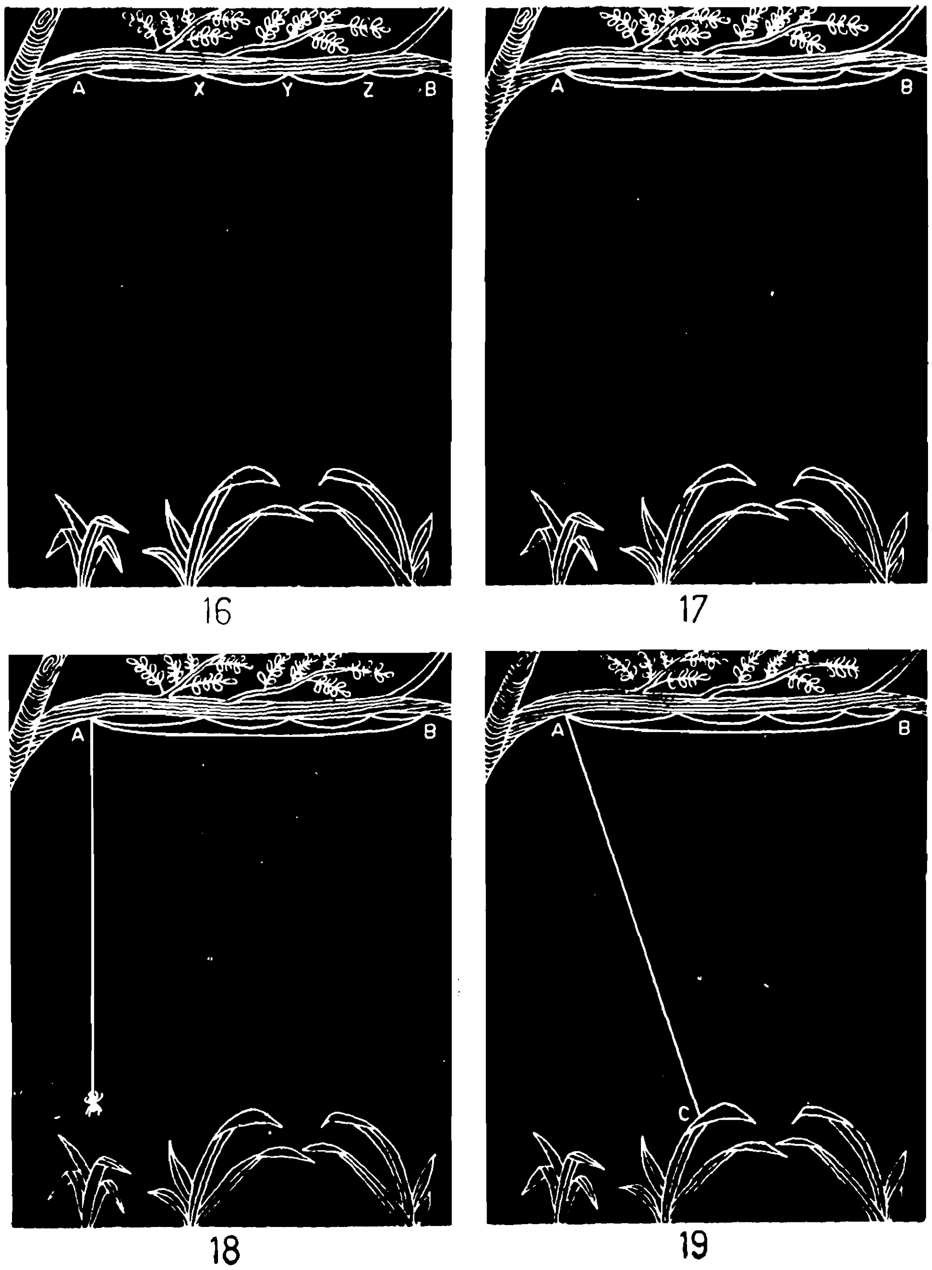
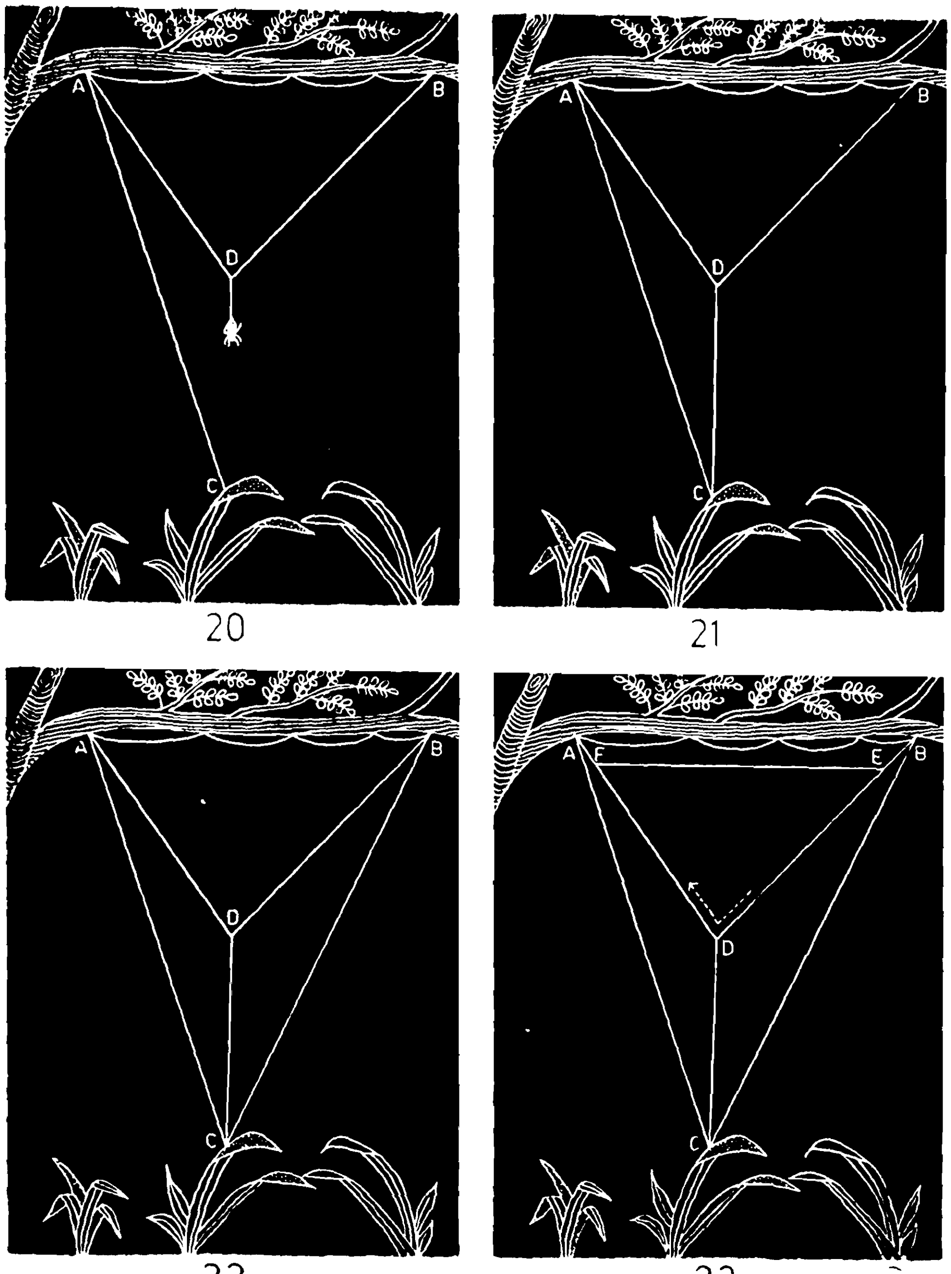
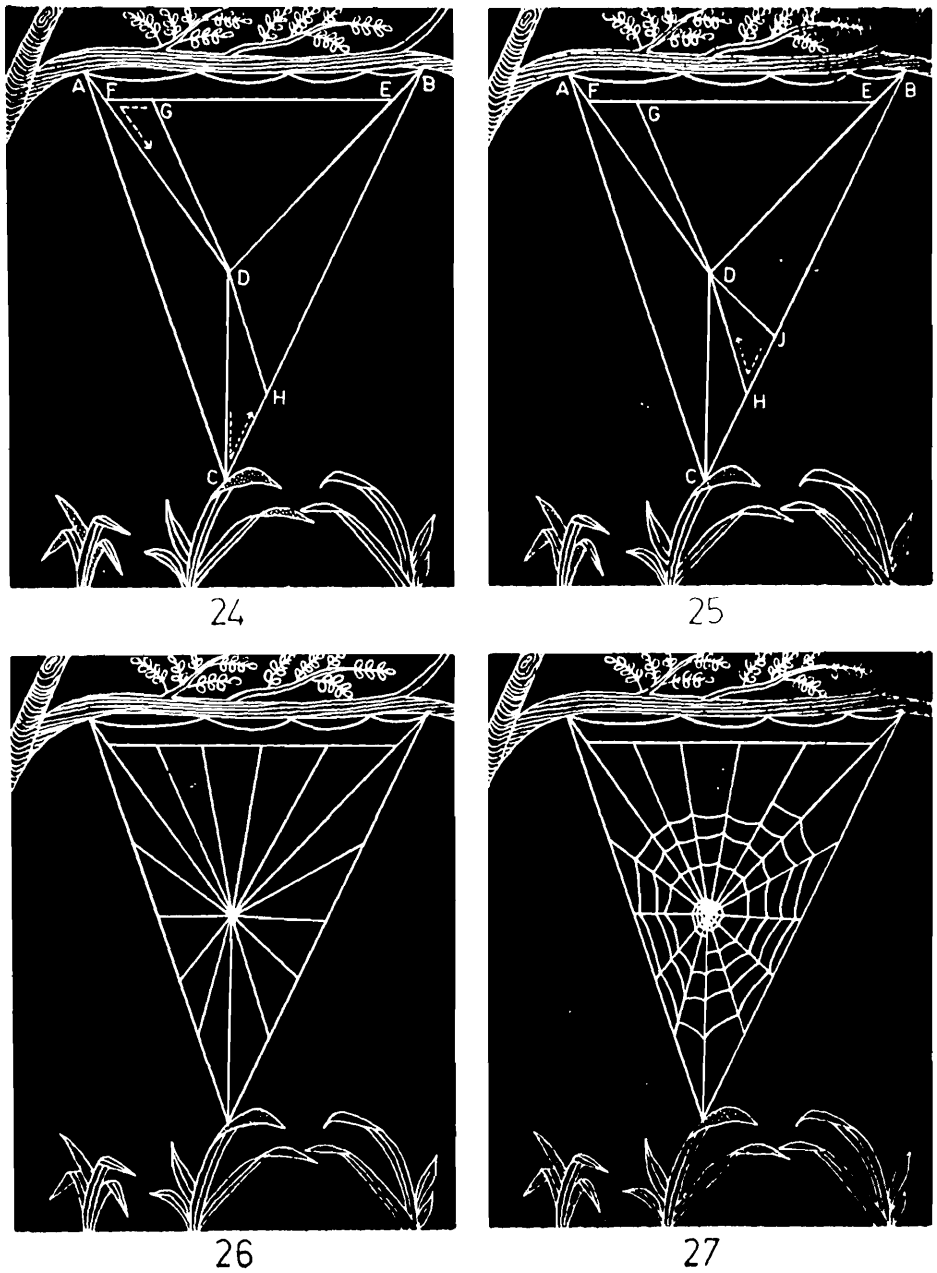
Figs. 13-15. Orb-weaving mechanism of *Gasteracantha mammosa* C. L. Koch.



