

**THE TAXONOMY AND BIONOMICS
OF BLACK FLIES (SIMULIIDAE : DIPTERA)
OF THE DARJEELING AREA**

Thesis submitted for the Degree of
DOCTOR OF PHILOSOPHY (Science)
of the
UNIVERSITY OF NORTH BENGAL
RAJA RAMMOHUNPUR, DARJEELING

MADANMOHAN DATTA, M. Sc.,
Post-Graduate Dept. of Zoology,
Darjeeling Government College, Darjeeling (India)

1972

Ref.

591.072

D 234t

73950

6 MAR 1981

DARJEELING GOVERNMENT COLLEGE

DEPARTMENT OF ZOOLOGY

Prof. B. Dasgupta

DARJEELING
WEST BENGAL
INDIA

October 14, 1972

This is to certify that Sri Madanmohan Datta worked out his dissertation on 'The Taxonomy and Bionomics of Black Flies (Simuliidae : Diptera) of the Darjeeling area' for fulfilment of the requirements of the degree of Doctor of Philosophy (Science) of the North Bengal University under my supervision.

He has a thorough knowledge on the literature extant in his field of specialization, and I am confident that in future he will be able to carry on researches in the line independently.

B. Dasgupta
14.10.72

S Y N O P S I S

The work on the black flies (Simuliidae:Diptera) of Darjeeling and its neighbourhood incorporated in this thesis is broadly divided into two parts:

Part I deals with the taxonomic account of seven proposed new species, namely, Simulium (Eusimulium) praelargum, S.(E.) gracilis, S.(E.) purii, S.(E.) nemorivagum, Simulium (Simulium) nigrifacies, Simulium (Gomphostilbia) tenuistylum and S.(G.) darjeelingense, four unnamed species; and of previously undescribed larval stages of four species, namely, S.(S.) himalayense Puri, S.(S.) rufibasis Brunetti, S.(S.) dentatum Puri and S.(S.) grisescens Brunetti. Diagnoses of the genus Simulium Latreille s.l. and the three subgenera Eusimulium Roubaud, Simulium Latreille s.str. and Gomphostilbia Enderlein along with keys to the species of this region are also given in this part. A new species-group in the subgenus Eusimulium Roub. is the special attraction of this part.

Part II deals with the assessment of the efficacy of a simple light trap device in sampling black flies in

Darjeeling; and with the determination of the relative abundance, seasonal incidence and succession, sex-ratio, internal conditions of females, host preferences of females, nocturnal periodicity, photophilic behaviour and a few other related aspects of bionomics of six major species of Darjeeling, namely, S.(E.) praelargum n.sp., S.(E.) gracilis n.sp., S.(S.) himalayense Puri, S.(S.) grisescens Brunetti, S.(S.) rufibasis Brunetti and S.(G.) tenuistylum n.sp.

F O R E W O R D

Insects belonging to the family Simuliidae (Nematocera:Diptera) are commonly known in English as "black flies". In the Spey valley of Scotland these insects are also known as birch flies. In different parts of the U.S.A., these flies are also known as buffalo gnats or turkey gnats. In India the term "black fly" is used in the scientific literature, and in Darjeeling these insects are popularly called "bhusuna".

Female black flies of most species are haematophagous, and some of them act as the efficient vectors of parasites and pathogens causing a lot of distress to mankind (Fallis, 1964). These flies are known to transmit some human and non-human filaroid nematodes in the tropical Africa, Central America, Brazil, Britain and the U.S.S.R. These flies also act as the vectors of some protozoan diseases like trypanosomiasis and leucocytozoonosis in America, Europe and Central Asia. These flies may also transmit some viral diseases. In India some black flies are known to be troublesome pests, but nothing is known about the role of these flies as the effective hosts and vectors of parasites and pathogens in this country.

The black fly fauna in many other temperate countries is well-known (see Davies, 1966). Recently, the workers of these countries have shown through cytological studies that many species of earlier taxonomists actually consist of several similar species, i.e., sibling species. It is now a high time to employ a more refined and restrictive species concept in black fly taxonomy. But in India regarding the taxonomic work nothing further is known since the works of Puri (1932-1933), who mainly traced the fauna of South India. In Darjeeling and its neighbourhood the occurrence of black flies is well-known but the fauna has not so far been widely surveyed, and the present work has been undertaken to supplement and add to the earlier taxonomic works through anatomical studies. For clarity and better understanding of the importance of these insects in relation to human and animal lives the present work also includes studies on certain important bionomical phenomena, viz., the abundance, seasonal distribution and succession, sex-ratio, nocturnal periodicity, host preferences and photophilic behaviour of these insects.

The present investigation is the first attempt of its kind to study comprehensively the fauna and bionomics of black flies of Darjeeling and its neighbourhood in the eastern Himalayas. Observations and collections made in this region over 3 years (1968-1971) form the basis of this work.

ACKNOWLEDGEMENTS

I am indebted to Prof.B.Dasgupta, formerly the Head of the Department of Zoology and now the Principal of Darjeeling Government College, Darjeeling (West Bengal, India) for his continuous guidance and for extending all sorts of facilities to me during the conduct of this investigation. I express my heart-felt gratitude to Dr.R.W.Crosskey of the Commonwealth Institute of Entomology, London, for his valuable suggestions and for providing me with a few pertinent literature; to Prof.D.M.Davies of the McMaster University, Hamilton, Ontario, Canada, for his most ██████ helpful advice and for his generosity regarding the identification of some specimens, provision of many pertinent literature and critical reading of the manuscript of Part I; to Mrs.H.Györkös for her assistance to Prof.D.M. Davies; to Dr.D.J.Lewis of the British Museum (Natural History), London, for his valuable suggestions and for the identification of a few specimens; and to Dr.P.F.L.Boreham of the Imperial College Field Station, Silwood Park, Ascot, Berks., England, for his unfailing kindness to conduct the precipitin tests reported here.

I am grateful to Drs. S.Adhikary, Head of the Department of Zoology, and K.Chatterjee, Lecturer of the same Department; and S.K.Das Gupta and K.K.Das, formerly of the same Department of this College, for their encouragement and cooperation.

I am also grateful to Prof.D.K.Choudhury, Head of the Department of Zoology, Burdwan University (West Bengal, India) for going through the manuscript and to the Director, Regional Meteorological Centre, Calcutta for facilities extended to me to study certain meteorological data, particularly those of rainfall and wind velocity.

I am thankful to my friends, Mr.R.P.Pal, Lecturer, Department of Chemistry of this College and Mr.B.N.Das, Lecturer, Department of Statistics, Presidency College, Calcutta for their vital assistance in statistical methods.

My thanks are due to Messrs. N.Paul, S.Barik, R.K.Dey, A.K.Paul, T.K.Pal, A.Sherpa and H.S.Ghatani of this Department for their painstaking help in the field.

Finally, I wish to acknowledge the generous financial support from the University Grants Commission, New Delhi, for this research project.

C O N T E N T S

PART - I (TAXONOMY)

	<u>Pages</u>
INTRODUCTION ...	1 - 12
MATERIALS AND METHODS ...	13 - 18
A. Topography of breeding sites ...	13
B. Collection from breeding grounds ...	16
C. Association of larva with pupa ...	16
D. Rearing of pupa ...	17
E. Preparation of microscopical slides ...	18
DISPOSITION OF TYPE MATERIAL ...	19
CHARACTERISTICS OF THE FAMILY SIMULIIDAE IN RELATION TO KEYS AND DESCRIPTIONS IN- CORPORATED IN THIS STUDY ...	20 - 27
KEY TO THE SUBFAMILIES AND TRIBES OF THE WORLD ...	28 - 29
KEY TO THE SPECIES OF <u>SIMULIUM</u> IN THE DARJEELING AREA ...	30 - 39
GENERIC DIAGNOSIS ...	40 - 42
SUBGENERIC DIAGNOSES AND DESCRIPTIONS OF SPECIES ...	43 -100

	<u>Pages</u>
Subgenus <u>Eusimulium</u> Roubaud	43 - 72
Diagnosis	44 - 46
Descriptions of species	46 - 72
1. <u>praelargum</u> n.sp.	46
2. <u>gracilis</u> n.sp.	51
3. <u>purii</u> n.sp.	56
4. <u>nemorivagum</u> n.sp.	61
5. Species A	65
6. Species B	66
7. Species C	68
8. Species D	70
9. <u>rufithorax</u> Brunetti	72
Subgenus <u>Simulium</u> Latreille	73 - 86
Diagnosis	74 - 76
Descriptions of species	76 - 86
10. <u>nigrifacies</u> n.sp.	76
11. <u>himalayense</u> Puri	80
12. <u>rufibasis</u> Brunetti	82
13. <u>dentatum</u> Puri	83
14. <u>grisescens</u> Brunetti	85
Subgenus <u>Gomphostilbia</u> Enderlein	87 -100
Diagnosis	87 - 88
Descriptions of species	88 -100
15. <u>tenuistylum</u> n.sp.	88
16. <u>darjeelingense</u> n.sp.	94
17. <u>metatarsale</u> Brunetti	99

		<u>Pages</u>
DISCUSSION	...	101 - 115
SUMMARY	...	116 - 117
REFERENCES	...	118 - 127
 <u>PART - II (BIONOMICS)</u> 		
INTRODUCTION	...	128 - 131
Work done abroad	...	128
Work done in India	...	130
MATERIALS AND METHODS	...	132 - 134
Description of the light trap and its operation	...	132
Description of the trapping site	...	134
STUDY OF EFFICACY OF LIGHT TRAP AS SAMPLING DEVICE FOR BLACK FLIES	...	135 - 149
Introduction	...	135
Method	...	136
Result	...	136
Discussion	...	146
Summary	...	149
RELATIVE ABUNDANCE	...	150 - 156
Introduction	...	150

		<u>Pages</u>
Method	...	150
Result	...	151
Discussion	...	154
Summary	...	155
SEASONAL INCIDENCE AND SUCCESSION	...	157 - 173
Introduction	...	157
Method	...	157
Observations	...	158
(a) Seasonal incidence in 1968	...	158
(b) Seasonal incidence in 1969	...	160
(c) Seasonal incidence in 1970	...	163
(d) Seasonal incidence in average	...	165
(e) Seasonal Succession	...	167
Discussion	...	169
Summary	...	172
SEX-RATIO	...	174 - 181
Introduction	...	174
Method	...	175
Result	...	175
Discussion	...	178
Summary	...	180

		<u>Pages</u>
INTERNAL CONDITIONS OF TRAPPED FEMALES	...	182 - 189
Introduction	...	182
Methods	...	182
Observations	...	183
Discussion	...	188
Summary	...	189
HOST PREFERENCE	...	190 - 199
Introduction	...	190
Methods	...	191
Observations	...	192
Discussion	...	195
Summary	...	198
NOCTURNAL PERIODICITY	...	200 - 208
Introduction	...	200
Methods	...	200
Observations	...	201
Discussion	...	206
Summary	...	208
PHOTOPHILIC BEHAVIOUR	...	209 - 218
Introduction	...	209
Methods	...	209

		<u>Pages</u>
Observations	...	210
Discussion	...	216
Summary	...	218
REFERENCES	...	219 - 230

PART-I
(TAXONOMY)

I N T R O D U C T I O N

Black flies belonging to the family Simuliidae (Nematocera) constitute a very homogenous group of insects included in the Order Diptera. At the beginning of the nineteenth century Latreille (1802) erected the genus Simulium to designate black flies. Prior to 1906 no entomologist had ever proposed to split the genus Simulium (sensu lato) but maintained the older tradition of integrity of the genus. Subsequent to 1906 the systematic study of black flies began to progress at an ever-increasing rate in some parts of the world resulting in the addition of more and more genera with subgeneric divisions to the literature. In fact, about 80 genus-group names and over 1300 species-group names were proposed, many of which are, however, recognized to be synonymous now (see Stone, 1964). It is felt desirable to present here a brief review of the episode of the systematic history on the basis of the works of Smart (1945) and others for the sake of clarity and better understanding.

In 1906 Roubaud for the first time proposed a subgeneric division of Simulium (sensu lato) with two subgenera,

Pro-Simulium (subgen.n.) and Eu-Simulium (subgen.n.). Thenceforward, many workers from almost all over the globe advanced suggestions regarding the internal classification of the family Simuliidae.

Surcouf and Gonzalez-Rincones (1911) raised the subgeneric status of Prosimulium Roubaud and Eusimulium Roubaud to genus level and added one more genus Simulium Latreille (sensu stricto) to them to form the family Simuliidae. Malloch (1914), Tonnoir (1925) and, Dyar & Shannon (1927) paid more attention to adding and sinking of genus names than to divide them. Thus, Malloch (1914) sank Eusimulium Roubaud and created the genus Parasimulium (gen.n.) which along with Prosimulium Roubaud and Simulium Latreille (sensu stricto) constituted the family. He regarded Eusimulium Roubaud as a synonym of Simulium Latreille. Based on the study of a restricted fauna Tonnoir (1925) formed the family including three genera, Prosimulium Roubaud, Simulium Latreille (sensu stricto) and Austrosimulium (gen.n.). Dyar and Shannon (1927) constituted the family Simuliidae with four genera, Parasimulium Malloch, Prosimulium Roubaud, Eusimulium Roubaud and Simulium Latreille (sensu stricto).

Enderlein (1921a, b, c, d, e; 1922; 1924a, b; 1925; 1926; 1928a, b; 1929a, b, c; 1930; 1931; 1934a, b; 1935; 1936a, b; 1937) began his classification from the suprageneric

level with a few genera and gradually elaborated this classification with more and more segregates at all levels. His works, however, suffered from some defects probably due to his ignorance of the earlier important works (see Smart, 1945).

Enderlein (1921a, b, c, d) showed a division of the family into two subfamilies - Prosimuliinae and Simuliinae, the latter with two tribes, Nevermanniini and Simuliini. He retained Parasimulium Malloch, Prosimulium Roubaud and Simulium Latreille (sensu stricto) in his classification and created twelve new genera including Gomphostilbia (gen.n.) in it (see Smart, 1945). According to him Eusimulium Roubaud was a synonym of Simulium Latreille (sensu stricto) as per the conception of Malloch (1914). Subsequently Enderlein (1930) presented a synoptic classification from his earlier works (1921e - 1929c). In that classification he accommodated six subfamilies with tribal categories and about thirty genera. This classification was followed by more contributions (1931 - 1937) through which he ultimately increased the number of subfamilies to seven, viz., Prosimuliinae, Hellichiinae, Ectemniinae, Cnesiinae, Stegopterninae, Nevermanniinae and Simuliinae, the last two subfamilies with tribal system. The tribes Nevermanniini, Friesiini and Wilhelmiini were included in the subfamily Nevermanniinae, while the tribes Simuliini and Odagmiini in the subfamily Simuliinae, but other subfamilies were without tribal categories. At the same time he increased the number of genera to fifty (see

Smart, 1945) including Gomphostilbia Enderlein and Simulium Latreille (sensu stricto) with their species but he continued to regard Eusimulium Roubaud as a synonym of Simulium Latreille (sensu stricto), and did not accommodate Austrosimulium Tonnoir in his classification.

Baranov (1926; 1935; 1938) followed Enderlein in his classification of the family Simuliidae of a restricted fauna. In 1926 he erected the subgenera Pseudosimulium (subgen.n.), Pseudodagmia (subgen.n.) and Pseudonevermannia (subgen.n.) to which he later (1935) added one more subgenus Danubiosimulium (subgen.n.). In 1938 he proposed the genus Echinosimulium (gen.n.) and raised the status of Danubiosimulium Baranov to generic level.

Edwards (1931) divided the family into two subfamilies - Parasimuliinae and Simuliinae equally distributing two genera Parasimulium Malloch and Simulium Latreille (sensu stricto), the latter containing seven subgenera, viz., Prosimulium Roubaud, Cnephia Enderlein, Gigantodax Enderlein, Austrosimulium Tonnoir, Eusimulium Roubaud, Morops Enderlein and Simulium Latreille (sensu stricto). In a later work Edwards (1934) held that the last three subgenera could form a single subgenus Simulium Latreille (sensu stricto).

Twinn (1936) followed Edwards (1931) in his classification of the North American fauna but regarded Cnephia Enderlein as a synonym of Eusimulium Roubaud.

Rubtsov (1937) classified the family Simuliidae into seven genera, Parasimulium Malloch, Prosimulium Roubaud, Austrosimulium Tonnoir, Gigantodax Enderlein, Helodon Enderlein, Eusimulium Roubaud and Simulium Latreille (sensu stricto), the last two genera being divided into seven and ten subgenera respectively. In 1940 Rubtsov reclassified Simuliidae containing five genera, Austrosimulium Tonnoir, Gigantodax Enderlein Parasimulium Malloch, Prosimulium Roubaud with subgenera Helodon Enderlein and Prosimulium Roubaud, and the last genus Simulium Latreille (sensu stricto) with subgenera Cnephia Enderlein, Hellichia Enderlein, Astega Enderlein, Eusimulium Roubaud, Nevermannia Enderlein, Byssodon Enderlein, Friesia Enderlein, Neosimulium (subgen.n.), Stegopterna Enderlein, Hearlea (subgen.n.), Morops Enderlein, Gnus (subgen.n.), Odagnia Enderlein, Wilhelmia Enderlein, Schönbaueria Enderlein and Simulium Latreille (sensu stricto). In 1956 he introduced two subfamilies in his classification, Gymnopauidinae for the genus Gymnopaig Stone and Simuliinae for the rest including a few new additions, all of which were given generic status. No tribal category found place in his classification. Later Rubtsov (1959-1964) introduced Twinnia Stone and Jannback in the subfamily Gymnopauidinae and a few other in the subfamily Simuliinae.

Smart (1945) followed Edwards (1931; 1934) and Rubtsov (1940) during his classification of the family Simuliidae. He included two subfamilies, viz., Parasimuliinae containing the

genus Parasimulium Malloch and Simuliinae containing the genera Prosimulium Roubaud, Cnephia Enderlein, Austrosimulium Tonnoir, Gigantodax Enderlein and Simulium Latreille (sensu stricto), the latter comprising the subgenera Simulium (sensu stricto), Eusimulium Roubaud and Morops Enderlein of Edwards. He recognized no tribes or subgenera.

Freeman and de Meillon (1953) recognized only two genera Cnephia and Simulium and no subgenera in their treatment of the Ethiopian Simuliidae.

Ogata and Sasa (1954) recognized a large number of well-defined segregates of the genus Simulium (sensu lato) as subgenera. Stone and Jamnback (1955), and Shewell (1958) recognized few genera of the family and accorded subgeneric rank to many of the genera of Enderlein and Rubtzov in their studies on the Nearctic Simuliidae.

Grenier and Rageau (1960) considered the subfamily Prosimuliinae to contain three genera, Gymnopsia Stone, Twinnia Stone and Jamnback, and Prosimulium Roubaud, and divided the subfamily Simuliinae of Edwards into three tribes: Cnephini (n. tr.) containing the genera Greniera Doby and David, and Cnephia Enderlein, Austrosimuliini containing the genera Gigantodax Enderlein and Austrosimulium Tonnoir, and Simuliini containing Simulium Latreille (sensu stricto).

Stone (1964) during the treatment of the world fauna held five tribes, viz., Parasimuliini, Gymnopauidini and Prosimuliini forming the subfamily Prosimuliinae, and Cnephiini and Simuliini forming the subfamily Simuliinae in suprageneric level. There is a single species of Parasimulium Malloch in the tribe Parasimuliini; the genera Twinnia Stone and Jamnback and Gymnopaia Stone were included in the tribe Gymnopauidini; the genus Prosimulium Roubaud in Prosimuliini; Cnephia Enderlein with several subgenera, Gigantodax Enderlein and Lutzsimulium d'Andretta and d'Andretta in Cnephiini, and Simuliini included Austrosimulium Tonnoir and Simulium Latreille (sensu stricto), the latter containing a number of subgenera.

Smart and Clifford (1965, 1968) adopted a conservative approach in their works. All the species described by them were assigned to the genus Simulium Latreille (sensu lato).

Davies (1966) followed the genus and subgenus concepts of Stone with minor modifications during his work on the British Simuliidae.

In the classification of the Simuliidae of the Middle East, Crosskey (1967a) mainly followed Rubtzov (1959-1964) in the suprageneric level and he introduced a few subgeneric segregates in his classification. In the same year (1967b) he presented four subgenera, viz., Hebridosisimulium Grenier and

Rageau, Morops Enderlein, Gomphostilbia Enderlein and Eusimulium Roubaud in the genus Simulium Latreille (sensu lato) occurring in Australia, New Guinea and the Western Pacific area. Crosskey (1969) while studying the Simuliidae of Africa and its islands recognized two tribes, Prosimuliini and Simuliini, within the subfamily Simuliinae, of which the former contains the only genus Prosimulium Roubaud with subgenera such as Prosimulium Roubaud, Procnephia (subgen.n.) and Paracnephia Rubtzov, and the latter tribe contains the genera Metacnephia (gen.n.), Afrosimulium (gen.n.) and Simulium Latreille with the following subgenera: Byssodon Enderlein, Dexomyia (subgen.n.) Eusimulium Roubaud, Pomeroyellum Rubtzov, Meilloniellum Rubtzov, Lewisellum (subgen.n.), Phoretomyia (subgen.n.), Xenosimulium (subgen.n.), Anasolen Enderlein, Freemanellum (subgen.n.), Wilhelmia Enderlein, Metomphalus Enderlein, Edwardsellum Enderlein, Tetisimulium Rubtzov, Odagnia Enderlein and Simulium Latreille (sensu stricto). He, however, could not place some of the species in his classification subgenerically.

In addition to the above works there exist other contributions as to the classification of the family Simuliidae based on the restricted fauna of different countries made by Vargas et al. (1946), d'Andretta and d'Andretta (1947), Vargas and Diaz Najera (1951), Doby and David (1959), Shewell (1959), Grenier and Rageau (1961), Wygodzinsky and Coscaron (1962) and

others, but most of the names proposed by them were later considered to be synonymous with other names mentioned earlier (see Stone, 1963).

In India no attempt has been made to classify the family Simuliidae probably due to inadequate knowledge of the Indian fauna though some sporadic systematic accounts from this country have appeared. Becher (1884), for the first time, reported the black fly fauna of India with the description of a single species Simulium indicum (sp.n.) from the female specimen from Assam. Brunetti (1911) described the male of the aforesaid species, revised the description of the female (see the Fauna of British India, 1912a) and recorded the species from Mussoorie, Simla, Darjeeling, Kurseong, Sylhet, Khasi Hills and Jaunsa, Tons Valley. At the same time he described seven species, all from the Himalayas and Assam Hills, with two species extending to the Western Ghats in North Kanara. Out of seven species, only two, Simulium rufithorax (sp.n.) and S. aureohirtum (sp.n.) were described from both sexes; S. grisescens (sp.n.) and S. senilis (sp.n.) from male specimens only and S. rufibasis (sp.n.) from female specimens only. The remaining two species S. metatarsalis (sp.n.) and S. griseifrons (sp.n.), the former described from male specimens and the latter from female specimens may represent alternative sexes

of a single species as per his comments. In the following year (1912b) he described a species S. striatum (sp.n.) from Ceylon; its distribution was later found to extend to the Palni Hills of the South India. Senior-White (1922) described three species, S. latistriatum (sp.n.), S. pattoni (sp.n.) and S. gurneyae (sp.n.) with the help of female specimens collected in Coonoor; the first species was later regarded by Puri (1932e) to be a synonym of S. striatum Brunetti. Edwards (1927) described two species, namely S. stevensoni (sp.n.) and S. kasmiricum (sp.n.) from female specimens only collected from the North-east Kashmir. He held that, according to Enderlein's classification, the former species would be referred to the genus Odagmia Enderlein.

All these works were published without illustrations and the descriptions contained therein were mostly inadequate. A detailed work was attempted by Puri, who in a series of papers (1932-1933) surveyed the blackfly fauna of India efficiently. Unlike earlier workers, Puri paid attention to the pupal stages, occasionally the larval stages too, of these flies and provided good illustrations. Puri was able to place two of the species in the subgenus Eusimulium Roubaud and two in the subgenus Wilhelmia Enderlein following Edwards' view, and described under the subgenus Simulium Latreille (sensu stricto) nineteen species and three varieties, namely, Simulium (Simulium) himalayense Puri (1932a), S. (S.) nilgiriicum

Puri (1932a), S.(S.) rufibasis var. fasciatum Puri (1932b),
S.(S.) ramosum Puri (1932b), S.(S.) christophersi Puri (1932b),
S.(S.) nitidithorax Puri (1932b), S.(S.) novolineatum
(= lineatum) Puri (1932c), S.(S.) barraudi Puri (1932c),
S.(S.) digitatum Puri (1932c), S.(S.) dentatum Puri (1932c),
S.(S.) howletti Puri (1932d), S.(S.) hirtipannus Puri
(1932d), S.(S.) lineothorax Puri (1932e), S.(S.) grisescens
var. palmatum Puri (1932e), S.(S.) consimilis Puri (1932e),
S.(S.) pallidum Puri (1932e), S.(S.) gravelyi Puri (1933a),
S.(S.) palniense Puri (1933a), S.(S.) tenuitarsus Puri (1933a),
S.(S.) nodosum Puri (1933b), S.(Wilhelmia) equinum var. medi-
terraneum Puri (1933d) and S.(W.) paraequinum Puri (1933d),
from different parts of India including Kurseong and Darjeel-
ing. He (1932 a, b, c & e; 1933c) also redescribed some of
the species of the earlier workers and these are S.(Eusimulium)
aureum Fries (1824), S.(E.) aureohirtum Brunetti (1911),
Simulium (Simulium) grisescens Brunetti (1911), S.(S.) rufi-
basis Brunetti (1911), S.(S.) griseifrons Brunetti (1911),
S.(S.) striatum Brunetti (1912b) and S.(S.) gurnevae Senior-
White (1922) from the region. In almost all the species he
described the females, males and pupae but he rarely touched
the larvae. Lewis (1964) described three species of black
flies from Nepal; only one of them was given a specific name,
Simulium nepalense (sp.n.).

From the above review of the taxonomic works done in India it is obvious that there is still much more to be done taxonomically in comparison to the vast area of this country and in relation to the rich critical investigation of the world fauna of black flies. Accordingly, the present work was undertaken with specimens from various localities surrounding Darjeeling (27°3"N latitude and 88°18"E longitude). The object of this work is to present the descriptions of seven proposed new species, four unnamed species and, of larvae of four species, Simulium (Simulium) himalayense Puri (1932a), S.(S.) rufibasis (Brunetti, 1911), S.(S.) dentatum Puri (1932c) and S.(S.) griseascens Brunetti (1911), occurring in Kurseong and Darjeeling, of which larval stages were previously undescribed. All the species are placed subgenerically so as to facilitate our future programme for the preparation of catalogues of black flies from different parts of India and also to contend with the desirable balanced classification of the family Simuliidae of the world.

MATERIALS AND METHODS

Materials for taxonomic studies were composed of imagines, pupae and larvae collected in their natural habitats XXXXXXXXXX in and around the township of Darjeeling ($27^{\circ}3''\text{N}$ latitude and $88^{\circ}18''\text{E}$ longitude) with an average altitude of 2044 metres in the eastern part of the Himalayas (see Fig.-1). The township is the head-quarters of a district of the same name.

A. TOPOGRAPHY OF BREEDING SITES

The area is moderately populated and abounds in pockets of water-courses of various kinds; almost all of these water-courses form ideal breeding centres for black flies. The breeding sites available in the whole area may be classified as follows:

River: The only river (Fig.-2) at Rangeet (Darjeeling) in which the survey of black flies was made is about 30m. wide, about 3m. deep and rising at about 300m. altitude. No marked reduction in volume of water occurs during the summer. This river is fed by melting snow and numerous springs of both Darjeeling district and Sikkim state. This river divides into a number of smaller branches with slightly

Locational map of Darjeeling District

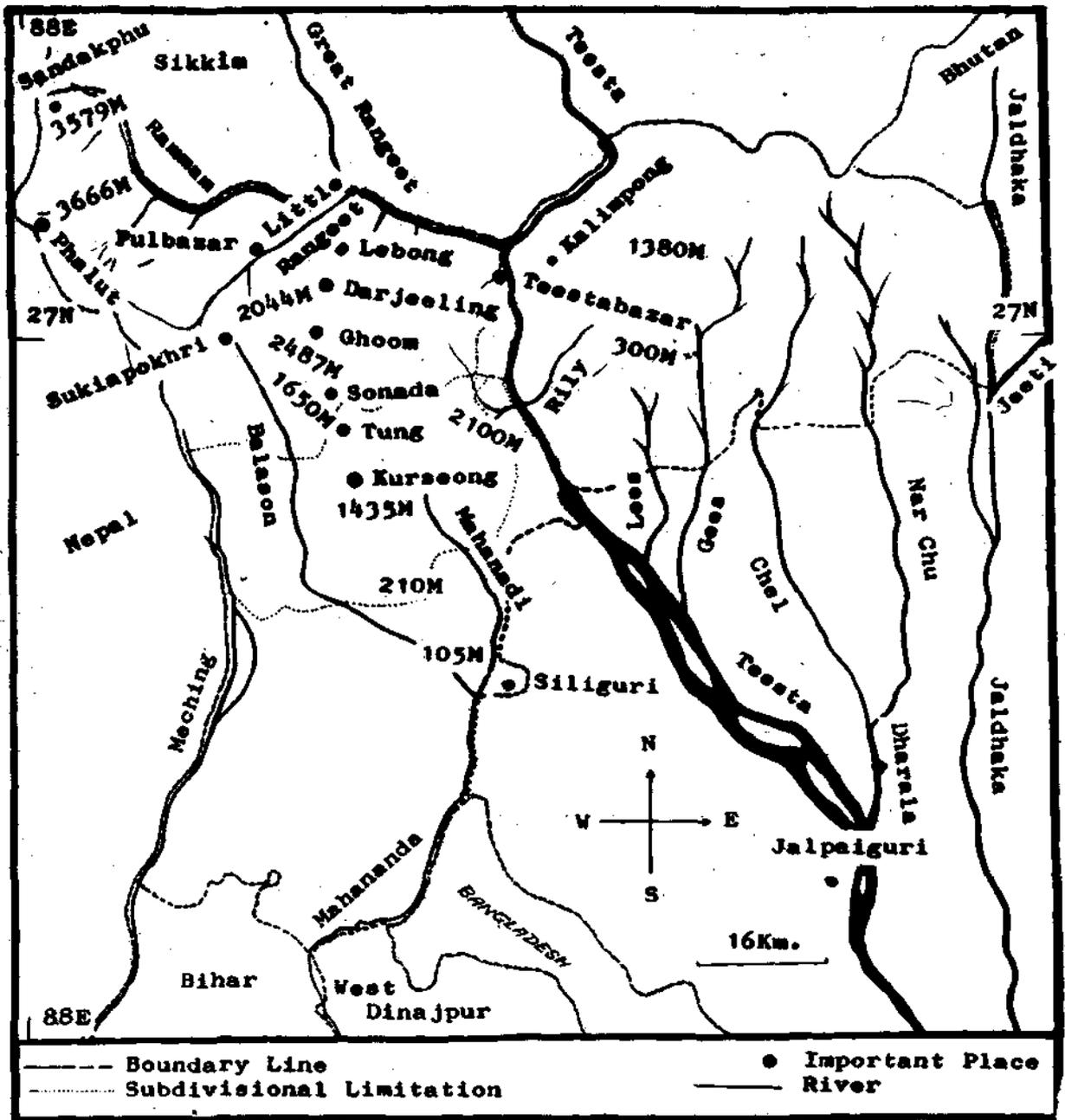


FIG.1: Locational map of Darjeeling District showing some sites of collection

slower current in its descending course. After flowing for certain distances these branches again join the main river. The strong river bed is made up of rocks and pebbles. On this bed there are decaying twigs and leaves blown away into the water from the nearest wood along the river side and these are used as the substrata by the immature stages of black flies. Direct sun rays are evident throughout the year (except in cloudy weather) since there are no shades of tall trees.

Stream: The natural water-course flowing down the Hill Cart Road near Kurseong Railways Station at an altitude of 1435m. may be called stream (Fig.-3). It is about 5 m. in width and 0.5m. to 1.0m. in depth. There is a remarkable variation in the volume of water during the summer. This is fed by a number of springs in the locality. At the downward course the stream puts forth a number of smaller branches which again join the main stream after a short distance. The stream bed is covered with big stones and numerous cobble stones. A rich vegetation of moss and algae and a little development of other aquatic vegetation is the characteristic floral make up of the stream along with a few tall trees at a little distance. The main substrata for attachment of larvae and pupae are submerged vegetation, decaying twigs and some foreign materials like papers, rags and other refuse but rarely stones. Direct sun rays are also evident here.



FIG.2: Sectional photographic view of the Great Rangeet river



FIG.3: Sectional photographic view of a stream near Kurseong Rly. Station



FIG.4: Sectional photographic view of a ditch flowing down the Lebong Cart Road in Darjeeling



FIG.5: Sectional photographic view of a trickle of water at North Point, Darjeeling

Ditch: The water-ways flowing down the Lebong Cart Road (Fig.-4), Ghoom Railway Station, the Ghoom-Teestabazar Road, the Hill Cart Road at Sonada, Kurseong and Batasia etc. are of this type. These ditches are about 75cms. to 90cms. in width and 5 cms. to 10 cms. in depth. Marked reduction in volume of water is evident during the summer. There are in most cases tall trees along the sides of these ditches and due to the presence of these tall trees penetration of sun rays becomes a matter of chance. Pebbles form the bed of these ditches and trailing vegetation is often used as substratum.

Trickle: The water-courses flowing down the Hill Cart Road near Darjeeling Railways Station, the Darjeeling-Sukia pokhri Road at Sukia pokhri and the Lebong Cart Road at North Point, Darjeeling (Fig.-5) are of this type. These are about 10 cms. to 15 cms. in width and about 3 cms. in depth, shaded by the tall trees. The crown of these trees form a canopy-like structure over these trickles and stand as barriers to sun rays so that these sites remain dark throughout the year. These trickles usually dry up completely during the hot seasons. These are mainly fed by precipitation. Pebbles are scattered over the bed of the trickles. There is also trailing vegetation crossing the trickles. Larvae and pupae of black flies prefer ████████ decaying leaves fallen from tall trees as substrata.



73900
28 MAR 1981

B. COLLECTION FROM BREEDING GROUNDS

It was easy to collect larvae and pupae of black flies in undamaged condition as these were mostly found attached to decaying or hydrophytic vegetation. The larvae were collected by lifting the substratum and then picking up the attached larvae with a light tin forceps. Those larvae which are fully grown (determined by the presence of dark respiratory histoblast on the lateral sides of the thorax) were preserved in 95% ethanol for taxonomical studies.

Portions of leaves containing pupae were cut out by scissors. Pupae from twigs or stones were carefully scraped by means of needles. Some pupae were preserved in 90% ethanol while some others from the same lot were reared in the laboratory under suitable conditions.

During the collection of larvae and pupae in the field occasionally a few imagines were found to rest on herbs by the side of the breeding grounds. These imagines were captured with the help of fine net and preserved in 90% ethanol for studies.

C. ASSOCIATION OF LARVA WITH PUPA

Due to lack of elaborate laboratory facilities, rearing of larvae to imagines through pupal stages could not be undertaken, but larvae were associated with pupae following

the method of Smart and Clifford (1965). The respiratory histoblasts found on the lateral sides of the thorax of the mature larva as somewhat dark spots are the developing respiratory organs of the pupa. The diagnostic features, which are useful in species discrimination, could be distinctly noted in dissecting the larval respiratory histoblast.

D. REARING OF PUPA

The device used by Wood and Davies (1966) was adopted with suitable modifications for rearing the pupae to adults, in the laboratory. About 30 small plastic vials were arranged on a petri dish and each vial was given a specific number for easy record. In each vial a small cotton bed was prepared and the bed was moistened with water. The dark pupae were separated species-wise, examining the respiratory organs and also the cocoon with the help of a stereoscopic binocular microscope, and were transferred to the cotton bed. A single pupa was placed in each bed and each vial was plugged loosely with dry cotton. It was necessary to keep the pupae moist but care was taken to see that the pupae were not bathed in surplus water. The whole device was then placed in a dark room at $10^{\circ}\text{C} - 20^{\circ}\text{C}$. At intervals of 5 or 6 hours the hatched imagines with the pupal exuviae of a given species were taken out of the vials, and each imagine with its exuviae was transferred to a separate vial and kept for about 5 hours to allow

hardening and darkening of the different parts of the insect. Keeping each pupal skin with the adult aids in the proper identification of the specimen. Thus, a good number of specimens consisting of both males and females of a given species were obtained. Some of these emerged adults were pinned after exposure to chloroform vapour and placed in the deep freeze for a week or more to prevent shrinkage of the head and abdomen (Wood and Davies, 1966). Some of these were preserved in 90% ethanol after exposure to chloroform vapour for dissection. The tinctorial characteristics of different parts of the individual specimen was, however, noted in live specimens prior to preservation.

E. PREPARATION OF MICROSCOPICAL SLIDES

The larvae, pupae and imagines of a given species preserved in ethanol after proper association were put into a saturated solution of pure phenolic crystals in absolute ethanol and were then kept in an oven at 60°C for 24 hours. Well-cleared specimens were placed on micro-slides in a drop of a mounting medium consisting of the above clearing solution and Canada Balsam in equal proportions. The specimens were then dissected for studying the taxonomically important parts and were covered with cover-slips after proper orientation.

DISPOSITION OF TYPE MATERIAL

Holotypes, allotypes and paratypes of new species will be deposited in the Indian Museum, Calcutta. Unfortunately, complete sets of paratype material of all species will not be available for distribution, but where sufficient materials are available, it is intended to deposit some of these paratypes in the British Museum (Natural History), London, and elsewhere.

CHARACTERISTICS OF THE FAMILY SIMULIIDAE
IN RELATION TO KEYS AND DESCRIPTIONS
INCORPORATED IN THIS STUDY

For a better understanding of the anatomical features and taxonomical terminology used in the following pages, a brief discussion on the same is presented below. In this context the works of Puri (1925), Edwards (1934), Nicholson (1945), Mackerras & Mackerras (1948), Grenier (1949), Freeman & de Meillon (1953), Stone & Jamnback (1955), Rubtzov (1956), Crosskey (1960), Davies et al. (1962), Wood et al. (1963), Stone (1964), Smart & Clifford (1965), Davies (1968), Ussova (1961) and others have been followed with appropriate modifications.

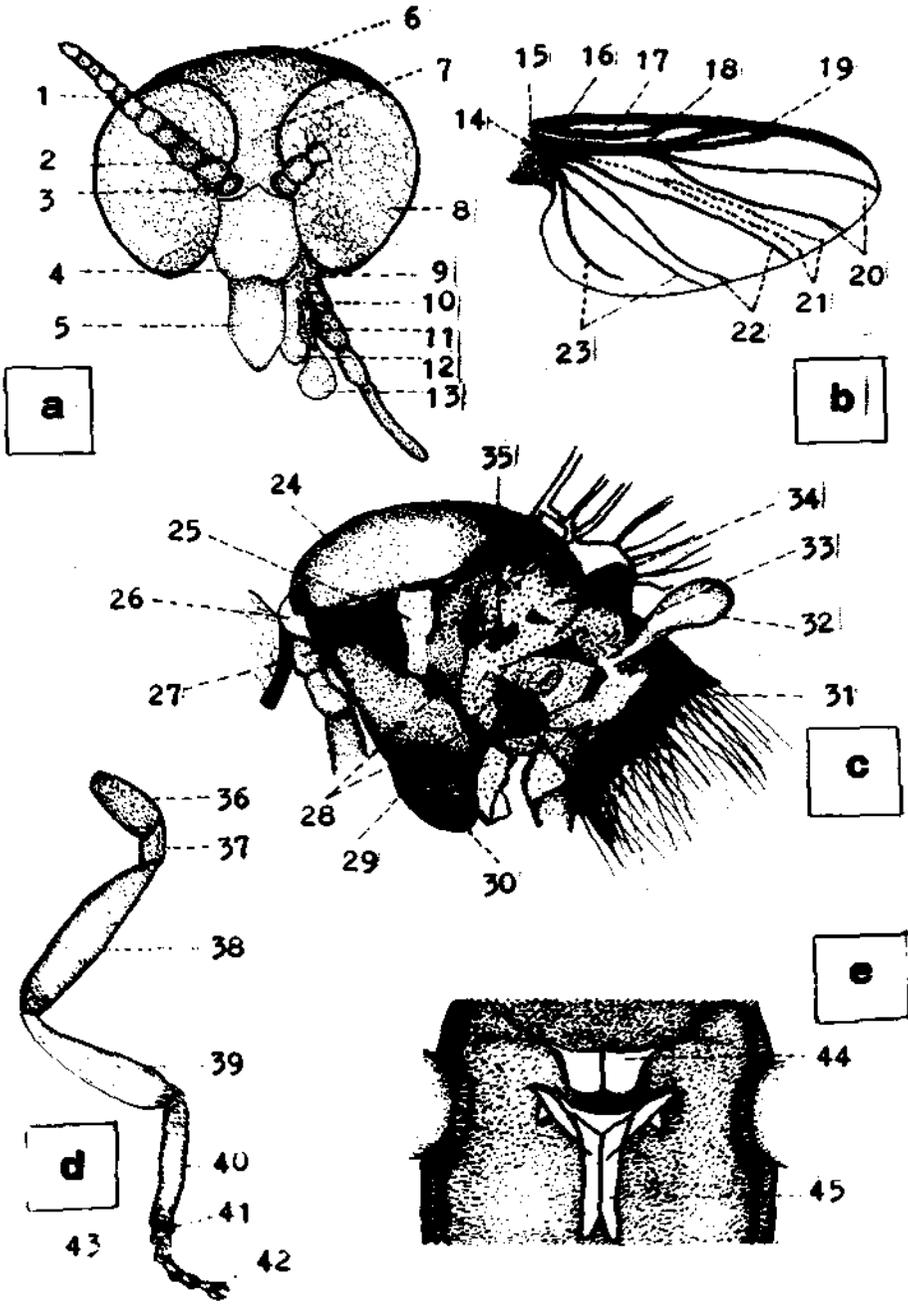
IMAGINES: Simuliidae are relatively small nematoceran Diptera (2-5 mm. in length) with wing-lengths of about 1.5-3.0 mm.

Head: (Plate-A, fig.-a). The eyes (8) of the females are isolated from each other by the frons (7) which is usually narrower anteriorly above the antennae (1) and broader towards the vertex (6), i.e., females are dichoptic. The males in contrast to females are holoptic, most with larger upper eye facets and lower smaller ones. Each antenna (1) consists of scape (3), pedicel (2) and flagellum with 9 (as in fig.) or rarely 7 or 8 flagellomeres. A convex clypeus (4) is present

EXPLANATION OF PLATE A

- Fig. - a. Anterior view of head of a female black fly (incomplete).
- Fig. - b. Right wing of a female black fly.
- Fig. - c. Side view of thorax and abdominal scale of a female black fly.
- Fig. - d. Hind leg of a female black fly.
- Fig. - e. Basisternum and furcasternum of metasternum of a female black fly.

Plate- A



anterior to antennae, and below the clypeus is the somewhat tapering labrum (5). The plate-like mandibles (12) are wide and thin. These are usually provided with lateral and medial serrations. The maxillae (10) are slender plates often with retrorse teeth on both margins. Each maxillary palpus (9) is composed of 5 segments, first two segments being short, the third being usually enlarged with a sensory vesicle (11), and the fourth being slender and longer but not as long and slender as the fifth one. The shape, size and position of the sensory vesicle (11) are important criteria in taxonomy. The massive bilobate labium (13) lies ventral to the maxillae. The cibarium is an internal, trough-shaped organ attached to the proximal end of the hypopharynx and labrum-epipharynx. The dorso-lateral portions of the cibarial pump are produced as arms which are often heavily sclerotized. The median space between these arms may have a central patch of teeth or nodules. The shape and size of the arms, and the shape and depth of the median space, and the arrangement of teeth or nodules are of taxonomic value.

Thorax: (Plate-A, figs.-c & e). The thorax (fig.-c) is strongly convex dorsally, particularly in males. The scutum (24) may be provided with characteristic colour pattern with pollinosity or hairs in females but in males there is rarely a scutal pattern and in the male the scutum is darker than in the female. The scutellum (34) along with the scutum

(24) forms the alinotum and posterior to alinotum is the postnotum (33) which is usually bare. The pleuron is usually uniform in all Simuliidae. The prothoracic part (26) can be found anterior to the pleuron. The pleural membrane (25) is situated between the anterior epimeron (27) and the median episternum (28). The presence or absence of hairs on it is a good taxonomical character. The colour and size of the pleural tuft (35) on the median epimeron (29) is important. The sternopleuron (30) may be provided with hairs which are important in taxonomy. The metasternum (fig.-e) is composed of a basisternum (44) and furcasternum (45). The latter has paired internal dorsal apophyses or furca which may have ventral tubercles. The shape and size of the basisternum and furcasternum are of taxonomic value.

Wings: (Plate-A, fig.-b). The wing-length (base of the costa straight to wing tip) is important. The costa (upper outermost vein), sub-costa (17) and radius (18) are strong longitudinal veins. The arrangement of hairs or spinules or both on the dorsal and ventral surface of these veins are highly characteristic. The media (20), cubitus (22) and anal veins (23) are weak and have no taxonomic value. There is a fold called sub-median fold (21) between the media and cubitus veins. The radius (18) is produced from the end of the stem vein (15) to the point where it divides into vein R_1 and radial sector (19). The radial sector may rarely be

divided distally into two branches. The colour of hairs of the stem vein (15) at the base of the humeral cross vein (16) is important. There may be a basal cell (14) at the base of the media vein.

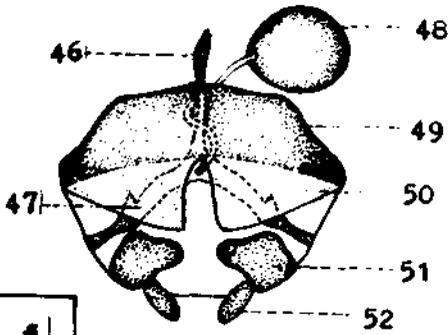
Legs: (Plate-A, fig.-d). Both tinctorial and structural variations are the characteristic of most simuliidae. The leg is differentiated into coxa (36), trochanter (37), femur (38) tibia (39) and tarsus, the latter with 5 tarsomeres, the last having tarsal claws (42) and occasionally with teeth. The apex of the first hind tarsomere (40) is usually produced on the posteroventral margin as a flattened lobe, the calceipala (41), and the second tarsomere is sometimes provided dorsally with a notch called the pedisulcus (43). The sub-basal or basal tooth is highly significant.

Abdomen: (Plate-A, fig.-c and Plate-B, figs.-f & g). The abdomen in males is darker than in females. The first abdominal tergum is modified into a basal scale (Fig.-c, 31) with long marginal hairs. The intermediate terga are usually more reduced than the posterior ones. The hair cover and pollinosity of the terga and the shape, size and the degree of sclerotization of the first sternum are taxonomically important. In males almost all the sterna are more sclerotized than in females in which only sternum 8 is highly sclerotized. The shape of the sternum 8 (49), genital fork (47),

EXPLANATION OF PLATE B

- Fig. - f. Ventral view of terminalia of a female black fly.
- Fig. - g. Ventral view of terminalia of a male black fly.
- Fig. - h. Side view of a pupa with cocoon of black fly.
- Fig. - i. Side view of a larva of black fly.

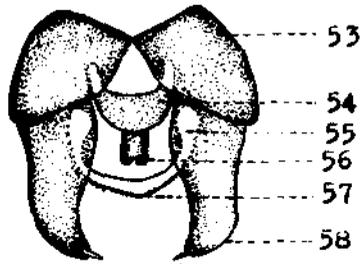
Plate- B



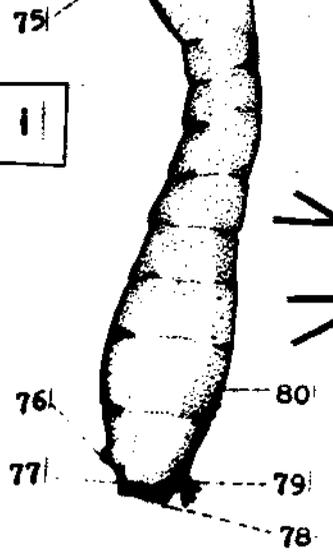
f



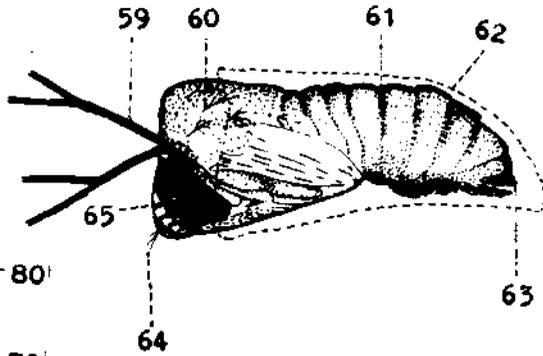
g



h



i



j

ovipositor lobe (50), anal lobe (51), cerci (52) and spermatheca (48) is highly characteristic. The eighth sternum (49) is produced posteriorly so as to form two ovipositor lobes (50). The genital fork (47) is an inverted Y-shaped internal structure with heavily sclerotized stem (46); the arms are of different shape and sclerotization, sometimes with dorsal or ventral teeth. The genital complex (Plate-B, fig.-g) in males offers excellent characters for species discrimination. The relative size of the basimere (53) and distimere (58) of the paramere provides good taxonomic character. The ventral plate (54), median sclerite (56) and the endoparameral organ (55) with endoparameral hooks (57) form the aedeagus. These structures are very important in taxonomy.

PUPA: (Plate-B, fig.-h). The measurement of the total length is exclusive of the respiratory organ (59). The length of the respiratory organ is measured from the base to the tip of the longest filament. The filaments are usually arranged in pairs. The structure of the filaments and the mode of branching are useful in taxonomy. Below the respiratory organ is the eye (65) on each side. The head and thorax usually bear simple or branched setae; these setae on the head are called head trichomes (64) and these on the thorax called thoracic trichomes (60). These trichomes provide good characters. The abdominal terga and sterna usually bear transverse rows of hooks in various shapes and sizes. The number

of these rows, the number of hooklets (61) in these rows and their mode of branching are important in taxonomy. The last abdominal segment may have a pair of dorsal tail hooks (63).

The cocoon (62) is rarely absent, and when present it may be either irregularly woven or regularly woven. The cocoon may either be shoe-shaped, i.e., when the anterior margin is complete ventrally, or slipper-shaped, i.e., when the anterior margin is incomplete. The cocoon may either be loosely woven or very tightly woven. It may bear an antero-dorsal projection. It may also have some windows or air spaces. All these are important.

LARVA: (Plate-B, Fig.-1). In taxonomic work the total length of the 6th-stage larva having the dark respiratory histoblast is measured. The head-spots on the cephalic apotome (69) may either be negative or positive; sometimes an intermediate stage may also be found. The ventral surface of the head or the post-gena has an anteromedian portion, the hypostomium (72), the post-genal bridge and the post-genal cleft posteriorly. The hypostomium (72) has an anterior row of teeth, usually composed of a median tooth, a pair of corner teeth and intermediate teeth between these, and lateral serrations. The hypostomial setae are found in the lateral sides. The nature of the teeth and number of the setae are important. The relative length of the post-genal bridge and the post-genal

cleft is highly significant. The form of the cleft is also important. The antenna (66) is basically 4-segmented, the last one being minute. The relative length of the segments and their colour are important. The cephalic fan (67) contains a number of curved filaments on the cephalic fan stem. The number of filaments is important. The relative length of the antenna and the cephalic fan stem is also important. The mandible (71) usually has at its apex 3 large teeth, posterior to which there is a series of comb teeth. Below the comb teeth there are two or three teeth called mandibular serrations on the inner margin of the mandible. Between the mandible (71) and the hypostomium (72) there is a maxilla (68) with a palp on each side. The head usually bears a pair of eye-spts (73) on each lateral side. The posterior margin of the head is bordered laterally by a sclerotized post-occiput terminating ventrally in an occipital condyle just behind a posterior tentorial pit. Dorsally, behind the head capsule is a pair of cervical sclerites. The body of the larva is elongate and swollen posteriorly. It is indistinctly segmented. The shape of the body in dorsal and lateral view may be significant. The first thoracic segment bears a proleg (75) ventrally with a circlet of hooks (74) at the apex and a small lateral sclerite. The pupal respiratory organs in the form of respiratory histoblast (70) in the thorax is the most useful character for species discrimination. The body may be provided with cuticular setae and

spines (80). The last abdominal segment may bear a pair of ventral papillae (76). Dorsally there may be a simple or compound rectal 'gill' (79). Below the rectal 'gill' (79) is the anal sclerite (77) with two anterior and two posterior arms in front of the posterior circlet of hooks which surround the posterior sucker (78). All these characters are highly significant in taxonomy.

KEY TO THE SUBFAMILIES AND TRIBES OF
THE WORLD

The family Simuliidae (Nematocera:Diptera) is divided into two subfamilies with a few tribes by Stone (1964) on the basis of the world fauna. The key is reviewed here in relation to the simuliid fauna of Darjeeling.

1. Costa with fine hairs only, no stout spinules; radial sector forked; no calcipala; larva with first two antennal segments pale, the last two contrastingly dark; cocoon, if present, irregular and shapeless.

Subfamily PROSIMULIINAE 2

Costa usually with spinules intermixed with fine hairs; radial sector usually unbranched; calcipala usually present; larval antenna rarely coloured as in the Prosimuliinae; cocoon often of a very definite shape.

Subfamily SIMULIINAE 4

2. Only 7 flagellomeres; vein R_1 joining costa well beyond middle of wing; at least an indication of a bulla behind eye; full grown larva without cephalic fans; anal sclerite of larva Y-shaped; pupal terga 6 to 8 without an anterior row of fine spine-like hooks; cocoon nearly or quite lacking.

..... Tribe GYMNOPAIDINI.

Not with this combination of characters (only 7 flagellomeres and vein R₁ joining costa well beyond middle of wing known for Parasimulium Malloch, 1914) 3

3. Vein R₁ joining costa near middle of wing; submedian fold apparently unforked Tribe PARASIMULIINI.

Vein R₁ joining costa beyond middle of wing submedian fold forked Tribe PROSIMULIINI.

4. Pedisulcus very weak or absent Tribe CNEPHIINI.

Pedisulcus usually well developed Tribe SIMULIINI.

Each tribe includes one or more genera and the genera are with or without subgenera. The characters shown by the species found in Darjeeling and its adjacent areas reported here fall into three subgenera, viz., Gomphostilbia Enderlein (1921a), Eusimulium Roubaud (1906) and Simulium Latreille (1802) s.str. as defined by Crosskey (1967b, 1969). All these species belong to the Genus Simulium Latreille (1802) s.i. under the tribe Simuliini of the subfamily Simuliinae.

KEY TO THE SPECIES OF SIMULIUM IN THE
DARJEELING AREA

(New species marked with an asterisk)

(Females)

1. Basal section of vein R haired; first fore tarsomere slender and rounded 2
- Basal section of vein R bare (except in grisescens); first fore tarsomere distinctly widened and flattened 7
2. Sternopleuron haired 10
- Sternopleuron bare 3
3. Alinotum dark grey 4
- Alinotum bright orange-red 6
4. Third palpal segment distinctly swollen, sides convex; genital fork with large and heavily sclerotized external (dorsal) teeth 1. praelargum*
- Third palpal segment not distinctly swollen, sides sub-parallel; genital fork with weak external teeth 5
5. Five longitudinal dark stripes forming a lyre-shaped pattern on scutum; sternum 8 about to cover tip of genital fork 2. gracilis*
- Three longitudinal dark stripes only on scutum; sternum 8 covering only half of genital fork 3. purii*

6. Scutum striped 8. Species D*
 Scutum unstriped 9. rufithorax
7. Scutum unstriped 8
 Scutum with lyre-shaped pattern 9
8. Abdominal sternum 7 with evenly distributed adequal hairs; tarsal claw with a small sub-basal tooth.
 11. himalayense
 Abdominal sternum 7 with a pair of sub-median clusters of fairly long and thick hairs; tarsal claw simple.
 12. rufibasis
9. Basal half of first middle tarsomere pale yellow, rest of middle tarsi black; basal section of vein R always bare.
 13. dentatum
 First middle tarsomere pale yellow with a black tip, second yellowish basally, rest of middle tarsi black; basal section of vein R invariably with some hairs.
 14. grisescens
10. Third palpal segment elongated, sensory vesicle also elongated; sternum 8 broad and almost rectangular; anal lobe produced postero-laterally 15. tennistylum*
 Third palpal segment almost rounded, sensory vesicle corn-like; sternum 8 narrow and semi-lunar; anal lobe not produced postero-laterally 16. darjeelingsense*

(Males)

1. Basal section of vein R haired; first fore tarsomere slender and rounded 2
- Basal section of vein R bare; first fore tarsomere distinctly flattened and widened 9
2. Sternopleuron haired 7
- Sternopleuron bare 3
3. Alinotum dark grey 4
- Alinotum bright orange-red 9. rufithorax
4. Distimere almost as wide as one-third of basimere at greatest width and bent down against basimere ... 4. nemorivagum*
- Width of distimere nearly half of basimere at greatest width and not bent down against basimere 5
5. Scutum with three faint longitudinal stripes; distimere, ventral plate and median sclerite of male terminalia as in figs. 12, 13 & 14 of Plate II 1. praelargum*
- Scutum without stripes; distimere, ventral plate and median sclerite not as above 6
6. Distimere, ventral plate and median sclerite of male terminalia as in figs. 12, 13 & 14 of Plate V ... 2. gracilis*

Distimere, ventral plate and median sclerite of male terminalia as in Plate VIIA 3. purii*

7. Abdomen entirely black 17. metatarsale

Abdominal scale and tergum 2 paler 8

8. Distimere gradually tapering; ventral plate much broader.
..... 15. tenuistylum*

Distimere widened distally; ventral plate much longer.

..... 16. darjeelingense*

9. Scutellum reddish brown 13. dentatum

Scutellum black 10

10. First hind tarsomere greatly dilated 11

First hind tarsomere moderately dilated 12

11. A pair of crescent-shaped large shiny coppery spots at fore corners of scutum 10. nigrifacies*

A pair of elongated silvery spots at fore corners of scutum. 12. rufibasis

12. Halteres pale yellow 11. himalayense

Halteres orange-yellow 14. griseocens

(Pupae)

1. Respiratory filaments 4 2
 Respiratory filaments more than 4 3
2. Respiratory filaments rather stout basally and all diverging near base; head and thoracic trichomes multiple-branched; cocoon with a veil-like dorsal projection, often trifid. 2. gracilis*
 Respiratory filaments always distinctly petiolate and almost parallel to each other; head and thoracic trichomes simple; cocoon with a median dorsal projection.
 3. purii*
3. Respiratory filaments 6 4
 Respiratory filaments more than 6 8
4. Respiratory filaments more or less parallel to each other; cocoon with a well-developed median dorsal projection.
 1. praelargum*
- Respiratory filaments divergent from base; cocoon without median dorsal projection 5
5. Cocoon with large lateral aperture anteriorly.
 7. Species C*
- Cocoon without lateral aperture 6

6. Respiratory filaments of middle pair distinctly arising from common stalk of upper pair of filaments.

..... 12. rufibasis

Respiratory filaments of middle pair distinctly arising beside base of common stalk of upper pair of filaments.

..... 7

7. Lower pair of filaments without a common stalk; outer filament of upper pair stoutest of all 10. nigrifacies*

Lower pair of filaments with a short common stalk; outer filament of upper pair not stoutest of all.

..... 11. himalayense

8. Respiratory filaments 8 9

Respiratory filaments more than 8 11

9. Respiratory filaments arranged in 4 pairs; cocoon with large lateral aperture anteriorly 13. dentatum

Respiratory filaments not arranged in 4 pairs; cocoon without lateral aperture 10

10. Respiratory filaments arranged in 3+3+2 combinations; cocoon having no strong anterior margin but with a minute median projection 15. tenuistylum*

Respiratory filaments apparently arranged in 2+(2+2)+2 combinations; cocoon with a strong anterior margin but without any projection 16. darjeelingense*

11. Respiratory filaments 10, arranged in pairs; basal stalk not enlarged; cocoon with irregular interspaces anteriorly
 14. griseocens
- Respiratory filaments more than 10, and not in pairs; basal stalk much enlarged; cocoon without such interspaces.
 12
12. Respiratory filaments 12; cocoon having no definite anterior margin 4. nemorivagum*
- Respiratory filaments 14; cocoon having a strong anterior margin 6. Species B*

(Larvae)

1. Abdomen with two large, usually sub-conical ventral papillae; abdominal cuticle occasionally with setae 2
- Abdomen without ventral papillae (true) or setae 8
2. Cephalic apotome ornamented with spots of different shades. 3
- Cephalic apotome with regular dark line-impressions.
 7. Species C*
3. Post-genal cleft minute and notch-like; at least corner teeth specially prominent 4
- Post-genal cleft usually large and not as above; corner teeth not so specialized 5

4. Post-genal dark spots two pairs; respiratory histoblast having 12 filaments with conical projections
 4. memorivagum*
- Post-genal dark spots more than two pairs; respiratory histoblast with a collapsed horn having 14-16 filaments
 5. Species A*
5. Post-genal cleft sub-quadrate and its depth less than one-third of post-genal bridge; respiratory histoblast with 6 filaments. 1. praelargum*
- Post-genal cleft almost rounded or spear-shaped and its depth rather as large as or larger than post-genal bridge; respiratory histoblast with either 4 or 8 filaments.
 6
6. Antenna brownish yellow, apex of segment 3 always above cephalic fan stem; respiratory histoblast rather slender, with 4 filaments. 7
- Antenna greyish, short, scarcely longer than cephalic fan stem; respiratory histoblast massive, with 8 filaments.
 15. tenuistylum*
7. Post-genal cleft almost rounded; spots of cephalic apotome pale brown; respiratory histoblast having broad stem.
 2. gracilis*

- Post-genal cleft spear-shaped; spots of cephalic apotome dark brown; respiratory histoblast having rather narrow stem 3. purii*
8. Cephalic apotome brownish; respiratory histoblast with 6 wrinkled filaments 9
- Cephalic apotome either yellowish or greyish; respiratory histoblast with either 8 or 10 filaments 10
9. Cephalic apotome with greyish head-spots; post-genal cleft almost subcordate 11. himalayense
- Cephalic apotome without definite head-spots but only with dark tinge; post-genal cleft sub-triangular.
..... 12. rufibasis
10. Cephalic apotome greyish; post-genal cleft mitre-shaped; respiratory histoblast with 8 wrinkled filaments.
..... 13. dentatum
- Cephalic apotome yellowish; post-genal cleft spear-shaped; respiratory histoblast with 10 wrinkled filaments.
..... 14 griseaene

REMARKS: The females of the following species are not known and, therefore, not placed in the key: nemorivagum, nigrifacies, species A, B and C. The species of which males are not known and hence not placed in the key are; species A,

B, C and D. The pupae of the following species are not known and are not placed in the key: rufithorax Brunetti, species A and D. The species of which larvae are not known and are not placed in the key are: rufithorax Brunetti, nigrifacies, darjeelingense, species B and D.

In this context it may be re-called that Edwards (1934) described the different stages of Simulium metatarsale Brunetti (1911) var.(?) from East Java. Here the female, pupa and the larva are exempted from the keys since it is felt undesirable to lump this variety (?) with the Indian form.

Simulium indicum Becher (1884) was originally described (J.Asiat.Soc.Bengal, Liii, 199) from female specimens labelled merely "Assam". Brunetti (1911, 1912a) recorded the distribution of this species also in Kurseong and Darjeeling (West Bengal) but this was possibly a case of misidentification as noted in the case of some other Indian species (see Puri, 1933c). Hence this species has not been placed in the above key.

GENERIC DIAGNOSIS

Genus SIMULIUM Latreille (1802) sensu lato

Simulium Latreille, 1802, Hist. nat. gén. part. Crust. Ins. .
3:426.

Type-species: Rhagio colombaschensis Fabricius, 1787,
by monotypy.

Melusina Meigen, 1800, Nouv. Class.:19.

Type-species: Tipula regelationis Linnaeus of Meigen
(1803) = Simulia ornata Meigen (1818), apud Meigen
(1818), this being the first named species associated
with the genus by Hendel (1908:50) when synonymising
it with Atractocera Meigen.

Atractocera Meigen, 1803, Illiger's Mag. 2:263.

Type-species: Tipula regelationis Linnaeus of Meigen
(1803) = Simulia ornata Meigen (1818), apud Meigen
(1818), by original designation.

(There are several other synonymous genus-group names of Simu-
lium sensu lato, most of which are at present regarded as valid
for subgeneric segregates by different authors and the rest may
be treated otherwise).

The diagnostic features for this genus in a broad sense are as follows (after appropriate modification from Crosskey, 1969):

Male and Female: Antenna with scape, pedicel and nine flagellomeres (very rare exceptions with eight or ten flagellomeres in some other countries). Head and eyes usually normal. Last segment of maxillary palp longest of all (exceptions rarely found in other countries). Mesepisternal groove sharply defined. Pleural membrane and sternopleuron bare or haired. Costa with spinules intermixed with stout hairs. Basal section of radius vein bare or haired. Radial sector simple. Second cubitus vein sinuous with double curvature. Second cubitus vein and anal vein approximated apically. Basal cell absent (vestigial form found in other countries). First hind tarsomere with a well-developed calcipala (exceptions found in some Neotropical species). Second hind tarsomere with usually well-developed pedisulcus.

Female: Cibarium unarmed or with a central patch of teeth or nodules. Tarsal claws with or without basal or sub-basal tooth. Anal cerci either blunt lobes or tapering processes.

Male: Distimere with one apical spinule (exceptions found in other countries). Ventral plate sometimes with teeth. Median sclerite very variable. Endoparameral hooks usually numerous.

Pupa: Respiratory organ variable in form. Abdomen with basic arrangement of hooks as follows: terga 3 and 4 each with four hooks on either side; sternum 5 with a pair of hooks close together on each side; sterna 6 and 7 each with the same number of hooks on each side but widely spaced; backwardly directed transverse rows of spines usually on most of terga beginning from tergum 5; last abdominal segment usually with a pair of hooks of varied form. Cocoon usually well-developed, with or without neck, sometimes with anterodorsal median projection.

Larva: Cephalic apotome generally broadening posteriorly. Cephalic fans present. Head-spots positive, negative or with shades of different tinge. Hypostomium with a row of 9 apical teeth of which corner and median teeth more prominent than others (rare exceptions occur in island and phoretic forms of other countries); median tooth not trifold. Inner margin of mandible with a pair of mandibular serrations, rarely reduced (exceptions found in other countries very rarely). Post-genal cleft usually well-developed but not reaching base of hypostomium (exceptions occur in some species of other countries). Anal sclerite X-shaped, having two anterior arms and two posterior arms. Ventral papillae present or absent. Rectal 'gills' with secondary lobules, sometimes without lobules. Cuticle bare or with setae of different forms.

SUBGENERIC DIAGNOSES AND
DESCRIPTIONS OF SPECIES

Subgenus EUSIMULIUM Roubaud, 1906

Eusimulium Roubaud, 1906, C.R.Acad.Sci. Paris 143:521.

Type-species: Simulia aurea Fries, 1824, by monotypy.

Cnetha Enderlein, 1921, Deuts.Tierarztl. Woch. 29:199.

Type-species: Atractocera latipes Meigen, 1804, by original designation.

Nevermannia Enderlein, 1921, Deuts.Tierarztl. Woch. 29: 199.

Type-species: Simulium annulipes Becker, 1908,
(= Simulium ruficorne Macquart, 1838). by original designation.

Stilboplax Enderlein, 1921, Deuts.Tierarztl Woch. 29:199

Type-species: Simulium speculiventris Enderlein,
1934, by original designation.

Friesia Enderlein, 1922, Konowia 1:69.

Type-species: Nevermannia tristricata Enderlein,
1921, by original designation.

Pseudonevermannia Baranov, 1926, N.Beitr.syst.Insektenk. 3:164.

Type-species: Atractocera latipes Meigen, 1804, by original designation (Isogenotypic with Cnetha Enderlein, 1921).

Chelocnetha Enderlein, 1936, S.B.Ges.naturf.Fr.Berl. 1936:117.

Type-species; Chelocnetha biroi Enderlein, 1936,
(= Simulium ornatipes Skuse, 1890), by original
designation.

Cryptectemnia Enderlein, 1936, S.B.Ges.naturf.Fr.Berl.1936:114.

Type-species: Cryptectemnia laticox Enderlein, 1936,
by original designation.

Miodasia Enderlein, 1936, Tierwelt Mitteleur. 6:39.

Type-species: Miodasia opalinipennis Enderlein, 1936,
by original designation.

DIAGNOSIS

(After appropriate modification from Crosskey, 1967b)

Male and Female: Basal section of radius haired. Vein
R₁ with spinules intermixed with hairs. Pleural membrane bare.
Sternopleuron bare (exceptions in Holarctic aureum- and latipes
-groups). Fore tarsus slender; first fore tarsomere about 6 -
10 times as long as its greatest width. First hind tarsomere
narrow and parallel-sided (may be dilated in male only).

Female: Cibarium usually unarmed (rare exceptions in
other countries). Tarsal claws with very large basal tooth
(exceptions found rarely in other countries). Scutum with in-
conspicuous colour pattern. Abdomen with pollinosity entirely.

Anal cerci simple bluntly rounded or truncate lobes. Spermatheca usually with reticulate surface pattern, without internal hairs (exceptions very rare).

Male: Upper eye facets not exceptionally enlarged. Genitalia with distimeres of varied form, usually, broad and truncate or large and tapering, mostly as long as basimere; basimere not produced beyond base of distimere; ventral plate not toothed, nearly always in form of large transverse plate with haired median keel and short forwardly directed basal arms; median sclerite normally narrow and elongate, sometimes bifurcate with splayed ends, rarely short and broad; endoparameral hooks usually numerous (exceptions in Holarctic aureum-group).

Pupa: Respiratory organ with 4 - 14 filaments; filaments typically as long or longer than body. In addition to basic arrangement of hooks, rarely accessory hooks present. Cocoon without neck (rare exceptions found in other countries), and weakly woven, often produced into a median antero-dorsal process.

Larva: Cephalic apotome with positive head-spots, rarely boldly marked. Hypostomium usually with sharply pointed teeth in which median and corner teeth strongly prominent. Hypostomial setae 3 - 7 in row lying more or less parallel to lateral margin of hypostomium. Post-genal cleft variable,

notch-like only or subquadrate or subtriangular or mitre-shaped (absent in some forms in other countries). Mandible without supernumerary mandibular serrations (some exceptions in Palaearctic forms). Thoracic and abdominal cuticle almost always bare. Ventral papillae present, usually large and subconical. Rectal 'gills' usually compound in Indian species.

DESCRIPTIONS OF SPECIES

1. Simulium (Eusimulium) praelargum, n.sp.

MATERIALS AVAILABLE: female, male (pinned and slide-mounted), pupa and larva, associated.

FEMALE: Length 3.5 - 4.5 mm.

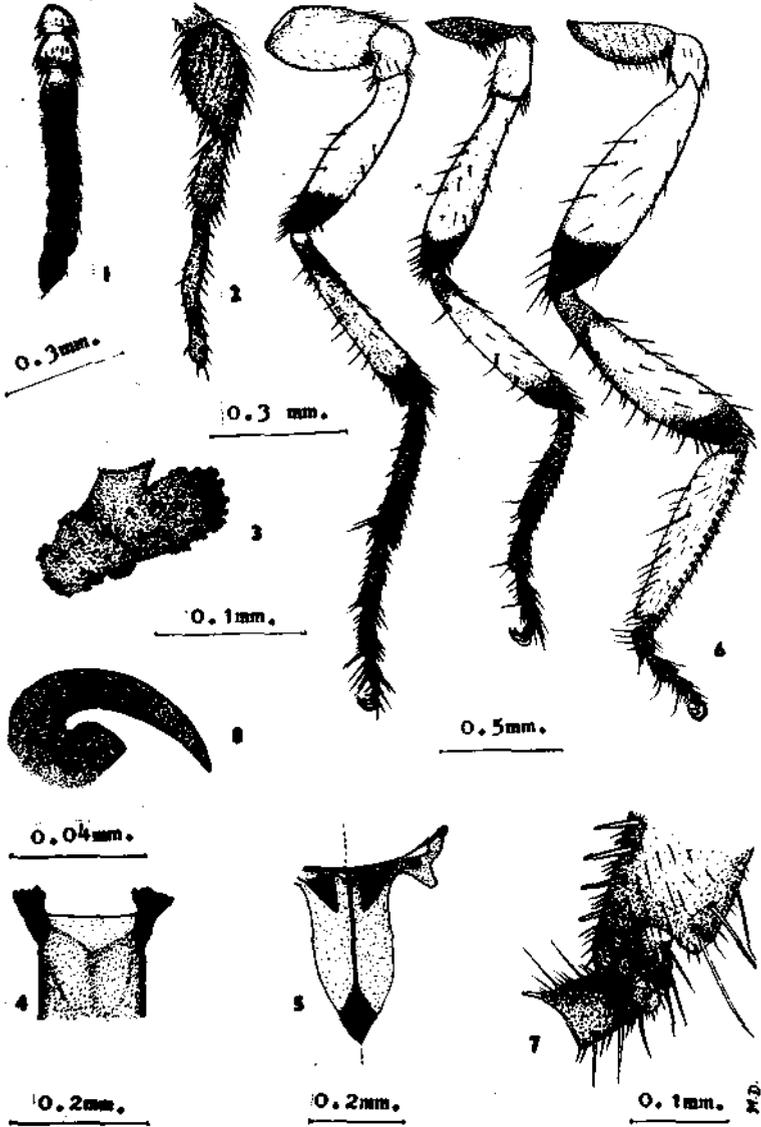
HEAD: width of head more or less equal to that of thorax; face dark grey; vertex with many erect golden hairs and a few long dark hairs; frons at top slightly wider than that in front (almost parallel-sided), shiny, with fine golden recumbent hairs - more laterally; clypeus with a coating of golden pollinosity and a few dark erect hairs anteriorly. Scape, pedicel and base of first flagellomere of antenna (Plate-I, fig.-1) brown, rest almost black, with fine golden pilosity. Palpus (Plate-I, fig.-2) dark grey or black; sensory vesicle (Plate-I, fig.-3) of third segment more than twice as long as wide; many pits present, often in rows or in clusters or scattered. Base of cibarium (Plate-I, fig.-4) unarmed.

EXPLANATION OF PLATE I

Simulium (Eusimulium) praelargum n.sp.

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Furcasternum of metasternum of female
- Fig. 6. Fore leg, mid leg and hind leg of female
- Fig. 7. End of first hind tarsomere and second tarsomere of female
- Fig. 8. Claw of female

Plate- I



THORAX: mesonotum dark grey; scutum with three faint longitudinal stripes arising from prescutellar region and ending to anterior margin; two dark spots on either side near lateral margins - one anteriorly and other posteriorly; scutum covered with golden recumbent hairs all over. Scutellum shiny, with a few golden recumbent and darkerect hairs. Post-notum shiny, bare. Pleuron dark grey; pleural membrane bare; dark brown hairs on pleural tuft; sternopleuron shiny, bare; furca-ternum (Plate-I, fig.-5) as figured. Knob of haltere brown, stem and base somewhat darkened.

Wing-length 2.81 mm. (2.6 - 2.95 mm., n=5). Veins brownish; costa with heavy stout black spinules intermixed with erect black hairs; hair tufts on base of costa and stem vein dark; sub-costa hairy upto about level of origin of radial sector; radial sector simple; radius hairy entirely and R_1 with spinules as well.

Legs (Plate-I, fig.-6) lighter than those of males. Fore coxa brown; trochanter brown with its (pale base; femur ^{tr₂} yellow with black distal end; tibia brownish yellow with black distal end and with a sub-basal dark grey ring; tarsus mainly black; first tarsomere elongated and not flattened, with brown base. Middle coxa nearly black; trochanter yellow; femur yellow, with its black tip; tibia as fore-one; tarsus black, first tarsomere with pale base. Hind coxa brownish

black; trochanter yellow; femur yellow with black tip; tibia as fore-one, excepting outer side of sub-basal ring extended upto tip; first tarsomere brownish with black end; almost parallel-sided, other tarsomeres black. Calcipala (Plate-I, fig.-7) much enlarged; pedisulcus deep. Each claw (Plate-I, fig.-8) with a strong sub-basal tooth.

ABDOMEN: abdominal scale dark brown with long golden hairs; terga 2, 3, 4 and 5 almost black and non-shiny; terga 6, 7 and 8 lighter and shiny; terga 3, 4 and 5 each with a median large dark spot. Venter brown to dark brown. Posterior segments with more and more golden and dark hairs. Terminalia (Plate-II, figs.-9, 10 and 11) as figured.

MALE: Length 3 - 4.5 mm.

HEAD: width of head greater than that of thorax; upper eye facets not exceptionally larger than lower ones; vertex black, with erect black hairs; clypeus nearly black, with a coating of golden pollinosity and recumbent golden hairs. Scape, pedicel and first flagellomere of antenna grey, rest black; first flagellomere largest of all; flagellum with fine black pilosity. Palpus as in females.

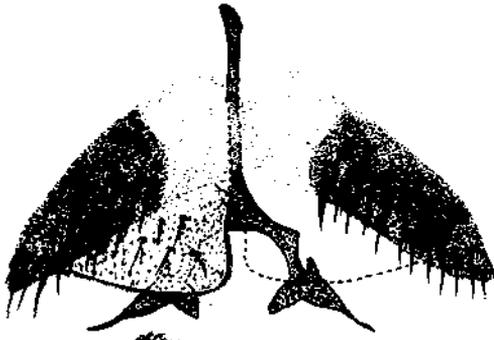
THORAX: same as in females excepting following characters: three faint longitudinal stripes only visible from anterior margin and dark spots absent; hairs on scutum more abundant.

EXPLANATION OF PLATE II

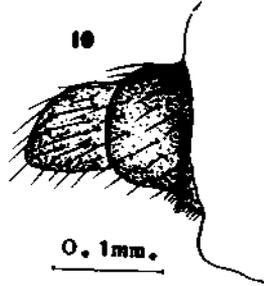
Simulium (Eusimulium) praelargum n.sp.

- Fig. 9. Terminalia of female (ventral view)
- Fig.10. Cercus and anal lobe (side view)
- Fig.11. Spermatheca
- Fig.12. Terminalia of male (ventral view) - paramere of one side not shown
- Fig.13. Distimere (side view)
- Fig.14. Ventral plate (end view)
- Fig.15. Pupa within cocoon (side view)
- Fig.16. Respiratory organ (right side)

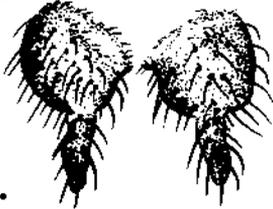
Plate- II



0.1mm.



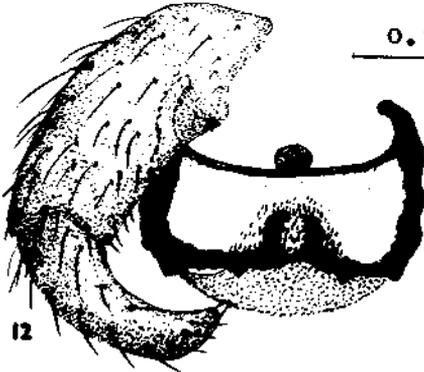
0.1mm.



0.1mm.



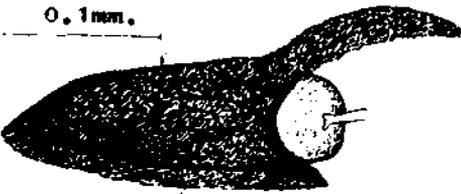
0.1mm.



0.1mm.



0.1mm.



1 mm.



0.5mm.

MB.

Wing-length 3 mm. (2.78 - 3.18 mm., n=5). Veins as in females excepting sub-costa hairy only at base.

Legs more darkened than those of females and having dilated first hind tarsomere, otherwise similar in both sexes.

ABDOMEN: abdominal scale dark grey with dark hairs; terga mainly dark grey; tergum 2 pale laterally; venter brown. Terminalia (Plate-II, figs.-12, 13 and 14) as figured.

PUPA: Body length 4 - 4.5 mm. without anterior projection. Dorsum of head and thorax with disc-like tubercles. Head trichomes 3 pairs, all simple. Thoracic trichomes 6 pairs, coiled apically, simple, long and thick. Respiratory organ (Plate-II, fig.-16) about 4 mm. long; filaments arranged in following manner: upper pair with a short stalk, from underside a third independent filament; fourth filament also arising apparently independently below upper pair; fifth and sixth filaments from lower side with fairly long common stalk (variable). Terga 1 and 2 with a few simple setae; terga 3 and 4 each with 4 simple stout hooks and a few setae on either side near posterior margin; tergum 5 with only about 5 spines whereas posterior ones having about 14 spines on each. Sternum 5 with a pair of branched hooks, close together, on each side near posterior margin; sterna 6 and 7 each with same number of hooks on each side but widely spaced; a pair of minute dorsal tail-

EXPLANATION OF PLATE III

Simulium (Eusimulium) praelargum n.sp.

- Fig.17. Head of larva (dorsal view)
- Fig.18. Head of larva (ventral view)
- Fig.19. Antenna of larva (right side)
- Fig.20. Hypostomium
- Fig.21. Tip of mandible of larva
- Fig.22. Respiratory histoblast of larva
- Fig.23. Rectal gills of larva
- Fig.24. Anal sclerite of larva

Plate- III



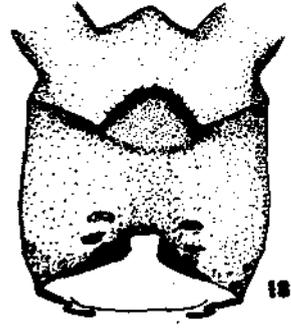
17

0.3mm.



19

0.2mm.



18

0.3mm.



20

0.1mm.



21

0.05mm.



23

0.2mm.



22

0.2mm.



24

0.2mm.

M.D.

hooks present. Cocoon (Plate-II, fig.-15) slipper-shaped, loosely woven, with a strong anterior margin; dorsal projection well-developed.

LARVA: Length about 6 - 7 mm.

Head (Plate-III, fig.-17) with brownish cephalic apotome, with positive head-spots. Antenna (Plate-III, fig.-19) more or less uniformly brownish yellow, third segment entirely extending beyond apex of cephalic fan stem. Cephalic fan with about 27 filaments. Post-genal cleft (Plate-III, fig.-18) small, subquadrate and much shorter than post-genal bridge. Corner and median teeth of hypostomium (Plate-III, fig.-20) strongly prominent; five or six hypostomial setae on either side lying nearly parallel to lateral margins. Tip of mandible (Plate-III, fig.-21) with two mandibular serrations. Respiratory histoblast (Plate-III, fig.-22) with six filaments as in pupa. Rectal 'gills' (Plate-III, fig.-23) compound with secondary lobules. Anal sclerite (Plate-III, fig.-24) showing incomplete anterior arms.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m., collected by M.Datta and sometimes assisted by A.Sherpa, 26.IV.70 and 12.IX.70. Lebong, Darjeeling, in a number of watercourses flowing down the Lebong Cart Road, 1931 m. - 2025 m., coll.

M.Datta, 15.V.70., 3.X.70., 12.VI.71. and 26.VIII.71. Sonada, Darjeeling, in a few watercourses near Sonada Rly.Station, 1660 m., coll.M.Datta, 12.VI.70. Taken as larvae and pupae mostly from decaying leaves found in watercourses mainly shaded by tall trees.

SPECIMENS EXAMINED: Holotype ♀ (IM; pinned), reared from pupa, North Point, Darjeeling, woody vegetation with trickle, 26.IV.70. (M.Datta). Allotype ♂ (IM; pinned), reared from pupa, same data as holotype. Paratypes from the localities mentioned above.

REMARK: This species is dominant in the area of investigation among all the species of the subgenus Eusimulium Roub. Hence the name praelargum has been proposed. This species is closely related to Simulium senilis Brunetti (1911), S.fuscinervis Edwards (1933), S.feuerborni Edwards (1934) and Simulium (Eusimulium) sasai Rubtzov (1959-1964), but it has certain important characters of its own for which it is treated as a new species. The affinities shown by praelargum with the above related species have been discussed in detail in the chapter on "DISCUSSION" so as to justify its validity.

2. Simulium (Eusimulium) gracilis, n.sp.

MATERIALS AVAILABLE: female, male (pinned and slide-mounted), pupa and larva, associated.

EXPLANATION OF PLATE IV

Simulium (Eusimulium) gracilis n.sp.

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Furcasternum of metasternum of female
- Fig. 6. Fore leg, mid leg and hind leg of female
- Fig. 7. End of first hind tarsomere and second tarsomere of female
- Fig. 8. Claw of female

Plate- IV

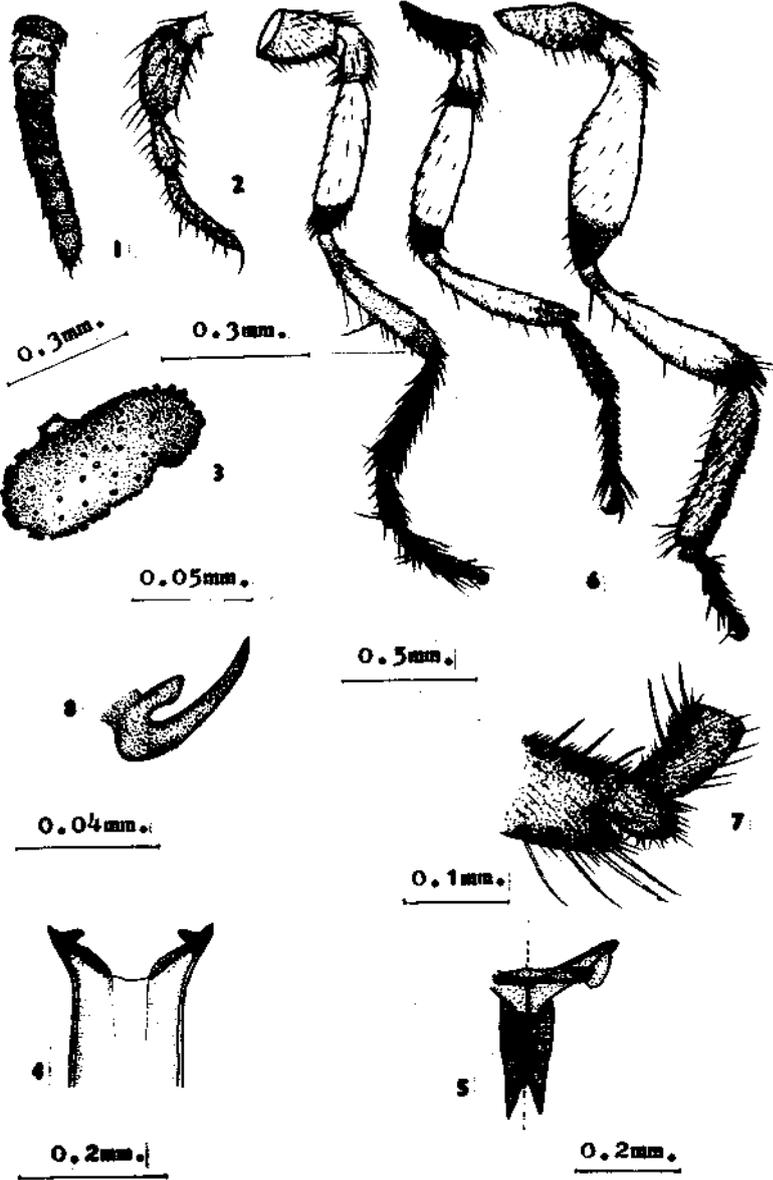


Fig.

FEMALE: Length 3.0 - 3.5 mm.

HEAD: width of head same as that of thorax; face and vertex dark grey; vertex with many erect golden hairs; frons narrower anteriorly, sub-shining, with many silvery recumbent hairs; clypeus with a coating of silvery pollinosity and a few golden recumbent hairs. Scape of antenna (Plate-IV, fig.-1) dark grey, pedicel grey and flagellum almost black, with fine dark grey pilosity. Palpus (Plate-IV, fig.-2) black; sensory vesicle (Plate-IV, fig.-3) of third segment as long as wide; many pits present, often in rows or in clusters or scattered. Base of cibarium (Plate-IV, fig.-4) unarmed.