Figs. 16-19. Orb-weaving mechanism of young *Araneus* spider.



Figs. 20-23. Orb-weaving mechanism of young *Araneus* spider.



Figs. 24-27. Orb-weaving mechanism of young *Araneus* spider.

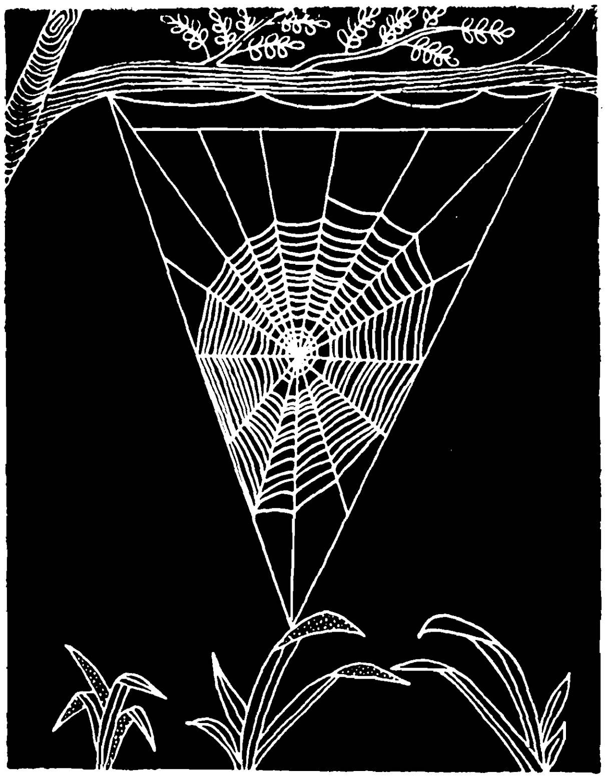


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Fig. 28. Orb-weaving mechanism of young *Araneus* spider.

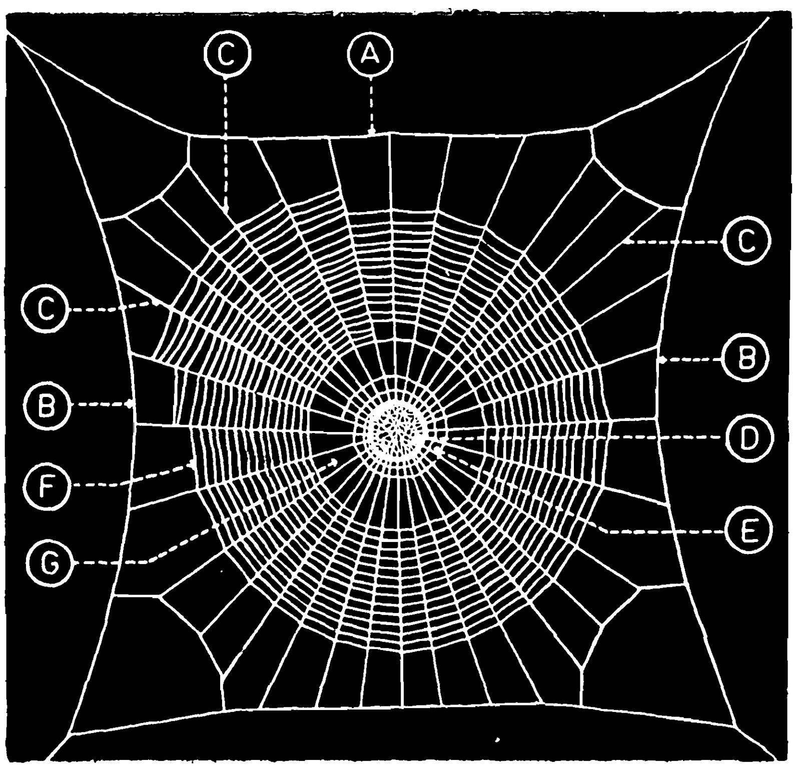

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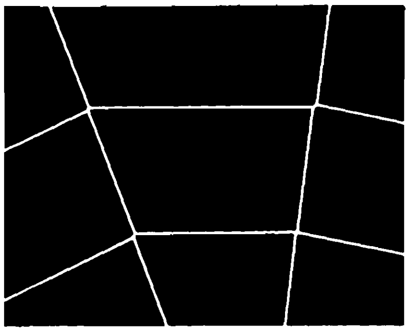
Fig. 29. Different parts of a typical orb-web.