THORAX: mesonotum dark grey; scutum with five faint longitudinal stripes arising from prescutellar region and ending to anterior margin; each sub-median stripe on either side joined to lateral stripe of that side anteriorly, while median one free anteriorly; all stripes united together posteriorly and only there they are prominent very much; golden recumbent hairs all over on scutum. Scutellum shiny, with golden recumbent and dark erect hairs. Post-notum shiny, bare. Pleuron greyish; pleural membrane bare; dark brown hairs on pleural tuft; sternopleuron shiny, bare; furcasternum (Plate-IV, fig.-5) as figured. Knob of haltere reddish yellow, base and stem darkened.

Wing-length 2.4 mm. (2.3 - 2.62 mm., n=5). Veins same as in praelargum.

Legs (Plate-IV, fig.-6) lighter than those of males. Fore coxa grey, middle coxa black and hind coxa dark grey; trochanters grey with pale bases; femora brownish yellow with black distal ends; tibiae brownish yellow with black distal tips and with a sub-basal ring of dark grey colour in each - faint in middle one. Fore and middle tarsi black with first and second fore tarsomeres having pale bases. First hind tarsomere brownish yellow with black end, almost parallel-sided; second tarsomere yellow on basal half or so, others black. Calcipala (Plate-IV, fig.-7) much enlarged; pedisulcus moderately deep. Each claw (Plate-IV, fig.-8) with a strong sub-basal tooth.

ABDOMEN: very slender; abdominal scale yellow, with golden marginal hairs; tergum 2 darker; others grey; terga 3, 4, 5 and 6 with a dark median spot. Terga 6, 7 and 8 shiny; all with golden hairs - more laterally. Venter yellow at first and second sterna, rest brown. Terminalia (Plate-V, figs.-9, 10 and 11) as figured.

MALE: Length 3.0 - 3.5 mm.

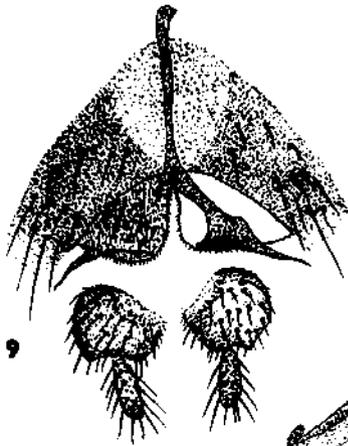
HEAD: width of head greater than that of thorax; upper eye facets not exceptionally larger than lower ones. Vertex with black erect hairs; clypeus dark grey, with a coating of golden pollinosity and a few recumbent brown hairs. Antenna entirely dark with dark pilosity; first flagellomere largest of all. Palpus as in female.

EXPLANATION OF PLATE V

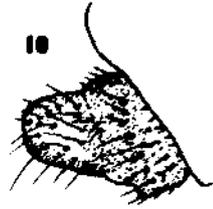
Simulium (Eusimulium) gracilis n.sp.

- Fig. 9. Terminalia of female (ventral view)
- Fig.10. Cercus and anal lobe (side view)
- Fig.11. Spermatheca
- Fig.12. Terminalia of male (ventral view) - paramere of one side not shown.
- Fig.13. Distimere (side view)
- Fig.14. Ventral plate (end view)
- Fig.15. Pupa within cocoon (side view)
- Fig.16. Respiratory organ (right side)

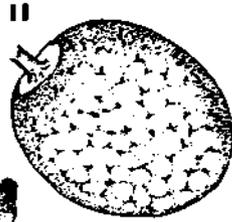
Plate- V



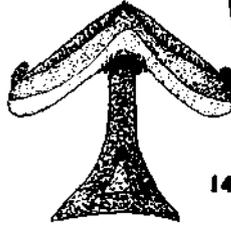
0.1mm.



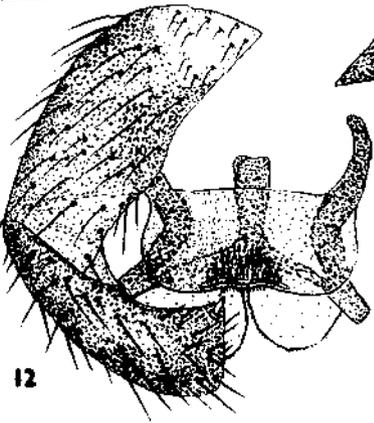
0.1mm.



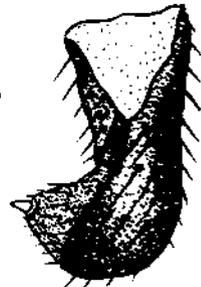
0.1mm.



0.1mm.



0.1mm.



0.1mm.



1 mm.

15



0.5mm.

16

THORAX: same as that of female excepting scutum without stripes.

Wing-length and veins as in female excepting sub-costa with hairs only at base.

Legs as in female excepting following differences: fore tarsomeres wholly black; first hind tarsomere dilated to some extent.

ABDOMEN: abdominal scale dark grey; all terga dark grey; venter brown, somewhat greyish posteriorly. Terminalia (Plate-V, figs.-12, 13 and 14) as figured.

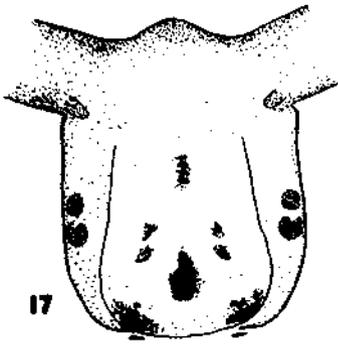
PUPA: Body length 3.5 - 4.0 mm. without anterior projection. Dorsum of head and thorax non-granulated. Head trichomes 4 pairs, large and multiple-branched. Thoracic trichomes 6 pairs, large and multiple-branched. Respiratory organ (Plate-V, fig.-16) about 3.5 mm. long, 4-filamented, arranged in following manner: basal stem divided into two branches; lower pair having short stem and upper pair with a fairly long stem; all divergent from base. Terga 1 and 2 with branched and unbranched setae. Arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7 same as in praelargum; posterior terga each with some spines ranging upto 20. A pair of minute blunt dorsal tail-hooks present. Cocoon (Plate-V, fig.-15) slipper-shaped, loosely woven, with a strong anterior margin; dorsal projection

EXPLANATION OF PLATE VI

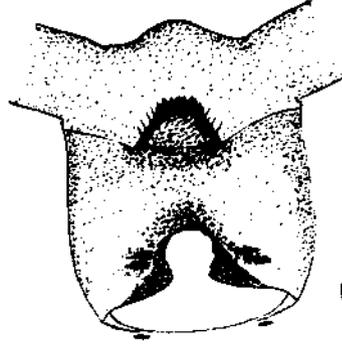
Simulium (Eusimulium) gracilis n.sp.

- Fig.17. Head of larva (dorsal view)
- Fig.18. Head of larva (ventral view)
- Fig.19. Antenna of larva (right side)
- Fig.20. Hypostomium
- Fig.21. Tip of mandible of larva
- Fig.22. Respiratory histoblast of larva
- Fig.23. Rectal gills of larva
- Fig.24. Anal sclerite of larva

Plate- VI



17



18

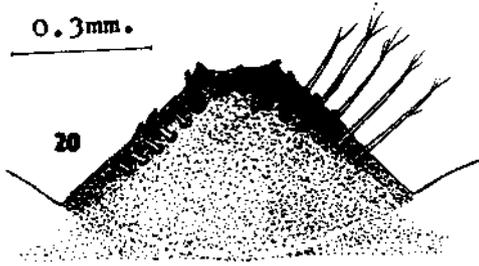
0.3mm.

0.3mm.



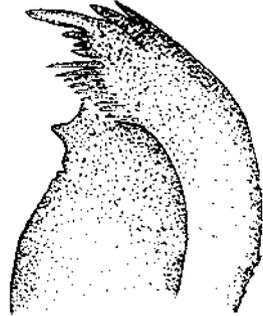
19

0.2mm.



20

0.1mm.



21

0.05mm.



22

0.3 mm.



23

0.2mm.



24

0.2mm.

M. D.

large and veil-like, generally trifold.

LARVA: Length about 5.0 - 5.5 mm.

Head (Plate-VI, fig.-17) with brownish cephalic apotome having positive head-spots. Antenna (Plate-VI, fig.-19) more or less uniformly brownish yellow, distal end of second segment at same level with apex of cephalic fan stem. Cephalic fan with about 38 filaments. Post-genal cleft (Plate-VI, fig.-18) almost rounded and shorter than post-genal bridge. Corner and median teeth of hypostomium (Plate-VI, fig.-20) strongly prominent as in praelargum; four or five hypostomial setae on either side lying nearly parallel to lateral margins. Tip of mandible (Plate-VI, fig.-21) with two mandibular serrations as in praelargum. Respiratory histoblast (Plate-VI, fig.-22) with four filaments as in pupa. Rectal 'gills' (Plate-VI, fig.-23) compound as in praelargum. Anal sclerite (Plate-VI, fig.-24) showing more or less complete anterior arms.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m., 26.VI.70. (coll. M.Datta) and 12.IX.70. (coll. M.datta and assisted by A.Sherpa). Lebong, Darjeeling, in a number of watercourses flowing down the Lebong Cart Road, 1931 m. - 2025 m., coll. M.Datta, 15.V.70., 3.X.70., 12.VI.71 and 26.VIII.71.

Sukia pokhri, Darjeeling, in a few watercourses, 1735 m. - 1850 m., 5.VII.70. coll. M.Datta and assisted by N.Pal.

Taken as larvae and pupae from decaying leaves and grasses found in watercourses mostly shaded by tall conifers. Occasionally imagines caught at rest.

SPECIMENS EXAMINED: Holotype ♀ (IM; pinned), reared from pupa, North Point, Darjeeling, woody vegetation with trickle, 26.IV.70. M.Datta. Allotype ♂ (IM; pinned), reared from pupa, same data as holotype. Paratypes from the localities mentioned above.

REMARK: The name of the species has been derived from its slim appearance. This species is closely related to Simulium (Eusimulium) latipes Mg. (1804), S.(E.) costatum Fried.(1920) E.fontinale Radz. (1948), S.(E.) bertrandi Grenier & Dorier (1959) and S.(E.) purii, n.sp., but it has certain important characters of its own for which it is treated as a new species. The affinities shown by gracilis with the above related species have been discussed in detail in the chapter on "DISCUSSION" so as to justify its validity.

3. Simulium (Eusimulium) purii, n.sp.

MATERIALS AVAILABLE: female, male (pinned and slide-mounted), pupa and larva, associated.

FEMALE: Length 3.0 - 3.5 mm.

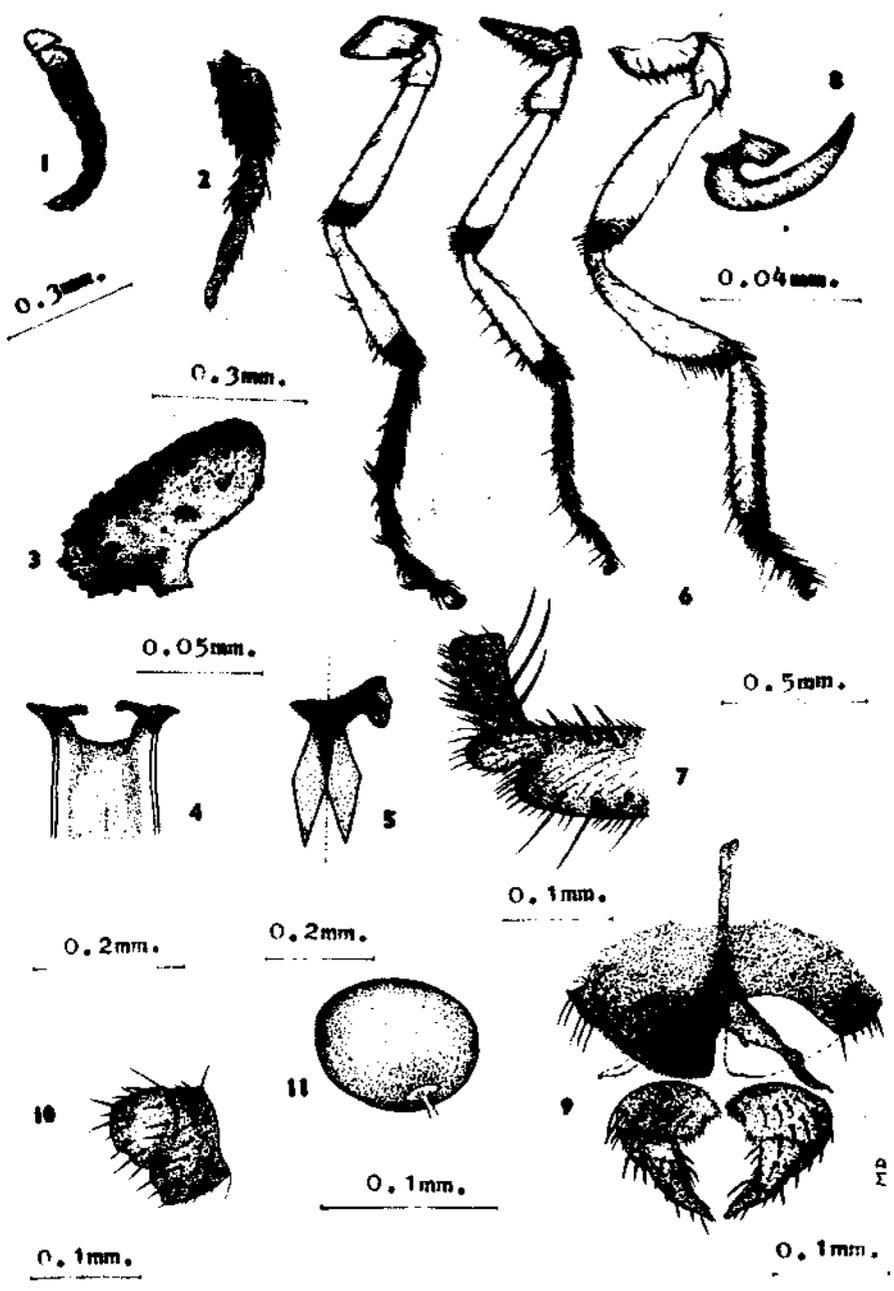
HEAD: width of head more or less same as that of thorax; face greyish black; vertex with a few dark up-stand-

EXPLANATION OF PLATE VII

Simulium (Eusimulium) purii n.sp.

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Furcasternum of metasternum of female
- Fig. 6. Fore leg, mid leg and hind leg of female
- Fig. 7. End of first hind tarsomere and second tarsomere of female
- Fig. 8. Claw of female
- Fig. 9. Terminalia of female (ventral view)
- Fig. 10. Cercus and anal lobe (side view)
- Fig. 11. Spermatheca

Plate-VII



ing hairs; frons same as in gracilis; clypeus with golden pollinosity and a few brownish hairs. Scape and pedicel of antenna (Plate-VII, fig.-1) brownish, flagellum black with dark grey pilosity. Palpus (Plate-VII, fig.-2) black; sensory vesicle (Plate-VII, fig.-3) of third segment about twice as long as wide; many pits present, often in clusters or in rows or rarely scattered. Base of cibarium (Plate-VII, fig.-4) unarmed.

THORAX: mesonotum greyish black; scutum clothed with golden hairs, three faint longitudinal stripes of scutum ending at prescutellar region. Scutellum shiny, with many recumbent golden hairs and a few dark erect hairs as in gracilis. Post-notum shiny, bare as in praelargum and gracilis. Pleuron greyish as in gracilis, pleural membrane bare as in praelargum and gracilis; dark brown hairs on pleural tuft as in praelargum and gracilis; sternopleuron bare as in praelargum and gracilis; furcasternum (Plate-VII, fig.-5) as figured. Knob and stem of haltere brownish yellow, base darkened.

Wing-length about 2.3 mm. Veins same as in praelargum and gracilis.

Legs (Plate-VII, fig.-6) lighter than those of males. Fore coxa and trochanter brownish; femur brownish with black end; tibia greyish with black end and with a black sub-basal ring; tarsus black, slender; first tarsomere about 6 times as

long as its greatest width. Middle coxa greyish black; trochanter greyish; femur brownish yellow with black tip; tibia brownish with black end, sub-basal ring inconspicuous; first tarsomere black with pale base, rest black. Hind coxa and trochanter greyish; femur brownish with black end; tibia as fore one excepting sub-basal ring extending upto tip; first tarsomere greyish, narrow, almost parallel-sided; second tarsomere black with pale base, rest black. Calcipala (Plate-VII, fig.-7) much enlarged; pedisulcus deep. Each claw (Plate-VII, fig.-8) with a strong sub-basal tooth.

ABDOMEN: abdominal scale yellowish, with greyish marginal hairs, terga greyish with pale hairs scattered all over. Terga 6, 7 and 8 shiny while others non-shiny. Terminalia (Plate-VII, figs.-9, 10 and 11) as figured.

MALE: Length about 3.5 mm.

HEAD: width of head greater than that of thorax; upper eye facets not exceptionally larger than lower ones as in praelargum and gracilis. Vertex with large dark erect hairs; clypeus dark grey with a coating of golden pollinosity and many recumbent dark hairs. Scape and pedicel of antenna dark grey, flagellum black; flagellomere first largest of all as in praelargum and gracilis. Palpus as in female.

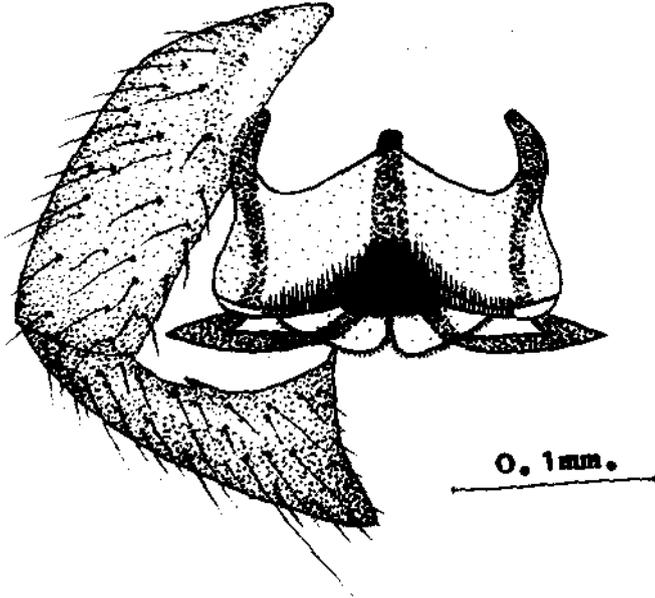
THORAX: same as that of female excepting scutum without stripes and colour of hairs darker than in females.

EXPLANATION OF PLATE VII A

Simulium (Eusimulium) purii n.sp.

Terminalia of male (ventral view) - paramere of one side not shown

Plate- VIIA



Wing-length about 2.7 mm., veins as in females excepting sub-costa with hairs only at base.

Colouration of legs as in females excepting following differences: fore trochanter grey; femur grey with black tip; middle coxa black; femur brownish with black end; all sub-basal rings more extended; first hind tarsomere dilated.

ABDOMEN: abdominal scale brownish, other terga dark grey except paler second tergum, with dark hairs all over. Terminalia (Plate-VII A) as figured.

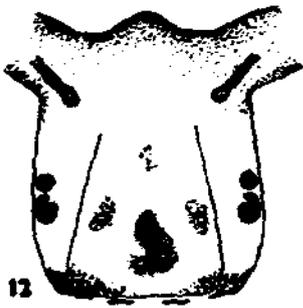
PUPA: Body length about 4.0 mm. without anterior projection. Dorsum of head and thorax almost non-granulated. Head trichomes 4 pairs; large and simple. Thoracic trichomes on dorsum 5 pairs, larger than head trichomes, simple. Respiratory organ (Plate-VIII, fig.-21) about 3.5 mm. long, 4-filamented, arranged in following manner: main stem divided into two almost equal branches - each of them having two filaments of equal calibre. Terga 1 and 2 with a few unbranched setae; arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7 same as in praelargum and gracilis; posterior terga each with a row of about 14 spines. A pair of curved and pointed dorsal tail-hooks present. Cocoon (Plate-VIII, fig.-20) slipper-shaped, moderately loosely woven, with a strong anterior margin; dorsal anterior projection present.

EXPLANATION OF PLATE VIII

Simulium (Eusimulium) purii n.sp.

- Fig.12. Head of larva (dorsal view)
Fig.13. Head of larva (ventral view)
Fig.14. Antenna of larva (right side)
Fig.15. Hypostomium
Fig.16. Tip of mandible of larva
Fig.17. Respiratory histoblast of larva
Fig.18. Rectal gills of larva
Fig.19. Anal sclerite of larva
Fig.20. Pupa within cocoon (side view)
Fig.21. Respiratory organ (right side)

Plate- VIII



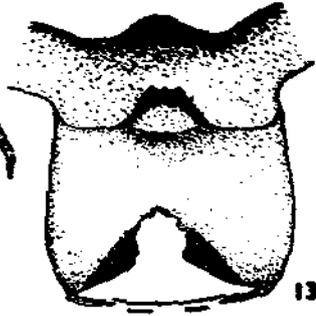
12

0.3mm.



14

0.2mm.



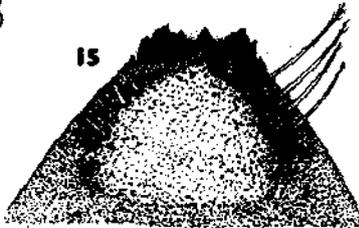
13

0.3mm.



17

0.3 mm



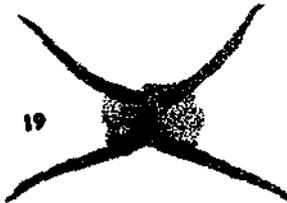
15

0.1mm.



16

0.05mm.



19

0.2mm.



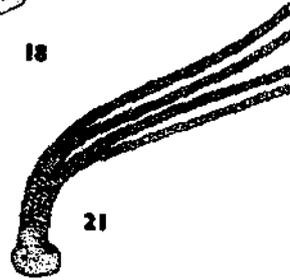
18

0.2mm.



20

1 mm.



21

0.5mm.

PLD

LARVA: Length about 5.3 mm.

Head with brownish cephalic apotome (Plate-VIII, fig.-12) having positive head-spots as in praelargum and gracilis, but markings different in these species. Antenna (Plate-VIII, fig.-14) more or less uniformly brownish yellow, distal end of second segment below apical level of cephalic fan stem. Cephalic fan with about 36 filaments. Post-genal cleft (Plate-VIII, fig.-13) almost spear-shaped and shorter than post-genal bridge. Corner and median teeth of hypostomium (Plate-VIII, fig.-15) strongly prominent as in praelargum and gracilis; five or ~~six~~ hypostomial setae on either side lying nearly parallel to lateral margins. Tip of mandible (Plate-VIII, fig.-16) with two mandibular serrations as in praelargum and gracilis. Respiratory histoblast (Plate-VIII, fig.-17) with four filaments as in pupa. Rectal 'gills' (Plate-VIII, fig.-18) compound as in praelargum and gracilis. Anal sclerite (Plate-VIII, fig.-19) showing incomplete anterior arms as in praelargum.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m., coll.M.Datta, 26.IV.70 and 15.V.70. Sukia pokhri, Darjeeling, in a small trickle of water flowing down the Darjeeling-Sukia Road, 1750 m., coll.M.Datta and assisted by N.Pal, 5.VII.70. Mungpoo, Darjeeling, in a small trickle of water, 1360 m., coll.M.Datta, 12.IX.71. Taken as larvae and pupae from decaying leaves

found in water courses occasionally exposed to sun.

SPECIMENS EXAMINED: Holotype ♀ (IM; pinned), reared from pupa, North Point, Darjeeling, woody vegetation with a small trickle, 26.IV.70. M.Datta. Allotype ♂ (IM; slide-mounted), reared from pupa, same data as holotype, 15.V.70. Paratypes from the localities mentioned above.

REMARK: This species is named after Dr.I.M.Puri, a widely recognized Indian worker on Simuliidae. This species is closely related to Simulium (Eusimulium) latipes Mg. (1804), S.(E.) costatum Fried. (1920), E.fontinale Radz. (1948) and S.(E.) gracilis, n.sp., but it has certain important characters of its own for which it is treated as a new species. The affinities shown by puri with the above related species have been discussed in detail in the chapter on "DISCUSSION" so as to justify its validity.

4. Simulium (Eusimulium) nemorivagum, n.sp.

MATERIALS AVAILABLE: male (slide-mounted), pupa and larvae, associated.

MALE: Length 4.3 mm.

HEAD: width of head greater than those of thorax; upper eye facets not exceptionally larger than lower ones as in former species; vertex with long dark erect hairs as in

former species; clypeus dark grey with a coating of golden pollinosity and with a few dark hairs on surface. Scape, pedicel and base of first flagellomere dark brown, rest black; width of scape greater than its length; pedicel larger than its breadth; first flagellomere largest of all as in former species (Plate-IX, fig.-1). Palpus (Plate-IX, fig.-2) dark; sensory vesicle (Plate-IX, fig.-3) of third segment almost rounded, provided with a few clusters of pits.

THORAX: mesonotum mostly dark. Scutum with dark areas laterally, with many recumbent golden hairs; scutellum covered with some dark erect hairs along with golden pollinosity. Postnotum shiny, bare as in former species. Pleuron mainly dark grey; pleural membrane dark brown, bare; dark brown hairs on pleural tuft. Sternopleuron dark with shining surface, bare as in former species; halteres somewhat pale at stem, base and knob darker.

Wing-length about 3.1 mm. Veins as in former species.

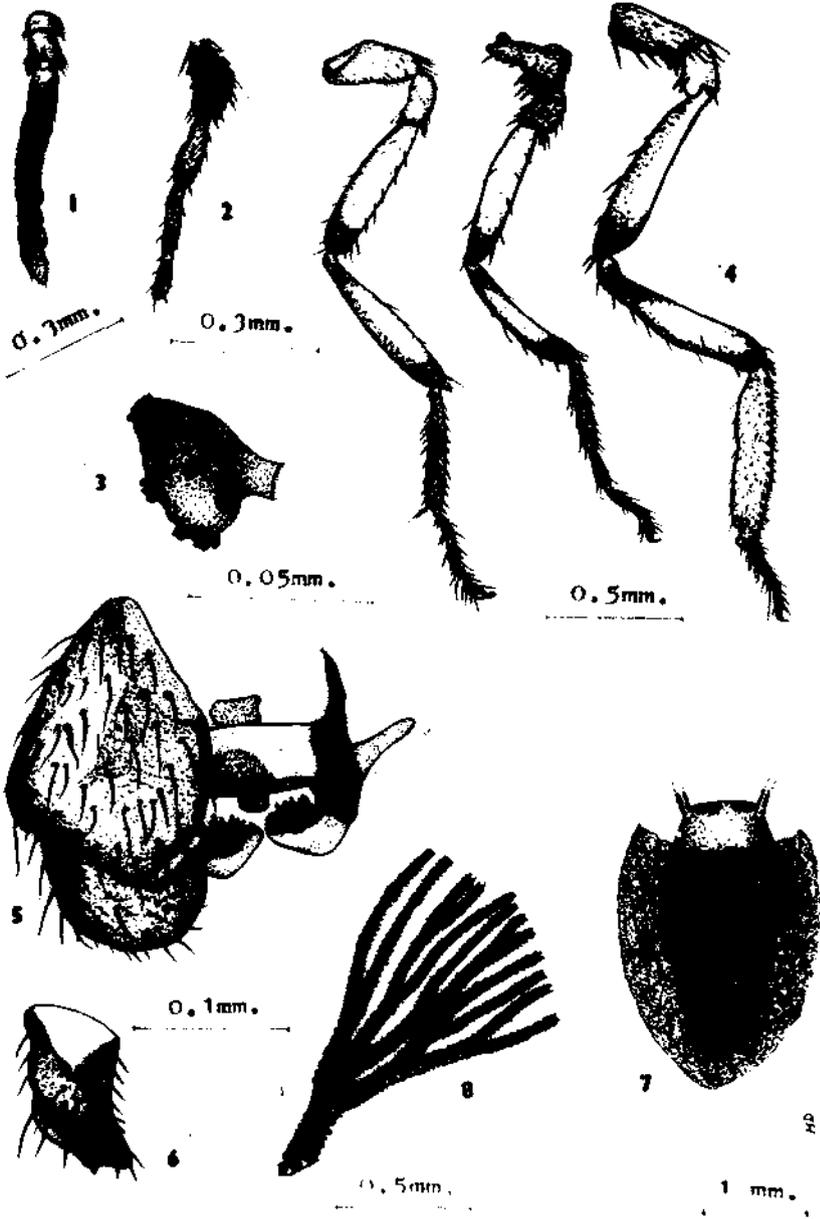
Legs (Plate-IX, fig.-4) rather slender. Fore coxa dark brown; trochanter brown with its pale base; femur brown, with black distal end; tibia brownish with distal black end and a sub-basal grey ring; tarsus mainly black; first tarsomere elongated and almost equal to second, third and fourth tarsomeres together in length. Middle coxa black; trochanter grey; femur brown with black distal end; tibia as fore one; tarsus

EXPLANATION OF PLATE IX

Simulium (Eusimulium) nemorivagum n.sp.

- Fig. 1. Antenna of male
- Fig. 2. Maxillary palpus of male
- Fig. 3. Sensory vesicle of male
- Fig. 4. Fore leg, mid leg and hind leg of male
- Fig. 5. Terminalia of male (ventral view) - paramere of one side not shown
- Fig. 6. Distimere (side view)
- Fig. 7. Pupa within cocoon (dorsal view)
- Fig. 8. Respiratory organ (right side)

Plate- IX



mainly black. Hind coxa nearly black; trochanter yellow; femur brown with black end; tibia as fore one but sub-basal ring extended; first tarsomere brown, dilated at distal end. Calcipala much enlarged, pedisulcus deep.

ABDOMEN: abdominal scale pale; marginal hairs greyish; other terga nearly black with dark hairs; all sterna comparatively pale, with dark hairs. Terminalia (Plate-IX, figs. -5 and 6) as figured.

PUPA: Body length about 3.6 mm.

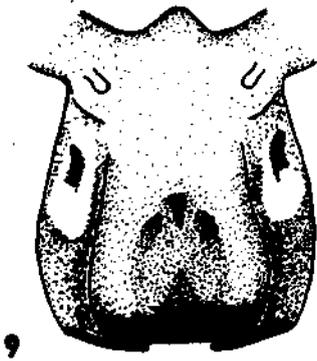
Dorsum of head and thorax and, also venter coarsely granulated. Head trichomes 3 pairs, simple, short and thick as in praelargum. Thoracic trichomes 6 pairs, simple, long and thick as in praelargum. Respiratory organ (Plate-IX, fig.-8) about 3.2 mm. long; filaments arranged in following way: from a fairly long stalk 3 branches arise - upper, middle and lower branches (lower and middle ones joined together to form a common stalk in left organ); upper one divided to form two filaments; middle one primarily divided into two branches; each again divided into two secondarily, outer ones divided again to form two tertiary filaments, thus middle branch consisting of 6 filaments in one organ; lower branch primarily divided into two branches, each of them again divided into two secondarily in sub-equal proportions, thus lower branch consisting of 4 filaments in one organ. All 12 filaments on either side beset with

EXPLANATION OF PLATE X

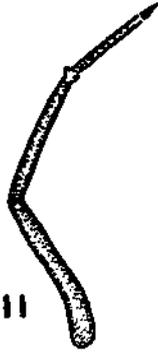
Simulium (Eusimulium) nemorivagum n.sp.

- Fig. 9. Head of larva (dorsal view)
- Fig.10. Head of larva (ventral view)
- Fig.11. Antenna of larva (right side)
- Fig.12. Hypostomium
- Fig.13. Tip of mandible of larva
- Fig.14. Respiratory histoblast of larva
- Fig.15. Rectal gills of larva
- Fig.16. Anal sclerite of larva

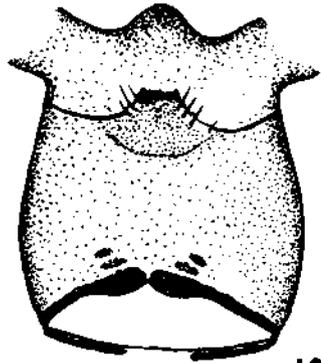
Plate- X



0.3mm



0.2mm



0.3mm



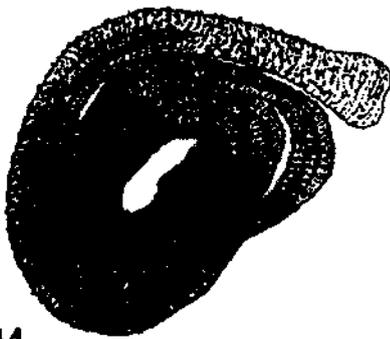
0.1mm



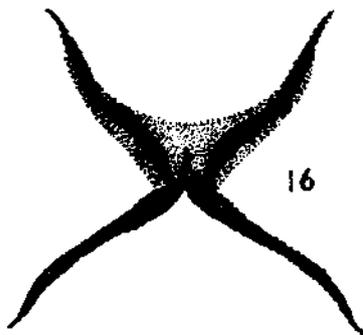
0.05mm



0.2mm



0.2mm



0.1mm

MD

numerous conical projections which are remarkable in this species. Terga 1 and 2 with a few simple setae on either side as in praelargum and purii; arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7 same as in former species; tergum 5 bare while posterior terga with about 6 - 10 spines on each. Tail-hooks blunt. Cocoon (Plate-IX, fig.7) small, slipper-shaped, loosely woven, without a definite anterior margin; dorsal projection absent.

LARVA: Length about 5.5 mm.

Head (Plate-X, fig.-9) with slightly brownish cephalic apotome excepting yellowish tinge around eyes and anterior part of apotome; head-spots positive. Antenna (Plate-X, fig.-11) brownish yellow, portion of third segment extending beyond apex of cephalic fan stem. Cephalic fan with about 28 filaments. Post-genal cleft (Plate-X, fig.-10) minute and notch-like, cosequentially post-genal bridge very large. Hypostomium (Plate-X, fig.-12) with rather blunt apical teeth, corner and median teeth highly prominent, about 3 hypostomial setae on either side lying subparallel to lateral margins. Tip of mandible (Plate-X, fig.-13) with two mandibular serrations as in former species. Respiratory histoblast (Plate-X, fig.-14) with 12 filaments identical with those of pupa. Rectal 'gills' (Plate-X, fig.-15) compound as in former species. Anal sclerite (Plate-X, fig.-16) with a double connection between anterior and posterior arms leaving

a small lacuna. Ventral papillae two as in former species.

FEMALE: Unknown.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m. 26.IV.70(coll. M.Datta)and 1.V.71.(coll.R.K.Dey and A.K.Paul). Lebong,Darjeeling, in a small trickle of water, 2025 m. coll.M.Datta 28.III.71. Ghoom, Darjeeling, in a small trickle of water flowing down the Hill Cart Road, 2250 m. 2.V.71.(coll.R.K.Dey, and assisted by A.K.Paul and T.K.Pal). Taken as larvae and pupa from stones shaded by tall trees beside the waterways.

SPECIMENS EXAMINED: Holotype ♂ (IM; slide-mounted), reared from pupa, North Point, Darjeeling, woody vegetation with a small trickle, 26.IV.70. (M.Datta). Morphotypes from the localities mentioned above.

REMARK: This species is the wanderer of the woods. Hence the name nemorivagum has been proposed. The male of this species apparently resembles that of praelargum but it has certain important distinctive characters by which it can be treated as a new species and this has been discussed in the chapter on "DISCUSSION" so as to justify its validity.

5. Simulium (Eusimulium) Species A

MATERIAL AVAILABLE: Larva only

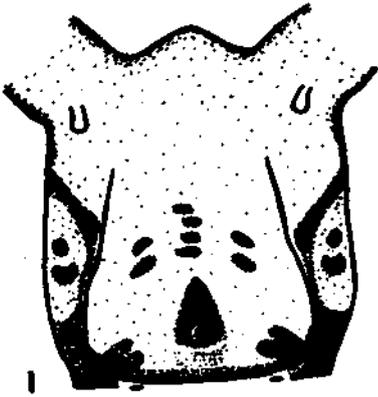
LARVA: Length about 6.5 mm.

EXPLANATION OF PLATE XI

Simulium (Eusimulium) Species A

- Fig. 1. Head of larva (dorsal view)
- Fig. 2. Head of larva (ventral view)
- Fig. 3. Antenna of larva (right side)
- Fig. 4. Hypostomium
- Fig. 5. Tip of mandible of larva
- Fig. 6. Respiratory histoblast of larva
- Fig. 7. Rectal gills of larva
- Fig. 8. Anal sclerite of larva

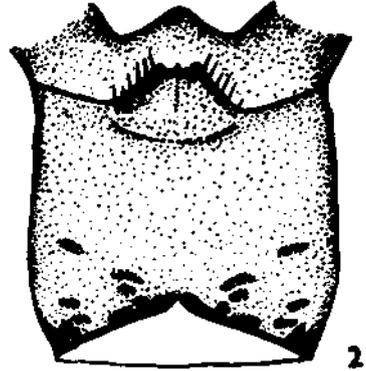
Plate- XI



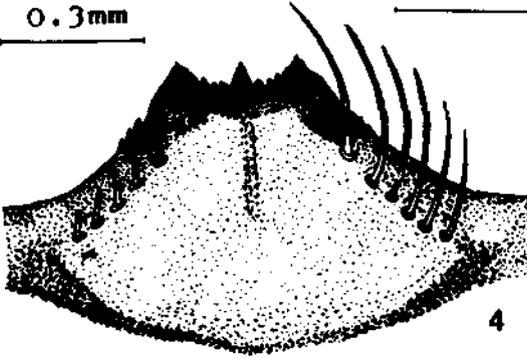
0.3mm



0.2mm



0.3mm



0.1mm



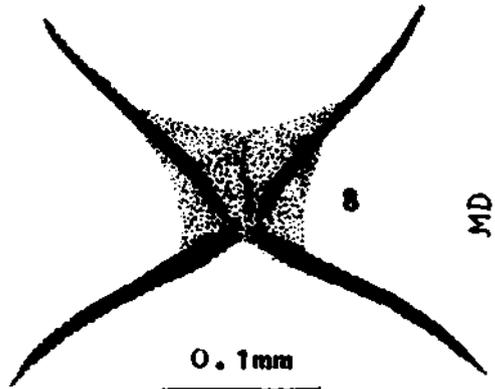
0.05mm



0.2mm



0.3mm



0.1mm

MD

Head (Plate-XI, fig.-1) with pale yellow cephalic apotome excepting brownish tinge around eyes; head-spots positive. Antenna (Plate-XI, fig.-3) light brown, third segment almost at same level of cephalic fan stem. Cephalic fan with about 32 filaments. Post-genal cleft (Plate-XI, fig.-2) minute and notch-like, very large post-genal bridge as in nemorivagum. Hypostomium (Plate-XI, fig.-4) with sharp apical teeth, corner and median teeth strongly prominent as in nemorivagum, about 6 hypostomial setae on either side lying sub-parallel to lateral margins. Tip of mandible (Plate-XI, fig.-5) with two mandibular serrations as in former species. Respiratory histoblast (Plate-XI, fig.-6) with collapsed horn having 14-16 filaments along whole length. Rectal 'gills' (Plate-XI, fig.-7) compound as in former species. Anal sclerite (Plate-XI, fig.-8) with incomplete anterior arms as in praelargum and purji. Ventral papillae two as in former species.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m., coll.M.Datta. 28.III.71. Larva taken from undersurface of a stone shaded by trees.

6. Simulium (Eusimulium) Species B

MATERIAL AVAILABLE: Pupa only.

PUPA: Body length about 4 mm.

Dorsum of head and thorax with profuse disc-like tubercles. Head trichomes 3 pairs, simple and coiled apically as in praelargum and nemorivagum. Thoracic trichomes 3 pairs, long, thick, simple and coiled apically. Respiratory organ (Plate-XII, fig.-2) with 14 filaments; filaments arranged in following manner: from a long basal stem apparently closely three primary branches; lower one with two filaments; middle one divided into two secondary branches, lower branch with two filaments, upper branch dichotomously divided to form 2 + 2 filaments; upper primary branch divided into two secondary branches, each again into 2 + 1 tertiary filaments; all beset with heavy conical projections. Terga 1 and 2 respectively with 3 and 6 simple setae on either side; arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7 as in former species but in this species all hooks branched; tergum 5 bare while of posterior terga maximum number of spines being 17 on tergum 8, all simple. A pair of blunt dorsal tail-hooks present. Cocoon (Plate-XII, fig.-1) slipper-shaped, very loosely woven, with a strong anterior margin; dorsal projection absent as in nemorivagum.

DISTRIBUTION: Lebong, Darjeeling, in a ditch-like watercourse flowing down the Lebong Cart Road, 2025 m., coll.M.Datta, 2.X.70. Pupa taken from undersurface of a stone exposed to full sun.

EXPLANATION OF PLATE XII

Simulium (Eusimulium) Species B

Fig. 1. Pupa within cocoon (dorsal view)

Fig. 2. Respiratory organ (right side)

Simulium (Eusimulium ?) Species C

Fig. 3. Pupa within cocoon (dorsal view)

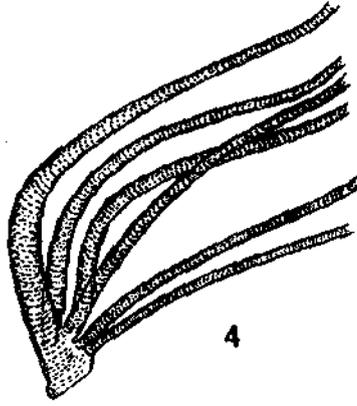
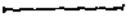
Fig. 4. Respiratory organ (right side)

Plate- XII



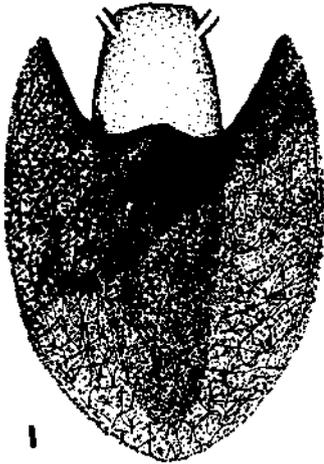
3

1mm



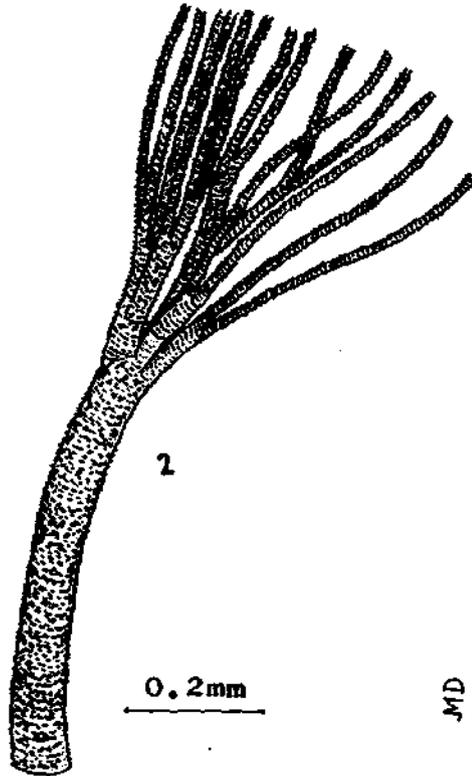
4

0.2mm



1

1mm



2

0.2mm



JMD

7. Simulium (Eusimulium ?) Species C

MATERIALS AVAILABLE: Pupae and larvae only, associated.

PUPA: Body length about 4.0 mm.

Dorsum of head with inconspicuous tubercles but that of thorax with profuse disc-like tubercle. Head trichomes 3 pairs, long, multiple-branched and brush-like. Thoracic trichomes 5 pairs long, multiple-branched and brush-like. Respiratory organ (Plate-XII, fig.-4) about 2 mm. long, with 6 filaments arranged in 3 pairs; first upper pair somewhat wrinkled, first one stoutest of all; middle pair almost equal in thickness and apparently originated from base of first pair; last lower pair weakest and practically free from others. Terga 1 and 2 with a number of setae; arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7 as in the species B; terga 5 and 6 with setae only while of posterior terga maximum number of spines being 18 on tergum 8, all simple. A pair of blunt dorsal tail-hooks present. Cocoon (Plate-XII, fig.-3) slipper-shaped, tightly woven, only ventral surface reticulate, two large windows antero-laterally; anterior margin strong but without dorsal projection as in the species B.

LARVA: Length about 6.5 mm.

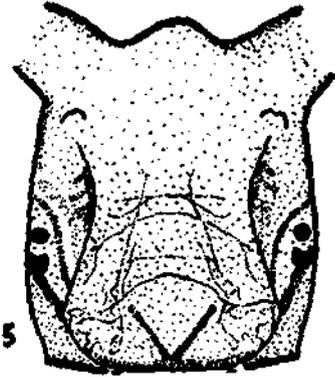
Head (Plate-XIII, fig.-5) with brownish cephalic apotome, peculiar line-markings instead of dark spots on apotome.

EXPLANATION OF PLATE XIII

Simulium (Eusimulium?) Species C

- Fig. 5. Head of larva (dorsal view)
- Fig. 6. Head of larva (ventral view)
- Fig. 7. Antenna of larva (right side)
- Fig. 8. Hypostomium
- Fig. 9. Tip of mandible of larva
- Fig. 10. Respiratory histoblast of larva
- Fig. 11. Rectal gills of larva
- Fig. 12. Anal sclerite of larva

Plate- XIII



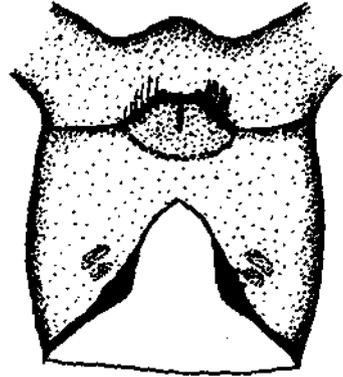
5

0.3mm



7

0.2mm



6

0.3mm



8

0.1mm



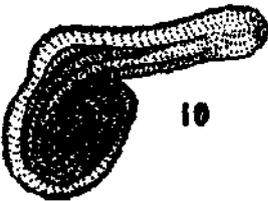
9

0.05mm



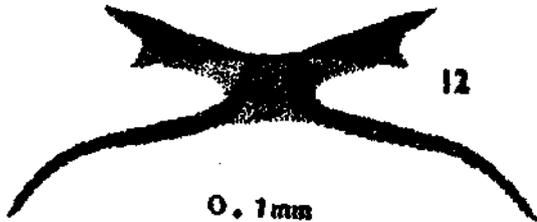
11

0.2mm



10

0.2mm



12

0.1mm

MID

Antenna (Plate-XIII, fig.-7) pale yellow; portion of segment third extending beyond apex of cephalic fan stem as in nemorivagum. Cephalic fan with about 36 filaments as in purii. Post-genal cleft (Plate-XIII, fig.-6) large, sub-triangular, very much longer than post-genal bridge. Hypostomium (Plate-XIII, fig.-8) with blunt apical teeth; corner and median teeth strongly prominent as in nemorivagum and Species A; about 9 hypostomial setae on either side lying sub-parallel to but slightly divergent behind from lateral margins. Tip of mandible (Plate-XIII, fig.-9) with two mandibular serrations as in former species. Respiratory histoblast (Plate-XIII, fig.-10) with 6 filaments identical with those of pupa. Rectal 'gills' (Plate-XIII, fig.-11) compound as in former species. Anal sclerite (Plate-XIII, fig.-12) with a double connection between anterior and posterior arms as in nemorivagum, anterior arms also connected with each other. Ventral papillae two as in former species.

DISTRIBUTION: Lebong, Darjeeling, in small trickles of water flowing down the Lebong Cart Road, 2031 - 2050 m., coll.M.Datta 2.X.70 and 9.X.70. Larvae and pupae taken from undersurface of stones exposed to full sun.

REMARK: The author did not attempt to name this species at present because of insufficient material.

EXPLANATION OF PLATE XXIV

Simulium (Eusimulium) Species D

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Fore leg, mid leg and hind leg of female
- Fig. 6. Claw of female
- Fig. 7. Terminalia of female (ventral view)
- Fig. 8. Spermatheca

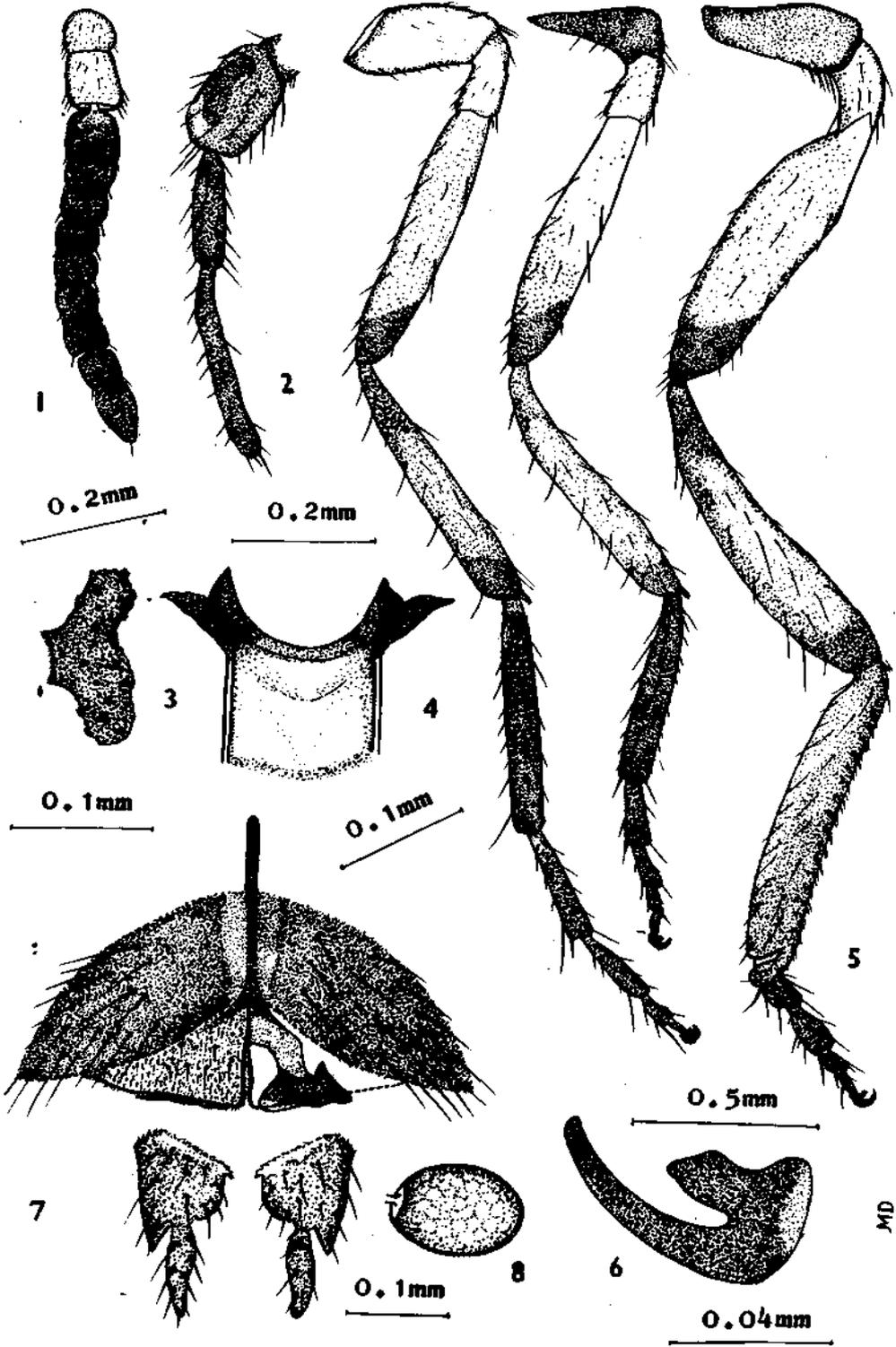
8. Simulium (Eusimulium) Species D

MATERIAL AVAILABLE: female only.

FEMALE: Length about 5.5 mm.

HEAD: width of head slightly less than that of thorax; vertex with many dark erect hairs; frons almost parallel-sided, black, shiny, with long black hairs and short golden recumbent hairs; clypeus black, with golden pollinosity and a few dark hairs. Antenna (Plate-XXIV, fig.-1) with scape, pedicel and base of first flagellomere brown as in praelargum, rest black, with fine golden pilosity. Palpus (Plate-XXIV, fig.-2) dark grey as in praelargum; sensory vesicle (Plate-XXIV, fig.-3) of third segment more than twice as long as wide; many pits present, mostly in clusters. Base of cibarium (Plate-XXIV, fig.-4) unarmed.

THORAX: alinotum orange-red; scutum with three black stripes and two lateral dark grey bands; median stripe extending from prescutellar region to anterior margin; two sub-median stripes extending from same area meet on either side with lateral bands; scutum covered with golden hairs. Scutellum with long black hairs - more laterally. Post-notum dark grey, shiny and bare as in praelargum and gracilis. Pleuron orange-red; pleural membrane bare as in former species; brown hairs on pleural tuft; sternopleuron shiny and bare as in former species. Knob of haltere yellow, base and stem dark grey.



Wing-length 4.0 mm. Veins same as in former species excepting sub-costa almost entirely hairy (proximal three-fourths).

Legs (Plate-XXIV, fig.-5) not uniformly coloured.

Fore coxa and trochanter pale brown; femur almost brown with dark grey distal end; tibia grey with dark tip and with a dark sub-basal ring; tarsus mainly black; first tarsomere elongated and not flattened as in former species, with grey base. Middle coxa nearly black; trochanter yellowish; femur yellow gradually becoming brownish with dark grey tip; tibia as fore one but paler; tarsus black. Hind coxa dark brown; trochanter almost yellow; femur pale brown with dark grey distal end; tibia as fore one but outer side of ring extended upto tip; first tarsomere pale brown with somewhat darker end; almost parallel-sided; other tarsomeres nearly black. Calcipala much enlarged; pedisulcus deep. Each claw (Plate-XXIV, fig.-6) with a very strong sub-basal tooth.

ABDOMEN: abdominal scale dark brown with grey marginal hairs; tergum 2 brown with a large median spot; terga 3 - 7 grey with a large dark median spot on each; terga 6, 7 and 8 shiny. Sterna mostly yellowish with small hairs more medially. Terminalia (Plate-XXIV, fig.-7 and 8) as figured.

MALE, PUPA AND LARVA: Unknown.

SPECIMEN EXAMINED: Light-trapped specimen (slide-mounted):
Darjeeling Government College area, 2014 m., 19.IV.71., 1 ♀,
coll. R.K.Dey.

REMARK: The author did not name this species because only
a single female specimen was studied.

9. Simulium rufithorax Brunetti, 1911

Simulium rufithorax Brunetti, 1911, Rec. Ind. Mus. 4 : 282.

Brunetti (1911) described the female and male of this
species from materials (Type ♂ in Pusa Coll., Type ♀ in IM)
collected in Bombay and Kureeong (Darjeeling). The pupa and
larva are still unknown. The characters of this species seem
to be included in the subgenus Eusimulium Roub. in which it is
treated at present.

Subgenus SIMULIUM Latreille, 1802, g.str.

Simulium Latreille, 1802, Hist. nat. gen. part. Crust. Ins.
3:426.

Type-species: Rhagio colombaschensis Fabricius,
1787, by monotypy.

Gynonychodon Enderlein, 1925, Zool. Anz. 62:208.

Type-species: Simulium nobile De Meijere, 1907, by
original designation.

Pseudodagmia Baranov, 1926, N. Beitr. syst. Insektenk. 3:164.

Type-species: Simulia variegata Meigen, 1818, by
original designation. (As subgenus of Simulium
Latreille, 1802).

Pseudosimulium Baranov, 1926, N. Beitr. syst. Insektenk.
3:164.

Type-species: Simulia argyreata Meigen, 1838, by
original designation. (As subgenus of Simulium
Latreille, 1802). Junior homonym, preoccupied by
Pseudosimulium Handlirsch, 1908 (Diptera).

Aspathia Enderlein, 1935, Sitzber, Ges. naturf, Freunde
1935:359.

Type-species: Simulium hunteri Malloch, 1914, by
original designation.

Danubiosimulium Baranov, 1935, Arb.Morph. tax. Ent. Berlin.

2:158.

Type-species: Culex columbaczensis Schönbauer, 1795
(= Rhagio colombaschensis Fabricius, 1787), by monotypy. (As subgenus of Simulium Latreille, 1802).

Cleitosimulium Séguy & Dorier, 1936, Trav. Lab. Hydrobiol.

Pisciculture, Grenoble, 27:9.

Type-species: Simulium rupicolum Séguy & Dorier, 1936
by original designation. (As subgenus of Simulium
Latreille, 1802).

Gnus Rubtzov, 1940, Faune de l'U.S.S.R., Insectes Diptères

6:363.

Type-species: Simulium decimatum Dorogostajskij,
Rubtzov & Vlasenko, 1935, by original designation.
(Available with date 1940, since Gnus Rubtzov, 1937:
1290 is an unavailable nomen nudum).

DIAGNOSIS

(After appropriate modification from Crosskey,
1969).

Male and Female: Basal section of radius bare (rarely
haired in females). Vein R_1 without spinules. Both pleural
membrane and sternopleuron bare. Fore tarsus flattened to some
extent and not very much elongated; first fore tarsomere 4-6
times as long as its greatest width. First hind tarsomere
variable.

Female: Cibarium armed with blunt denticles or nodular granulations between cornuae, rarely apparently unarmed. Tarsal claws usually simple, rarely with a minute sub-basal tooth. Scutum usually with definite colour pattern, sometimes boldly marked. Abdomen shining and with sparse fine hair on broad terga 6-8, narrower preceding terga dull and matt. Anal cerci simple, usually bluntly truncate or rounded lobes. Spermatheca without definite polygonal pattern, without internal hairs (rare exceptions in other countries).

Male: Upper eye facets normal. Genitalia with very heavy elongate sub-parallel distimere from one and a half to three times as long as basimere; distimere with one apical spinule and often with inner basal projection; basimere not produced beyond base of distimere; ventral plate complex, angled and three-dimensional, body of plate relatively small, often toothed and with haired beak-like process, when sub-triangular with divergent basal arms, but plate rarely wider and basal arms sub-parallel; median sclerite large and elongate-ovate or sometimes sub-cordate or sub-triangular or clove-shaped, cleft apically; endoparameral hooks numerous.

Pupa: Respiratory organ filamentous, elongate and slender but rarely dilated basally, branching near base; filaments arranged usually in even numbers like 6, 8, 10 in Indian forms but larger numbers found in other countries;

filaments directed forwards but shorter than pupal body. Abdominal setae and hooks usually normal. Cocoon of varied form, a simple pocket, well-woven, sometimes with anterior windows or spaces, always more or less covering pupal body.

Larva: Head pigmentation variable, most often with pale spots, sometimes head-spots clearly positive. Hypostomium with usual nine apical teeth, teeth rather blunt and median and corner teeth not very strongly prominent. Hypostomial setae 4-8 in row lying sub-parallel to or only slightly divergent from lateral margins of hypostomium. Post-genal cleft large, longer than post-genal bridge, mitre-shaped, elongate-subcordate or subtriangular. Mandible normal, first three comb-teeth evenly decreasing in size, other comb-teeth long and fine; mandibular serrations two. Thoracic and abdominal cuticle bare. Ventral papillae absent, though rudimentary sub-lateral papillae rarely visible. Rectal 'gills' with secondary lobules.

DESCRIPTIONS OF SPECIES

10. Simulium (Simulium) nigrifacies, n.sp.

MATERIALS AVAILABLE: male (slide-mounted) and pupa, associated.

MALE: Length about 2.5 mm.

HEAD: width of head much greater than that of thorax; upper eye facets enlarged; vertex black, with long erect black hairs; clypeus black, shiny, with a few black erect hairs. Scape, pedicel and base of first flagellomere of antenna (Plate-XIV, fig.-1) dark grey, rest black; first flagellomere largest of all; flagellum with fine black pilosity. Palpus (Plate-XIV, fig.-2) black; sensory vesicle (Plate-XIV, fig.-3) of third segment almost rounded; pits usually in clusters.

THORAX: mesonotum black. Scutum velvety with two crescent-shaped large shiny coppery spots on lateral sides near anterior margin and with a large median spot covering prescutellar region, with many long erect black hairs. Postnotum shiny, bare. Pleuron black; pleural membrane bare; dark hairs on pleural tuft; sternopleuron shiny, bare. Knob yellow, rest of haltere black.

Wing-length 2.30 mm. Veins brownish; costa with heavy stout black spinules intermixed with erect black hairs; subcosta with a few black hairs only at base; basal section of radius bare; radial sector simple, hairy; tufts of black hairs at base of vein radius.

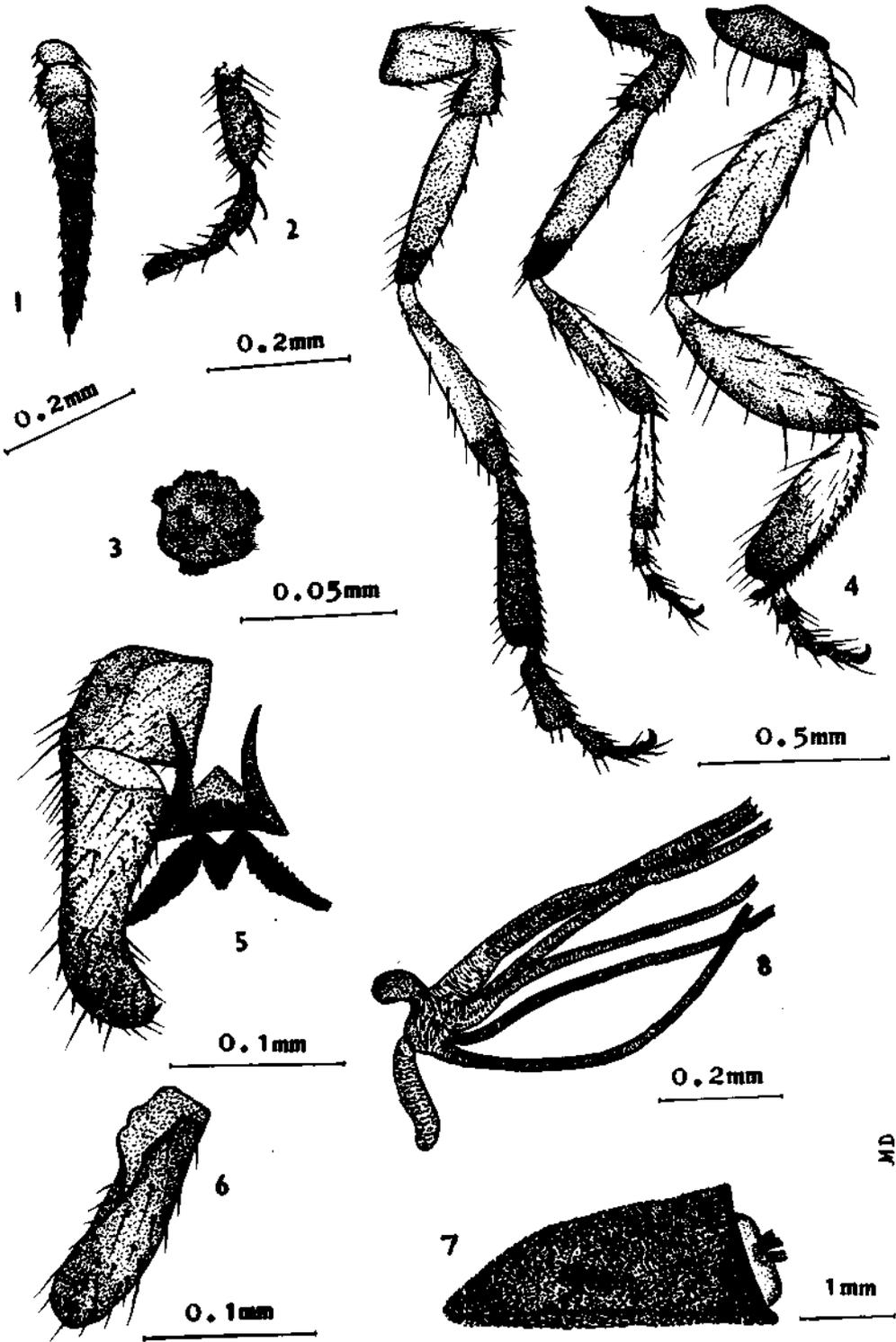
Legs (Plate-XIV, fig.-4) essentially dark. Fore coxa brown; trochanter dark grey with pale base; femur dark grey with black tip; tibia nearly black with yellowish base and outer side; tarsus black, flattened; first tarsomere about 5

EXPLANATION OF PLATE XIV

Simulium (Simulium) nigrifacies n.sp.

- Fig. 1. Antenna of male
- Fig. 2. Maxillary palpus of male
- Fig. 3. Sensory vesicle of male
- Fig. 4. Fore leg, mid leg and hind leg of male
- Fig. 5. Terminalia of male (ventral view) - paramere of one side not shown
- Fig. 6. Distimere (side view)
- Fig. 7. Pupa within cocoon (side view)
- Fig. 8. Respiratory organ (right side)

Plate- XIV



MD

times as long as its greatest width. Middle coxa and trochanter nearly black; femur dark grey with black tip; tibia dark grey with black tip and outer side, first tarsomere yellow, somewhat darkened at tip, bases of second and third tarsomeres yellowish, rest of tarsus black. Hind coxa black; trochanter and femur dark grey, latter with black tip; tibia dark grey with yellow base and black tip, with black outer side extended from proximal portion; first tarsomere strongly dilated, basal halves of first and second tarsomeres yellow, rest of tarsus black.

ABDOMEN: abdominal scale black; long marginal hairs black; other segments velvety black; large lateral coppery spots on terga 2, 6 and 7; black hairs more towards posterior segments. Terminalia (Plate-XIV, figs.-5 and 6) as figured.

PUPA: Body length about 3 mm.

Dorsum of head and thorax with profuse disc-like tubercles. Head trichomes 3 pairs, long, thin and simple. Thoracic trichomes 6 pairs - six dorsally on anterior end and six laterally on posterior end, long, thin and simple. Respiratory organ (Plate-XIV, fig.-8) about 1.2 mm. long, six-filamented; outer filament of upper pair stouter than inner one and first travelling horizontally, directed downwards and then upwards, inner one directed forwards and upwards; middle pair arises beside base of upper pair, thinner than first pair, inner one almost

parallel to inner one of first pair proximally but to outer one also distally, outer one going downwards and then upwards; lower pair apparently having no stalk arising independent of other pairs, thinnest of all, inner one almost parallel to outer filament of middle pair, outer one almost forming a right angle to first pair directed downwards and then upwards. Tergum 1 with a single seta on either side laterally; tergum 2 with 3 setae on either side of median line; in addition to normal arrangement of hooks with terga 3 and 4, and sterna 5, 6 and 7, sternum 8 with same number of hooks and same manner of arrangement as in sterna 6 and 7, all branched; tergum 5 bare and of posterior terga maximum number of spines being 12 on tergum 8, all simple. Tail-hooks absent. Cocoon (Plate-XIV, fig.-7) slipper-shaped, densely woven, only ventral surface reticulate; anterior margin strong and without dorsal projection.

FEMALE AND LARVA: Unknown.

DISTRIBUTION: North Point, Darjeeling, in a small trickle of water flowing down the Lebong Cart Road, 1900 m., 25.X.70. coll.M.Datta.

SPECIMENS EXAMINED: Holotype ♂ (IM; slide-mounted), reared from pupa, North Point, Darjeeling, woody vegetation with a small trickle of water, 25.X.70. (M.Datta). 1 ♂ with associated pupal exuvium examined.

REMARK: The name of the species is based on its dark coloured face. The species suggests its alignment with Simulium (Simulium) rufibasis Brunetti (1911) described from Kurseong (Darjeeling District) but this species has certain important characters of its own which appear to be sufficient to treat it as a new species. Its specific validity has been discussed in the chapter on "DISCUSSION".

11. Simulium (Simulium) himalayense Puri, 1932

Simulium (Simulium) himalayense Puri, 1932, Ind.Jour.Med.

Res. 19:885.

Puri (1932a) described the female, male and pupa of this species from materials collected in different parts of India including Kurseong and Darjeeling. The larva has previously been unknown and is described for the first time from materials collected in different parts of Kurseong and Darjeeling. The larvae have properly been associated with pupae which have been reared to adults and it is now possible, therefore, to describe the mature larval stage of this species.

LARVA: Length about 7.0 mm.

Head (Plate-XV, fig.-1) with brownish cephalic apotome, with greyish head-spots. Antenna (Plate-XV, fig.-3) entirely brownish, third segment almost at same level with cephalic fan stem. Cephalic fan with about 50 filaments. Post-genal cleft

REMARK: The name of the species is based on its dark coloured face. The species suggests its alignment with Simulium (Simulium) rufibasis Brunetti (1911) described from Kurseong (Darjeeling District) but this species has certain important characters of its own which appear to be sufficient to treat it as a new species. Its specific validity has been discussed in the chapter on "DISCUSSION".

11. Simulium (Simulium) himalayense Puri, 1932

Simulium (Simulium) himalayense Puri, 1932, Ind.Jour.Med.

Res. 19:885.

Puri (1932a) described the female, male and pupa of this species from materials collected in different parts of India including Kurseong and Darjeeling. The larva has previously been unknown and is described for the first time from materials collected in different parts of Kurseong and Darjeeling. The larvae have properly been associated with pupae which have been reared to adults and it is now possible, therefore, to describe the mature larval stage of this species.

LARVA: Length about 7.0 mm.

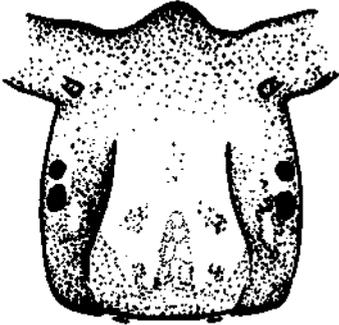
Head (Plate-XV, fig.-1) with brownish cephalic apotome, with greyish head-spots. Antenna (Plate-XV, fig.-3) entirely brownish, third segment almost at same level with cephalic fan stem. Cephalic fan with about 50 filaments. Post-genal cleft

EXPLANATION OF PLATE XV

Simulium (Simulium) himalayense Puri

- Fig. 1. Head of larva (dorsal view)
- Fig. 2. Head of larva (ventral view)
- Fig. 3. Antenna of larva (right side)
- Fig. 4. Hypostomium
- Fig. 5. Tip of mandible of larva
- Fig. 6. Respiratory histoblast of larva
- Fig. 7. Rectal 'gills' of larva
- Fig. 8. Anal sclerite of larva

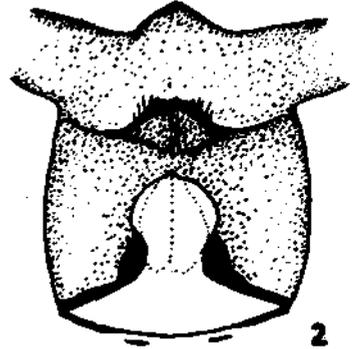
Plate - XV



0.3mm.



0.2mm.



0.3mm.



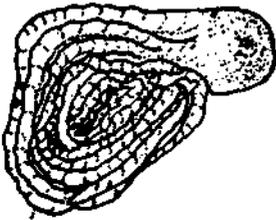
0.1mm.



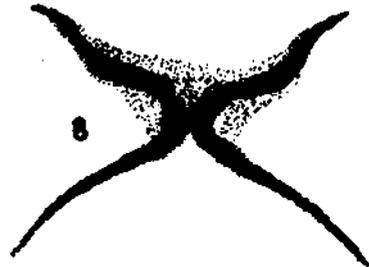
0.05mm.



0.2mm.



0.2mm.



0.2mm.

M.D.

(Plate-XV, fig.-2) large, almost subcordate and very much longer than post-genal bridge. Hypostomium (Plate-XV, fig.-4) with rather blunt apical teeth, corner and median teeth not very strongly prominent; about 4 hypostomial setae on either side lying nearly parallel to lateral margins. Tip of mandible (Plate-XV, fig.-5) with two mandibular serrations. Respiratory histoblast (Plate-XV, fig.-6) with 6 wrinkled filaments arranged in the same manner as in pupa. Rectal 'gills' (Plate-XV, fig.-7) 3 with secondary lobules. Anal sclerite (Plate-XV, fig.-8) with a double connection between anterior and posterior arms, leaving a median lacuna. Ventral papillae absent. No sub-lateral protuberances as in grisescens.

DISTRIBUTION: Rangeet, Darjeeling, in the Rangeet river, 200-300 m., collected by M.Datta and assisted by S.Barik and R.K.Dey, 12.IV.70., 1.V.70.and 28.IX.70. Lebong, Darjeeling, a number of waterways flowing down the Lebong Cart Road, 2025-2250 m., coll.M.Datta and sometimes assisted by A.Sherpa, 26.IV.70., 22.VII.70., 30.VIII.70., 26.IX.70., 2.X.70., 14.X.70. and 11.IV.71. Kurseong, Darjeeling, in a large stream flowing down the Hill Cart Road near Kurseong Rly.Station, 1150 m., 18.X.70. and 15.IV.71., coll.M.Datta and assisted by H.S.Ghatani. Taken as larvae and pupae from undersurface of decaying leaves or twigs or refused materials exposed to full sun.

12. Simulium (Simulium) rufibasis Brunetti, 1911

Simulium rufibasis Brunetti, 1911, Rec.Ind.Mus. 4:285.

Simulium (Simulium) rufibasis Brunetti; Puri, 1932, Ind.
Jour. Med. Res. 19:899.

Brunetti (1911) described the species from a single female specimen (Type ♀ in IM) collected at Kurseong (Darjeeling District). Later Puri (1932b) described the female, male and pupa from materials collected in Bengal Tarai, Kurseong, Simla and the adjacent areas, and placed the species in the subgenus Simulium s.str. The larva has previously been unknown and, is described for the first time from materials collected at Kurseong, Sonada and Darjeeling (all in Darjeeling District).

LARVA: Length about 5.0 mm.

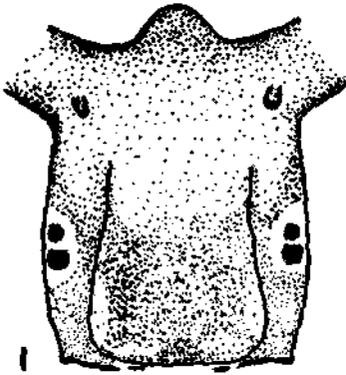
Head (Plate-XVI, fig.-1) with brownish cephalic apotome as in himalayense, without positive head-spots but only with dark tinge. Antenna (Plate-XVI, fig.-3) yellowish, third segment almost at same level with cephalic fan stem. Cephalic fan with about 40 filaments. Post-genal cleft (Plate-XVI, fig.-2) large, sub-triangular and much longer than post-genal bridge. Hypostomium (Plate-XVI, fig.-4) with blunt apical teeth, corner and median teeth not very strongly prominent as in himalayense; about 5 hypostomial setae on either side lying sub-parallel to lateral margins. Tip of mandible (Plate-XVI, fig.-5) with two mandibular serrations as in himalayense. Respiratory

EXPLANATION OF PLATE XVI

Simulium (Simulium) rufibasis Brunetti

- Fig. 1. Head of larva (dorsal view)
- Fig. 2. Head of larva (ventral view)
- Fig. 3. Antenna of larva (right side)
- Fig. 4. Hypostomium
- Fig. 5. Tip of mandible of larva
- Fig. 6. Respiratory histoblast of larva
- Fig. 7. Rectal 'gills' of larva
- Fig. 8. Anal sclerite of larva

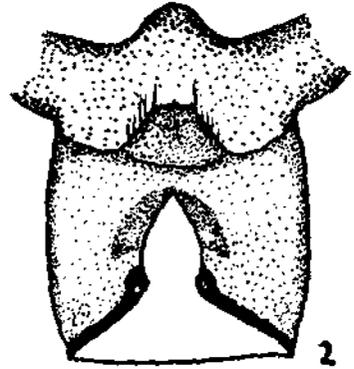
Plate-XVI



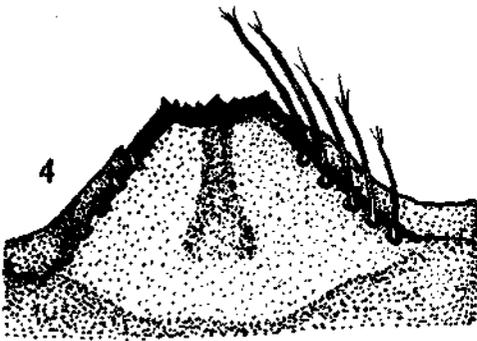
0.3mm



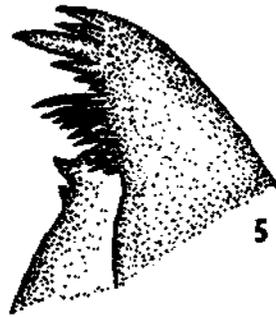
0.2mm



0.3mm



0.1mm



0.05mm



0.2mm



0.2mm



0.1mm

MD

histoblast (Plate-XVI, fig.-6) with 6 wrinkled filaments arranged in same manner as in pupa. Rectal 'gills' (Plate-XVI, fig.-7) compound as in himalayense. Anal sclerite (Plate-XVI, fig.-8) with complete posterior arms with which anterior arms united individually. Two rudimentary sub-lateral papillae-like protuberances present.

DISTRIBUTION: Lebong, Darjeeling, in a number of waterways flowing down the Lebong Cart Road, 2025-2250 m., coll.M.Datta and sometimes assisted by A.Sherpa, 26.IV.70., 22.VII.70., 30.VIII.70., 26.IX.70., 2.X.70., 14.X.70. and 11.IV.71. Happy Valley, Darjeeling, in a ditch-like watercourse, 1470-1600 m., coll.M.Datta, 15.VI.70. Sonada, Darjeeling, in a number of watercourses flowing down the Hill Cart Road, 1500-1750 m., coll.R.K.Dey, A.K.Paul and T.K.Pal, 30.V.71. Kurseong, Darjeeling, in a small stream near Kurseong Rly.Station, 1270 m., coll.R.K.Dey, A.K.Paul and T.K.Pal. 30.V.71. Larvae taken from undersurface of decaying leaves or twigs or submerged vegetation containing also pupae exposed to full sun in most instances.

13. Simulium (Simulium) dentatum Puri, 1932.

Simulium (Simulium) dentatum Puri, 1932, Ind.Jour.Med.Res.
19:1135.

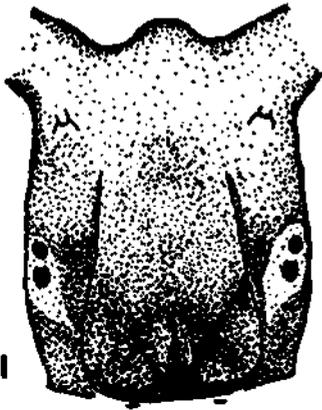
Puri (1932c) described the species from materials consisting of females, males and pupae collected in Bengal

EXPLANATION OF PLATE XVII

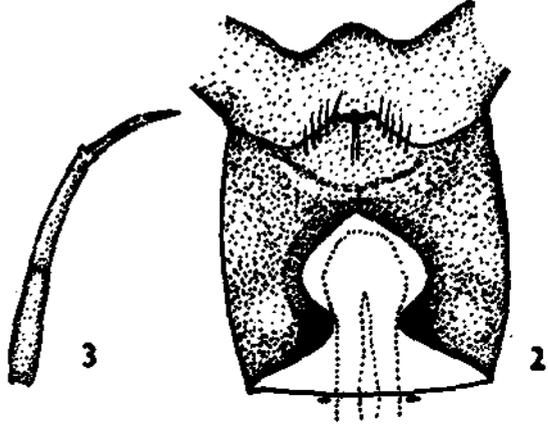
Simulium (Simulium) dentatum Puri

- Fig. 1. Head of larva (dorsal view)
- Fig. 2. Head of larva (ventral view)
- Fig. 3. Antenna of larva (right side)
- Fig. 4. Hypostomium
- Fig. 5. Tip of mandible of larva
- Fig. 6. Respiratory histoblast of larva
- Fig. 7. Rectal gills of larva
- Fig. 8. Anal sclerite of larva

Plate- XVII

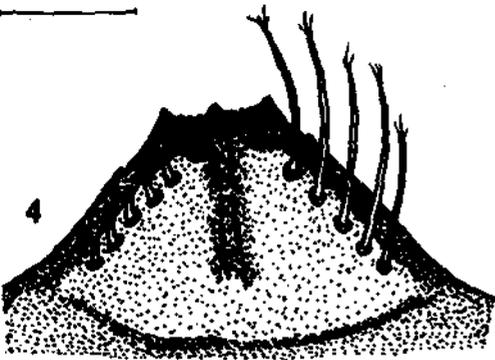


0.3mm



0.2mm

0.3mm



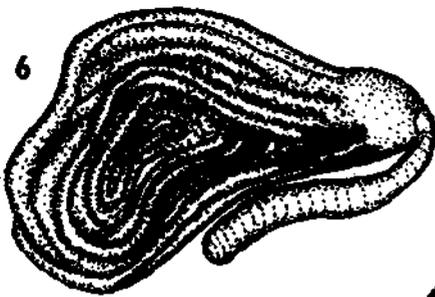
0.1mm



0.05mm



0.2mm



0.2mm



0.1mm

MD

Tarai, Kurseong (West Bengal) and in Garo Hills (Assam). The larva has previously been unknown and is described for the first time from materials collected at Kurseong and Darjeeling (Darjeeling District).

LARVA: Length about 6.5 mm.

Head (Plate-XVII, fig.-1) with greyish cephalic apotome, with negative pattern of pale spots surrounded by dark areas deep at base. Antenna (Plate-XVII, fig.-3) entirely greyish, third segment shorter than cephalic fan stem. Cephalic fan with about 56 filaments. Post-genal cleft (Plate-XVII, fig.-2) large, mitre-shaped and almost reaching hypostomium, only leaving a narrow post-genal bridge. Hypostomium (Plate-XVII, fig.-4) with blunt apical teeth, corner and median teeth rather weak; about 5 hypostomial setae on either side lying sub-parallel to lateral margins. Tip of mandible (Plate-XVII, fig.-5) with two mandibular serrations as in himalayense and rufibasis. Respiratory histoblast (Plate-XVII, fig.-6) with 8 wrinkled filaments arranged in same manner as in pupa. Rectal 'gills' (Plate-XVII, fig.-7) compound as in himalayense and rufibasis. Anal sclerite (Plate-XVII, fig.-8) with a double connection between anterior and posterior arms, leaving a median lacuna as in himalayense. Two rudimentary sub-lateral papillae-like protuberances present as in rufibasis.

DISTRIBUTION: Lebong, Darjeeling, in a ditch-like water-course flowing down the Lebong Cart Road, 2030 m., coll.M.Datta

2.X.70. Kurseong, Darjeeling, in a large stream flowing down the Hill Cart Road near Kurseong Rly. Station, 1150 m., coll. M.Datta, 18.X.70. Larvae taken from undersurfaces of both decaying leaves and stones exposed to full sun.

14. Simulium (Simulium) grisescens Brunetti, 1911.

Simulium grisescens Brunetti, 1911, Rec. Ind. Mus. 4:283.

Simulium (Simulium) grisescens Brunetti; Puri, 1932, Ind.

Jour. Med. Res. 20:523.

Brunetti (1911) described the species from a single male specimen (Type ♂ in IM) collected at Kurseong (Darjeeling District). Later Puri (1932e) described the female, male and pupa from materials collected in various parts of India including Kurseong, and placed it in the subgenus Simulium s.str. The larva has previously been unknown and is described for the first time from materials collected at Rangeet, Kurseong and Darjeeling, all in Darjeeling District.

LARVA: Length about 6.0 mm.

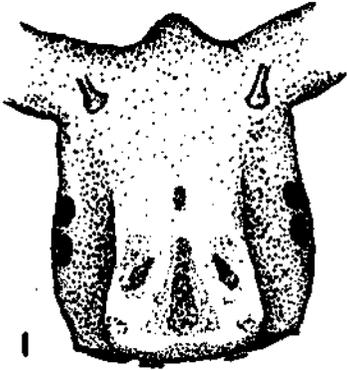
Head (Plate-XVIII, fig.-1) with yellowish cephalic apotome, having faint head-spots. Antenna (Plate-XVIII, fig.-3) entirely yellowish, segment third entirely extending beyond apex of cephalic fan stem. Cephalic fan with about 50 filaments as in himalayense. Post-genal cleft (Plate-XVIII, fig.-2) large, almost spear-shaped and very much longer than post-genal bridge.

EXPLANATION OF PLATE XVIII

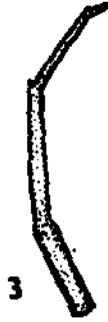
Simulium (Simulium) grisescens Brunetti

- Fig. 1. Head of larva (dorsal view)
- Fig. 2. Head of larva (ventral view)
- Fig. 3. Antenna of larva (right)
- Fig. 4. Hypostomium
- Fig. 5. Tip of mandible of larva
- Fig. 6. Respiratory histoblast of larva
- Fig. 7. Rectal gills of larva
- Fig. 8. Anal sclerite of larva

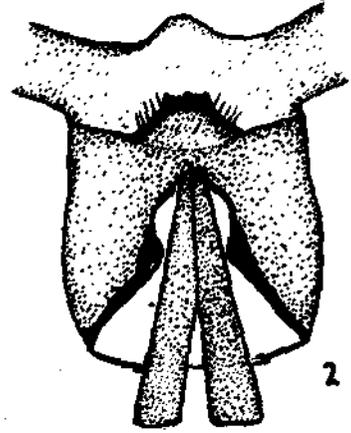
Plate- XVIII



0.3mm.



0.2mm.



0.3mm.



0.1mm.



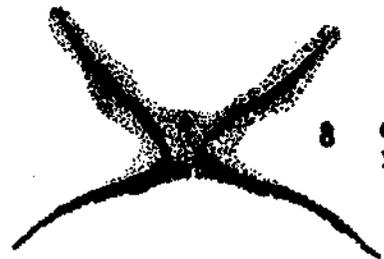
0.05mm.



0.3mm.



0.2mm.



0.2mm.

M.D.

Hypostomium (Plate-XVIII, fig.-4) with sharply pointed apical teeth unlike those in himalayense, rufibasis and dentatum, corner and median teeth strongly prominent unlike those in all above species; about 5 hypostomial setae on either side lying nearly parallel to lateral margins. Tip of mandible (Plate-XVIII, fig.-5) with two mandibular serrations as in himalayense, rufibasis and dentatum. Respiratory histoblast (Plate-XVIII, fig.-6) with 10 wrinkled filaments arranged in the same manner as in pupa. Rectal 'gills' (Plate-XVIII, fig.-7) compound as in all above species. Anal sclerite (Plate-XVIII, fig.-8) with a double connection between anterior and posterior arms, leaving a median lacuna as in himalayense and dentatum. No sub-lateral papillae-like protuberances as in himalayense.

DISTRIBUTION: Rangeet, Darjeeling, in the Rangeet river, 200-300 m., coll.M.Datta and sometimes assisted by S.Barik and R.K.Dey, 1.V.70., 9.V.70. and 12.VI.70. Kurseong, Darjeeling, in a small stream near Kurseong Rly.Station, 1270 m., coll. R.K.Dey, A.K.Paul and T.K.Pal, 30.V.71. Lebong, Darjeeling, in a number of watercourses flowing down the Lebong Cart Road, 2025-2250 m., coll.M.Datta and sometimes assisted by A.Sherpa, 26.IV.70., 22.VII.70., 30.VIII.70., 26.IX.70., 14.X.70. and 11.IV.71. Taken as larvae and pupae from undersurfaces of decaying leaves or twigs or submerged vegetation exposed to full sun.

Subgenus GOMPHOSTILBIA Enderlein, 1921

Gomphostilbia Enderlein, 1921a, Deuts. Tierarztl. Woch. 29:199.