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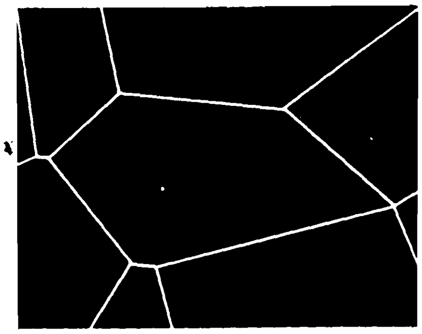

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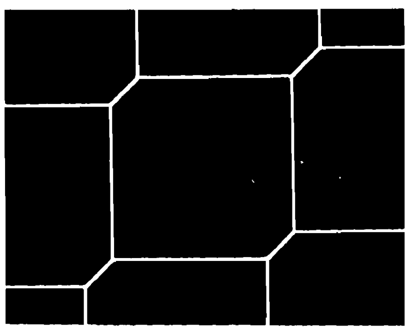

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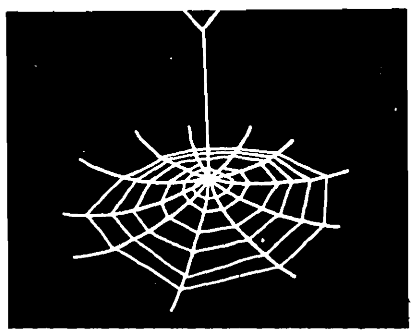

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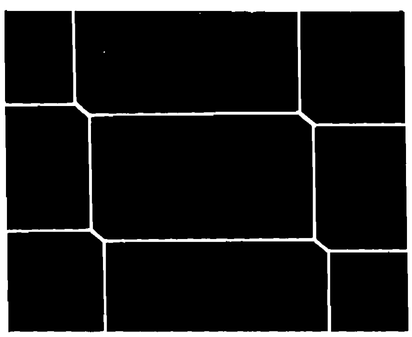

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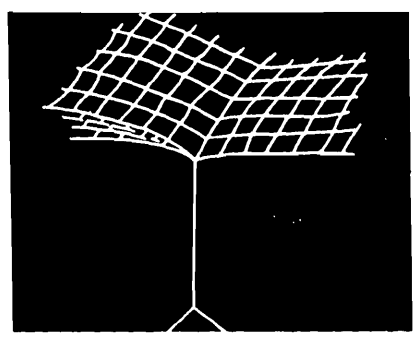

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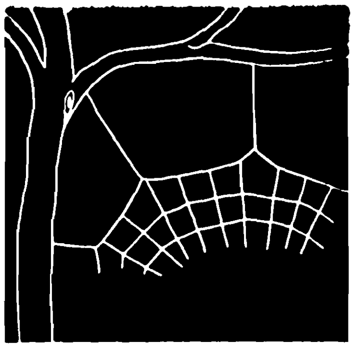
Fig. 30. Trapezoid mesh.
Fig. 31. Square mesh.
Fig. 32. Rectangular mesh.

Fig. 33. Irregular mesh.
Fig. 34. Anchoring threads.
Fig. 35. Anchoring threads.



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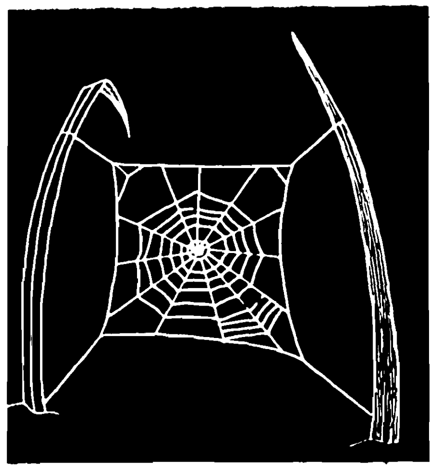

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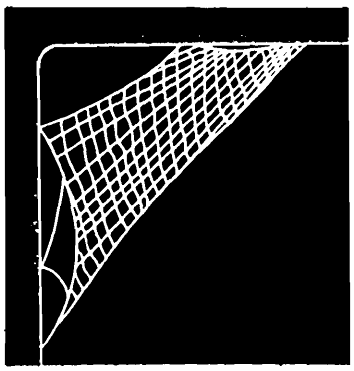

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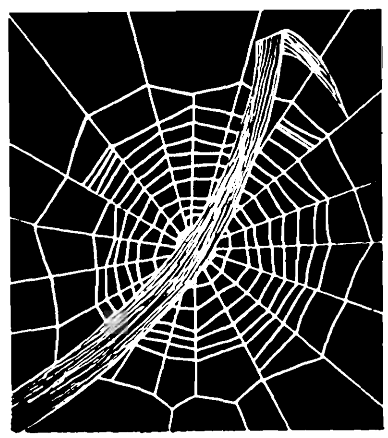

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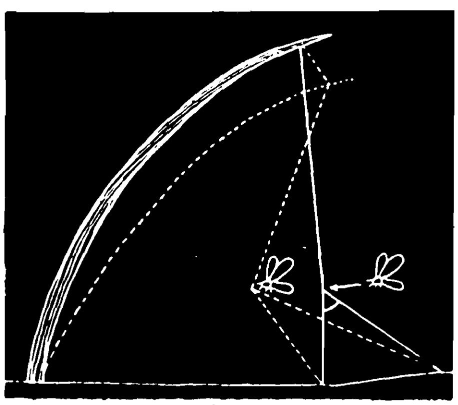

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Fig. 36. Tree branches.

Fig. 37. Blades of grass.

Fig. 38. Building corners.

Fig. 39. Blade of grass as internal net-support.

Fig. 40. Very flexible grass,

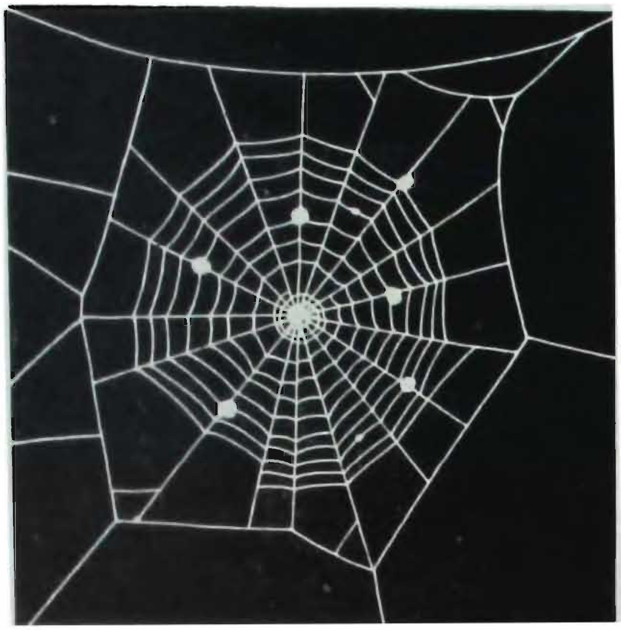

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Fig. 41. Orb-web of *Gasteracantha* with fussy silk balls.