Type-species: Gomphostilbia ceylonica Enderlein, 1921a, by original designation.

DIAGNOSIS

After appropriate modification from Crosskey, 1967b)

Male and Female: Basal section of radius haired.

Vein R₁ with spinules intermixed with hairs. Pleural membrane bare. Sternopleuron haired. Fore tarsus cylindrical; first fore tarsomere about 6 or 7 times as long as its greatest width. First hind tarsomere mostly narrow and parallel-sided.

Female: Cibarium unarmed. Tarsal claws usually with large basal tooth. Scutum with inconspicuous colour pattern. Last three abdominal terga distinctly shining, abdomen not evenly covered with pale pollinosity. Anal cerci simple bluntly rounded or truncate lobes. Spermatheca with reticulate surface pattern, without internal hairs.

Male: Upper eye facets exceptionally enlarged. Genitalia with simple tapering distimere, distimere usually rather broad basally and shorter than basimere; distimere with single apical spinule; basimere not produced beyond base of distimere; ventral plate simple rather flat, plate-like with subparallel

basal arms and without teeth; median sclerite apparently undeveloped; endoparameral hooks strong and numerous.

Pupa: Respiratory organ with eight simple slender filaments either arranged in 3+3+2 or in pairs; filaments extending forwards and beyond opening of coceon. Abdomen with normal complement of hooks and with spines dorsally on sixth segment onwards; second tergum dorsally with a row of four setae on each side. Cocoon simple, without neck, loosely woven and not with anterodorsal projection.

Larva: Cephalic apotome with positive head-spots, not so boldly marked. Hypostomium with usual nine sharp apical teeth, teeth moderately strong; 4-5 setae in each hypostomial row, row subparallel to lateral margin of hypostomium. Post-genal cleft of medium size, longer than post-genal bridge, almost spear-shaped or subcordate (as in most forms of the Australian region). Mandible without supernumerary mandibular serrations. Thoracic cuticle bare but abdominal cuticle rarely with minute hairs postero-dorsally. Ventral papillae very prominent and subconical. Rectal 'gills' compound (rare exceptions in the other countries).

DESCRIPTIONS OF SPECIES

15. Simulium (Gomphostilbia) tenuistylum, n.sp.

MATERIALS AVAILABLE: female, male (Pinned and slide-mounted), pupa and larva, associated.

FEMALE: Length 2.0 - 2.5 mm.

HEAD: width of head more or less equal to that of thorax; face dark grey; vertex with many erect dark hairs; frons at top much wider than that in front, with profuse fine golden recumbent hairs; clypeus with also profuse golden recumbent hairs. Scape, pedicel and first flagellomere of antenna (Plate-XIX, fig.-1) yellowish, rest almost black, with fine dark pilosity. Palpus (Plate-XIX, fig.-2) black, sensory vesicle (Plate-XIX, fig.-3) of third segment twice as long as wide, elongated and curved, pits often in clusters. Base of cibarium (Plate-XIX, fig.-4) unarmed.

THORAX: scutum dark grey; with three longitudinal stripes arising from prescutellar region, sub-median stripes shorter than median one which is extended upto anterior margin; scutum covered with golden recumbent hairs all over. Scutellum greyish with golden recumbent hairs and black erect hairs. Post-notum dark grey, shiny, bare. Pleuron grey; pleural membrane bare; golden hairs on pleural tuft; sternopleuron with golden hairs; furcasternum (Plate-XIX, fig.-5) as figured. Knob and stem of haltere pale yellow, base greyish.

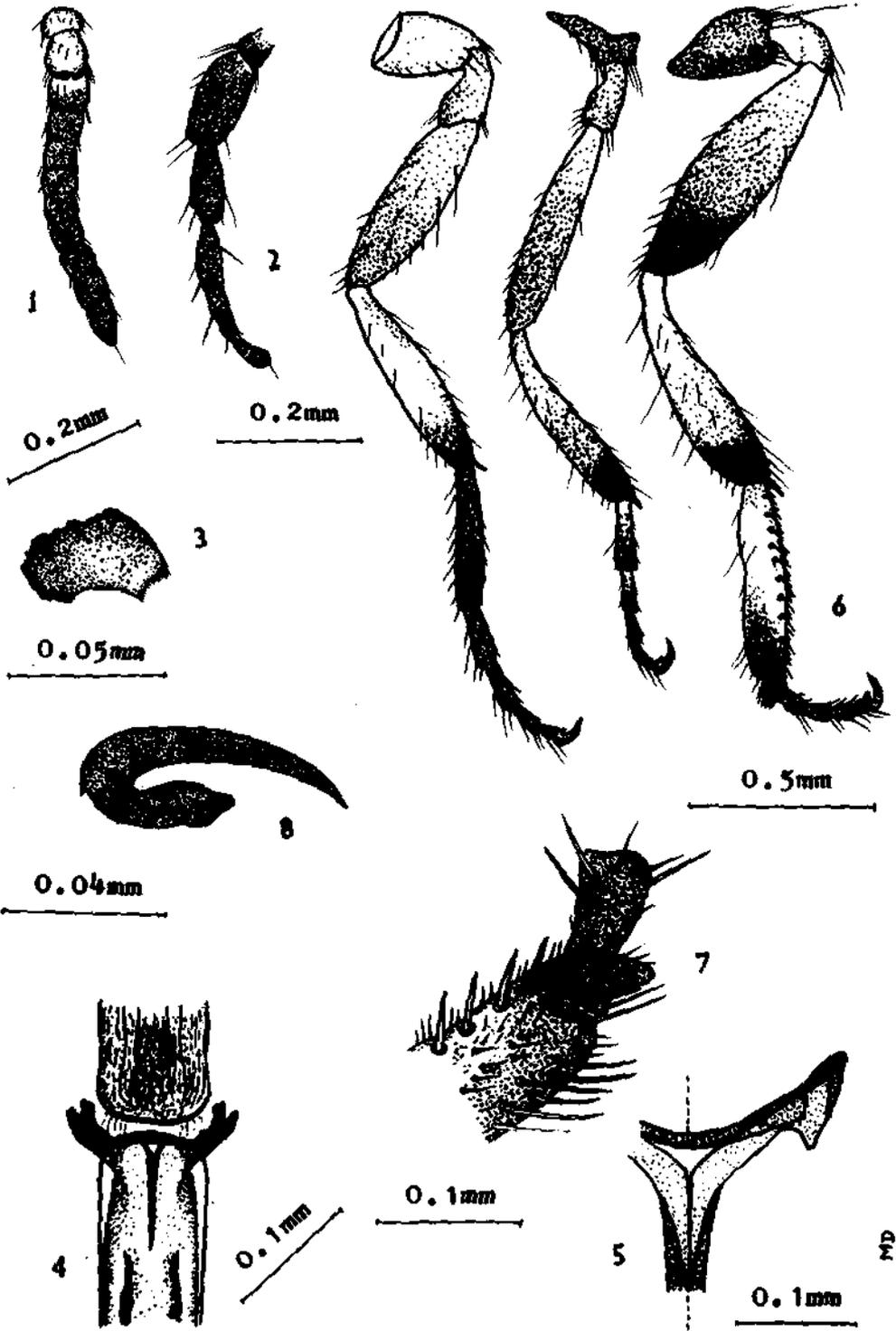
Wing-length 2.0 mm. (1.8 - 2.1 mm., n=5). Veins pale brown. Costa with heavy stout black spinules intermixed with

EXPLANATION OF PLATE XIX

Simulium (Gomphostilbia) tenuistylum n.sp.

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Furcasternum of metasternum of female
- Fig. 6. Fore leg, mid leg and hind leg of female
- Fig. 7. End of first hind tarsomere and second tarsomere of female
- Fig. 8. Claw of female

Plate- XIX



erect black hairs. Hair-tufts on base of costa brownish but those of stem vein black. Sub-costa entirely hairy. Radial sector simple, with hairs; radius entirely hairy; R_1 with spinules as well.

Legs (Plate-XIX, fig.-6) as figured. Fore coxa yellow; trochanter brownish with pale base; femur brownish gradually darkening towards tip; tibia yellowish with darkening tip, inner surface on proximal end with greyish tinge; fore tarsus slender, rounded and not flattened, black; first tarsomere about six times as long as its greatest width. Middle coxa nearly black; trochanter brown with pale base; femur yellow at base gradually darkening towards tip; tibia yellowish at base gradually darkening to black tip; first and second tarsomeres with yellow bases gradually darkening to black tips. Hind coxa greyish; trochanter yellowish; femur yellow at base gradually darkening to black tip; tibia yellowish, somewhat darkening distally with black end; outer side of distal part of first tarsomere black, rest yellow, other tarsomeres black. Calcipala (Plate-XIX, fig.-7) much enlarged; pedisulcus highly deep. Each claw (Plate-XIX, fig.-8) with a strong basal tooth.

ABDOMEN: abdominal scale pale yellow, with golden marginal hairs; tergum 2 brownish; terga 3, 4 and 5 dark grey, with a large median spot on each, non-shiny, terga 6, 7 and 8 blackish, shiny, with dark hairs - more distally. Venter paler

anteriorly and darker posteriorly. Terminalia (Plate-XX, figs.-9, 10 and 11) as figured.

MALE: Length 2.5 - 3.0 mm.

HEAD: width of head greater than that of thorax; upper eye facets exceptionally larger than lower ones; vertex black, with erect black hairs; clypeus dark grey, with silvery hairs. Antenna with brown scape, pedicel and base of first flagellomere and other flagellomeres dark grey, with fine black pilosity. Palpus as in females.

THORAX: same as in females excepting following characters: mesonotum entirely dark grey; scutum without pattern; base of haltere somewhat darkened.

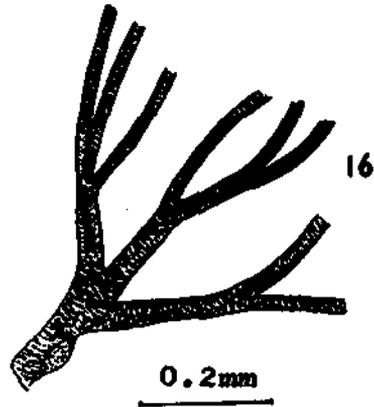
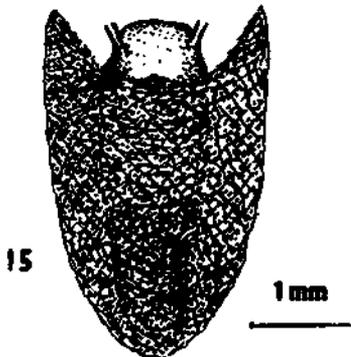
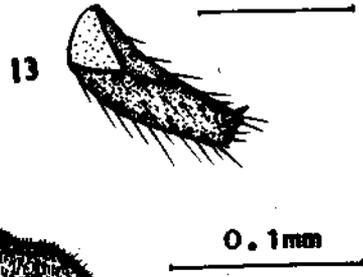
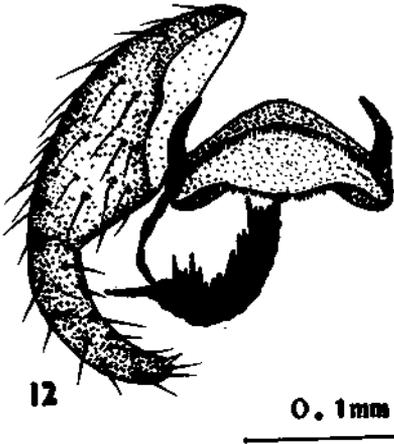
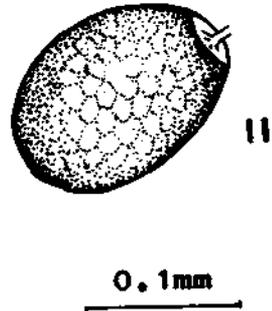
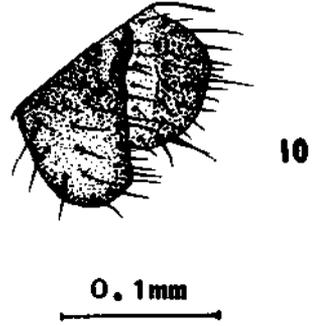
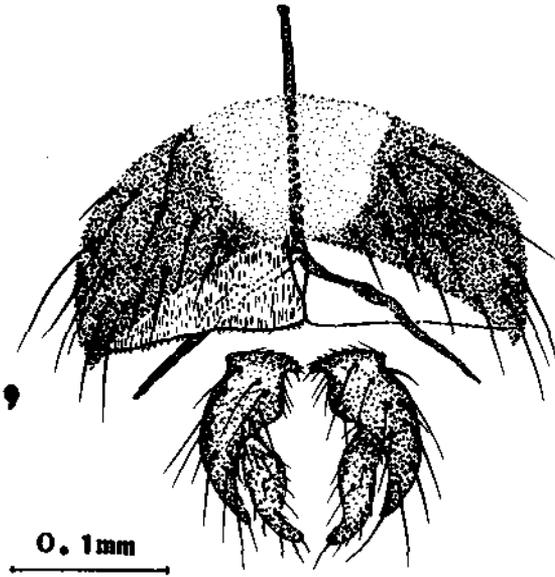
Wing-length 1.8 mm. (1.6 - 2.0 mm., n=5). Veins as in females excepting subcosta which is hairy entirely minus distal portion.

Legs more darkened than those of females in general and similar excepting following characters: fore femur greyish with dark distal end; tibia black at distal one-third. Second tarsomere of middle tarsus black. Proximal half of hind tibia yellow and distal half dark grey with black tip; first tarsomere much dilated distally; proximal half yellow and distal half dark.

EXPLANATION OF PLATE XX

Simulium (Gomphostilbia) tenuistylum n.sp.

- Fig. 9. Terminalia of female (ventral view)
- Fig.10. Cercus and anal lobe (side view)
- Fig.11. Spermatheca
- Fig.12. Terminalia of male (ventral view) - paramere of one side not shown
- Fig.13. Distimere (side view)
- Fig.14. Ventral plate (end view)
- Fig.15. Pupa within cocoon (dorsal view)
- Fig.16. Respiratory organ (right side)



ABDOMEN: abdominal scale brown with long dark marginal hairs; tergum 2 dark grey, rest black; posterior terga shiny laterally; venter paler; hairs dark. Terminalia (Plate-XX, figs.-12, 13 and 14) as figured.

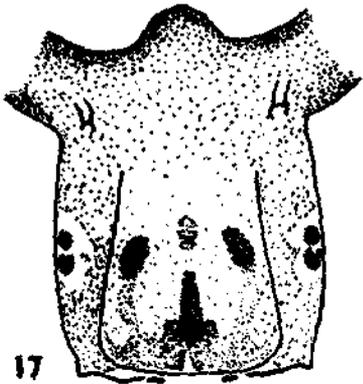
PUPA: Body-length about 3.0 mm.

Dorsum of head and thorax with disc-like tubercles. Head trichomes 4 pairs, very long, simple and thick; 3 pairs antero-laterally and 1 pair ventro-laterally. Thoracic trichomes 5 pairs, very long, simple and thick; 4 pairs antero-dorsally and 1 pair postero-laterally. Respiratory organ (Plate-XX, fig.46) about 2.5 mm. long; filaments arranged in following manner: practically short basal stalk divided into two - one comprising upper and middle branches and, lower branch, latter at right angle to upper one and divided into two filaments; upper branch (variable in length) divided into two, an inner filament and two outer filaments on a stalk of variable length; middle branch also divided into two branches - an upper filament and two lower filaments on a stalk of variable size. Tergum 1 with a single seta on either side; tergum 2 with 4 setae on either side; terga 3 and 4 with 4 branched stout hooks and a few setae on either side near posterior margin; tergum 5 bare; of posterior terga maximum number of spines being about 20 on tergum 8. Sternum 5 with a pair of branched filamentous hooks, close together on each side near posterior margin; sternum 6 and 7 each with same number of hooks on each side but

EXPLANATION OF PLATE XXI

Simulium (Gomphostilbia) tenuistylum n.sp.

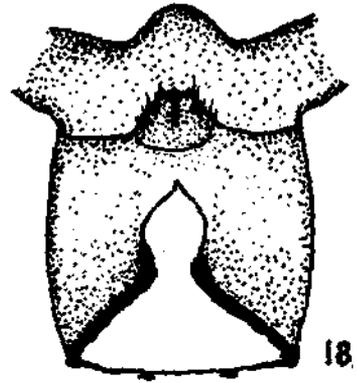
- Fig.17. Head of larva (dorsal view)
- Fig.18. Head of larva (ventral view)
- Fig.19. Antenna of larva (right side)
- Fig.20. Hypostomium
- Fig.21. Tip of mandible of larva
- Fig.22. Respiratory histoblast of larva
- Fig.23. Rectal 'gills' of larva
- Fig.24. Anal sclerite of larva



0.3mm



0.2mm



0.3mm



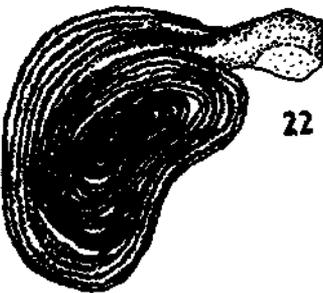
0.1mm



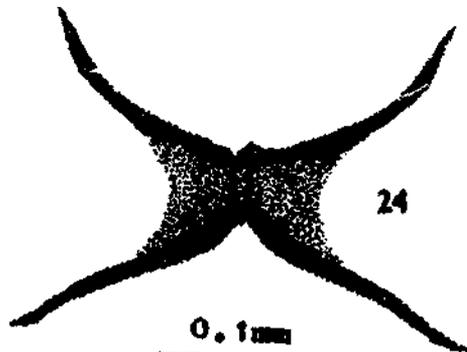
0.05mm



0.2mm



0.2mm



0.1mm

MD

widely spaced; tail-hooks inconspicuous. Cocoon (Plate-XX, fig.-15) slipper-shaped, very loosely woven, without a strong anterior margin; dorsal projection absent but a minute median lip-like projection present.

LARVA: Length about 5.5 mm.

Head (Plate-XXI, fig.-17) with pale yellow cephalic apotome; head-spots positive, greyish in colour. Antenna (Plate-XXI, fig.-19) greyish, almost at same level of cephalic fan stem. Cephalic fan with about 36 filaments. Post-genal cleft (Plate-XXI, fig.-18) large, spear-shaped, much larger than post-genal bridge. Hypostomium (Plate-XXI, fig.-20) with sharp apical teeth, apparently median tooth more developed than corner teeth; about 4-5 hypostomial setae on either side lying sub-parallel to lateral margins. Tip of mandible (Plate-XXI, fig.-21) without supernumerary serrations. Respiratory histoblast (Plate-XXI, fig.-22) with 8 filaments identical with those of pupa. Rectal 'gills' (Plate-XXI, fig.-23) 3 with secondary lobules. Anal sclerite (Plate-XXI, fig.-24) with incomplete arms. Ventral papillae two.

DISTRIBUTION: Lebong, Darjeeling, in a number of watercourses flowing down the Lebong Cart Road, 1931 m. - 2025 m., coll. M.Datta, 2.X.70., 9.X.70, 14.X.70., 12.VI.71. and 26.VIII.71. Kurseong, Darjeeling, in a number of small waterways near Kurseong Rly. Station, 1150 m., coll.M.Datta and assisted by

H.S.Ghatani, 18.X.70. and 5.XI.70. Mungpoo, Darjeeling in a small trickle of water, 1450 m., coll.M.Datta, 7.VII.71. and 12.IX.71.

SPECIMENS EXAMINED: Holotype ♀ (IM; pinned), reared from pupa, Lebong, Darjeeling, shrubby vegetation with ditch-like water-course, 2.X.70. (M.Datta). Allotype ♂ (IM; pinned), reared from pupa, same data as holotype. Paratypes from the localities mentioned above.

REMARK: The name of this species has been derived from its narrow distimere of male genitalium. This species is closely related to Simulium metatarsale Brunetti (1911), S.sundaicum Edwards (1934), S.ravohense Smart & Clifford (1968) and even S.pegalanense Smart & Clifford (1968), but it has certain important characters of its own for which it is treated as a new species. The affinities shown by tenuistylum with the above related species have been discussed in detail in the chapter on "DISCUSSION" so as to justify its validity.

16. Simulium (Gomphostilbia) darjeelingense, n.sp.

MATERIALS AVAILABLE: female, male (pinned and slide-mounted) and pupa, associated.

FEMALE: Length 1.8 - 2.0 mm.

HEAD: width of head more or less equal to that of thorax as in tenuistylum; face dark grey as in tenuistylum;

vertex with many erect golden hairs; frons much narrower anteriorly giving almost a triangular shape, with a coating of silvery pollinosity and recumbent golden hairs; clypeus with a coating of silvery pollinosity and recumbent golden hairs. Scape, pedicel and slightly base of first flagellomere of antenna (Plate-XXII, fig.-1) grey, rest of flagellum black, with fine brownish pilosity. Palpus (Plate-XXII, fig.-2) black as in tenuistylum; sensory vesicle (Plate-XXII, fig.-3) of third segment corn-like, pits mostly in clusters. Base of cibarium (Plate-XXII, fig.-4) unarmed as in tenuistylum.

THORAX: scutum dark grey as in tenuistylum; with three longitudinal stripes extended from prescutellar region to anterior margin, free at both extremities, with recumbent golden hairs all over. Scutellum greyish, with golden recumbent hairs and a very few black erect hairs as in tenuistylum. Post-notum dark grey, shiny, bare as in tenuistylum. Pleuron dark grey; pleural membrane bare as in tenuistylum; golden hairs on pleural tuft as in tenuistylum; sternopleuron shiny, with dark erect hairs; furcasternum (Plate-XXII, fig.-5) as figured. Knob of haltere pale yellow, and stem and base greyish to dark grey.

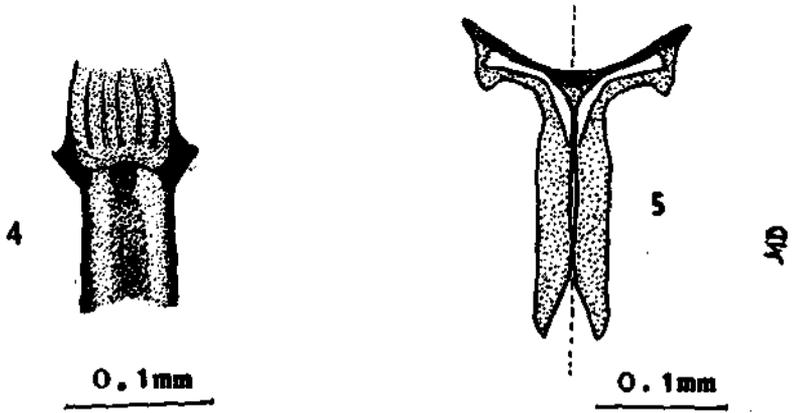
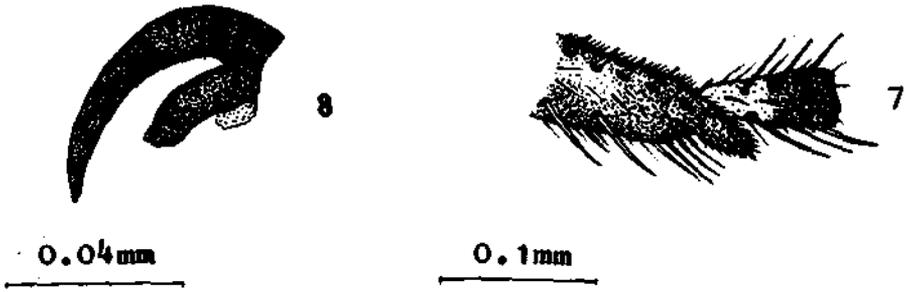
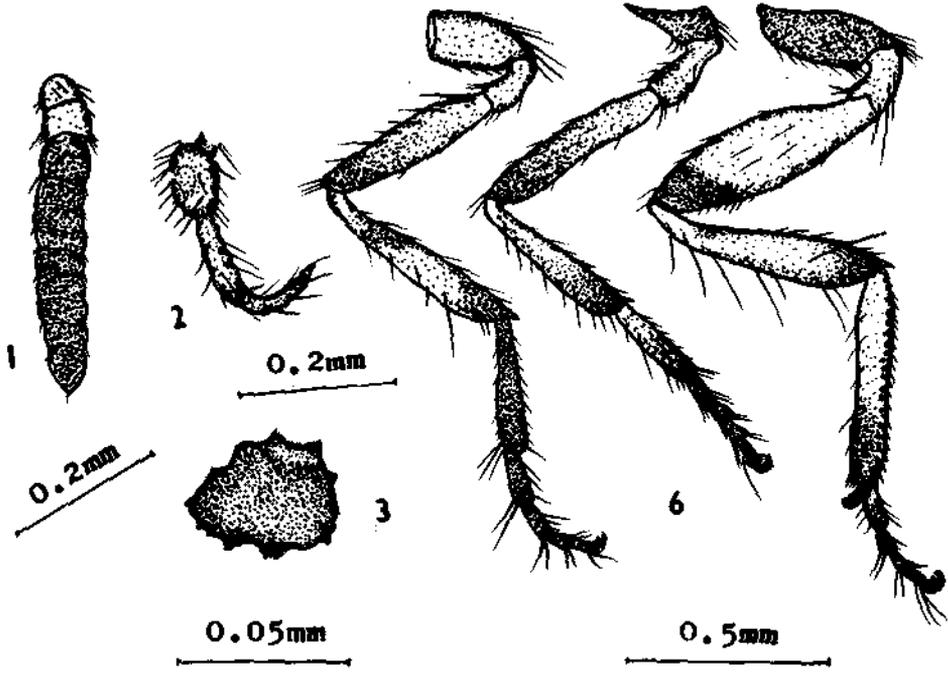
Wing-length 1.78 mm. (1.75 - 1.8 mm., n=5). Veins brownish; costa as in tenuistylum; hair-tufts on base of costa and stem vein black; sub-costa hairy upto level of origin of

EXPLANATION OF PLATE XXII

Simulium (Gomphostilbia) darjeelingense n.sp.

- Fig. 1. Antenna of female
- Fig. 2. Maxillary palpus of female
- Fig. 3. Sensory vesicle of female
- Fig. 4. Base of cibarium of female
- Fig. 5. Furcasternum of metasternum of female
- Fig. 6. Fore leg, mid leg and hind leg of female
- Fig. 7. End of first hind tarsomere and second tarsomere of female
- Fig. 8. Claw of female

Plate- XXII



AD

radial sector; radial sector as in tenuistylum; radius entirely hairy; R₁ with spinules as well as in tenuistylum.

Legs (Plate-XXII, fig.-6) as figured. Fore coxa brownish; trochanter greyish with pale base; femur greyish gradually darkening towards tip; tibia greyish with darkened tip, base brown, inner one-third of proximal end with dark patch; tarsus long, slender and not flattened, black as in tenuistylum. Middle coxa almost black as in tenuistylum; trochanter greyish with pale base; femur greyish gradually darkening to tip; tibia greyish gradually darkening to tip; first tarsomere black with basal one-third brownish, other tarsomeres black. Hind coxa dark grey; trochanter brownish, femur brownish gradually darkening to black tip; tibia greyish gradually darkening towards tip, proximal one-third on outer surface with greyish patch; first tarsomere almost parallel-sided as in tenuistylum, distal one-third greyish, rest yellow; second tarsomere black with pale base, other tarsomeres black. Calcipala (Plate-XXII, fig.-7) highly enlarged, pedisulcus deep. Each claw (Plate-XXII, fig.-8) with a strong basal tooth.

ABDOMEN: abdominal scale brown with long golden marginal hairs; tergum 2 grey; other terga dark grey; terga 3, 4 and 5 non-shiny; terga 6, 7 and 8 shiny; all terga with dark grey hair. Venter pale anteriorly and gradually darkening towards posterior end. Terminalia (Plate-XXII, figs.-9, 10 and 11) as figured.

MALE: Length 2.0 - 2.3 mm.

HEAD: width of head greater than that of thorax as in tenuistylum; upper eye facets exceptionally larger than lower ones; vertex black, with black erect hairs as in tenuistylum; clypeus black, with long recumbent golden hairs. Antenna entirely black, with dark pilosity. Palpus as in females.

THORAX: same as in females excepting following characters: mesonotum entirely black; no longitudinal stripes on scutum; knob of halteres grey, rest black.

Wing-length about 1.75 mm. (n=5). Veins as in females excepting sub-costa hairy only at basal one-third.

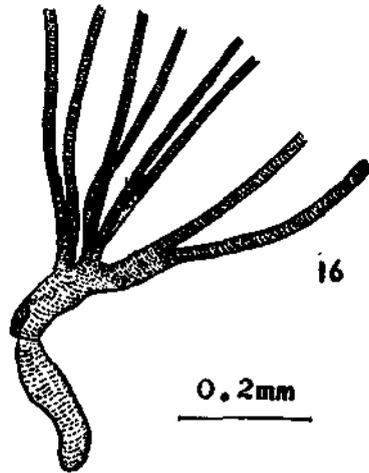
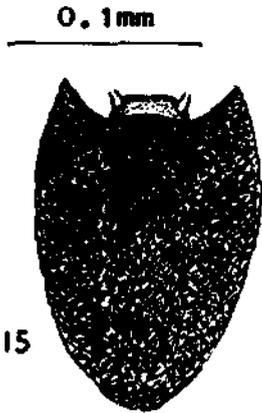
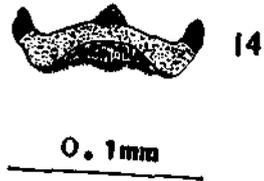
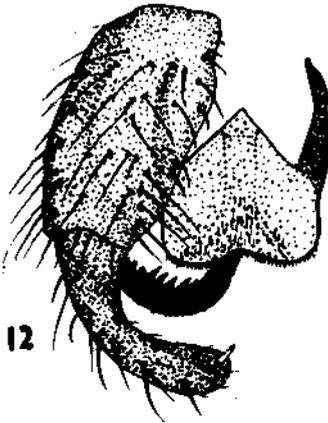
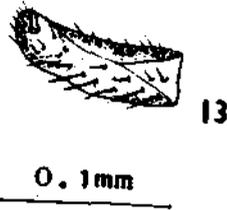
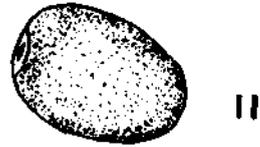
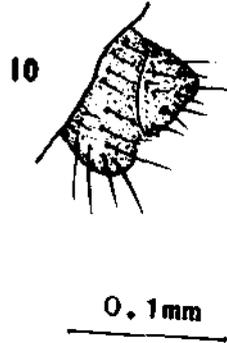
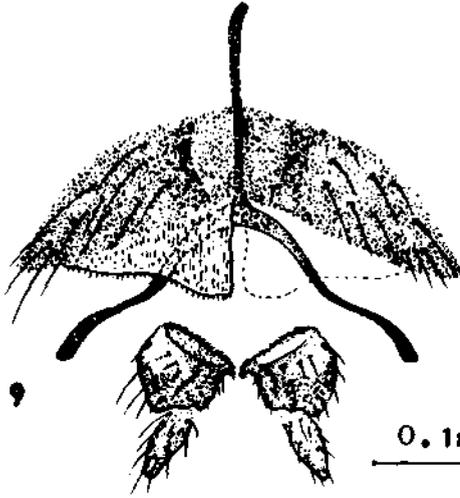
Legs darker than those of females and as follows: coxae of fore and hind legs dark grey; middle coxa black. Fore and hind trochanters dark grey with pale bases; middle trochanter entirely dark grey; all femora and tibiae dark grey with dark tips of femora and pale bases of tibiae. All tarsi black except bases of first mid tarsomeres and four-fifths of first hind tarsomeres being, brownish.

ABDOMEN: abdominal scale grey with black long marginal hairs; tergum 2 also grey, other terga velvety dark grey to black, with erect black hairs. Sternum 3 pale, other sterna dark. Terminalia (Plate-XXIII, figs.-12, 13 and 14) as figured.

EXPLANATION OF PLATE XXIII

Simulium (Gomphostilbia) darjeelingense n.sp.

- Fig. 9. Terminalia of female (ventral view)
- Fig.10. Cercus and anal lobe (side view)
- Fig.11. Spermatheca
- Fig.12. Terminalia of male (ventral view) - paramere of one side not shown
- Fig.13. Distimere (side view)
- Fig.14. Ventral plate (end view)
- Fig.15. Pupa within cocoon (dorsal view)
- Fig.16. Respiratory organ (right side)



MD

FUPA: Body-length about 2.7 mm.

Dorsum of head and thorax with pale small disc-like tubercles. Head trichomes 4 pairs as in tenuistylum, simple and long; 3 pairs antero-laterally and 1 pair ventro-laterally. Thoracic trichomes 7 pairs, all simple, long and thick; 4 pairs near mid-dorsal line anteriorly, 1 pair posteriorly and 2 pairs ventro-laterally. Respiratory organ (Plate-XXIII, fig.-16) about 1.2 mm. long; filaments arranged in following manner: almost from base of a short stout basal stem apparently three branches arise - upper branch with two filaments, middle branch divided into two very small branches each of which again divides into two branches secondarily; middle branch may be too short to recognize its clear identity; third or lower stoutest branch divided into two filaments, lower one being stoutest of all; upper 7 filaments of equal thickness. Arrangement of setae, hooks and spines on both tergum and sternum same as in tenuistylum excepting presence of a few setae on tergum 5 and absence of tail-hooks. Cocoon (Plate-XXIII, fig.-15) slipper-shaped, loosely woven and with a strong anterior margin but any kind of dorsal projection absent.

LARVA: Unknown.

DISTRIBUTION: Lebong, Darjeeling, in a number of watercourses flowing down the Lebong Cart Road, 2030-2050 m., coll.M.Datta.

16.VIII.70., 26.IX.70., 2.X.70., 9.X.70., 14.X.70. and
26.VIII.71.

SPECIMENS EXAMINED: Holotype ♀ (IM; pinned), reared from pupa, Lebong, Darjeeling, trailing vegetation with ditch-like watercourse, flowing down the Lebong Cart Road, 2030 m., 16.VIII.70. (M.Datta). Allotype ♂ (IM; pinned), reared from pupa, same data as holotype. Paratypes from the localities mentioned above.

REMARK: The name of this species has been derived from its type-locality, Darjeeling. This species seems to be related to Simulium pattoni Senior-White (1922), S.batoense Edwards (1934) and S.heldsbachense Smart & Clifford (1965), but it has certain important characters of its own for which it is treated as a new species. The affinities shown by darjeelingense with the above species have been discussed in detail in the chapter on "DISCUSSION" so as to justify its validity.

17. Simulium (Gomphostilbia) metatarsale Brunetti, 1911.

Simulium metatarsalis Brunetti, 1911, Rec. Ind. Mus. 4:284

Simulium (Gomphostilbia) metatarsale Brunetti; Crosskey,
1967, J. nat. Hist. 1:38.

Brunetti (1911) described the species from a single male specimen (Type ♂ in IM) collected in Kurseong (Darjeeling).

Edwards (1934) described the different stages of S. metatarsale var (?) from East Java. Croskey (1967b) placed the species in the subgenus Gomphostilbia Enderlein during his classification of the Simuliidae of Australia, New Guinea and the Western Pacific following the definition of Edwards (1934). No type-material has been available from the type-locality for further study.

D I S C U S S I O N

The characters shown by the four named proposed new species, praelargum, gracilis, purii and nemorivagum confirm that these species are allied to the species of the subgenus Eusimulium Roubaud (1906) as defined by Crosskey (1967b).

After a preliminary examination of the specimens of praelargum, gracilis and purii, Lewis (personal communication, 1969) informed the author that these species belong to the subgenus Eusimulium Roub. Later Mrs. Györkös and Prof. Davies (personal communication, 1971) confirmed the subgeneric status of praelargum and gracilis after their careful examination and re-examination of the specimens of these two species, and informed the author that these two species are in Sub-group D of Group II of Edwards (1934). In addition, the author was able with very limited material to relate purii to Sub-group D of Group II of Edwards and nemorivagum to an undetermined group. This sub-group of Edwards included species which Crosskey (1969) assigned to two species groups of Eusimulium: latipes-group and ruficorne-group, the latter including aureo-hirtum Brunetti.

Simulium (Eusimulium) praelargum n.sp. is close to the Javan species, S.feuerborni Edwards (1934), S.fuscinervis Edwards (1933) described from Sabah (British North Borneo) and S.(E.) sasai Rubtzov (1959-1964) described from Russia, but seems less closely related to S.genilis Brunetti (1911) described from the Western Himalayas.

Although praelargum shows similarities to feuerborni in the following characters: markings on the larval head and abdomen, shape and size of the post-genal cleft, structure of the male ventral plate, presence of several hooks on the male endoparameral organ and the shape of the cocoon along with certain other characters, the legs of feuerborni males are apparently darker than those of praelargum and there are a few hairs on the dorsal hind abdomen of the larvae. The pupa of feuerborni differs in having respiratory filaments arranged in pairs and almost sessile upper pair. The male of fuscinervis differs from that of praelargum in some respects including uniformly brown first hind tarsomere. S.(E.) sasai resembles praelargum in the shape of male distimere (although only one of the three spines is true spinule in sasai), presence of six to seven large endoparameral hooks in males; structures of anal lobe, cercus and genital fork stem, colour pattern of tibia and first tarsomere, width of first hind tarsomere, shape of calcipala and pedisulcus and also of tooth on the tarsal claw in females; shape of cocoon with dorsal median

projection, and branching and petiolar structure of the respiratory organ in pupae. However, sasai differs in having wide male ventral plate with a more convex anterior margin and short (only 6:1) female first fore tarsomere (compared with about 8.5:1 in praelargum). The male of senilis differs from that of praelargum in having a few distinctive characters including the lack of terminal spinule in the distimere (see Edwards, 1934). Thus, the distinctive characters in relation to the allied species discussed above justify that praelargum is a valid new species.

However, both praelargum and feuerborni, and the other species mentioned in the preceding paragraph fail to fit into the latipes-group, ruficorne-group (= angustitarse-group), or loutetense-group of Crosskey (1969).

The main distinguishing characteristics of praelargum from Crosskey's (1969) features for the latipes-group are as follows: the distimeres appear not to be produced much beyond the spinule insertion, each endorparameral organ bears six to seven large spines instead of one, the median sclerite if slightly Y-shaped has the centre of the Y filled in by the membrane, the calcipala of the female hind leg is large - almost covering the sub-proximal tarsomere, the pedisulcus is shallow, the pupal respiratory filaments are six instead of four. (It is similar in having no secondary annulations on the larval antenna nor supernumerary teeth on the mandible).

S.(E.) praelargum differs from the ruficorne-group in the shape of the male ventral plate, endoparameral organ and median sclerite (but the hypostomial teeth are similar); and it differs from the loutetense-group as follows: the male ventral plate differs considerably (Crosskey, 1969), the male first fore tarsomere is long and slender (9-10:1) (but the endoparameral hooks and the median sclerite agree), the tooth on the claw of the female hind leg is large and not minute as in this group, the petiole of the ventral pair of the pupal respiratory filaments is eight times longer than that of the dorsal pair and also than the main trunk and not sub-equal (but number of the respiratory filaments agrees), the cocoon has a long median process, the larval post-genal cleft is small, subquadrate and much shorter than the post-genal bridge and, the ventral papillae are ventral and distinct.

Thus, it appears that, with the kind consents of Prof.D.M.Davies (personal communication, 1971) and Dr.Crosskey (to whom Prof.Davies communicated), the author proposes to erect another species group in the Oriental Eusimulium Roub., namely, the feuerborni-group, with praelargum a member.

It may be re-called that Rubtzov (1959-1964) included sasai in the batoense-group of Eusimulium Roub. Mrs.Gyorkos and Prof.Davies (personal communication, 1971) studied Rubtzov's description of sasai that Crosskey (1969) considered close to the loutetense-group, and informed the author that this

species shows differences from other members of the batoense-group (some of which Crosskey considered to belong to Gomphostilbia Enderlein). Thus, the closely related species, S.(E.) sasai, another member fits into the feuerborni-group as well. It appears that fuscinervis and senilis are also members of of this group.

Both the species, S.(E.) gracilis and S.(E.) purii belong to the latipes-group sensu lato. A large number of species of this group have been described from various parts of the world and most of these species are often very difficult to distinguish one from another without making very careful examination.

These two species, gracilis and purii can readily be differentiated from each other by the scutal pattern and the structure of the eighth sternum in females; by the shape and size of the distimere, ventral plate and median sclerite in males; by the nature of trichomes, mode of arrangement of the respiratory filaments and the structure of dorso-median projection of the cocoon in pupae; and the nature of post-genal cleft and the respiratory histoblast in larvae.

Some species like Simulium (Eusimulium) latipes Mg. (1804) and S.(E.) costatum Fried. (1920) re-described by L. Davies (1966) from Britain, and Eusimulium fontinale Radz. (1948) re-described by Ussova (1961) from the Murmansk region

are compared with these two species and discussed for their identities. The other species of the latipes-group appear to be easy to differentiate by means of the keys provided.

The females of latipes differ from those of both gracilis and purii in many respects including the entirely black antenna, absence of the longitudinal stripes on the scutum, presence of pale yellow pleural tuft and brown abdominal scale. The males of latipes differ from those of gracilis and purii in having strongly convergent base of the ventral plate along with certain other characters. The pupa of latipes differs from that of gracilis in having simple trichomes; respiratory organ with shorter upper common stalk and cocoon with almost parallel-sided dorso-median projection, while in purii the cocoon shows no difference but the respiratory organ with two almost equal common stalks with filaments lying parallel to each other, is quite different. The larvae of latipes differs from those of both gracilis and purii in certain characters including the subquadrate post-genal cleft and the larger post-genal bridge.

The female of costatum differs from that of gracilis in many respects including the entirely black antenna, the adpressed pale scale patches on the post-notum, the pale yellow knob of the halteres, three longitudinal stripes on the scutum and the blackish brown abdominal scale. The female of costatum

appears to be more close to that of purii in that the latter species possesses the similar scutal stripes and the post-notal coating of pollinosity but this species does not possess the entirely black antenna, the pale yellow knob of the haltere and the blackish brown abdominal scale along with certain other characters. The males of costatum differ from those of both gracilis and purii in having shorter basimere and the markedly convergent base of the ventral plate including some other characters. The pupae of costatum differ from those gracilis and purii in some respects including the shorter upper common stalk and the cocoon having no dorso-median projection. The arrangements of the respiratory filaments of all these species are quite different. The larvae of costatum shows many differences including a notch-like post-genal cleft in contrast to the large rounded or spear-shaped clefts of gracilis or purii respectively.

The females of fontinale differ from those of both gracilis and purii in many respects including the dark brown antenna, the brown palpus, the light yellow haltere, legs yellowish in their greater parts and entirely black abdomen. The scutal pattern is, however, similar in both purii and fontinale in having only three longitudinal stripes but in gracilis there are five longitudinal stripes. The males of fontinale are different from those of both gracilis and purii in having brown palpus, and the shorter basimere and distimere

along with certain other characters. The pupa of fontinale differs from that of gracilis in having upper filament of lower pair not lying between the filaments of the upper pair and the cocoon without dorso-median projection. The arrangement of the respiratory filaments of purii resembles that of fontinale to some extent, but the latter species possesses the longer upper common stalk. The cocoon of purii has, however, a dorso-median projection as in latipes. The larvae of fontinale differ from those of both gracilis and purii in having shorter post-genal cleft along with some other characteristics.

Mrs. Györkös and Prof. Davies (personal communication, 1971) have examined the cocoon of S.(E.) bertrandi Grenier and Dorier (1959) of Southern France, which looks somewhat like that of gracilis, and informed the author that this species differs in other respects.

Thus, the combinations of characters shown individually by gracilis and purii discussed above have led to determine each of these two species as new.

The male of nemorivagum apparently resembles that of praelargum but the latter species has three faint longitudinal stripes on the scutum, while the former species is without such scutal stripes. Again these two species are readily separable from each other by the features of the genitalia

used in the keys provided. The characters shown by nemori-vagum through the pupa are quite different from those of any other species of this region. This species, therefore, deserves new specific status.

Among the four unnamed species, the species A, B and D show many distinctive characters to treat them in the subgenus Eusimulium Roub., but the subgeneric placement of the species C which has provisionally been placed in this subgenus, will only be confirmed when the associated adults will be available for future studies. The characters of the species D show that this species is related to rufithorax but the latter species has unstriped thorax in contrast to striped thorax of the species D. However, pending further studies on the materials of both these species from the type-localities no definite conclusion could be reached at.