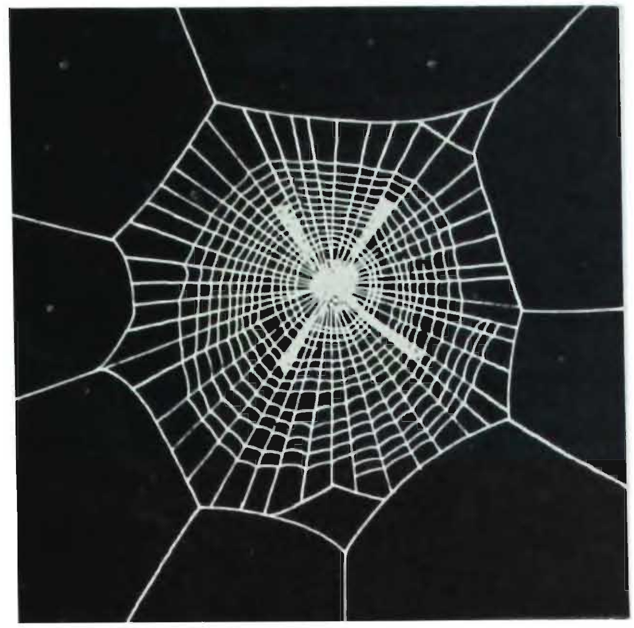

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Fig. 42. Orb-web of *Argiope*, provided with X-shaped stabilimentum.

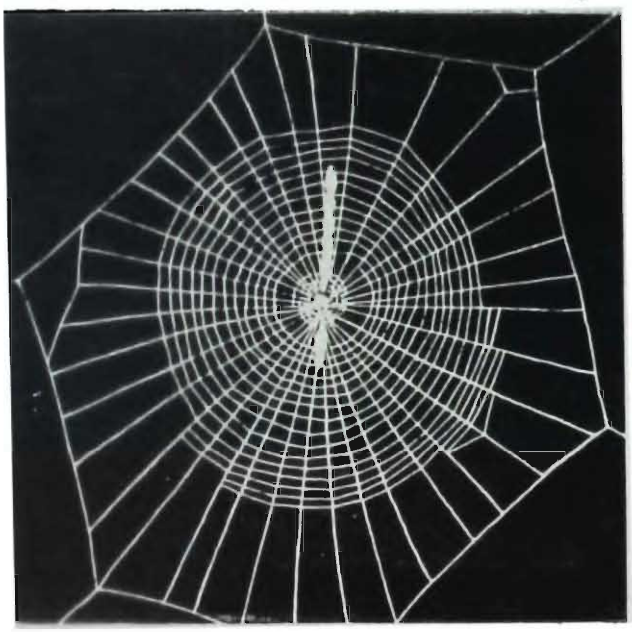

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Fig. 43. Orb-web of *Cyclosa insulana* (Costa).

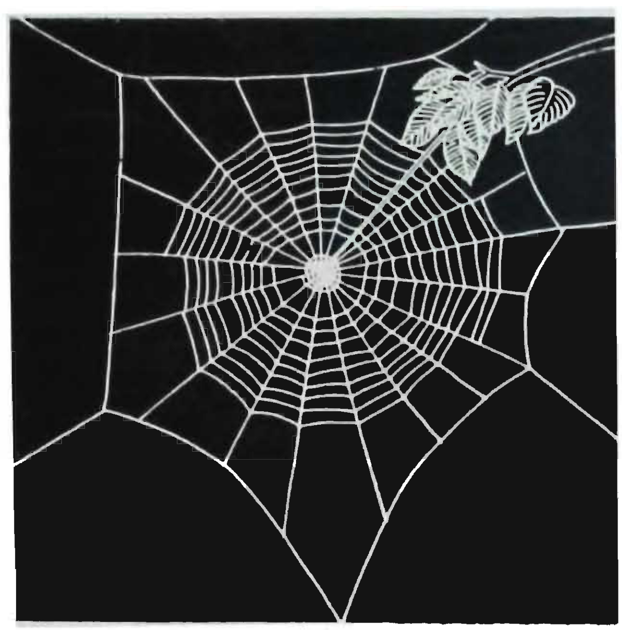

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Fig. 44. Orb-web of an araneid spider with retreat.

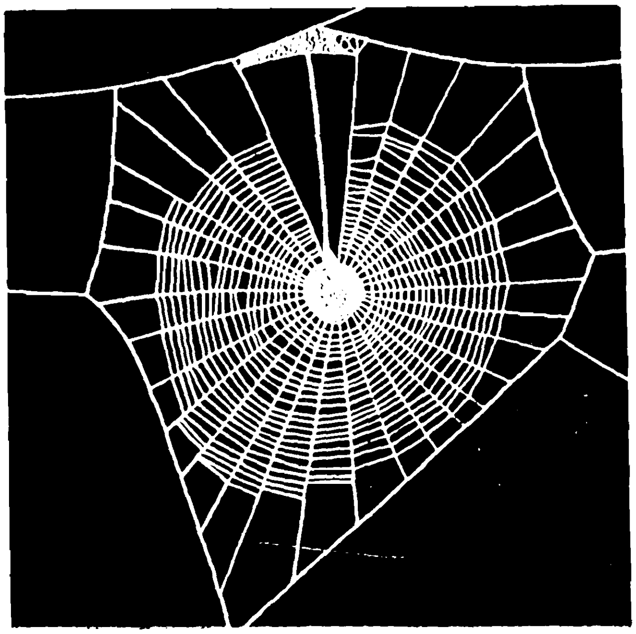

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Fig. 45. Orb-web of *Zygeilla*.

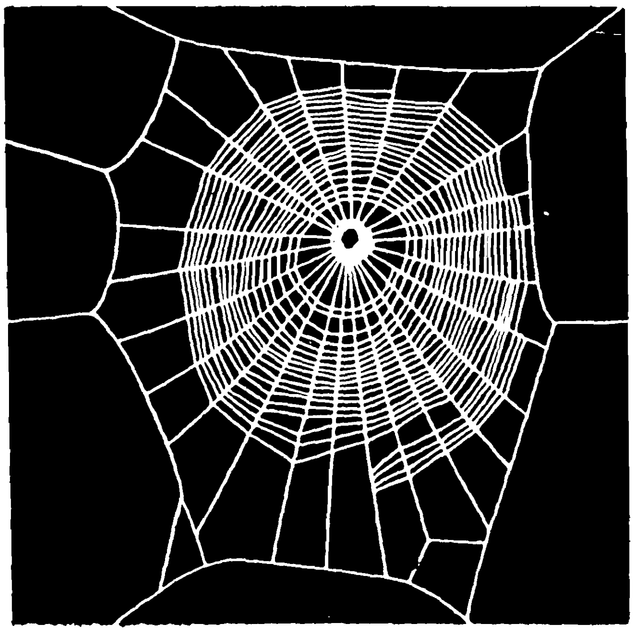

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Fig. 46. Orb-web of *Neoscona*.

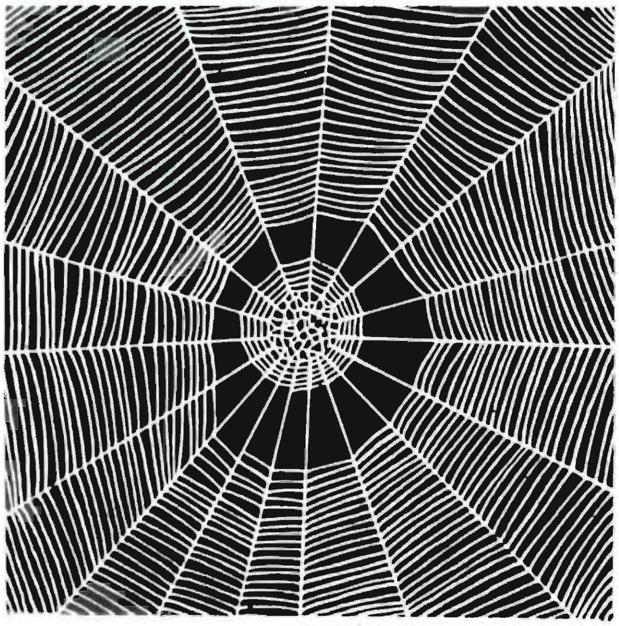

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Fig. 47. Orb-web of *Araneus*.

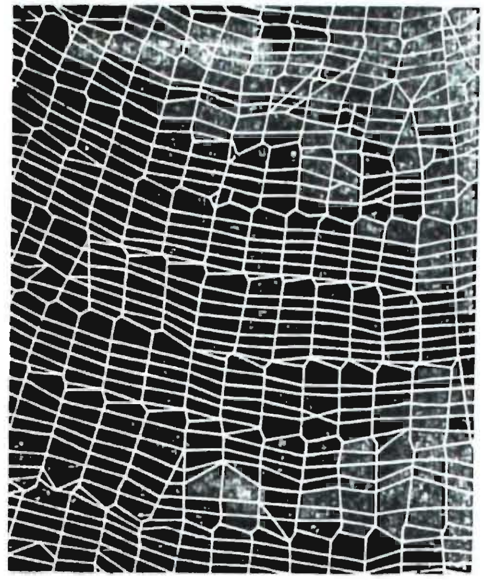

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Fig. 48. Part of the orb-web of *Nephila*.

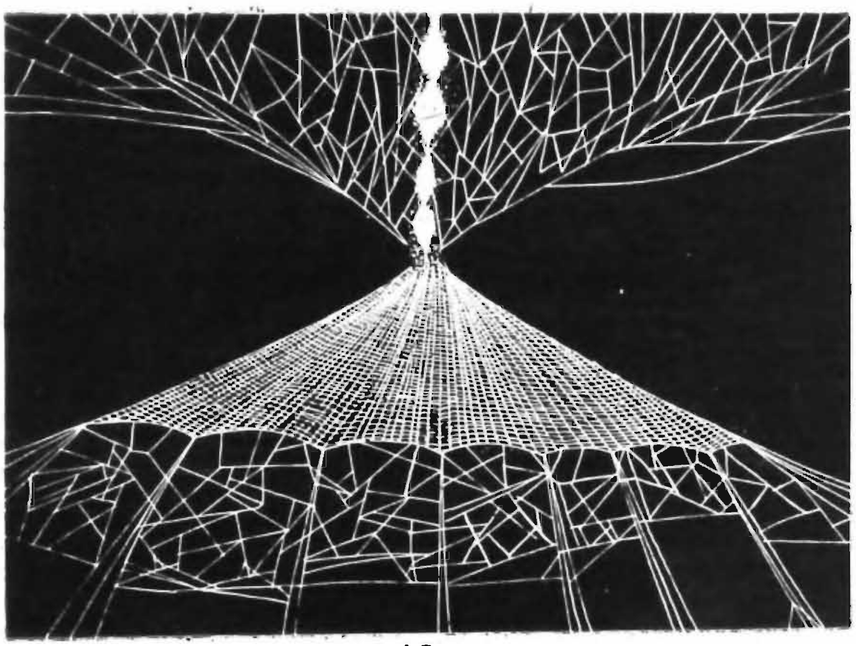

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Fig. 49. Horizontal dome shaped web of *Cyrtophora citricola* (Forskal) with a barrier web above and below.

Acknowledgements

We are thankful to Dr. T. N. Ananthakrishnan, former Director, Zoological Survey of India for providing facilities and encouragement for undertaking this ecological studies on Indian araneid spiders. The illustrations used in this paper are prepared by Shri P. W Garde and Shri D. J. Kamble, Artists of the Western Regional Station, Poona, to whom our thanks are due.

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Bull. zool. Surv. India, **4** (3) : 385-386, 1981

FIRST RECORD OF *STIGMATOGOBIUS DURBANENSIS* (PISCES : GOBIIDAE) FROM INDIAN WATERS

The gobioid, *Stigmatogobius durbanensis* (Barnard) is known so far only from its type locality in the western Indian ocean (Smith, 1960). Recently, the author discovered four well-preserved specimens of this rather rare gobioid from the Orissa coast. The present communication reports the occurrence of this gobioid for the first time in Indian waters thereby extending its range to the central Indian ocean.

The genus *Stigmatogobius* Bleeker is represented by 21 species in the Indo-Pacific region. Of these, nine species including the present one are known from Indian waters : *S. sadanundio* (Hamilton), *S. poicilosoma* (Bleeker), *S. hoevenii* (Bleeker), *S. oligactis* (Bleeker), *S. roemeri* Weber, S. *minima* (Hora), *S. durbanensis* (Barnard), *S. yanamensis* Visweswara Rao and *S. micrognathus* Visweswara Rao.

A brief description of *Stigmatogobius durbanensis* is given below.

Stigmatogobius durbanensis (Barnard)*

(Plate VIII)

Gobius durbanensis Barnard, 1927, *Ann. S. Afr. Mus.*, **21** : 815. (type locality : Durban Bay).

Stigmatogobius durbanensis : Smith, 1960, *Ichthyol. Bull. Rhodes Univ.*, (18) : 306.

Material : 4 specimens, 16-27 mm. standard length ; Orissa coast, no further data ; Z. S. I. Regd. No. F 7651/2.

Description : D_1 VI, D_2 I, 7 ; A I, 7 ; V I, 5 ; P 15-16 ; C 16 (segmented rays) ; scales : lat. sr. 36-38, tr. sr. 10-11, pred. sr. 15-16.

Body elongated, somewhat compressed posteriorly ; head depressed. Depth of body 18.4-20.3%, length of head 27.7-30. 0%, both in standard length. Predorsal distance 38.8-42. 5%, preanal distance 56.2-61.1%, preventral distance 34.4-37.5% in standard length. Eye 25.3-29.1%, snout 26.6-29.1% in head length. Maxilla extending to vertical from mid-eye to posterior margin of eye, 40.9-46.6% in head length. Anterior nostril tubular. Tip of tongue rounded. Teeth in jaws multiserial, close-set, outer rows somewhat enlarged ; in lower jaw, outer row extends to half of jaw length ; no canines. Only nasal sensory canal-pores present. Scales ctenoid, on nape and operculum weakly ctenoid, on breast and belly cycloid. Head scaled above behind eyes, the foremost scale a large unpaired one in the median line. Preoperculum naked, operculum scaled in the upper part. Caudal fin rounded, shorter than head.

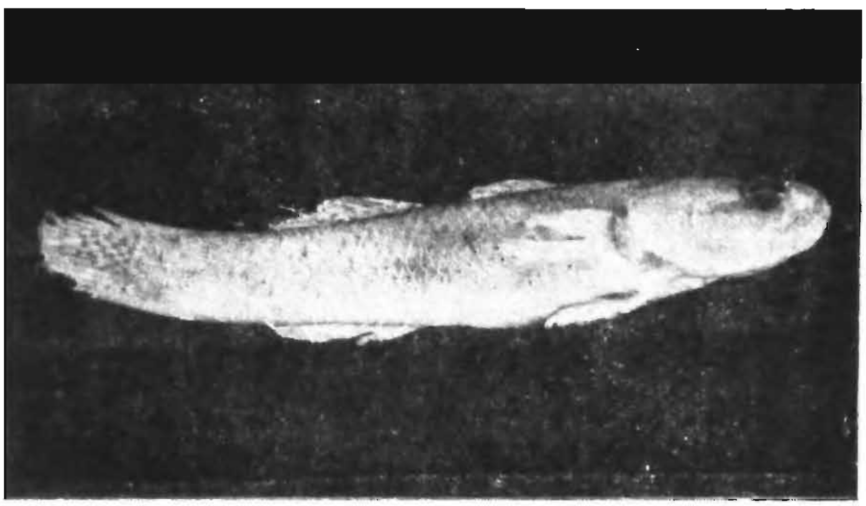
Colour, in alcohol : yellowish brown, with faint irregular cross-bands. Dorsal fins with brownish spots arranged in two longitudinal rows ; caudal fin also spotted.

Remarks : The present specimens agree well with the original description of the species but have a lesser number (10-11 vs. 12) of scales in the transverse series.

* While the manuscript of this communication was in press, the author received the paper of Hoese & Winterbotton (1979, *Occ. Pap. Life Sci. R. Ont. Mus.*, (31) : 4) wherein *durbanensis* is placed in the genus *Mugilogobius* Smitt. 1899.