The proposed new species nigrifacies implies its alignment with Simulium (Simulium) rufibasis Brunetti (1911) described from Kurseong (Darjeeling District). Following the classification of Crosskey (1969) this species has been included in the subgenus Simulium Latr. (1802) s.str. in which Puri (1932b) placed rufibasis during his studies on the materials collected both in the type-locality as well as in Bengal Terai, Simla and its adjacent areas.

The male of rufibasis differs from that of nigrifacies in having the entirely black antenna, a pair of elongated silvery spots anteriorly and a broad silvery border posteriorly on mesonotum, only yellowish base of the first middle tarsomere and shorter basimere among certain other characters. The pupa of rufibasis differs from that of nigrifacies in some respects including the arrangement of the respiratory filaments.

Thus, the distinctive characters such as a pair of crescent-shaped shiny coppery spots anteriorly and a large median spot posteriorly on the scutum, yellowish first middle tarsomere, somewhat darkened at the tip and the larger basimere in males and the middle pair of respiratory filaments independent of the upper pair in pupa of nigrifacies are sufficient to treat this species as new.

The characters shown by the two proposed new species, tenuistylum and darjeelingense suggest that these two species are allied to the species of Sub-group C of Group II of Edwards (1934). Following Edwards (1934), Crosskey (1967b) treated this sub-group as a separate subgenus Gomphostilbia Enderlein (1921) available to define some Oriental species.

Simulium (Gomphostilbia) tenuistylum is more closely related to Simulium metatarsale Brunetti (1911) than to S. sundaicum Edwards (1934) described from East Java, S. rayohense

Smart & Clifford (1968) and S.pegalanense Smart & Clifford (1968), both described from Sabah (British North Borneo).

Mrs.Györkös and Prof.Davies (personal communication, 1971) compared tenuistylum with metatarsale and informed the author of their most close relationship after careful re-evaluation of all stages of these species they possessed. The female of tenuistylum differs from that of metatarsale in the shape and colour of the hind tibia in that the tapering is widest near middle and not distally, more than distal half is pale and the sub-basal brown ring is faint. The male of tenuistylum differs in having larger basimere and wider ventral plate. The petiole of the dorsal triplet in pupa is shorter than in metatarsale. The post-genal cleft of larva in tenuistylum is larger than in metatarsale.

The affinities of tenuistylum also with the other related species are discussed below so as to determine its separate identity. The male of tenuistylum has wider first hind tarsomere than the tibia as in metatarsale but it differs from it in sundaicum, pegalanense and rayohense; and the ventral plate is less wide than in rayohense. The petioles of the respiratory filaments in pupa of tenuistylum are longer than in sundaicum and rayohense but shorter than in pegalanense (almost half). The petiole of the dorsal triplet in tenuistylum is similar to that of pegalanense but shorter than in metatarsale as already mentioned above. The petiole of the lower pair of tenuistylum

is nearly always longer (occasionally much longer but sometimes shorter) than the petiole of the middle triplet. The length and the width of the respiratory filaments in tenuistylum is sub-equal, as in metatarsale, but these differ in sundaicum and rayohense. The post-genal cleft in the larva of tenuistylum is larger than the post-genal bridge as in rayohense but differs from that in sundaicum and metatarsale (being shorter), and pegalanense (being extended upto the base of the hypostomium). Moreover, the larva has a dark dorsal band on the hind abdomen with two pairs of dark lateral spots posterior to it, and agreeing with that of sundaicum and metatarsale the rectal 'gills' are branched and the hind abdomen is provided with sparse hairs dorsally.

Thus, the above discussed combinations of characters which the species tenuistylum possesses, confirm that this species is new. In fact, all these species are very close to one another. It may be mentioned that, after a tentative examination of this species, Prof. Davies (personal communication, 1971) once informed the author that tenuistylum is close to rayohense and may actually be that species. He further informed in the same communication that rayohense may eventually prove to be synonymous with sundaicum. Of course, later he informed the author of the separate identity of tenuistylum after further careful studies with Mrs. Györkös (personal communication, 1971).

Simulium (Gomphostilbia) darjeelingense seems to be related to Simulium pattoni Senior-White (1922) described from South India; S. batoense Edwards (1934) from East Java; and S. heldsbachense Smart and Clifford (1965) from New Guinea.

The females of darjeelingense are different from those of pattoni in many respects including more extensive pale colour of the hind tibia, pale hairs on half of the outer side of the hind femur and the lighter abdominal segments. The pupa of darjeelingense shows enough differences in regard to the arrangement and thickness of the respiratory filaments. The arrangement of the filaments is apparently not in 3+3+2 combinations but in pairs and the last filament is the stoutest of all, though all the filaments are almost equal in length. These characters of the filaments are distinct so much so that the separate identity of darjeelingense from pattoni and its related species described by Edwards (1934) shall be justified.

In the male of batoense the scape and the pedicel are paler than the flagellum while in darjeelingense the antenna is entirely black. The first hind tarsomere is quite slender in batoense but wider in this species. The shape and size of the paramere and the ventral plate are quite different in these two species. The female of batoense differs from that of this species in having almost uniformly pale hairs on the hind femur along with certain tinctorial characters of different

parts of the body. The respiratory filaments of the pupa of batoense are quite different. The two lower filaments are twice as long as the others and are borne on a long common stalk. The arrangement of the other six filaments are also quite different in batoense.

The female of heldbachense differs from that of this species in various respects including the pale brown basal half of the antenna and the second tergum as pale as the abdominal scale. The male shows many differences including the bare sub-costa. The pupa of heldbachense also differs in the arrangement and thickness of the filaments and in the shape of the cocoon.

Thus, the above account reveals that the proposed new species darjeelingense has many distinctive characters including the grey scape, pedicel and base of the first flagellomere and the black other flagellomeres; half of the hind femur with dark hairs on the outer side; the brown abdominal scale; second tergum and other terga dark grey in females. In males the distinctive characters are entirely black antenna; wide first hind tarsomere; sub-costa hairy at basal one-third; and the shape and size of the basimere, distimere and ventral plate. In the pupa the respiratory filaments are apparently arranged in pairs and are almost equal in length, the last filament being stoutest of all. These combinations of characters have led to determine the species as new.

It is, therefore, concluded from the foregoing discussion that, as a result of the present investigation, seven new species, four unnamed new species and larvae of four previously known species from some parts of the Himalayan Darjeeling form new additions to the literature of the family Simuliidae. Moreover, a new species-group is erected in the subgenus Eusimulium Roubaud.

S U M M A R Y

A taxonomic account from materials constituting seven named species, namely, Simulium (Eusimulium) praelargum n.sp., S.(E.) gracilis n.sp., S.(E.) purii n.sp., S.(E.) nemorivagum n.sp. Simulium (Simulium) nigrifacies n.sp., Simulium (Gomphostilbia) tenuistylum n.sp. and S.(G.) darjeelingense n.sp. and four unnamed species designated as A, B, C and D of the family Simuliidae from some parts of the Himalayan Darjeeling is given. In addition to that, there are descriptions of the larvae of the four previously known species such as S.(S.) himalayense Puri (1932), S.(S.) rufibasis Brunetti (1911), S.(S.) dentatum Puri (1932) and S.(S.) grisescens Brunetti (1911) collected from the type-localities.

The species praelargum, gracilis, purii, and tenuistylum have been described with all stages while the female in nemorivagum, the female and larva in nigrifacies, the larva in darjeelingense, the female, male and pupa in Species A, the female, male and larva in Species B, the female and male in Species C and the male, pupa and larva in Species D are unknown. A new species-group, feuerborni-group of the subgenus Eusimulium Roub., is established into which the new species praelargum is placed.

Among the unnamed species, the Species A, Species B and Species D have been assigned to the subgenus Eusimulium Roub., while the Species C, though it is placed in the same subgenus, needs further materials to study for its confirmation.

Besides these accounts, dichotomous keys of the species of Simulium Latr. s.str. found in the Himalayan Darjeeling are incorporated in the present study.

R E F E R E N C E S

- Andretta, C.D.^o; Jr. and Andretta, M.A.V.D' (1947). As espécies neotropicais da família Simuliidae Schiner (Diptera, Nematocera) II. Inst. Oswaldo Cruz Mem. 44:401-412 (1946).
- Baranov, N. (1926). Eine neue Simuliiden-Art und einige Bemerkungen über das System der Simuliiden. N.Beitr. Syst. Insectenk. 3:161-164.
- (1935). Neues über die Kolumbatscher-Mücke (Simulium columbaczense Schönb.). Arb.Morph.tax.Ent.Berlein. 2: 156-158.
- (1938). K. poznavanju golubačke musice VI. Vet. Archiv. 8:313-328.
- Becher, E. (1884). A new species of Simulium from Assam. Jour. Asiat. Soc. Beng. 53(2):199-200.
- Becker, T. (1908). Dipteren der Kanarischen Inseln. Mitt. zool. Mus. Berlin. 4:72-74.
- Brunetti, E. (1911). New Oriental Nematocera (Simuliidae). Rec. Ind. Mus. 4(7):282-288.
- (1912a). Fauna of British India, Diptera. 1:182-195.
- (1912b). A new species of blood-sucking fly (Simulium) from Ceylon. Spol.Zeyl. 8:90-91.
- Crosskey, R.W. (1960). A taxonomic study of the larvae of West African Simuliidae (Diptera:Nematocera) with comments on the morphology of the larval black fly head. Bull. Br. Mus. Nat. Hist. (Eng.). 10:1-74.

- (1967a). A preliminary revision of the black flies (Diptera:Simuliidae) of the Middle East. Trans.R. ent. soc. Lond. 119(1):1-45.
- (1967b). The classification of Simulium Latreille (Diptera:Simuliidae) from Australia, New Guinea and the Western Pacific. J. nat. Hist. 1:23-51.
- (1969). A re-classification of the Simuliidae (Diptera) of Africa and its islands. Bull. Mus. Nat. Hist. (Ent.). 14:1-195.
- Davies, D.M., Peterson, B.V. and Wood, D.M. (1962). The black flies (Diptera:Simuliidae) of Ontario. I. Proc. Entomol. Soc. Ont. 92:70-154.
- Davies, L. (1966). The taxonomy of British Black Flies (Diptera:Simuliidae). Trans. R. ent. Soc. Lond. 118(14):413-511.
- (1968). A key to the British species of Simuliidae (Diptera) in the larval, pupal and adult stages. Freshwater Biol. Assoc. 24:1-126.
- Doby, J.M. and David, F. (1959). Description de Greniera fabri Doby et David, 1959 (Diptera-Nematocera:Simuliidae) on provenance de L'ouest de la France (Loire-Atlantique). Soc. de Path. Exot. Bul. 52:669-678.
- Dorogostaiskii, V.Ch., Rubtsov, I.A. and Vlasenko, N.M. (1935). Studies on the Systematics, Geographical distribution and Biology of the Simuliidae of Eastern Siberia. (In Russian). Mag. Parasit. Inst. Zool. Acad. Sci. U.S.S.R. 5:107-204.
- Dyar, H.G. and Shannon, R.C. (1927). The North American two-winged flies of the family Simuliidae. Proc. U.S. Nat. Mus. 69:1-54.

- Edwards, F.W. (1927). Two new Simulium from Kashmere.
Bull. Ent. Res. 18:169-170.
- (1931). Simuliidae. Diptera of Patagonia and South
Chile. Brit. Mus. (Nat. Hist.). II (Fasc.):
121-154.
- (1933). Diptera Nematocera from Mount Kinabalu.
J. Fed. Malay St. Mus. 17:223-296.
- (1934). The Simuliidae (Diptera) of Java and
Sumatra. Deutsche Limnologische Sunda-expedition.
91. Arch. F. Hydrobiol. 13:92-138.
- Enderlein, G. (1921a). Das System der Kriebelmücken (Simu-
liidae). Deuts. Tierärztl. Woch. 29(16): 197-200.
- (1921b). Neue Paläarktische Simuliiden.
Sitzber. Ges. naturf. Freunde. 1920:212-224.
- (1921c). Die systematische Gliederung der Simulii-
den. Zugleich eine Bitte um Überlassung von
Simuliidenmaterial. Zool. Anz. 53(1-2):43-46.
- (1921d). Neue außereuropäische Simuliiden.
Sitzber. Ges. naturf. Freunde. 1921:77-81.
- (1921e). Ein fossiler Simuliiden-Riese.
Zool. Anz. 53:73-75.
- (1922). Weitere Beiträge zur Kenntnis der
Simuliiden. Konowia 1(1-2): 67-76.
- (1924a). Zur Kenntnis der estländischen Moorfauna
(II Beitrag). Simuliiden. Dampf. A., Sitzber. Ges.
naturf. Dorpat. 31:46-48.
- (1924b). Die Simuliiden Bulgariens und ihre
Schäden im Jahre 1923. Zool. Anz. 61:280-288.

- (1925). Weitere Beiträge zur Kenntnis der Simuliiden und ihrer Verbreitung. Zool. Anz. 62:201-211.
- (1926). Neue Beiträge zur Kenntnis paläarktischer Simuliiden. Ibid. 66:139-142.
- (1928a). Bestimmungstabelle der Subfamilien der Kriebelmücken (Simuliiden). Z. Desinf. Gesund. 20(1):10-11.
- (1928b). Cnetha wigandi, eine neue Simuliide aus dem Leinegebiet. Zool. Anz. 76:315-317.
- (1929a). Neue Arten des Simuliidengenus Cnetha (Diptera). Wien. ent. Ztg. 46:73-78.
- (1929b). Über einige neotropische Simuliiden des Genus Friesia (Diptera). Deuts. ent. Z. 1929:327-328.
- (1929c). Beiträge zur Kenntnis des Prosimuliinen und Hellichinen. Sitzber. Ges. naturf. Freunde. 1929:224-226.
- (1930). Der heutige Stand der Klassifikation der Simuliiden. Arch. Klass. phylog. Ent. 1:77-97.
- (1931). Zur Beurteilung und Bekämpfung der Kriebelmücken Schäden des Leinegebietes. Arch. wiss. prakt. Tierhkl., 63:475-528.
- (1934a). Weitere Ausbau des Systems der Simuliiden (Diptera). Deuts. ent. Z. 1933:273-292.
- (1934b). Aussureuropäische Simuliiden aus dem Wiener Museum. Sitzber. Ges. naturf. Freunde. 1934:190-195.

- (1935). Neue Simuliiden, besonders aus Afrika.
Ibid. 1935:358-364.
- (1936a). Zweiflugler, Diptera. Tierwelt Mitteleuropas 6, Teil III, Lief 2 (xvi):1-259.
- (1936b). Simuliologica I. Sitzber. Ges. naturf. Freunde. 1936:113-130.
- (1937). Über bemerkenswerte Unkenntnisse von der Entwicklung zweier einheimischer Simuliidengattungen (Diptera). Märkische Tierwelt 3:68-70.
- Fabricius, J.C. (1787). Mantissa Insectorum, Hafniae 2:333.
- Fallis, A.M. (1964). Feeding and related behaviour of female Simuliidae (Diptera). Exptl. Parasitol. 15(5): 439-470.
- Freeman, P. and de Meillon, B. (1953). Simuliidae of the Ethiopian region. Brit. Mus. (Nat. Hist.), Lond. 1-224.
- Friederichs, K. (1920). Zur Kenntnis der Deutschen Simuliiden. Sitz. u. Abh. der naturf. Gesell. zu Rostock. Neue Folge 7:211-226.
- Fries, B.F. (1824). Observationes entomologicae. Pars I. 20 pp., Lund.
- Grenier, P. (1949). Contributions à l'étude biologique des Simuliidae de France. Physiol. Comp. 1:165-330.
- and Dorier, A. (1959). Deux Simulies nouvelles (S.bertrandi n.sp. et S.carthusiense n.sp.) du Groupe latipes, recoltées en France et en Espagne. Trav. Lab. Hydrobiol. Piscic. Univ. Grenoble. 50-51:205-223.

- and Rageau, J. (1960). Simulies (Dipt.Simuliidae) de Tahiti. Remarques sur la classification des Simuliidae. Bull.Soc.Pathol.Exot. 53(4):727-742.
- (1961). Un nouveau genre de Simulies: Hebridosimulium N.G. (Diptera:Simuliidae) des Nouvelles-Hébrides. Description des stades préimaginaux et du male, redescription de la femelle de H.Jolyi (Roubaud), 1906. Ibid. 54:95-102.
- Handlirsch, A. (1908). Die fossilen Insekten und die phylogenie der rezenten Formen. Leipzig. 629, 631, 981-982.
- Hendel, F. (1908). Nouvelle Classification des Mouches à deux Ailes (Diptera L.). Zool.-Bot. Gesell. Wein, Verhandl. 58: 43-69.
- Latreille, P.A. (1802). Dipteres; Tipulaires; Simulie; Simulium. Hist. Nat. gén. part. Crust. Ins. 3:426-427.
- Lewis, D.J. (1964). Diptera from Nepal (Simuliidae). Bull. Brit. Mus. Nat. Hist. Lond. 15:291-294.
- Mackerras, M.J. and Mackerras, I.M. (1948). Simuliidae (Diptera) from Queensland. Aust. J. Scient. Res. B 1(2):231-270.
- Macquart, J. (1838). Diptères exotiques nouveaux ou peu connus. Mem. Soc. Roy. Sci., Agric. et Arts, Lille 1838 (2): 9-225.
- Malloch, J.R. (1914). American black flies or buffalo gnats. U.S. Dept. Agric., Bur. Ent. (Tech. Ser.) 26:1-72.
- Meigen, J.W. (1800). Nouvelle classification des mouches à deux ailes (Diptera L.) d'après un plan tout nouveau. Paris. 1-40.

- (1803). Versuch einer Gattungseintheilung der europäischen zweiflügligen Insekten.
Illiger's Mag. f. Insekten. 2:259-281.
- (1804). Klassifikation und Beschreibung der europäischen zweiflügligen Insekten. (Diptera L.)
1:94-97.
- (1818). Systematische beschreibung der bekannten europäischen zweiflügligen Insekten. 1:289-298.
- (1838). Ibid. 7:52-54.
- Meijere, de J.C.H. (1907). Studien über südostasiatische Dipteren I. Tijdschr. Ent. 50:196-264.
- Nicholson, H.P. (1945). The morphology of the mouthparts of the non-biting black fly, Eusimulium dacotense D. and S. as compared with those of the biting species, Simulium venustum Say. Ann.Ent.Soc.Amer. 38:281-297.
- Ogata, K. and Sasa, M. (1954). Taxonomic notes on Simuliidae or black flies of Japan, with special reference on the subgenera Eusimulium Roubaud and Nevermannia Enderlein (Diptera). Jap.J.Exp.Med. 24:325-333.
- Puri, I.M. (1925). On the life history and structure of the early stages of Simuliidae. Parasitology. 17:295-369.
- (1932a). Studies on Indian Simuliidae. Part I.
Ind. J. Med. Res. 19(3):883-897.
- (1932b). Studies on Indian Simuliidae. Part II.
Ibid. 19(3):899-915.
- (1932c). Studies on Indian Simuliidae. Part III.
Ibid. 19(4):1125-1143.
- (1932d). Studies on Indian Simuliidae. Part IV.
Ibid. 20(2):505-514.

- (1932e). Studies on Indian Simuliidae. Part V.
Ibid. 20(2):515-532.
- (1933a). Studies on Indian Simuliidae. Part VI.
Ibid. 20(3):803-812.
- (1933b). Studies on Indian Simuliidae. Part VII.
Ibid. 20(3):813-817.
- (1933c). Studies on Indian Simuliidae. Part VIII.
Ibid. 21(1):1-9.
- (1933d). Studies on Indian Simuliidae. Part IX.
Ibid. 21(1):11-16.
- Radzivilovskaya, Z.A. (1948). On the Fauna and Ecology of Simuliidae of the Mountainous Regions of the Southern Ussuri Taiga. (In Russian). Mag. parasit. Inst. Zool. Acad. Sci. U.S.S.R. 10:131-150.
- Roubaud, E. (1906). Aperçus nouveaux, morphologiques et biologiques, sur les Diptères piqueurs du groupe des Simulies. C.R.Acad.Sci.Paris. 143:519-521.
- Rubtsov, I.A. (1937). On the evolution of blood-sucking flies (Simuliidae:Diptera). Bull. Acad. Sci. (Biol.) 1937:1289-1327.
- (1940). Fauna of U.S.S.R. Insects (Diptera). No.23, 6 (6):1-532 (In Russian with English keys and descriptions of new taxa).
- (1956). Fauna of U.S.S.R. Insects (Diptera). Black flies (family Simuliidae). Zool.Inst.Acad.Sci. U.S.S.R. (N.S.64) 6:1-860. (In Russian).
- (1959-1964). Simuliidae (Melusinidae) in Lindner. Fliegen Palaearkt. Reg. 14:1-689. (In Russian).
- Schönbauer, J.A. (1795). Geschichte der schädlichen Kolumbatzzer Mücken im Bannat. Wäen, 100 pp.

- Séguy, E. and Dorier, A. (1936). Description d'une nouvelle espèce de simulie récoltée en Dauphiné. Trav. Lab. Hydrobiol. Piscicult. Univ. Grenoble. 27:1-15.
- Senior-White, R. (1922). Notes on Indian Diptera. Mem. Dept. Agric. India Ent. Ser. 7(9):126-131.
- Shewell, G.E. (1958). Classification and distribution of Arctic and subarctic Simuliidae. Proc. Xth Int. Congr. Ent. (Montreal). 1956. 1:635-643.
- (1959). New Canadian black flies (Diptera: Simuliidae). Part II. Canad. Ent. 91:83-87.
- Skuse, F.A.A. (1890). Diptera of Australia. Nematocera. Proc. Linn. Soc. N.S. Wales (2) 5:595-640.
- Smart, J. (1945). The classification of the Simuliidae (Diptera). Trans. R. ent. Soc. Lond. 95(8):463-532.
- and Clifford, E.A. (1965). Simuliidae (Diptera) of the territory of Papua and New Guinea. Pac. Ins. 7 (3):505-619.
- (1968). Simuliidae (Diptera) of Sabah (British North Borneo). Zool. J. Linn. Soc. 48:9-47.
- Stone, A. (1963). An annotated list of genus-group names in the family Simuliidae (Diptera). Tech. Bull. U.S. Dept. Agric. No.1284:1-28.
- (1964). Simuliidae and Thaumaleidae, in Guide to the insects of Connecticut, Part VI. 9th fasc. Bull. Conn. St. Geol. Nat. Hist. Surv. 97:1-126.
- and Jamnback, H.A. (1955). The black flies of New York State (Diptera: Simuliidae). New York State Mus. Bull. 349:1-144.

- Surcouf, J.M.R. and Gonzalez-Rincones, R. (1911). Simuliidae. Essai sur les dipteres vulnerants du Venezuela. 1:274-295.
- Tonnoir, A.L. (1925). Australasian Simuliidae. Bull. Ent. Res. 15(3):213-255.
- Twinn, C.R. (1936). The black flies of eastern Canada (Simuliidae:Diptera). Can. J. Res. Sect. D. Zool. Sci. 14:97-150.
- Ussova, Z.V. (1961). Flies of Karelia and Murmansk Region (Diptera:Simuliidae). Acad. Sci. U.S.S.R. 1-268. (Translated from Russian).
- Vargas, L. and Díaz Nájera, A. (1951). Notas sobre systematica y Morphologia de Simulidos. Soc. Mex. de Hist. Nat. Rev. 12:123-172.
- , Martínez Palacios, A. and Díaz Nájera, A. (1946). Simulidos de Mexico. Rev. Inst. Salubridad y Enferm. Trop. 7:101-192.
- Wood, D.M. and Davies, D.M. (1966). Some methods of rearing and collecting black flies (Diptera:Simuliidae). Proc. Entomol. Soc. Ont. 96:81-89.
- , Peterson, B.V., Davies, D.M. and Györkös, H. (1963). The black flies (Diptera:Simuliidae). Part II. Ibid. 93:99-129.
- Wygodzinsky, P. and Coscarón, S. (1962). On the relationships and zoogeographical significance of Austrosimulium anthracinum (Bigot) a black fly from southern South America (Diptera, Simuliidae). Pae. Insects. 4:235-244.
-

PART-II
(BIONOMICS)

I N T R O D U C T I O N

The use of light trap for controlling night-flying insect pests has long been a conventional practice in various parts of the world. In recent times light trap has been successfully used by various workers in different countries for collecting positively phototropic insects for bionomical studies.

Work done abroad:

The efficacy of light traps in insect survey was convincingly demonstrated by Williams (1923, 1924, 1936, 1939, 1940, 1948, 1951, 1961, 1962 and 1964), and by Williams and Davies (1957) on the basis of extensive trials carried out in Scotland and also in Egypt. Some of these works in Scotland revealed various insect groups in the area, their relative abundance and incidence in a year, variations in their seasonal incidence from year to year, their differential activity in different hours of a night and so on. In England, Smith (1923), de Worms (1930, 1931, 1932 and 1933) and Andrews (1931) also

used light traps primarily for the collection of specimens. Working in the U.S.A., Cook (1921, 1923 and 1930) made a most excellent study on the ecology of Noctuidae (Lepidoptera) largely from trap records.

Frost (1957a, 1962, 1963, 1964a, b) carried out extensive light trap surveys in Florida, Tennessee and in some other parts of the U.S.A. In one of these works Frost (1963) successfully demonstrated the correlation of meteorological conditions to the activity of insects, and explained that a light drizzle hardly affected the incidence of insects, and a foggy weather with drizzle accompanied by high temperature increased the rate of collection, whereas the catch rate waned in heavy rains or in strong winds.

Working in Florida, Beck (1958) reported that it was possible with the help of light trap to survey the population of night-flying insects within a radius of one mile around the trapping site, and it was also possible to determine the relative abundance, seasonal incidence and seasonal succession of the insect species in question.

Snow and Pickard (1954), and Pickard and Snow (1955) undertook extensive light trap surveys of the night biting Diptera in the Tennessee river basin of the U.S.A.

Working in Central Asia, Mazokhin-Porshnyakov (1956) reported a very heavy catch of black flies. In Canada, Fredeen

(1961) demonstrated the suitability of a light trap for testing the attacking behaviour of a black fly. The time of flight of certain nocturnal lepidopteran insects was measured by Hanna (1968) in Egypt by means of a light trap.

Service (1969) published a bionomical note on some Ceratopogonids caught in Southern England with the help of light trap. In Japan, Kurashige (1970) studied the nocturnal succession of mosquitoes with the help of light trap.

Numerous other reports on the light-trapping of different insects in various parts of the world are extant.

Work done in India:

In India, systematic light-trapping for studying insect bionomics was undertaken by Banerjee and Basu (1951). For sampling work these workers (Banerjee and Basu, 1956) devised a standard light trap device which was later used by Sen and Das Gupta (1959) to determine the nocturnal periodicity and by Das Gupta (1961, 1967) to establish the dominant species and the relative abundance of some ceratopogonids in the Gangetic West Bengal. Working in Pilani, Rajasthan, Kundu et al. (1964) recorded the abundance of some insects caught in the light trap. These workers emphasized that the frequency rather than the quantity of rain fall influenced the incidence of insects. Sinbaray et al. (1969) working in Darjeeling assessed the abundance and nocturnal periodicity of some phototropic insect

populations by light-trapping. According to these workers cloudy nights with slight precipitation, accompanied by moderate temperature, yielded higher incidence of insects. Chaudhuri (1970) recorded the distribution of some ceratopogonids in Darjeeling and other parts of India with the help of light traps.

The present work was undertaken to assess the efficacy of the light trap in sampling black flies available in Darjeeling and its environs, and also to determine the relative abundance, seasonal incidence, seasonal succession, sex-ratio, internal conditions of females, host preferences, nocturnal periodicity, photophilic behaviour and some other aspects of bionomics of black flies. It will be noted that a comprehensive work on the bionomics of black flies, using light traps, was not previously undertaken in India.

MATERIALS AND METHODS

The imaginal forms of black flies (Simuliidae: Diptera) constituted the study material. These forms were collected by a light trap device operated between 7 P.M. and 5 A.M. during the period April 1 to September 30 for three consecutive years, i.e., 1968, 1969 and 1970, at Darjeeling Government College campus located at an altitude of 2014 metres from the sea-level. The light trap device used in this study did not strictly conform to any particular design reported earlier, such as the New Jersey light trap (Headlee, 1932), Rothamsted light trap (Williams, 1948), Robinson light trap as reported by Williams et al. (1955), Pennsylvania light trap (Frost, 1957b) and the Chinsuralight trap (Banerjee and Basu, 1956).

The light trap used in the present study was based on the essential principles of all these earlier devices.

Description of the light trap and its operation:

The light trap device (Fig.6) was essentially a four-walled chamber (60 cm. x 60 cm.) of plain sheets of tin (B), covered with a slopping roof (R), and open at the bottom.

LIGHT-TRAP DEVICE

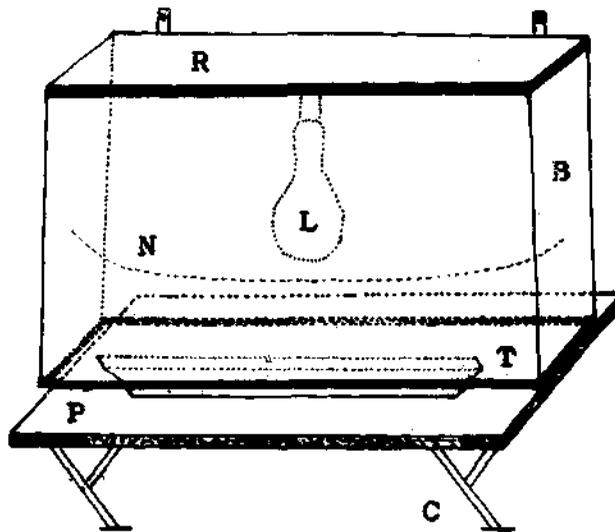


FIG. 6: Diagram of the simple light trap device of the present study

This chamber was fixed to the open terrace, facing north, in the second floor of the building housing Darjeeling Government College. A light source (L) of 500 wattage having a reflecting top-cover (not shown in the figure) was placed at about the middle of the open end of the chamber, hanging from its roof. An iron-wire netting (N) of 4 mesh per square centimetre was used to protect the light source. About 12 cms. beneath the open end of the chamber there was a platform (P) fixed to the wall with the help of two iron stands (C). A rectangular tray (T) measuring 45 cm. x 36 cm. x 5 cm., containing the trapping liquid layer of 5% aqueous solution of acetic acid to a depth of about 2.5 cms. and covered with an iron-wire netting (not shown in the figure) of 4 mesh per square centimetre was placed on the platform during the operational period.

The trap was switched on at 7 P.M. and switched off at 5 A.M. regularly every day. After night-long trapping the tray of the trap device was brought to the laboratory, and after removing the iron-wire netting fresh water was added to the tray-contents to increase the volume of the liquid. Surplus water thus added served to dilute the solution and took away the corrosive stench of acetic acid making direct collection of trapped black flies from the solution easy. The black flies were then collected in watch glasses containing 90% ethanol, and sorted under a stereoscopic binocular

Trap site and neighbourhood

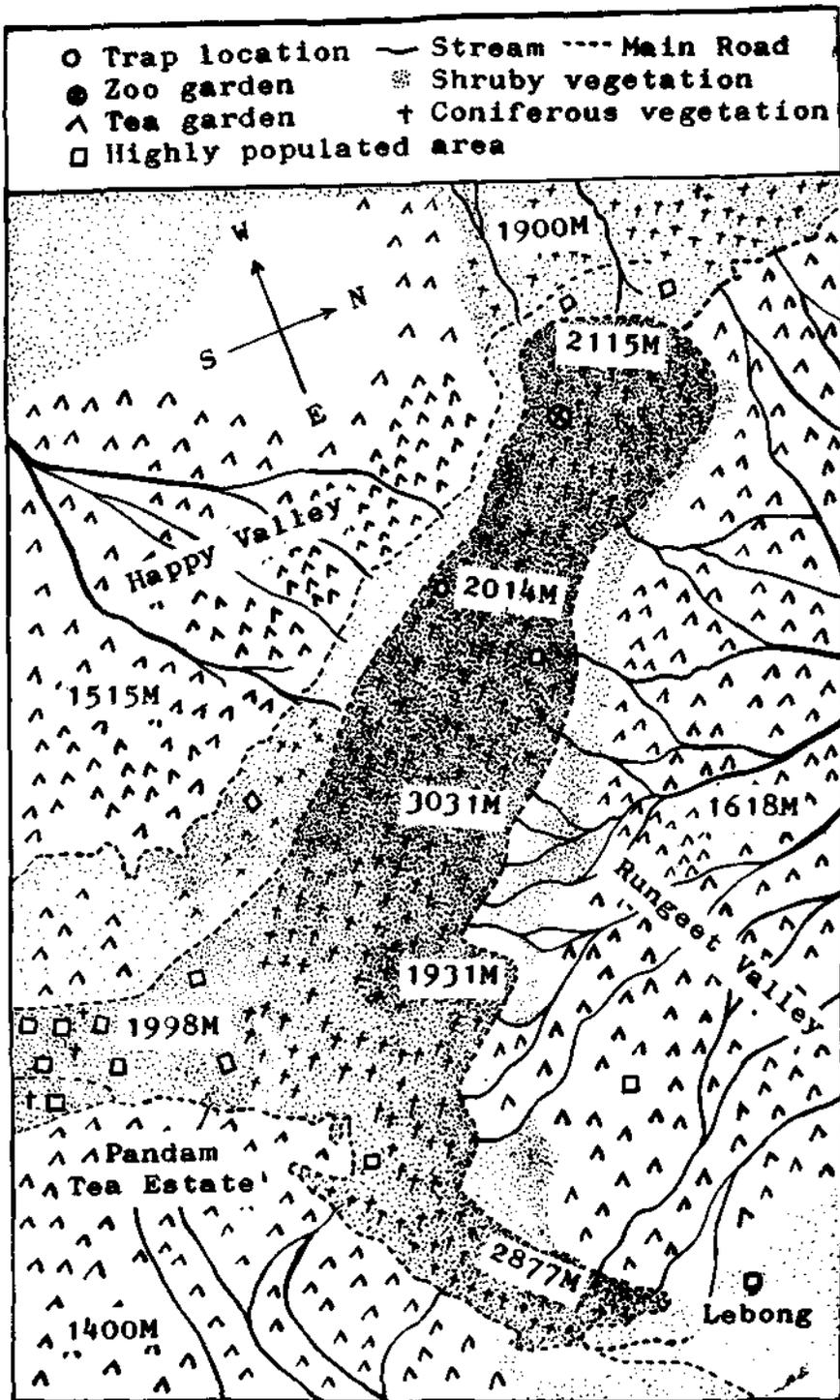


FIG.7: Diagram showing distribution of vegetation, various waterways, residential pockets, altitudinal variations of the terrain of more than one square mile area around the trapping site

FIG.8: North-East Side

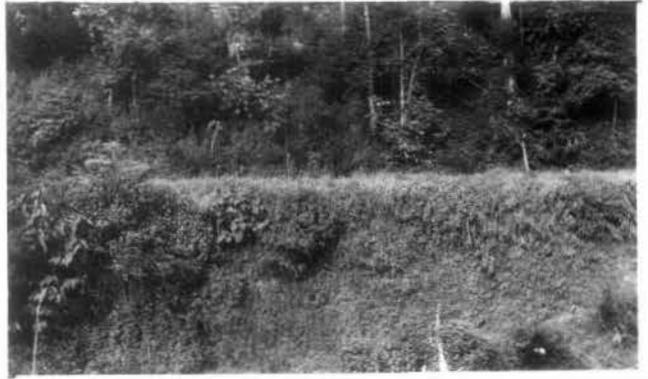


FIG.9: North-West Side

Photographic views of the backside of Darjeeling Government College campus towards the collecting site, showing vegetational covers

microscope, and the details of the catch were duly recorded. Specimens of each species-group were preserved in separate glass tubes or plastic receptacles containing 90% ethanol.

Description of the trapping site:

The campus of Darjeeling Government College which was the trap site for the purpose of this study is situated on a well-forested hill-slope known as Birch Hill (Altitude 2115 m. - 3031 m.) towering at the northern end of the township of Darjeeling ($27^{\circ}3'N$ latitude and $88^{\circ}18'E$ longitude). The terrain is undulating and covered with variegated flora (Figs. 7-9). The altitudinal level of one square mile area around the trapping site ranges from 1515 m. to 3031 m. and the terrain leads much further down to tea estates which border the trapping site. This area is thinly populated and abounds in pockets of water courses which are available as ideal breeding ground for black flies. The forest-clad slope is haunted by flying squirrels (Fam. Sciuridae) at night; and a considerable part of the slope is occupied by the Himalayan Zoological Park, an open air animal park, where tigers, bears, deer, leopards, Tebetan Yaks, and South American llama roam about. Domestic animals which occur in the vicinity, and which may also serve as blood source for black flies, include dogs, cats and cattle. Avian fauna in the Zoological Park includes mainly pheasants and Himalayan passerines.

STUDY OF EFFICACY OF LIGHT TRAP AS SAMPLING DEVICE FOR BLACK FLIES

Introduction

Black flies belonging to the family Simuliidae (Diptera) are positively phototropic (Williams and Davies, 1957), and many workers noticed that the light trap was an effective instrument for sampling these flies. Frost (1949) and Fox (1953) reported that black flies appeared at the trap as the individuals were stimulated to fly after they have settled for the night within the effective range of the trap. Fredeen (1961) experimented with different types of traps and conclusively proved the efficacy of light trap as the sampling device for these flies. Davies and Williams (1962), Davies et al. (1962) and Williams (1962) recorded high numbers and regularity of appearance of black flies at the light trap operated at Kincaig (Scotland).

To extend the above studies to eastern Himalayas the present work was undertaken at Darjeeling.

Method

Black flies were collected by continuous light trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights from April 1, 1968 to September 30, 1968; in 1800 trap-hours of 180 nights from April 1, 1969 to September 30, 1969; and in 1810 trap-hours of 181 nights from April 1, 1970 to September 30, 1970, with the help of the simple light trap device described in the page no.132.

Result

Black flies collected by the above method were found to consist of six major species, namely, Simulium (Eusimulium) praelargum, n.sp., S.(E) gracilis, n.sp., Simulium (Simulium) himalavense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp., and a few other minor species.

Monthwise collection data for each of the six species represented in 1968, 1969 and 1970 are given separately and in average (Table I-IV).

Table-I

Monthwise assortment of six species
of black flies in 1968

Months	<u>praelargum</u>	<u>gracilis</u>	<u>himalayense</u>	<u>griseocens</u>	<u>rufibasis</u>	<u>tenuistylum</u>	Total
April	53	23	69	7	7	9	160
May	135	68	178	8	25	85	499
June	51	25	86	113	114	53	442
July	14	9	52	79	35	6	195
August	7	4	21	43	18	12	105
September	4	2	54	52	77	43	232
TOTAL	264	131	460	302	276	208	1641

Table-II

Monthwise assortment of six species
of black flies in 1969

Months	<u>praelargum</u>	<u>gracilis</u>	<u>himalayense</u>	<u>griseocens</u>	<u>rufibasis</u>	<u>tennietrum</u>	Total
April	60	42	51	3	5	5	166
May	142	97	120	80	10	25	474
June	22	17	70	31	72	64	276
July	23	12	32	20	53	20	160
August	9	12	49	17	14	32	133
September	27	12	31	32	41	27	170
TOTAL	283	192	353	183	195	173	1379

Table-III

Monthwise assortment of six species
of black flies in 1970

Months	<u>praelargum</u>	<u>gracilis</u>	<u>himalayense</u>	<u>griseocens</u>	<u>rufibasis</u>	<u>tennistylum</u>	Total
April	260	171	316	55	142	132	1076
May	171	97	331	49	59	27	734
June	60	34	118	34	106	21	373
July	24	22	64	56	37	17	220
August	37	24	35	30	29	30	185
September	29	17	57	53	49	35	240
TOTAL	581	365	921	277	422	262	2828

Table-IV

Monthwise assortment of six species
of black flies in average (1968, 1969 and 1970)

Months	<u>praelargum</u>	<u>gracilis</u>	<u>himalayense</u>	<u>griseocens</u>	<u>rufibasis</u>	<u>tenuistylum</u>	Total
April	124.3	78.7	145.3	21.7	51.3	48.7	470.0
May	149.3	87.3	209.7	45.7	31.3	45.7	569.0
June	44.3	25.4	91.3	59.3	97.3	46.0	363.6
July	20.4	14.3	49.4	51.7	41.7	14.2	191.7
August	17.7	13.3	35.0	30.0	20.3	24.7	141.0
September	20.0	10.3	47.3	45.6	55.8	35.0	214.0
TOTAL	376.0	229.3	578.0	254.0	297.7	214.3	1949.3

Understanding of different bionomical aspects such as relative abundance, seasonal incidence and seasonal succession, sex-ratio, internal conditions of females, host preferences, nocturnal periodicity and photophilic behaviour of these species of black flies, was found possible through proper assessment of the periodic or nightwise catch.

Meteorological conditions such as atmospheric temperature, mean relative humidity, rain fall and wind velocity throughout the whole study period were recorded near the collection site. Correlation of these meteorological conditions to various bionomical aspects of black flies are provided in Tables V-VIII.