CHATTERJEE

PLATE VII



Stigmatogobius durbanensis (Barnard), specimen (ZSI F 7651/2, 27 mm S. L.) from Orissa coast, India.

ACKNOWLEDGEMENTS

I am grateful to the Director, Zoological Survey of India, and Dr. K. C. Jayaram, Deputy Director for their kind encouragements. I wish to express my deep sense of gratitude to Dr. P. K. Talwar, Superintending Zoologist for kindly critically going through the manuscript. The photograph of the specimen was taken by the departmental photographer, Shri Kanchan De.

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Zoological Survey of India,
Calcutta.

T. K. CHATTERJEE

SHORT COMMUNICATION

Bull. zool. Surv. India, 4 (3) : 387-388, 1981

ON THE RANGE EXTENSION OF THE CARIDEAN SHRIMP *CONCHODYTES TRIDACNAE* PETERS IN ASSOCIATION WITH THE BIVALVE *TRIDACNA TRIDACNA* LINNEAUS IN THE MINICOY ATOLL, LAKSHADWEEP[1]

While surveying the Lakshadweep group of Islands, one of the authors (A. M.) came across a caridean shrimp *Conchodytes tridacnae* Peters (Plate VIII, Figs. 1 & 2) ensconced within the mantle cavity of a giant bivalve *Tridacna tridacna* Linn. (Plate VIII, Fig. 3) from the coral bed of Minicoy atoll (Between Lat. 8°15' N and 8°20' N and Long. 73°0'E and 73°05'E), the southern most atoll in Lakshadweep, Arabian Sea.

Material : One example (♂), Minicoy atoll, 14.7mm in length, B. P. Halder & A. Misra, 11.12.1979, Reg. No. C 2533/2.

The present note reports the southward extension of the range of distribution of the shrimp within the Lakshadweep group of islands. From the published reports, it reveals that the species is widely distributed in the Indo-Pacific region and is confined to the insular regions *viz.*, Andamans and Lakshadweep group of islands in India.

The earliest report of the occurrence of this shrimp (as *Pontonia* sp.) within the mantle cavity of clam (*Tridaona* sp.) from the Indian waters, Cherbanian reef, the northern most open reef in Lakshadweep, is by Alcock (1902). Pearson (1905) errected the new genus *Conchodytes* for *Pontonia*. Kemp (1922) determined the shrimp of Cherbanian reef collected by Investigator, Octo. 1891 as *Conchodytes tridacnae* Peters and mentioned the extension of the range of distribution of this species to Port-Blair, Andamans, Indian Ocean. The first report of the association of this species with a holothurian host, off Cinque Island, South Andamans, is by Chopra (1937). The study of Nagabhusanam & Rao (1972) on the marine fauna of Minicoy atoll, Lakshadweep, reports the occurrence of the bivalve but not the shrimp.

The exact relationship of the shrimp with the host is not studied in detail. But from the observations, so far, made, it appears that the host provides not only a safe shelter but also sufficient food and oxygen through its activity. In turn, the benefit gained by the host through this association is apparently nil.

Concluding, it may be stated that future collections and observations from the mainland as well as the islands in the Indian region, should focus sufficient light on the nature of relationship existing between the associating partners.

ACKNOWLEDGEMENT

We are grateful to the Director, Zoological Survey of India, Calcutta, for the laboratory facilities and Shri G. Ramakrishna, retired scientist, Zoological Survey of India for going

Fig.1

Fig.2

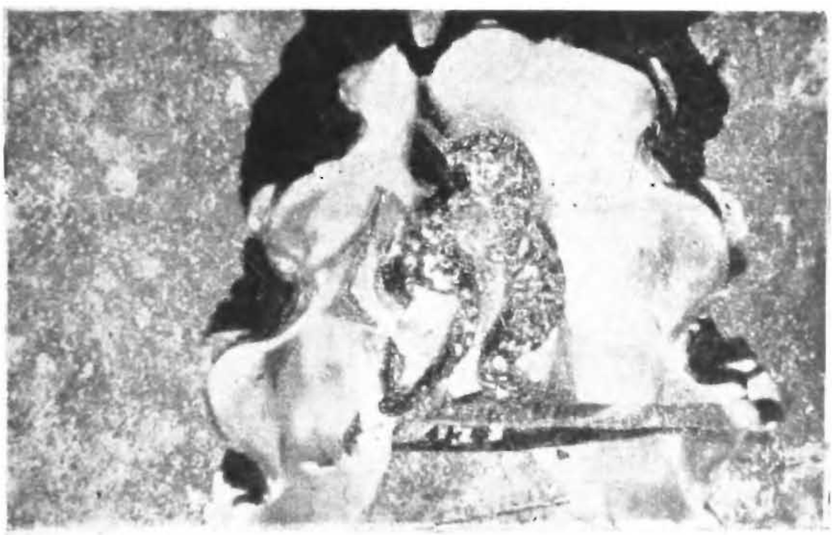

Fig. 3

Figs. 1 & 2. *Conchodytes tridacnae.* (1) Dorsal view ; (2) Ventral view. Fig. 3. *Tridacna tridacna*, shell opened

through the manuscripts and offering valuable suggestions in the preparation of this report.

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A. MISRA AND S. S. GHATAK

SHORT COMMUNICATION

Bull. zool. Surv. India, **4** (3) : 389, 1981

FIRST RECORD OF THE RUFOUS HORSESHOE BAT, *RHINOLOPHUS ROUXI ROUXI* TEMMINCK [CHIROPTERA : RHINOLOPHIDAE] FROM BURMA.

While studying some specimens of the genus *Rhinolophus* present in the collection of the Zoological Survey of India, a male specimen (Reg. No. 12726) collected from Toungoo, Burma in January, 1927 was identified as *Rhinolophus rouxi rouxi* Temminck.

According to extant literature (Ellerman and Morrison-Scott 1966 and Sinha 1973) this bat is hitherto known from Sri Lanka, peninsular India extending north to Nepal, the easternmost limit being Darjeeling Dist., West Bengal. This would, therefore, constitute not only its first authentic record from Burma but also extends its range of distribution for eastwards.

The measurements (in mm) taken from alcohol preserved specimen are as follows :

External : Length of ear 20 ; length of noseleaf 11.5 ; width of horseshoe 8 ; length of forearm 46.2 ; length of tail 23.7 ; length of tibia 20.7 ; length of foot and claw 10.8.

Skull : Total length 21.8 ; condylobasal length 19.4 ; interorbital width 2.6 ; zygomatic width 11.7 ; length of upper tooth row 8.5 ; width across caniness 5.9 ; length of lower tooth row 9.8 ; mandibular length 15.

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SHORT COMMUNICATION

Bull. zool. Surv. India, **4** (3) : 391-393, 1981

ON THE TEREDINID BORERS OF MANGROVES OF CAMORTA ISLAND, NICOBAR, INDIA

Considerable damage is caused to marine installations and timbers by teredinid borers (Teredinidae : Bivalvia : Mollusca) and have been investigated in detail from different coastal waters of the Indian mainland (*see* Turner, 1966 a & b ; Subba Rao, 1968 ; Nair and Saraswati, 1971 ; Purushotham and Satyanarayana Rao, 1971; Nair and Dharmaraj, 1980) as well as Andaman Islands (*see* Karande, 1978 ; Das and Dev Roy, 1980 ; Tiwari *et al*, 1980). Studies on this group of wood borers are very much essential in order to have an understanding of their incidence and activity in different aquatic biotypes particularly in view of our increasing mariculture necessitating installation of numerous wooden structures. Moreover it has also been found that each geographical location is having its own set of dominant borers and assemblage of less important ones (Nair, 1968 ; Nair and Dharmaraj, 1979). So, teredinids of Nicobar waters need special attention as barring two reports on the occurrence of *Nausitora dunlopei* Wright (Rajagopal and Daniel, 1972 ; Tiwari *et al*, *op. cit.*) no information on this group from Nicobar Islands are available till date. The said species has been recorded from Galathea river, Great Nicobar and mangrove zones of Car Nicobar, the southernmost and northernmost Islands of the Nicobar group respectively.