Table-V

Monthwise estimation of meteorological data taken near
Darjeeling Government College during April 1, 1968 to
September 30, 1968

Months	: Min. Tempera-		: Max. Tempera-		: Rel.Humidity		: Rainfall (mm.)		: Wind Velocity	
	: ture ('C)		: ture ('C)		: (%)		:		: (Km./Hr.)	
	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean
April	10-18	12.6	18-26	24.1	46-90	73.3	0.8- 16.0	6.2	2-7	3.2
May	11-20	16.0	20-28	23.7	67-83	74.7	1.0- 18.0	5.9	1-7	3.2
June	13-19	14.9	23-30	26.6	62-91	82.0	0.8- 58.6	17.3	1-9	2.9
July	9-15	13.1	18-29	22.9	81-99	88.9	1.6-102.0	24.7	1-3	2.1
August	15-20	17.6	22-28	24.7	85-96	90.4	0.6- 56.0	18.6	1-6	1.9
September	16-21	18.3	20-26	23.8	77-88	82.1	2.0- 69.8	10.7	1-3	1.8

Table-VI

Monthwise estimation of meteorological data taken near
Darjeeling Government College during April 1, 1969 to
September 30, 1969

Months	: Min. Tempera-		: Max. Tempera-		: Rel. Humidity		: Rainfall (mm.)		: Wind Velocity	
	: ture ('C)		: ture ('C)		: (%)				: (Km./Hr.)	
	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean
April	15-19	16.9	25-29	26.8	57-89	72.4	1.8- 11.8	6.0	1-12	3.4
May	18-23	20.9	27-30	28.9	70-95	84.3	0.8- 16.8	10.6	1- 9	2.8
June	15-19	17.5	22-29	25.6	85-96	92.8	1.8-116.6	24.6	1- 6	2.5
July	13-18	16.3	21-27	24.1	90-95	92.5	1.5- 74.7	25.1	1- 7	1.8
August	14-21	19.5	25-28	26.5	85-95	89.5	1.2- 72.0	21.1	1- 6	2.2
September	19-22	20.4	25-29	26.7	73-93	81.9	1.5-127.0	25.5	1- 9	2.1

Table-VII

Monthwise estimation of meteorological data taken near
Darjeeling Government College during April 1, 1970 to
September 30, 1970

Months	: Min. Tempera-		: Max. Tempera-		: Rel. Humidity		: Rainfall (mm.)		: Wind Velocity	
	: ture ('C)		: ture ('C)		: (%)		:		: (Km./Hr.)	
	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean
April	12-17	13.3	19-26	23.4	57-73	65.1	1.0- 11.8	5.4	1-8	2.6
May	13-15	14.3	20-26	23.2	70-94	82.8	1.5- 60.0	10.4	1-7	2.5
June	14-18	16.4	21-26	23.8	83-95	89.3	0.8-105.4	23.0	1-9	2.1
July	16-18	16.8	22-26	23.4	77-98	90.1	0.5-136.8	31.9	1-4	2.0
August	15-19	17.4	21-30	23.7	80-90	86.9	0.8- 66.6	15.3	1-4	1.8
September	15-19	17.3	21-27	25.0	81-88	84.1	0.6- 94.0	13.0	2-7	2.8

Table-VIII

Monthwise estimation of meteorological data taken near
Darjeeling Government College during the whole study period
(in average of 1968,1969 and 1970)

Months	: Min. Tempera-		: Max. Tempera-		: Rel.Humidity		: Rainfall (mm.)		: Wind Velocity	
	: ture ('C)		: ture ('C)		: (%)		:		: (Km./Hr.)	
	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean	: Range	: Mean
April	13-17	14.3	23-26	24.6	61-80	69.8	1.2- 13.2	5.9	1.3-9.0	3.1
May	14-19	17.2	24-27	25.2	71-87	80.7	1.1- 31.6	5.0	1.0-7.6	2.8
June	15-18	16.1	23-27	25.3	78-93	88.1	1.1- 93.2	22.7	1.0-8.0	2.5
July	14-16	15.4	22-25	23.4	87-93	90.4	1.2-104.5	27.2	1.0-4.6	2.0
August	16-20	18.2	23-27	25.0	86-92	89.0	0.9- 61.5	18.3	1.0-5.3	1.9
September	17-20	18.6	23-27	25.1	77-87	81.4	1.3- 96.9	17.0	1.3-6.3	2.2

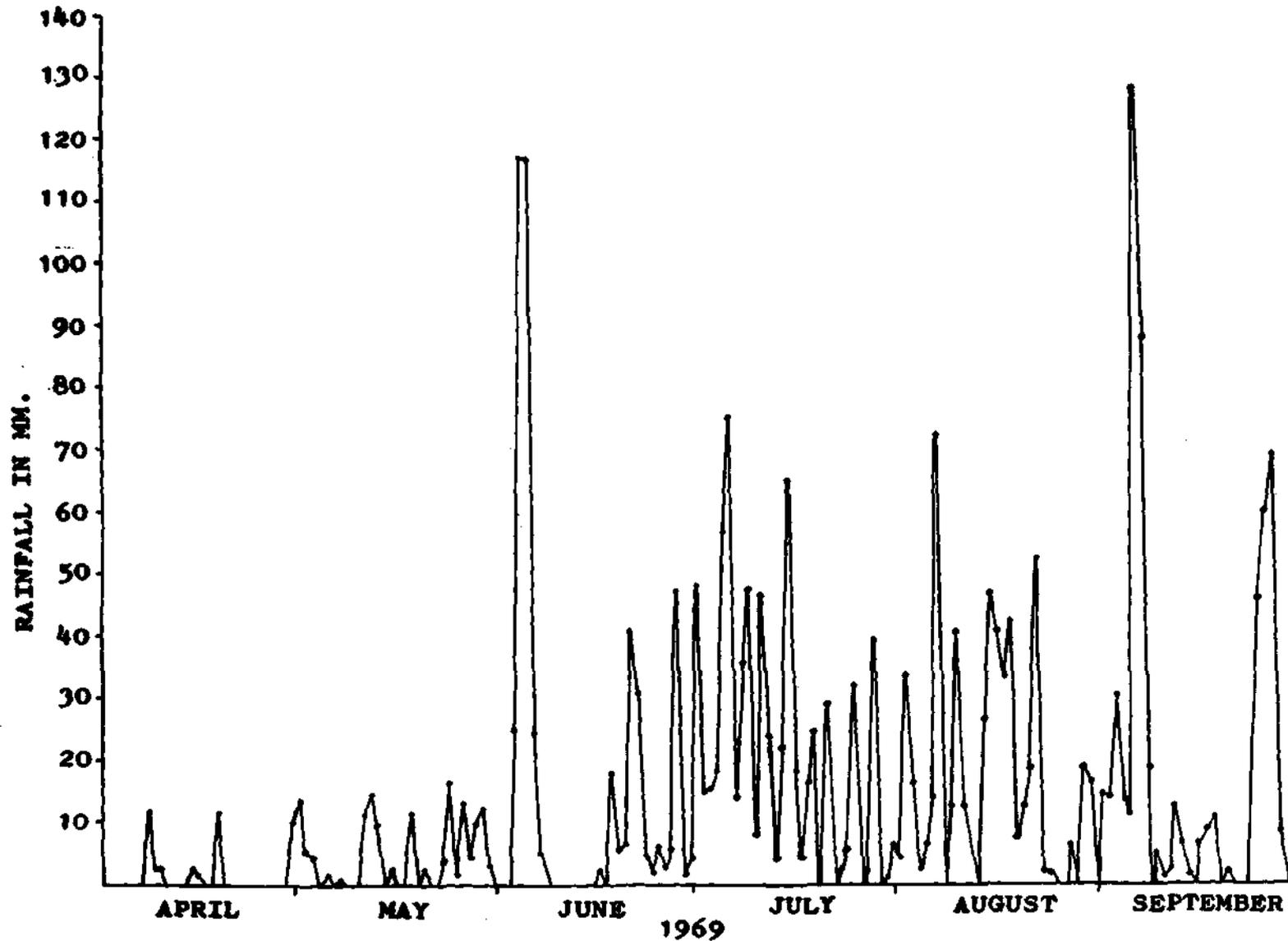


FIG.11: The rainfall in Darjeeling from April 1, 1969 to September.30,1969

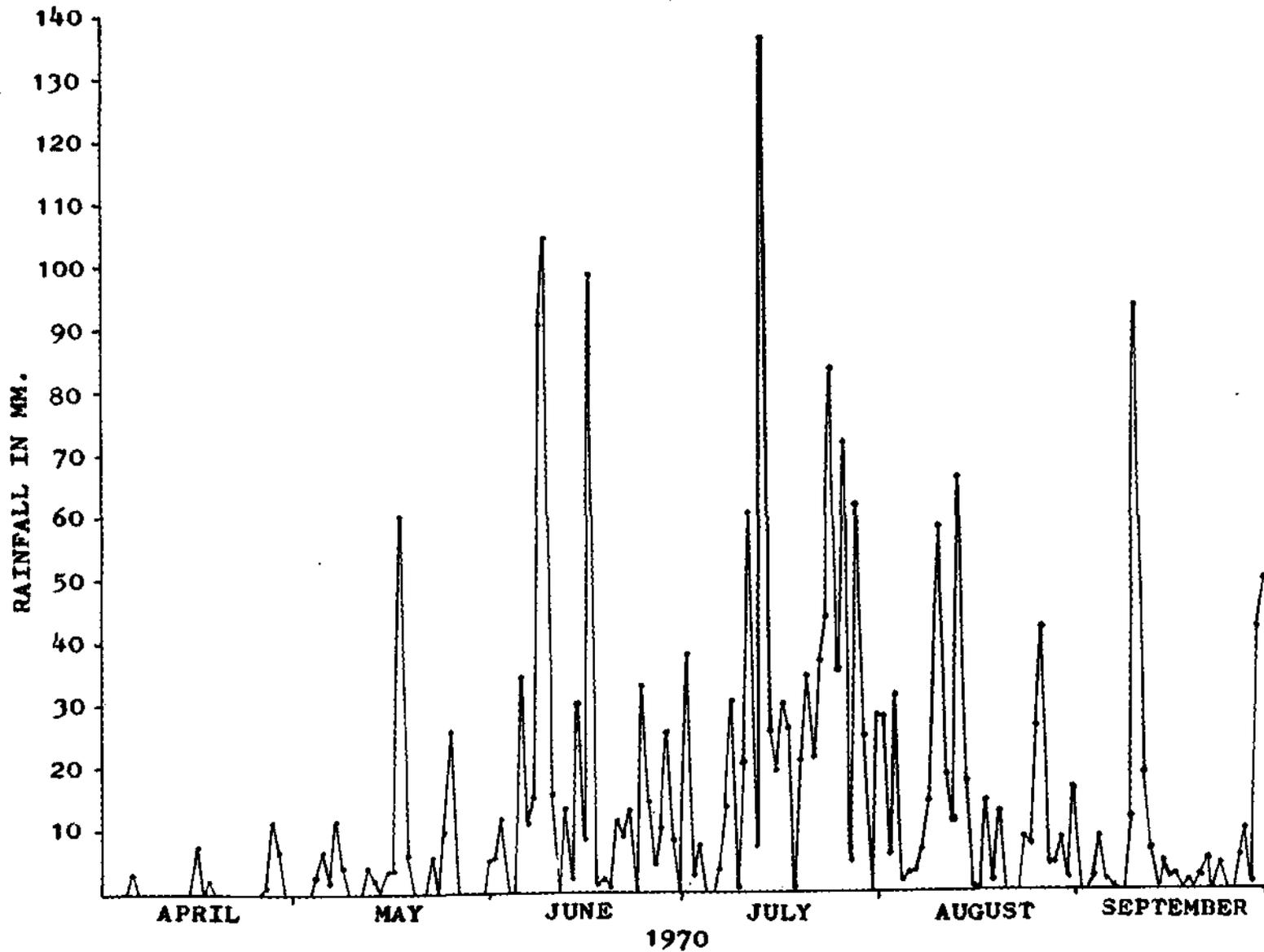


FIG.12: The rainfall in Darjeeling from April 1, 1970 to September 30, 1970

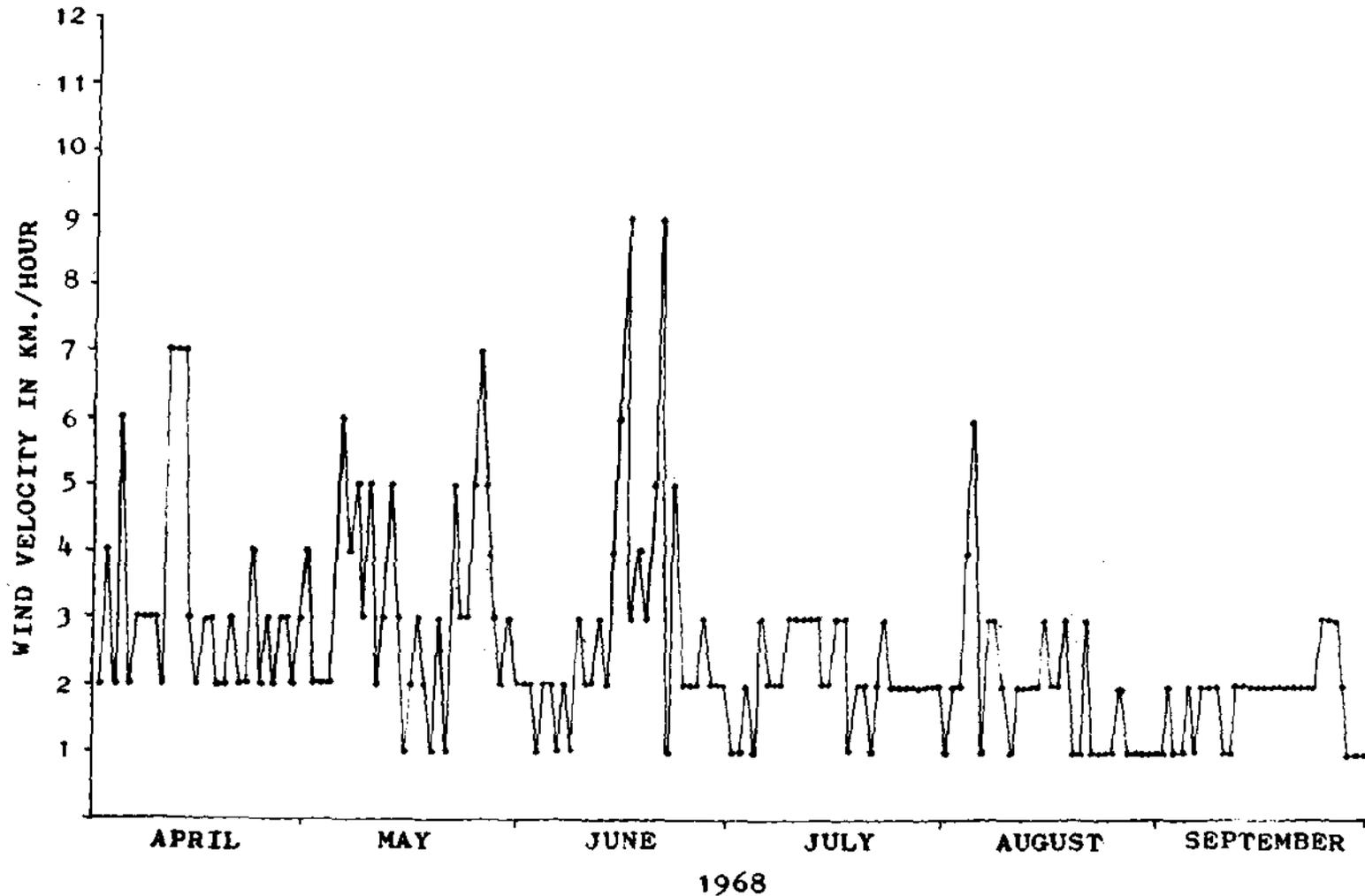


FIG.13: The wind velocity in Darjeeling from April 1 to September 30, 1968

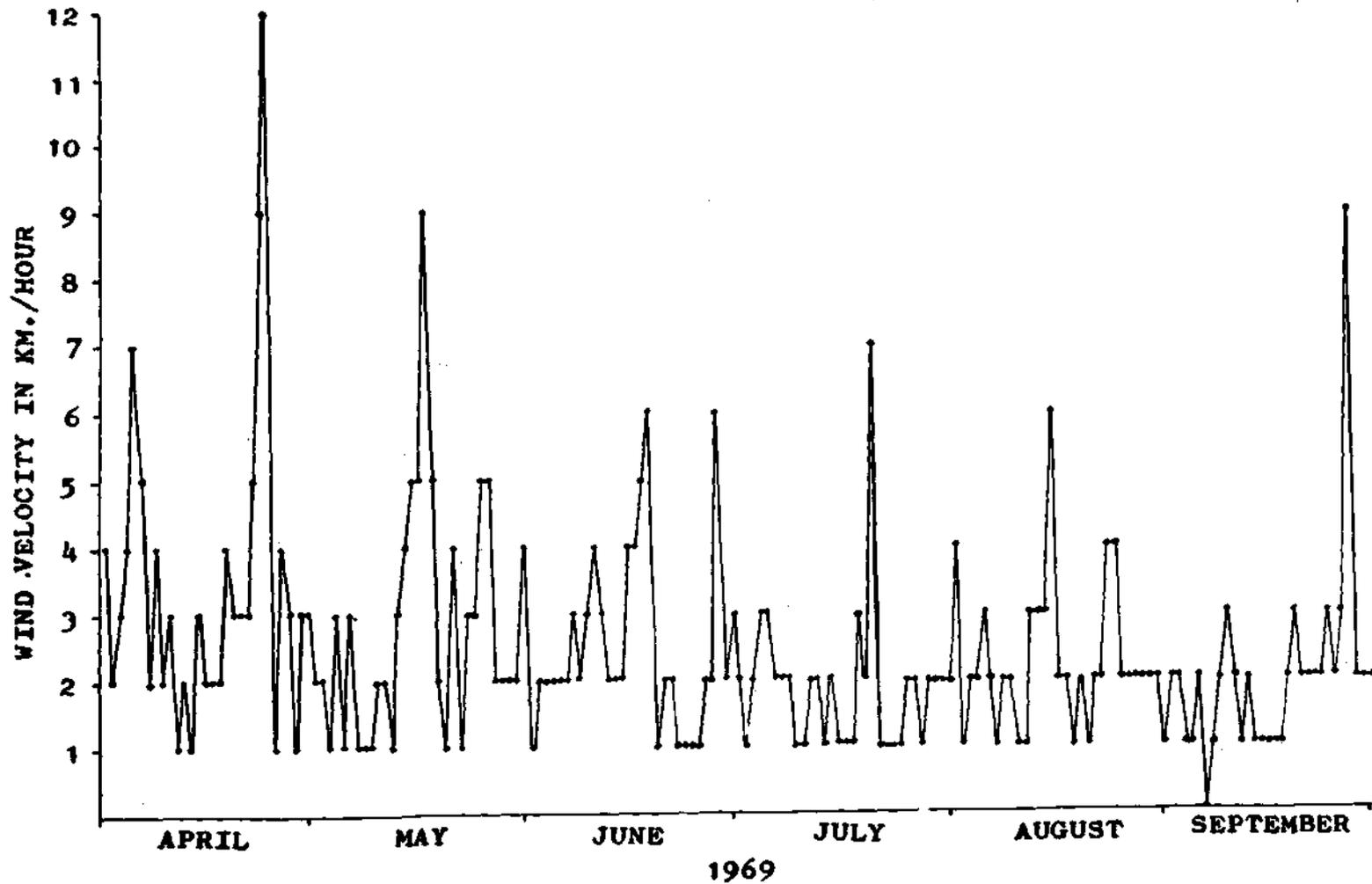


FIG.14: The wind velocity in Darjeeling from April 1 to September 30, 1969

The figures of rain fall (Figs.10-12) and wind velocity (Figs.13-15) are given here, and those of maximum and minimum temperature and mean relative humidity are given with the incidence of black flies in the following pages.

Discussion

The light trap device is expected to show more or less the same population-size picture of a given species in an area as that indicated by observations on the aquatic stages in the field, if conditions are favourable in both the situations. Working in Scotland, Williams (1939, 1961) showed beyond doubt that the light trap was a suitable sampling device for night-flying dipterans including black flies.

In the present work the total number of flies caught in 1968 was 1641; in 1969 the number was 1379; and in 1970 the number was 2828. It will be seen that the total number of black flies caught in 1970 nearly equalled the sum total for 1968 and 1969. This result probably did not only mean that the incidence of these flies in the trap was affected by some meteorological factors influencing the imagines or the spontaneous variation of the population-size of the area year to year, but it had another significance. Floods, logging and forest-fire are frequent near the breeding grounds of black flies, which might directly affect the population of these flies in Darjeeling as were also shown

by Wolfe and Peterson (1959) in Quebec. It is recalled in this context that in the late rainy season of 1968 there was extensive rain-fall and widespread land-slides in the area of investigation. This natural calamity disturbed the habitats of the black flies. The poor catch in 1968 was likely to be due to this natural calamity; and the lowest incidence of 1969 was mainly due to the preparation of suitable beds for the early aquatic stages of black flies, the adults of which flourished in 1970.

It was also found that in 1968, as well as in 1969 the black flies were most abundant in the months of May and June; whereas in 1970 the maximum availability of the insect was in April, though the insects were also abundant in May and June of that year. The above observation perhaps reflected the overlapping in life-cycles of at least some species.

The higher incidence of the insects in September than in August in all these three years was perhaps due to the occurrence of second generation of some species of black flies. It will be recalled in this context that Davies and Williams (1962) were of opinion that the light trap was expected to provide some information regarding successive generations of black flies as indicated by their incidence pattern. In the same way, the sex-ratio of a species, behavioural difference and their periodicity at night might be explained in the light of a trap device, though according to these workers some species of black

flies might not respond to the light trap during darkness in spite of their abundance.

In course of the analysis of trap data recorded in Scotland, Williams (1962) emphasised the importance of both preceding and current weather conditions. In the present investigation the optimum flying activity of black flies was recorded in the temperature between 14°C and 25°C , in the relative humidity of 65%-80%, in little or no rain fall and almost in calm wind. In Central Asia, Rubtzov (1939) noted that the flying activity was normal at temperatures between 10°C and 29°C with the optimum at about 20°C - 23°C and at 75%-90% humidity while in Canada, Davies (1952) observed more flies on the wings at temperatures between 15.5°C and 26.6°C with the optimum range from 24°C to 26.6°C , in moist air, i.e., at 70%-90% relative humidity and at wind velocity below 24 Km./hour. Working in Quebec, Wolfe and Peterson (1960) observed that the flight activity appeared to depend on light intensity if the temperature was not below 7.2°C , the wind velocity not above 3.2 Km./hour and the relative humidity not below 50%. Williams (1962) at the time of his extensive light trapping in Scotland observed the highest activity to occur on nights with high minimum temperature, with falling pressure and with quite heavy rain or no rain at all.

In the light of the present investigation it is clear that the incidence of black flies taken in the light trap was

the consequence of the interplay of a good many factors, viz., ecological factors, meteorological factors and other probable factors of physiological nature.

Summary

The efficacy of the light trap used in capturing black flies is discussed with reference to the incidence of these insects in relation to the environmental conditions. The total number of black flies captured was 1641 in 1968, 1379 in 1969 and 2528 in 1970 with a grand total of 5848 during April to September of each year. In 1968 and 1969 the maximum availability of these flies was registered in May and June, while in 1970 the period of maximum availability was in April in addition to May and June. It is considered that the extensive rain-fall and wide spread land-slides of 1968 had a direct impact on the incidence of the black flies in and around Darjeeling. The optimum flying activity of these flies was recorded in the temperature between 14°C and 25°C , in the mean relative humidity of 65%-80%, in little or no rain fall, and almost in calm wind.

RELATIVE ABUNDANCE

Introduction

The earlier works of Zahar (1951), Williams and Davies (1957), and Davies and Williams (1962) have shown that both field collection and light trapping are essential steps for assessing the relative abundance of various photophilic insects like black flies (Simuliidae:Diptera). According to these workers there is a remarkable variation in the incidence of each species of black flies in every month on the basis of species-population of a particular area. In the present study attempt has been made to determine the relative abundance of different species of black flies from the annual picture of appearance of these insects taken in light trap in Darjeeling.

Method

Black flies were collected by continuous light trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights from April 1, 1968 to September 30, 1968; in 1800 trap-hours of 180 nights from April 1, 1969 to

September 30, 1969; and in 1810 trap-hours of 181 nights from April 1, 1970 to September 30, 1970, with the help of a simple light trap device described in page no.132.

Result

Black flies collected by the above method were found to consist of six major species, namely Simulium (Eusimulium) praelargum n.sp., S.(E.) gracilis n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum n.sp., and also a few other minor species.

The total numbers of black flies captured in each of the three years were 1641 in 1968, 1379 in 1969 and 2828 in 1970 with a grand total of 5848 during the whole study period. The total numbers of each of the six major species of black flies in each of three years, their percentage occurrence and their average are shown in Table IX.

Table-IX

Total numbers of specimens of six species of black flies, their percentage occurrence for 1968, 1969 and 1970 and their average

Species	: Total no. of specimens :				% occurrence			
	: 1968:	1969:	1970:	Average:	1968 :	1969 :	1970 :	Average
<u>praelargum</u>	264	283	581	376.0	16.08	20.52	20.55	19.29
<u>gracilis</u>	131	192	365	229.3	7.98	13.92	12.91	11.76
<u>himalavense</u>	460	353	921	578.0	28.05	25.60	32.58	29.66
<u>griseocens</u>	302	183	277	254.0	18.40	13.27	9.79	13.03
<u>rufibasis</u>	276	195	422	297.7	16.82	14.15	14.92	15.27
<u>tenuistylum</u>	208	173	262	214.3	12.67	12.54	9.25	10.99

Thus, according to their decreasing abundance these six species of black flies may be arranged in the following three groups for each of the three years (Tables X - XIII)

Table-X

Relative abundance of six species of black flies in 1968

Group A:	Dominant (over 25%)	
	<u>himalavense</u>	28.05%
Group B:	Abundant (between 15% and 25%)	
	<u>griseocens</u>	18.4%
	<u>rufibasis</u>	16.82%
	<u>praelargum</u>	16.08%
Group C:	Sparse (between 15% and 5%)	
	<u>tenuistylum</u>	12.67%
	<u>gracilis</u>	7.98%

Table-XI

Relative abundance of six species of
black flies in 1969

Group A: Dominant (over 25%)		
	<u>himalayense</u>	25.6%
Group B: Abundant (between 15% and 25%)		
	<u>praelargum</u>	20.52%
Group C: Sparse (between 5% and 15%)		
	<u>rufibasis</u>	14.15%
	<u>gracilis</u>	13.92%
	<u>grisescens</u>	13.27%
	<u>tenuistylum</u>	12.54%

Table-XII

Relative abundance of six species of
black flies in 1970

Group A: Dominant (over 25%)		
	<u>himalayense</u>	32.58%
Group B: Abundant (between 15% and 25%)		
	<u>praelargum</u>	20.55%
Group C: Sparse (between 5% and 15%)		
	<u>rufibasis</u>	14.92%
	<u>gracilis</u>	12.91%
	<u>grisescens</u>	9.79%
	<u>tenuistylum</u>	9.25%

Table-XIII

Relative abundance of six species of black flies in average (1968, 1969 and 1970)

Group A: Dominant (over 25%)		
	<u>himalayense</u>	29.66%
Group B: Abundant (between 15% and 25%)		
	<u>praelargum</u>	19.29%
	<u>rufibasis</u>	15.27%
Group C: Sparse (between 5% and 15%)		
	<u>griseescens</u>	13.03%
	<u>gracilis</u>	11.76%
	<u>tenuistylum</u>	10.99%

In addition to these six species of black flies mentioned in the above tables there were a few minor species including S.(E.) purii n.sp., S.(E.) nemorivagum n.sp., S.(S.) nigrifacies n.sp., S.(S.) dentatum Puri (1932b), S.(G.) darjeelingense n.sp. and a few other unnamed species. These were rarely found in their natural habitats and they hardly visited the light trap device. These species might be placed in the additional 'rare' group since their populations appeared to be less than 5% in and around the township of Darjeeling.

Discussion

The percentage occurrence of a given species for the three consecutive years showed (on) remarkable variation, and himalayense

was the only dominant species in the area while praelargum was the abundant species. In average, rufibasis could also be placed in the abundant group, though both in 1969 and 1970 this species found no place in that group. All the other three species, namely, grisescens, gracilis and tenuistylum were found to be sparsely distributed in Darjeeling. It is interesting to note that grisescens scored the highest percentage of incidence in 1968 among the species of the abundant group. This was possibly due to the natural calamity in the middle of the study period of 1968 when there was heavy rain fall and extensive land-slides which apparently disturbed the breeding centres of other species of the group more than the breeding centres of this species.

The incidence of the species of the 'rare' group in the light trap was very poor since their populations were meagre. According to Davies and Williams (1962) certain species of black flies like Prosimulium hirtipes Fries were inactive in the darkness. If certain species of black flies in Darjeeling also are inactive at night, their appearance in the light trap could only be a matter of chance.

Summary

The relative abundance of six species of black flies, namely, S.(E.) praelargum n.sp., S.(E.) gracilis n.sp., S.(S.) himalayense Puri, S.(S.) grisescens Brunetti, S.(S.) rufibasis

Brunetti and S.(G.) tenuistylum n.sp. was studied with the help of light trap data for the three consecutive years, i.e., 1968, 1969 and 1970. These six species were arranged in sequence with himalavense as the dominant species, praelargum and rufibasis as the abundant species, and grisescens, gracilis and tenuistylum as the sparsely distributed species of the area. In addition, comments are made on some species of the 'rare' group of the area of investigation from their low incidence in the trap.

SEASONAL INCIDENCE AND SUCCESSION

Introduction

A striking feature in the bionomics of black flies belonging to the family Simuliidae is that there is a remarkable variation of incidence among the species in every month as revealed by field studies undertaken by earlier workers (see Smart, 1936; Rubtzov, 1939; Stukolkina, 1939; Davies, D.M., 1950; Davies, L., 1951; Peterson and Wolfe, 1956; Davies and Syme, 1958; Wolfe and Peterson, 1959; and Ussova, 1961). Davies and Williams (1962) working with the Rothamsted light trap also came across this type of variation. There is no report on the seasonal distribution and succession of the species of black flies in India. In the present chapter effort has been made to study the incidence of black flies in Darjeeling by continuous light trapping.

Method

Black flies were collected by continuous light trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights from April 1, 1968 to September 30, 1968; in 1800 trap-hours of 180 nights from April 1, 1969 to September 30, 1969; and in 1810 trap-hours of 181 nights from

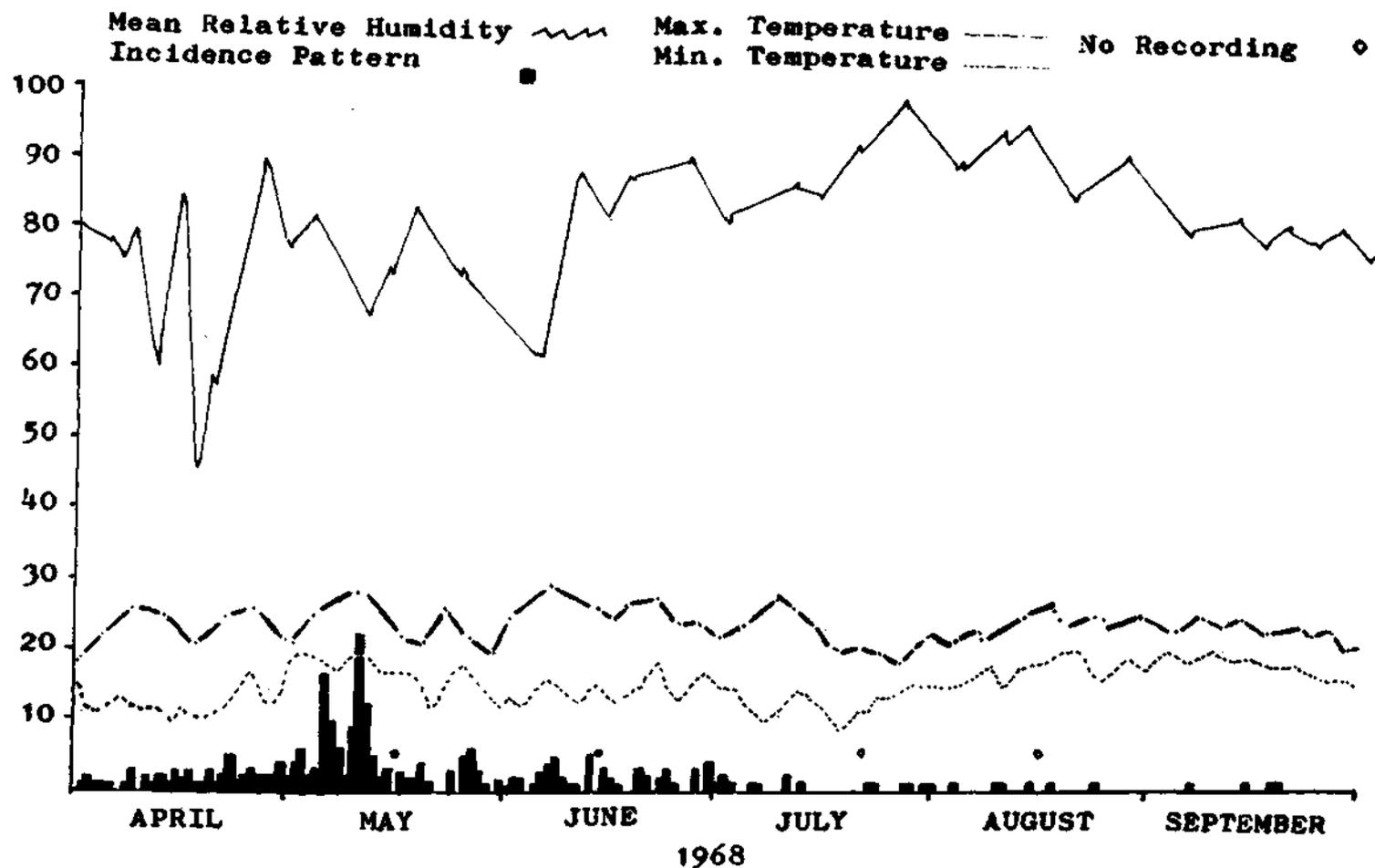


FIG.16: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) praelargum, n.sp. on the abscissa at Darjeeling Government College collecting station from April - September 1968. Figures on the ordinate indicate the quantity

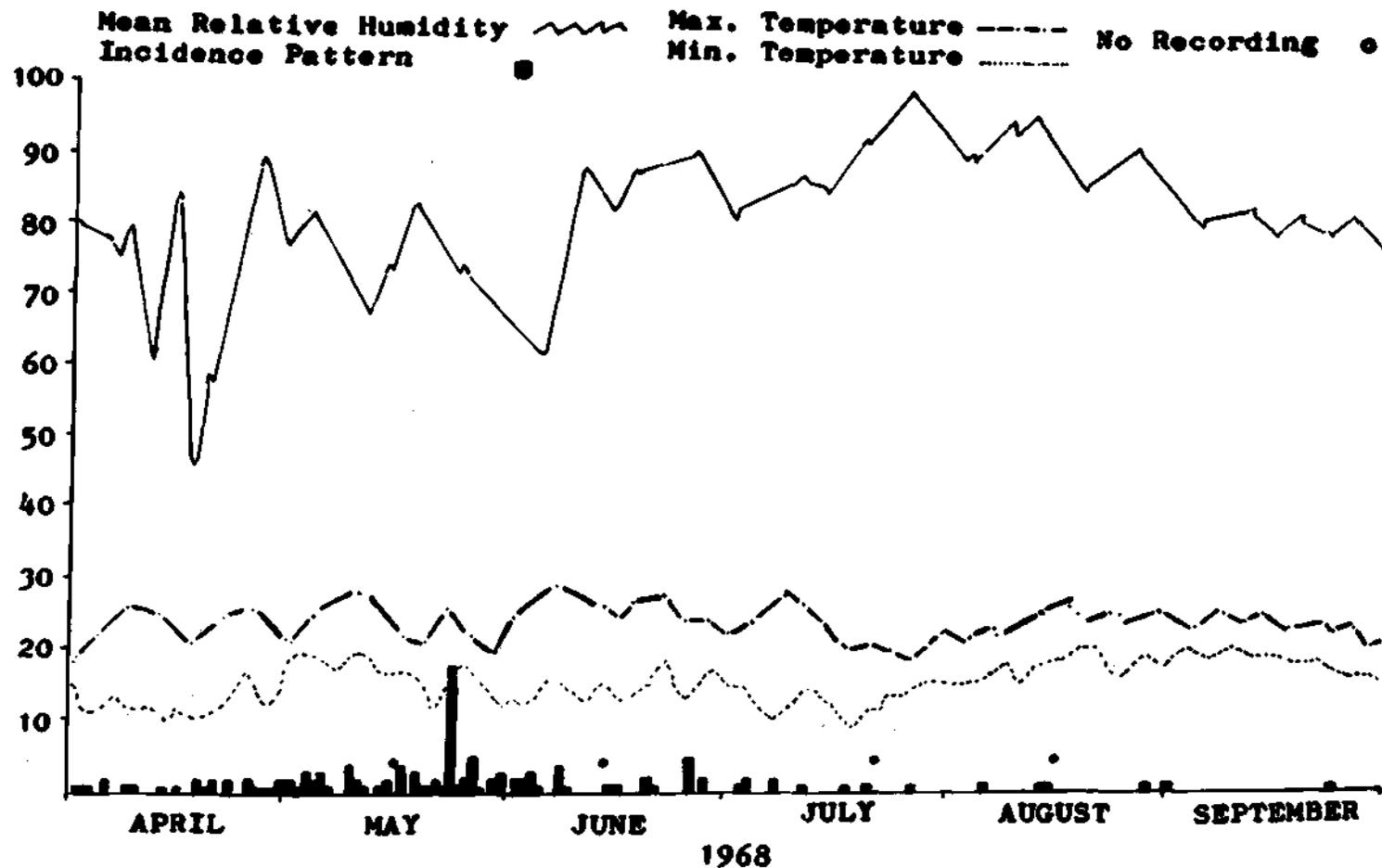


FIG.17: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) gracilis, n.sp. on the abscissa at Darjeeling Government College collecting station from April - September 1968. Figures on the ordinate indicate the quantity

April 1, 1970 to September 30, 1970. The simple light trap device described in page no.132 was used for the purpose.

Observations

Black flies collected by the above method were found to consist of six major species, namely Simulium (Eusimulium) praelargum n.sp., S.(E.) gracilis n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) griseescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostylbia) tenuistylum n.sp., and a few rare species, namely, S.(E.) puri n.sp., S.(E.) nemorivagum n.sp., S.(G.) darjeelingense n.sp., S.(S.) nigrifacies n.sp., S.(S.) dentatum Puri (1932b) and a few other unnamed species. The present study concerns six major species only.

(a) Seasonal incidence in 1968

The peak of praelargum (22 specimens in a single night) was encountered on 11.5.68, the month of May being the period of its maximum availability. There was a rise in incidence with 16 specimens on 6.5.68 before the principal peak. After this peak the population gradually went down. The average nightly turn-up of the species in May was 4.5 specimens and that of the species in the whole period was 1.47 specimens.

The peak abundance of gracilis was observed in the last part of May, 18 specimens being trapped on 24.5.68 and this was

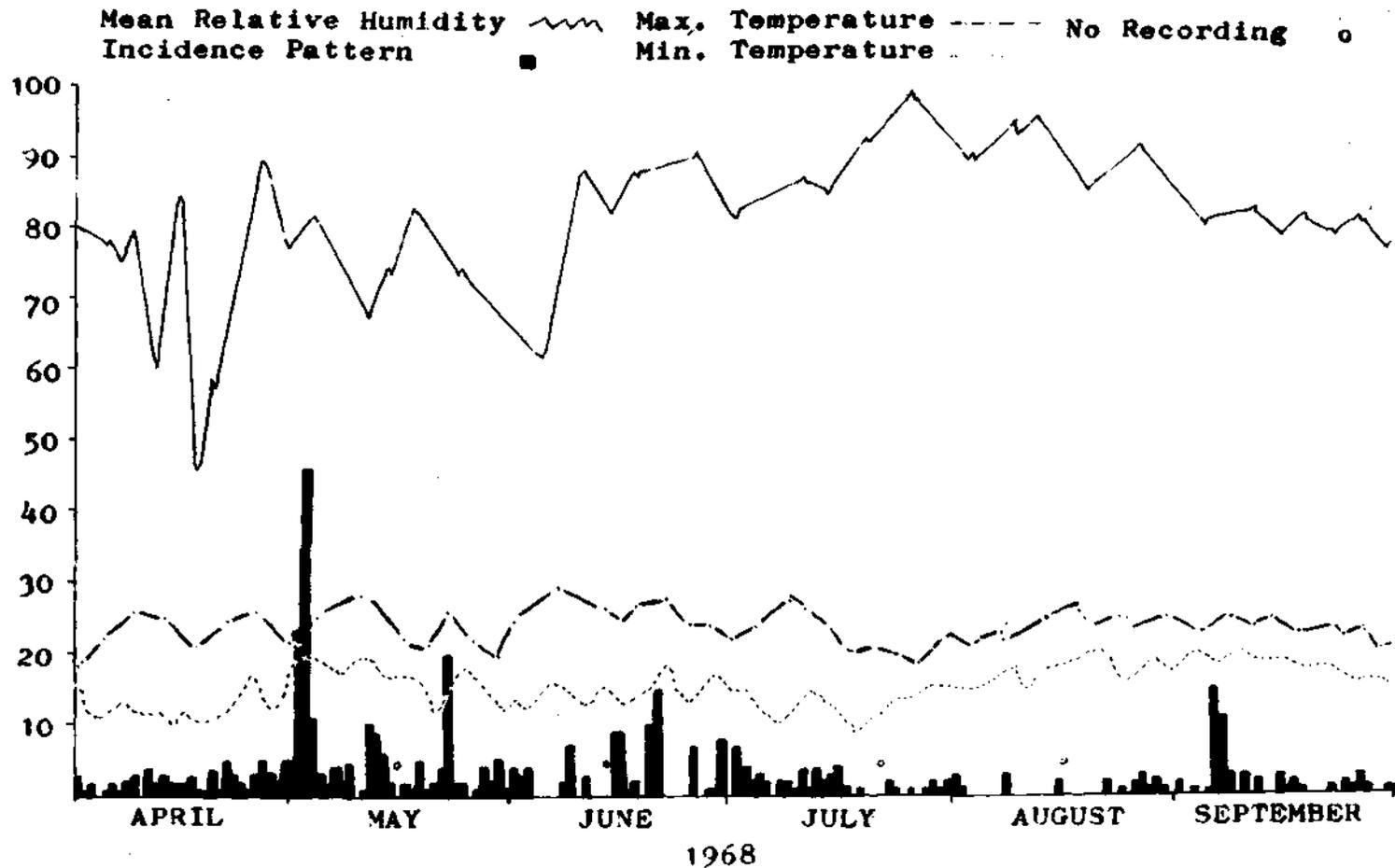


FIG.18: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) himalayense Puri (1932) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1968. Figures on the ordinate indicate quantity

the maximum record for any single night. On the whole, the population showed an abrupt rise and also an abrupt decline. In September, only 2 specimens were recorded for the whole month. The highly average catch in May was 2.26 specimens and that in the whole period only 0.73 specimens.

The peak abundance of himalayense was observed on 3.5.68. with trapping of 46 specimens, and the population tended to decline gradually with a number of rise and fall upto July. In August the incidence was significantly poor but in September the population represented a small sub-ordinate peak with 15 specimens on 6.9.68. The average nightly turn up of the species in May was 5.93 specimens; that in June 2.87 specimens; that in September 1.8 specimens; and that in the whole period 2.57 specimens.

S.(S.) grisescens was practically unrepresented both in April and May but this species attained its peak almost suddenly with 38 specimens on 16.6.68. The decline was very gradual with rise and fall in the following months upto August and in September there was a sub-ordinate peak with 17 specimens recorded on 11.9.68. The nightly average catch of the species was 3.9 specimens in June; 2.63 specimens in July; 1.43 specimens in August; 1.73 specimens in September; and 1.68 specimens in the whole period.