During the course of a recent survey three species of teredinid borers, namely, *Bactronophorus thoracites* (Gould), *Dicyathifer manni* (Wright), *Lyrodus pedicellatus* (Quatrefages) have been collected from the mangrove areas of Camorta Island, Nicobar lying between 08°03'-08°15'N and 93°27'-93°34' E. Thus all these three species constitute the first record from Nicobar waters.

Family TEREDINIDAE

Bactronophorus thoracites (Gould)

Material : 5 exs., Camorta Is., coll. M. Sil ; 6. VIII. 80 &8. VIII. 80.

Remarks : Among the teredinid borers collected in camorta island this species was found to be most dominant attacking the dried up stems of the mangrove, *Rhizophora apiculata*. It is one of the longest borer and the maximum length of our collected materials from this island was 50 cm.

Distribution : In India this species has so far been reported from Sundarbans, Mahanadi estuary, Visakhapatnam, Vellar-coleroom estuary (Porto Novo), Bombay and South Andaman. For detailed distribution outside India *see* Das and Dev Roy (*op. cit.*).

Dicyathifer manni (Wright)

Material : 2 exs., Camorta Is ; coll. M. Sil ; 8. VIII. 80.

Remarks : This species was found to infest dead stumps and stilt roots of the mangrove. Our collected materials are 8 cm. and 9. 5 cm. in length.

Distribution : This species is having world-wide distribution in tropical and temperate seas. In India it has been reported from Sundarbans, Mahanadi estuary, Visakhapatnam, Madras harbour, Pulicat Lake, Cochin, Bombay, South and Middle Andamans.

Lyrodus pedicellatus (Quatrefages)

Material : 2 exs., Camorta Is ; coll. M. Sil ; 8. VIII. 80.

Remarks : It has also been found to attack the dead stumps and stilt roots of the mangrove. Length of the specimens examined 9 cm and 10.2 cm.

Distribution : World-wide in tropical and temperate seas. In India this species has been recorded from Mahanadi estuary, Visakhapatnam, Madras, Pamban, Tondi and Adirampatnam, Tuticorin, Kayamkulam, Cochin, Mangalore, Karwar, Panaji, Ratnagiri, Bombay, Daman, Veraval, Okha, Kandla and South Andaman.

Acknowledgement

Sincere thanks are due to the Director, Zoological Survey of India for extending facilities and Dr. N.P. Balakrishnan, Botanical, Survey of India, Port Blair Circle for identifying mangrove species.

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Bull. zool. Surv. India, **4** (3) : 395-398, 1981

SILUROID FISHES OF INDIA, BURMA AND CEYLON. 24. THE SYSTEMATIC STATUS OF *ARIUS SATPARANUS* CHAUDHURI (ARIIDAE : SILURIFORMES)

Chaudhuri (1916) described *Arius satparanus* from a single example 210 mm long (probably SL)*, collected from the channel between Satpara and Barnikuda (Chilka Lake, Orissa), ZSI Regd. No F 8784/1. He differentiated his species from *Arius arius* (Hamilton) and *A. maculatus* (Thunberg) and also from all the other known species of this genus in its having a single oval patch of sparsely arranged globular teeth on either side of the posterior extremity of the palate. He did not compare it with *A. tenuispinis* Day, 1877, convinced as he was that *tenuispinis* belonged to the genus *Hemipimelodus* (palate teeth absent) as indicated by Day 1877.

Chandy (1954) published a description of *Tachysurus* (=*Arius*) *tenuispinis* based on the topotype specimens and contended that there are two distinct pear shaped patches of globular teeth placed far back almost at the posterior extremity of the buccal cavity. However, she included *T.* (=*Arius*) *satparanus* (Chaudhuri) in her catalogue without any comment. Misra (1976) placed *tenuispinis* under the genus *Hemipimelodus* following Day and he considered *A. satparanus* as a distinct species. Talwar (1976) examined the holotype of *A. tenuispinis* Day (original of pl. 107, fig. 5, 280 mm in SL, registered as *Hemipimelodus tenuispinis* in the National Zoological Collections of ZSI, Regd. No. 482) and demonstrated the species as having two pear shaped teeth patches on the palate. He concluded thereby that *tenuispinis* cannot be placed under the genus *Hemipimelodus* confirming Chandy's (1954) earlier contention. In respect of *A. satparanus* Chaudhuri, he considered it as most closely related to *A. tenuispinis* Day and distinguished the two species on the presence or absence of dorsal tubercles and the nature of the dorsal and pectoral spines.

During the course of our studies on the fishes of the family Ariidae, we have examined and compared the holotypes of *A. tenuispinis* Day (280 mm. SL, ZSI, Regd. No 482) and *A. satparanus* Chaudhuri (200 mm in SL, ZSI, Regd. No. F 8784/1). We have also examined more than 150 fresh specimens of *A. tenuispinis* collected from various localities of east and west coasts of India, besides other non-typical material preserved in the collections of ZSI, Calcutta. The size range of the specimens of *A. tenuispinis* examined by us is also wide (80 to 415 mm in SL) which

* The preserved holotype of *A. satparanus* is 200 mm in SL measured by us, however, Chaudhuri (1916) measured the same as 210 mm. Probably this difference of 10 mm may be attributable due to a different standards adopted by Chaudhuri.

covers the size of the holotype (200 mm in SL) of *A. satparanus* Chaudhuri.

As stated earlier, Chaudhuri (1916) did not compare *A. satparanus* with the already described species *A. tenuispinis* Day, presumably because he was convinced that the latter species did not belong to the genus *Arius*. The morphometric proportions for six characters given by Chauduri for *A. satparanus* are compared with the same features derived from the samples of *A. tenuispinis* (Table 1) collected by us. Further, 23 morphometric and meristic characters of *A. tenuispinis* are analysed statistically and compared with those of *A. satparanus* so as to have a perspective picture of the intraspecific range of variation in respect of each character (Table 2).

From the above analysis it is seen that there is hardly any character which distinguishes *A. satparanus* from *A. tenuispinis*. All the 23 major taxonomic characters of the former species intergrade completely with

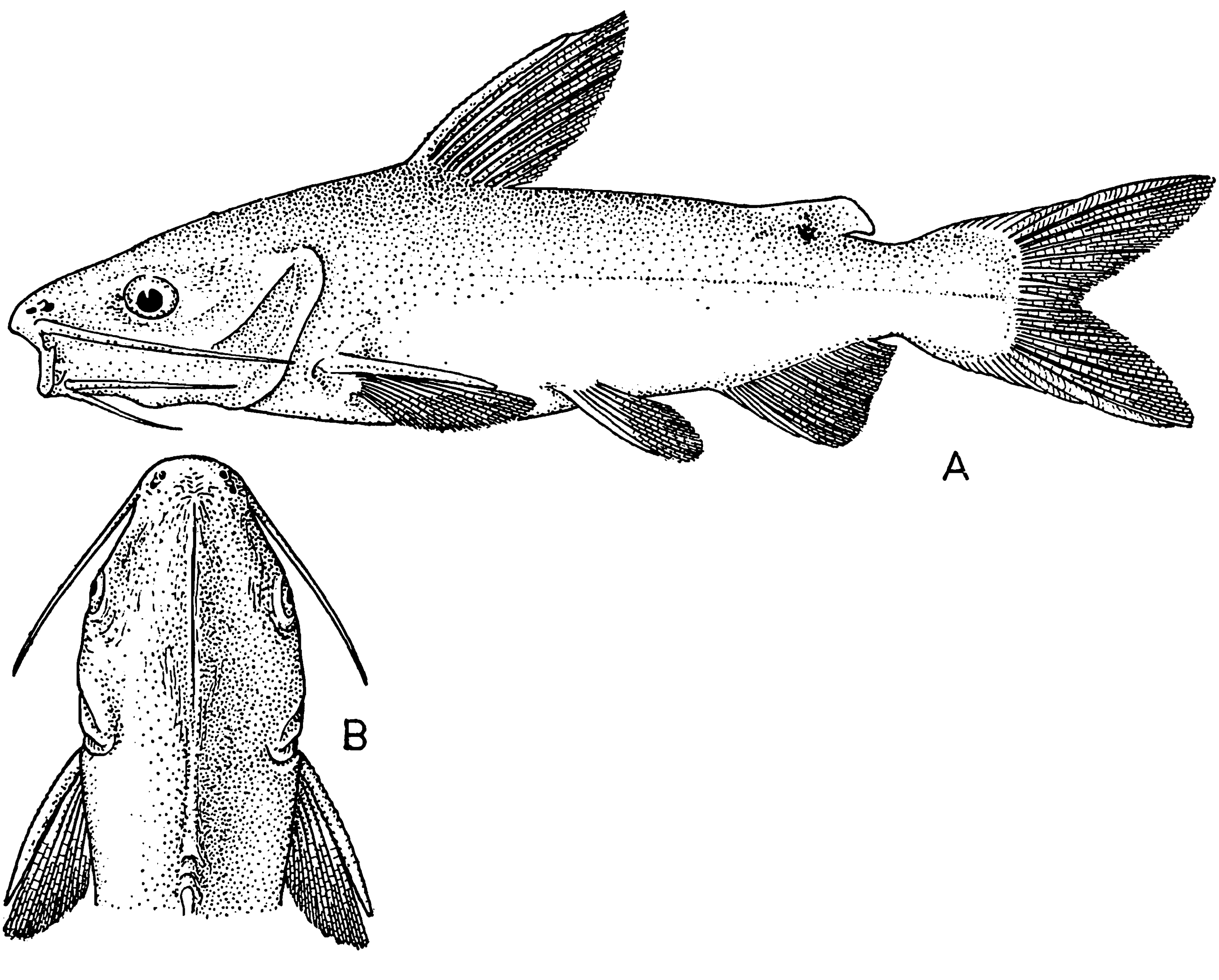

Fig. 1a. Lateral view of *Arius satparanus*, after Chaudhuri, 1916.
1b. Dorsal view of the head region of *A. satparanus*, after Chaudhuri, 1916.

that of the latter (Table 2). The morphological features considered by Talwar (1976) such as the dorsal tubercles and nature of the dorsal and pectoral spines are also not very helpful in distinguishing the two species when a series of large examples of all size groups are examined. Moreover it may be noted that there are no dorsal tubercles in the holotype of *A. satparanus* barring a few granulations on the occipital process which is very much similar to that of *A. tenuispinis*. It is also of interest to note that subsequent to Chaudhuri (1916), *A. satparanus* has not been recorded from Chilka Lake or any where else and no example has been so far identified by any ichthyologist as *A. satparanus*.

In view of the above reasons we relegate *A. satparanus* Chaudhuri (1916) as a junior synonym of *A. tenuispinis* Day (1877).

We are thankful to the Director, Zoological Survey of India, for facilities.

TABLE—1

Showing the various morphometric characters in *A. satparanus* (after Chaudhuri) *vs.* in the samples of *A. tenuispini.*

As percentage of Standard length	*Arius satparanus* (after Chaudhuri)	*Arius tenuispinis* Range	Mean
1. Length of head	28.6	27.02-33.24	29.5913
2. Depth of body	20.00	16.66-23.33	20.6230
3. Length of snout	12.00	9.35-14.68	12.7321
4. Diameter of Eye	4.76	3.65- 5.76	4.3542
5. Length of pectoral fin	19.00	16.39-21.85	18.6291
6. Length of ventral fin	14.3	12.95-18.23	15.4512

TABLE—2

Biometric comparison of various taxonomic characters in the type specimens of *A. satparanus* Chaudhuri from Chilka Lake vs. sample means of 150 specimens of *A. tenuispinis* Day from different localities of east and west coast of India

	150 specimens of *A. tenuispinis* Day			Type specimen of *A. satparanus* Chaudhuri			
	Range	$\overline{X}$	S	X	$\overline{X}$ —X	t	p
LH/TL%	22.18-28.60	24.1316	1.5211				
HB/TL%	13.10-18.94	17.1800	1.2721				
LH/SL%	27.02-33.24	29.5913	1.4718	30.00	-0.4087	-0.2745	80%
HB/SL%	16.66-23.33	20.6230	1.0452	22.00	-1.377	-1.3023	20%
PDL/SL%	37.57-44.88	40.5830	1.2275	40.00	0.583	0.4695	60-70%
PAL/SL%	65.10-74.88	70.7618	2.2145	68.25	2.5118	1.1212	20-30%
PPL/SL%	23.35-30.98	27.0720	1.7871	30.00	-2.9298	-1.6196	10%
WDF/WAF%	52.38-75.00	61.1797	5.3731	58.62	2.5597	0.4713	60-70%
WH/LH%	59.63-71.62	66.5188	3.3731	65.83	0.6888	0.2009	80-90%
HH/LH%	51.16-60.00	55.8555	3.0645	58.33	-2.4745	-0.7992	40-50%
LS/LH%	32.53-39.70	36.51674	1.6110	35.83	0.6867	0.4193	70%

TABLE—2. *Concluded.*

	150 specimens of *A. tenuispinis* Day			Type specimen of *A. sataparanus* Chaudhuri			
	Range	X	S	X	$\bar{X}$—x	t	p
ED/LH%	12.50-17.64	15.4134	1.1514	16.66	-1.2466	-1.0759	30%
INW/LH%	13.68-19.11	16.2041	1.1271	16.66	-0.4559	-0.3599	70%
IOW/LH%	43.55-53.70	50.9695	2.5706	55.83	-4.8605	-1.8704	10%
ED/LS%	32.35-47.62	42.2586	3.1125	46.51	-4.2514	-1.3508	20%
INW/LS%	38.46-55.55	44.5311	3.8001	46,51	-1.9789	-0.5152	60%
INW/WS%	40.91-62.79	49.5476	5.1681	50.00	-0.4524	-0.0865	More than 99%
ED/IOW%	25.80-39.86	30.6939	2.2450	29.85	0.8439	0.37129	70%
WPMT/ LPMT%	20.00-37.50	25.6848	3.9990	28.83	-3.1452	-0.7379	40-50%
HCPD/ LCPD%	41.34-68.00	55.2386	4.7068	57.14	-1.9014	-0.3999	70%
PFR	10.00-12.00	11.2325	0.5272	11.00	0.2325	0.4360	70%
AFR	17.00-19.00	17.9534	0.5324	18.00	-0.0466	-0.0865	More than 99%
GR	12.00-15.00	13.5348	0.6672	14.00	-0.4652	-0.6892	50%

AFR : anal fin ray counts ; ED : eye diameter ; GR : Gill raker ; HB : height of body ; HCPD : height of caudal peduncle ; HH : height of head ; INW : inter-nostril width ; IOW : inter-orbital width ; LCPD : length of caudal peduncle ; LH : Length of head ; LPMT : length of premaxillary band of teeth ; LS : length of snout ; P : observed probabilities for confidence intervals given in Simpson *et al.* (1960), Appendix Tab. II, for the corresponding calculated 't' value, PAL : pre-anal length ; PDL : predorsal length ; PFR : pectoral fin ray counts ; PPL : pre-pectoral length ; S : standard deviation of the sample mean ; SL : standard length ; TL : total length ; WAF : width of anal fin base ; WDF : width of dorsal fin base ; WH : width of head ; WPMT : width of premaxillary band of teeth ; $\bar{X}$: arithmetic mean of the various observation ; X : single observation.

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