The peak abundance of rufibasis was observed in the middle of June, 48 specimens being trapped on 13.6.68., and this

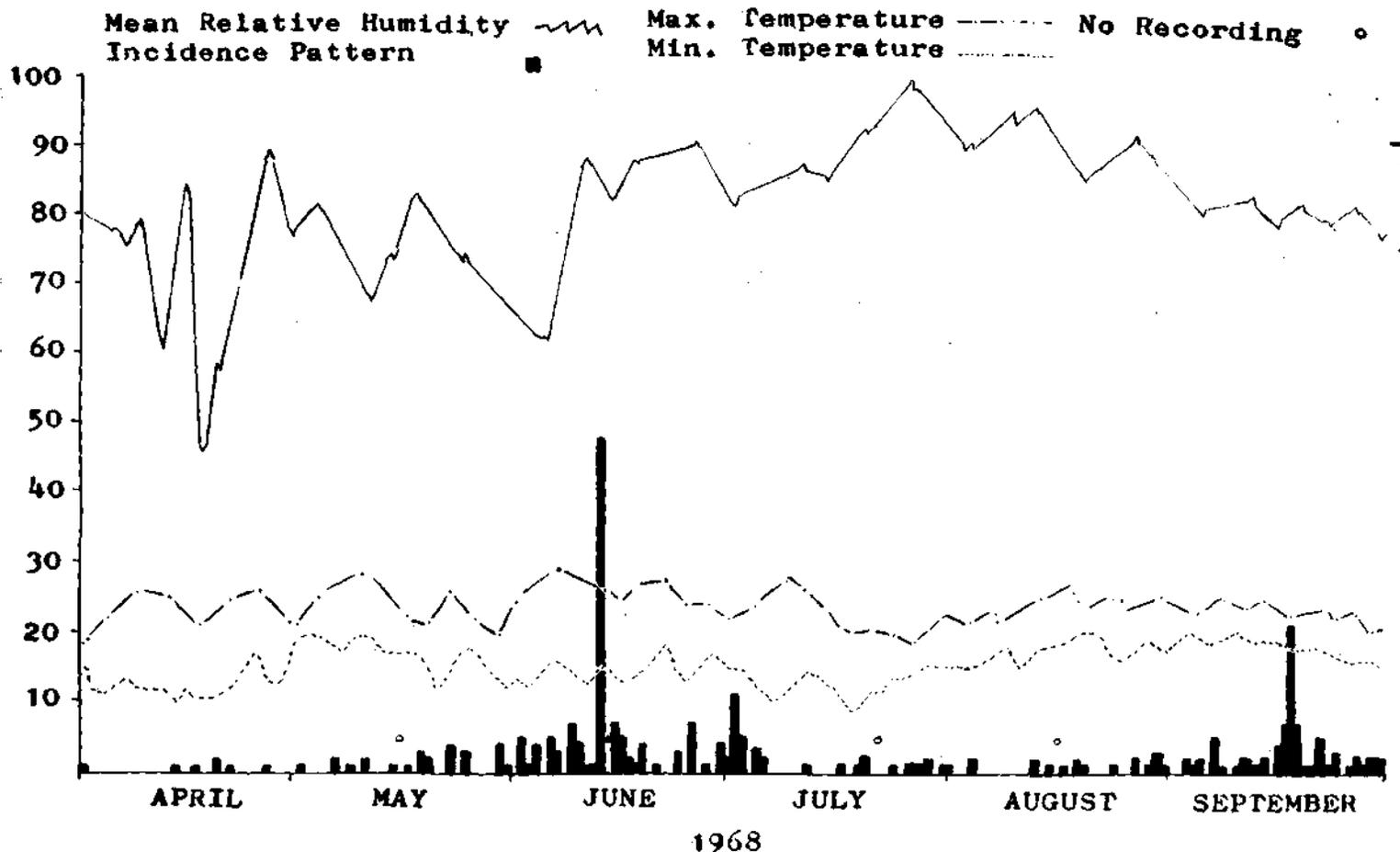


FIG.20: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) rufibasis Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1968. Figures on the ordinate indicate quantity

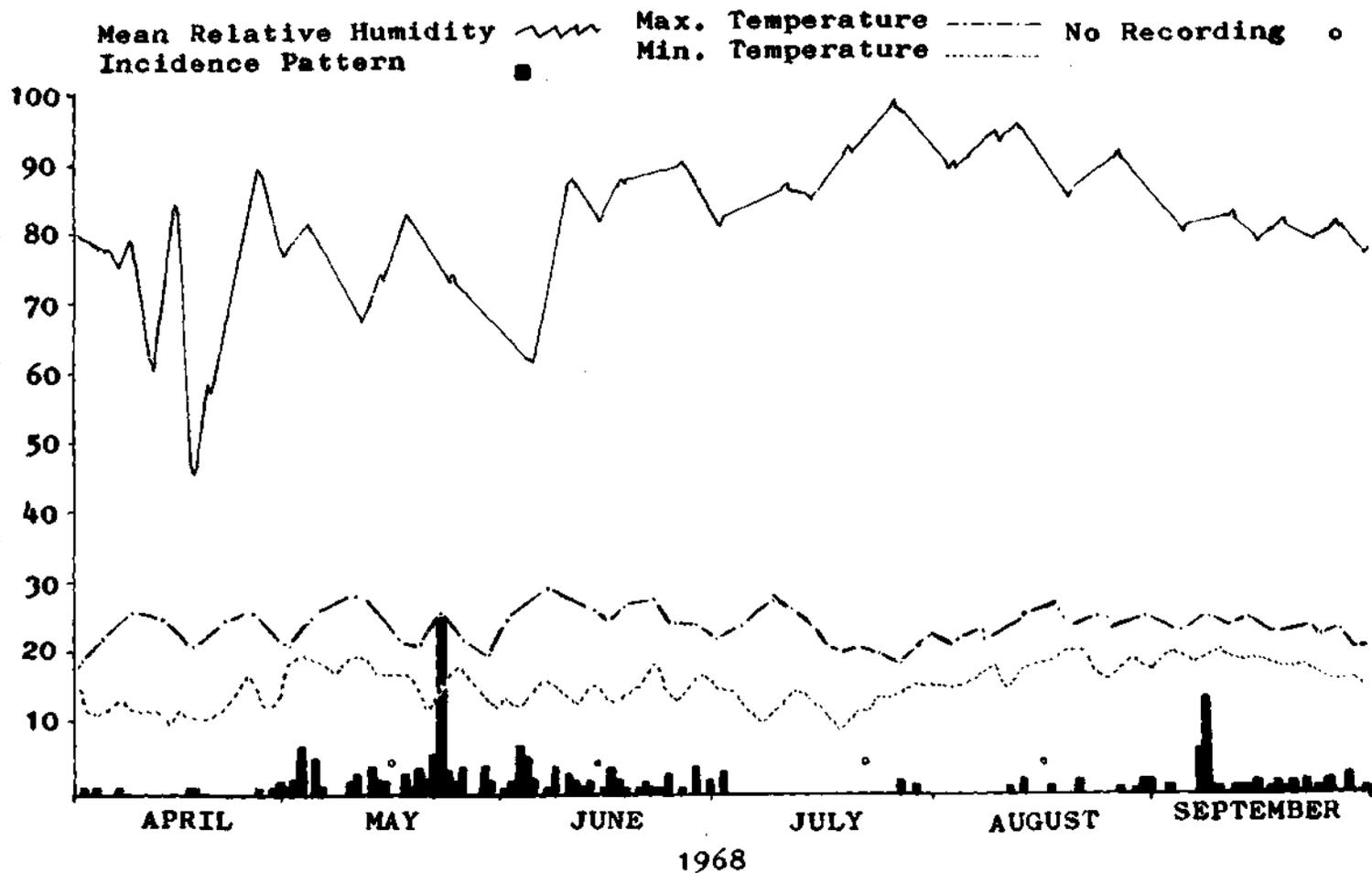


FIG.21: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Gomphostilbia) tenuistylum, n.sp. on the abscissa at Darjeeling Government College collecting Station from April - September, 1968. Figures on the ordinate indicate quantity

was the maximum for any single night. The rise and fall to and from the peak was very abrupt. The population showed a subordinate peak in September, with 21 specimens on 18.9.68. Here also the rise and fall to and from the peak was very abrupt. The average nightly turn-up of the species was 3.9 in June; 2.65 in September; and 1.54 specimens in the whole period.

The peak abundance of tenuistylum was shown in the last part of May, with 25 specimens recorded on 23.5.68. The population began to wane steadily upto the end of June and increased to a certain extent in September with a sub-ordinate peak with 14 specimens on 8.9.68. This species was practically unrepresented in April, July and August with only 9, 6 and 12 specimens respectively. The average nightly turn-up of the species was 2.87 specimens in May; that in June 1.83 specimens; that in September 1.43 specimens and that in the whole period 1.16 specimens.

The above incidence patterns of the six species of black flies of the study area and within the study period are shown along with the patterns of the existing relative humidity and atmospheric temperature in Figs.16-21.

(b) Seasonal incidence in 1969

, S.(E.) praelargum attained its peak in the middle of May with 28 specimens trapped on 14.5.69., this being the maximum for any single night. The rise in the incidence was very steady

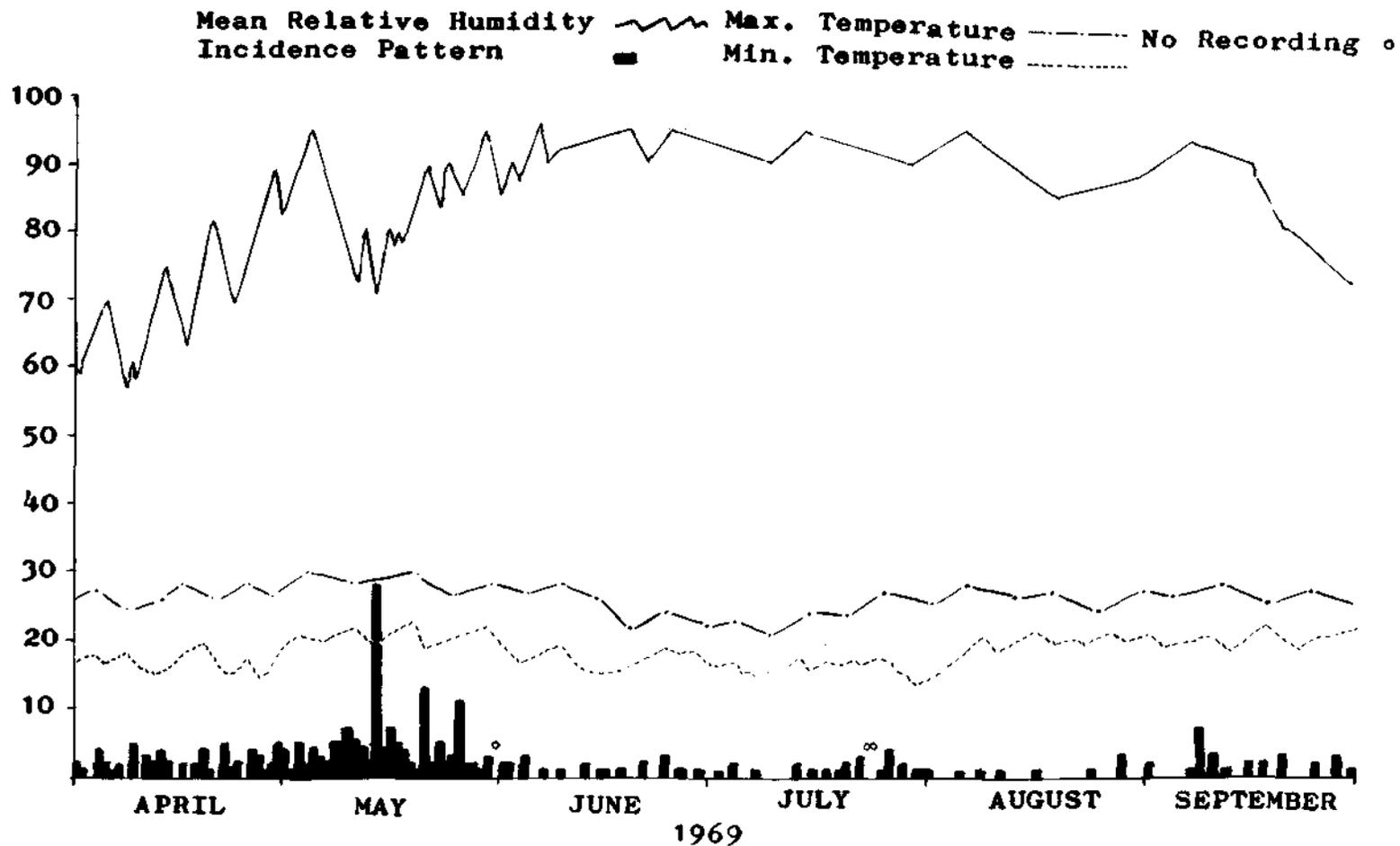


FIG.22: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) praelargum, n.sp. on the abscissa, at Darjeeling Government College collecting station from April - September 1969. Figures on the ordinate indicate the quantity

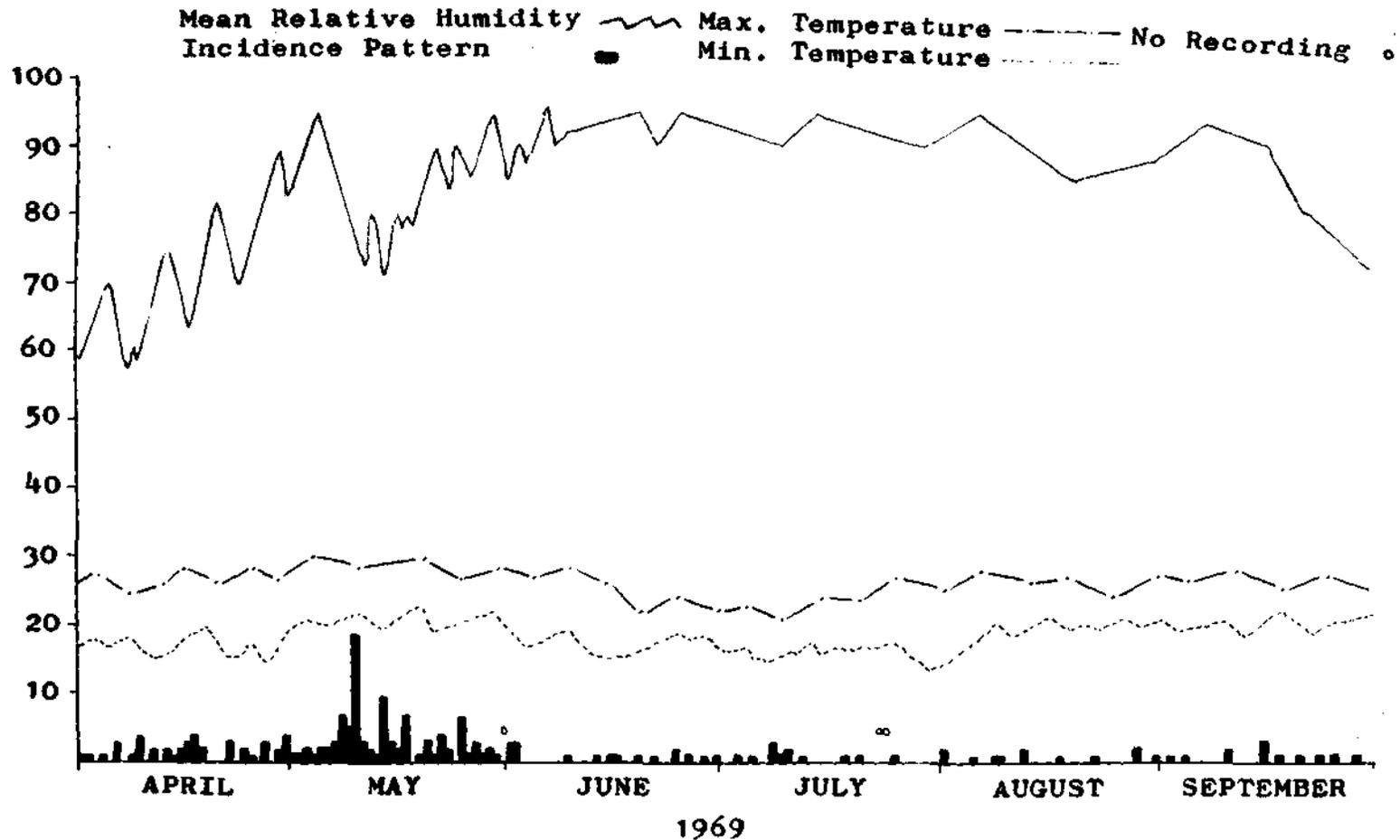


FIG.23: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) gracilis, n.sp. on the abscissa, at Darjeeling Government College collecting station from April - September 1969. Figures on the ordinate indicate the quantity

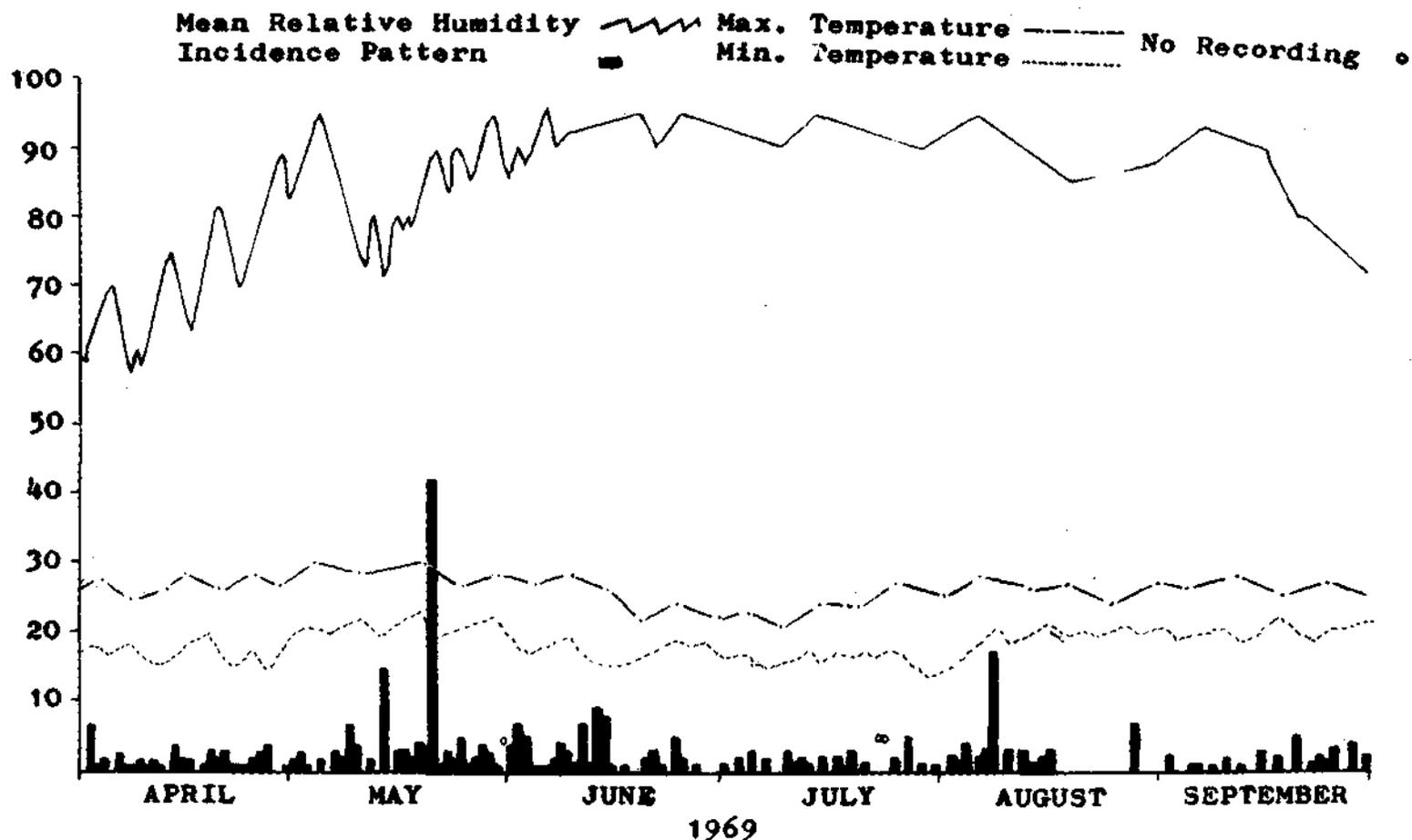


FIG.24: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) himalayense Puri (1932) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1969. Figures on the ordinate indicate quantity

from the first part of April, and after the principal peak the population began to decline almost abruptly with a little rise and fall. In August the incidence was very poor, and in September a little rise was noticed. The average nightly turn-up of the species was 2 specimens in April; 4.73 in May; 0.9 in September; and 1.57 specimens in the whole period.

The peak abundance of gracilis was observed on 10.5.69 with trapping of 19 specimens. The peak was attained almost suddenly, and after that the trend fell down with the end of May. The incidence of the following months was very poor. The nightly average catch in April was 1.4 specimens, in May 3.23 specimens and in the whole period 1.07 specimens.

The peak abundance of himalayense was observed in the last part of May, with 42 specimens on 21.5.69. The trend was shown from April and the incidence following the month of its peak abundance was maintained almost constantly. In August, a subordinate peak was experienced on 8.8.69, with 17 specimens. The nightly average turn-up was 1.7 specimens in April; 4 in May; 2.33 in June; 1.11 in July; 1.6 in August; 1.03 in September; and 1.97 in the whole period.

S.(S.) grisescens was practically unrepresented in April with only 3 specimens for the whole month. The species attained its peak with 31 specimens recorded on 26.5.69., this being the maximum for any single night. The peak was attained almost

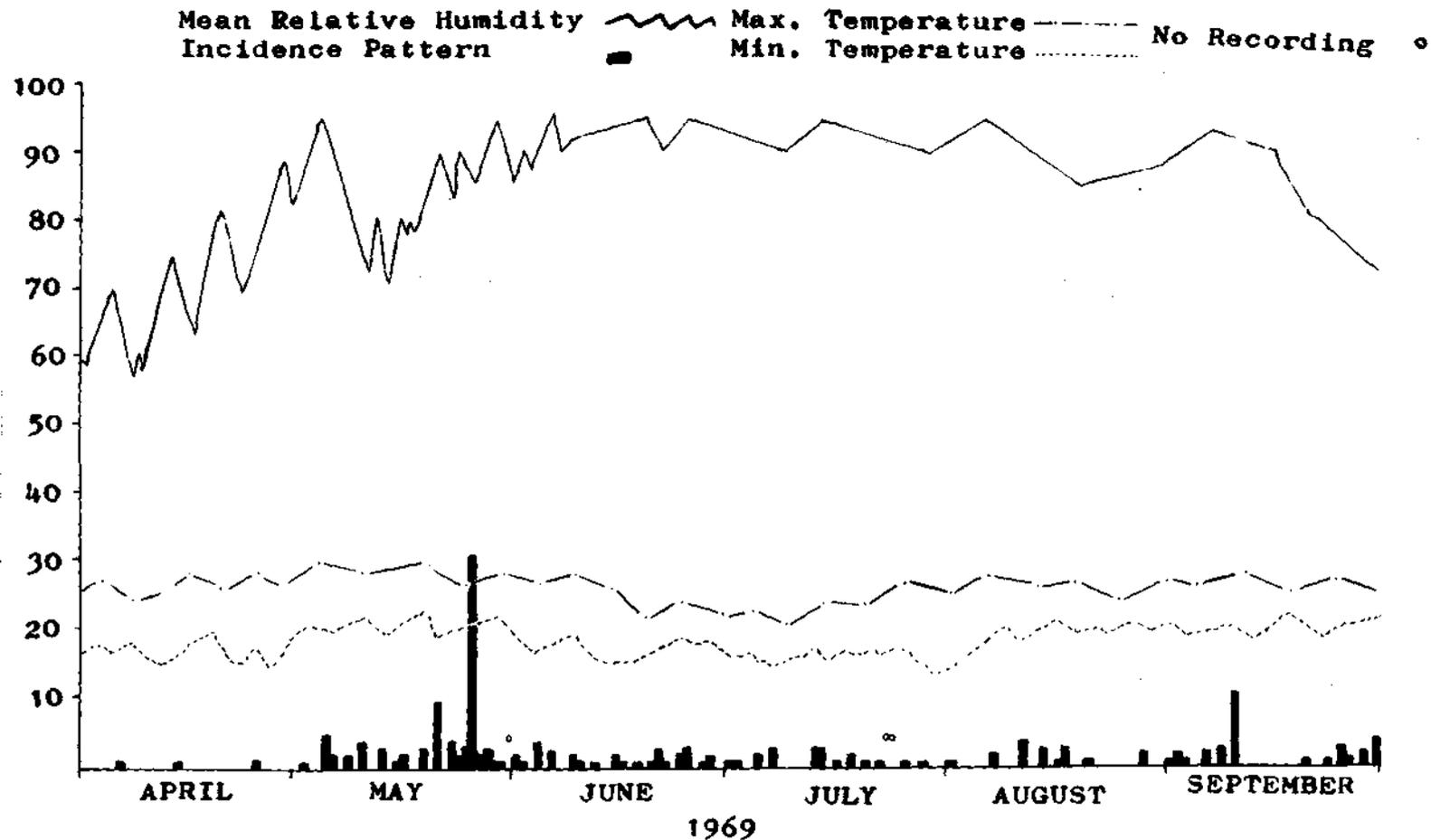


FIG.25: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) grisescens Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1969. Figures on the ordinate indicate quantity

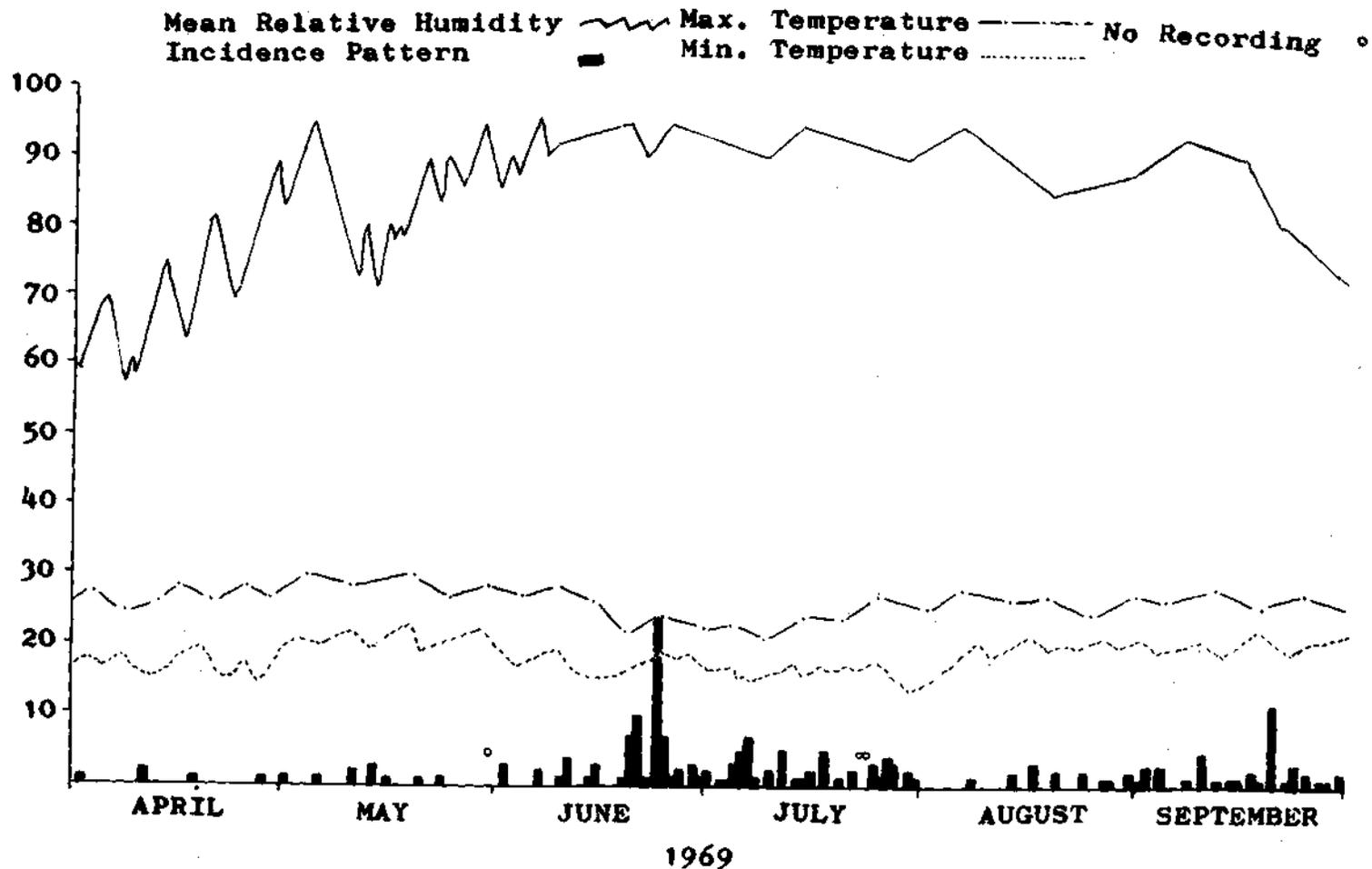


FIG.26: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) rufibasis Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1969. Figures on the ordinate indicate quantity

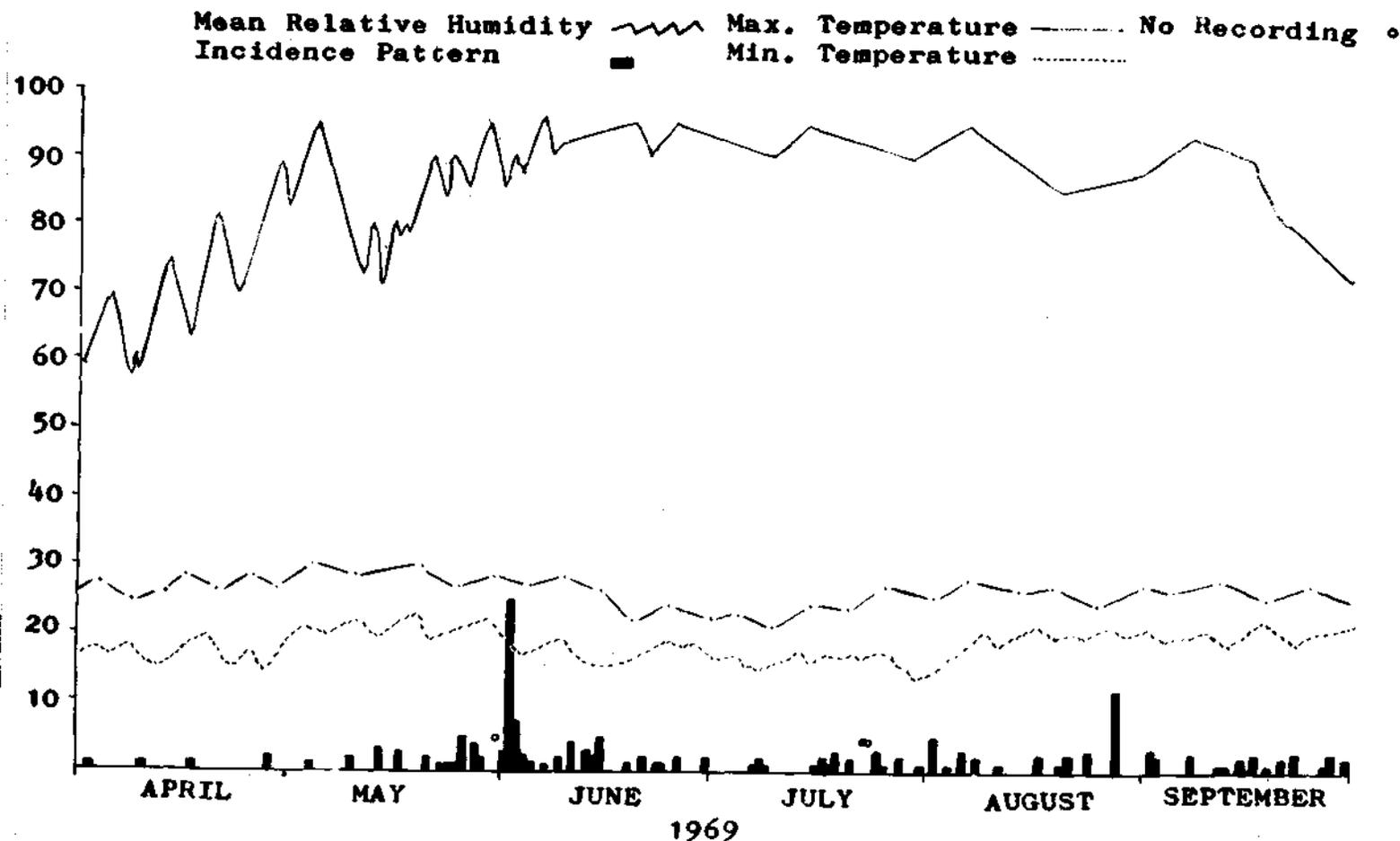


FIG.27: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Gomphostilbia) tenuistylum, n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September, 1969. Figures on the ordinate indicate quantity

abruptly, and subsequently the incidence was uniform but poor. There was, however, a small sub-ordinate peak with only 11 specimens on 10.9.69. The average nightly turn-up of the species was 2.66 specimens in May; 1.03 specimens in June; 0.69 in July; 0.55 in August; 1.07 in September; and 1.02 specimens for the whole period.

The peak abundance of rufibasis was seen in the last part of June with trapping of 24 specimens on 24.6.69. The peak was attained very abruptly, the catch-rate of the species being very poor both in April and May, and the population declined almost steadily. In September, the population showed a sub-ordinate peak with 12 specimens on 20.9.69. The average catch-rate per night was 2.4 specimens in June; 1.83 in July; 0.45 in August; 1.37 in September; and 1.08 in the whole period.

S.(G.) tenuistylum was practically unrepresented in April, with trapping of only 5 specimens on the whole. The peak was attained abruptly on 2.6.69, with 25 specimens representing the maximum for any single night, the catch-rate for May being very poor. In the succeeding period the population also showed an abrupt decline, though in August a sub-ordinate peak, with 12 specimens recorded on 28.8.69, was observed. The nightly average turn-up of the species was 0.83 specimens in May; 2.13 in June; 0.7 in July; 1.03 in August; 0.9 in September; and 0.96 specimens for the whole period.

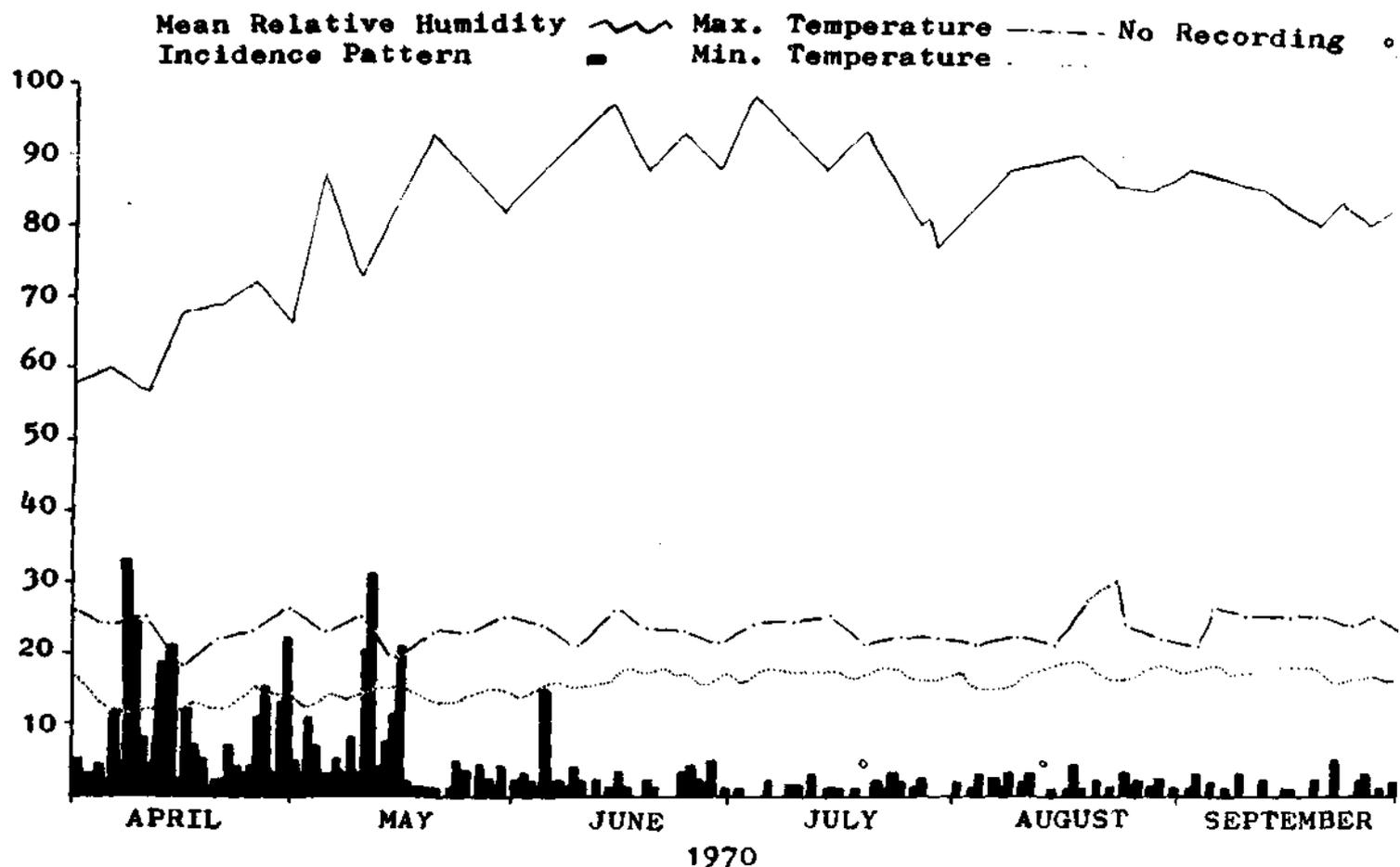


FIG.28: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) praelargum, n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September 1970. Figures on the ordinate indicate the quantity

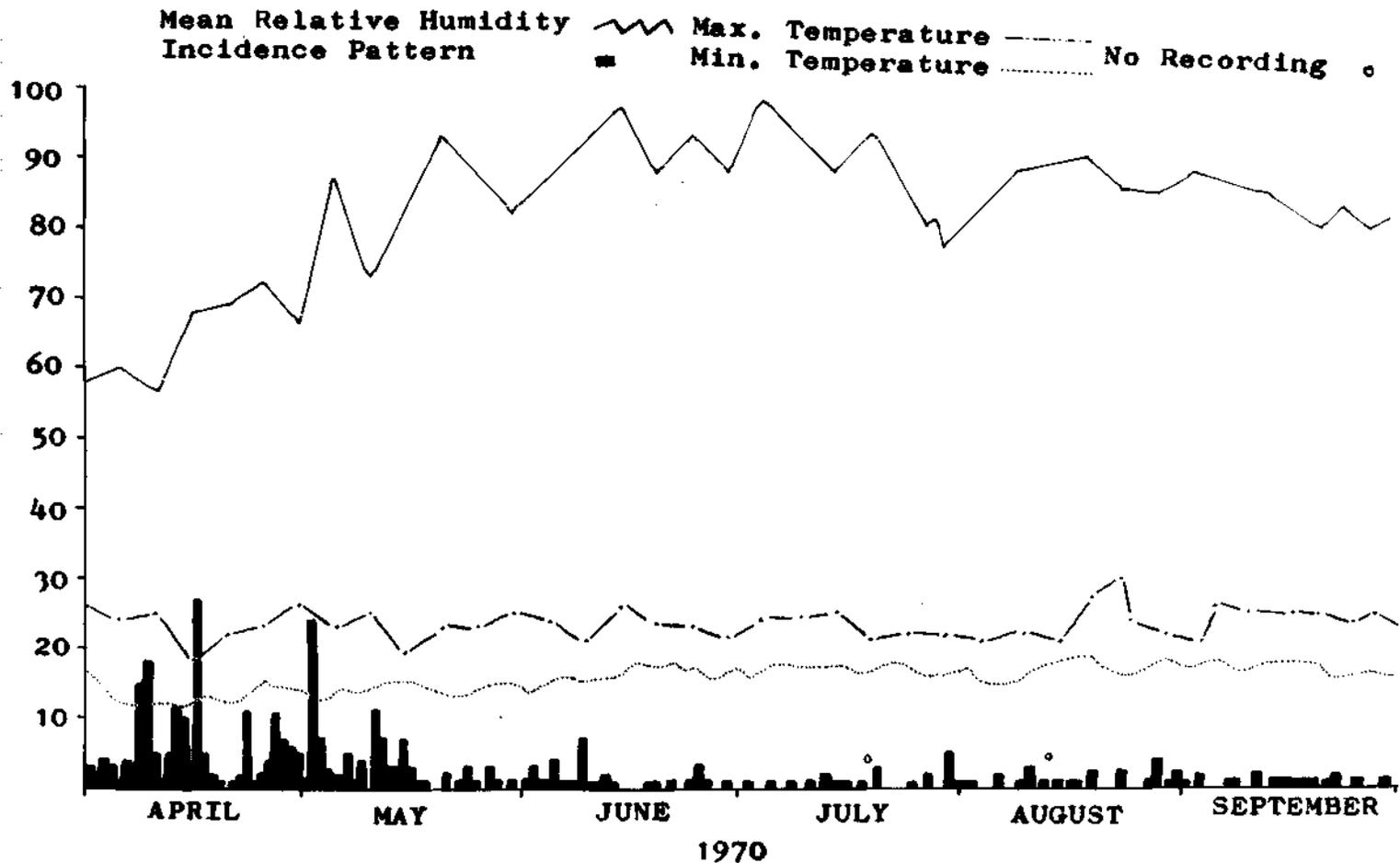


FIG.29: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) gracilis n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September 1970. Figures on the ordinate indicate the quantity

The above incidence patterns of the six species of black flies of the study area and within the study period are illustrated along with the patterns of the existing relative humidity and atmospheric temperature in the Figs. 22-27.

(c) Seasonal incidence in 1970

The peak abundance of praelargum was shown on 8.4.70, with the trapping of 33 specimens, which represented the maximum for any single night. The population, through a number of rise and fall, began to decline by the middle of June. The last rise (recorded on 5.6.70) with 15 specimens only, was seen a little after the last part of May. The average nightly turn-up of the species was 8.67 specimens in April; 5.52 in May; 2 in June; 1.23 in August; 0.8 in July; 0.97 in September; and 3.21 in the whole period.

S.(E.) gracilis showed a similar trend of incidence pattern as shown by the former species, attaining its principal peak with 27 specimens recorded on 16.4.70., and a further rise with 24 specimens recorded on 2.5.70., following a short decline. The incidence in July, August and September was very poor. The nightly average catch of the species was 5.7 specimens in April; 3.13 specimens in May; 1.13 in June; as compared with 2.02 specimens for the whole period.

S.(S.) himalayense attained its peak in the middle of May, with 60 specimens recorded on 16.5.70, being the maximum for

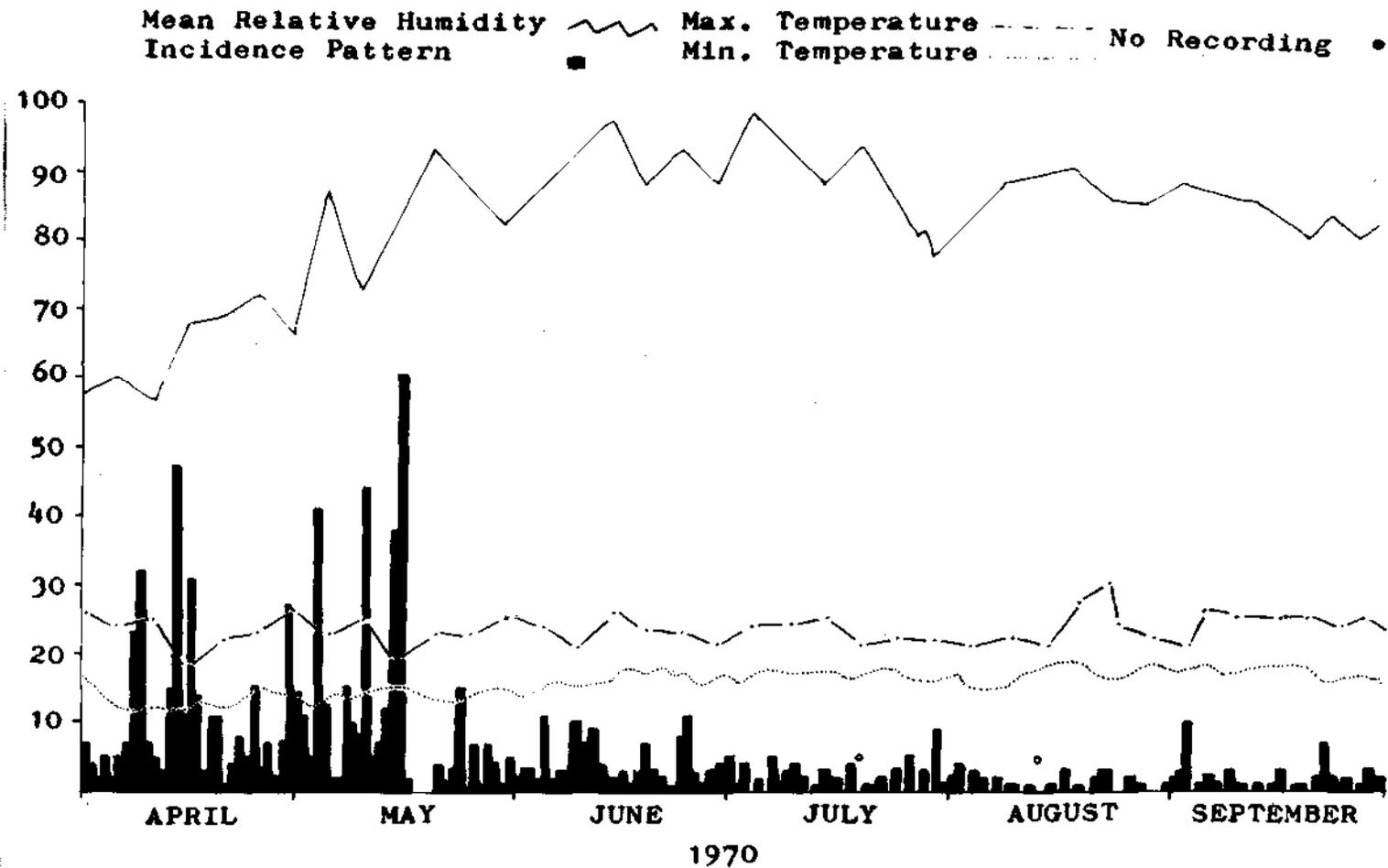


FIG.30: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) himalayense Puri (1932) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1970. Figures on the ordinate indicate quantity

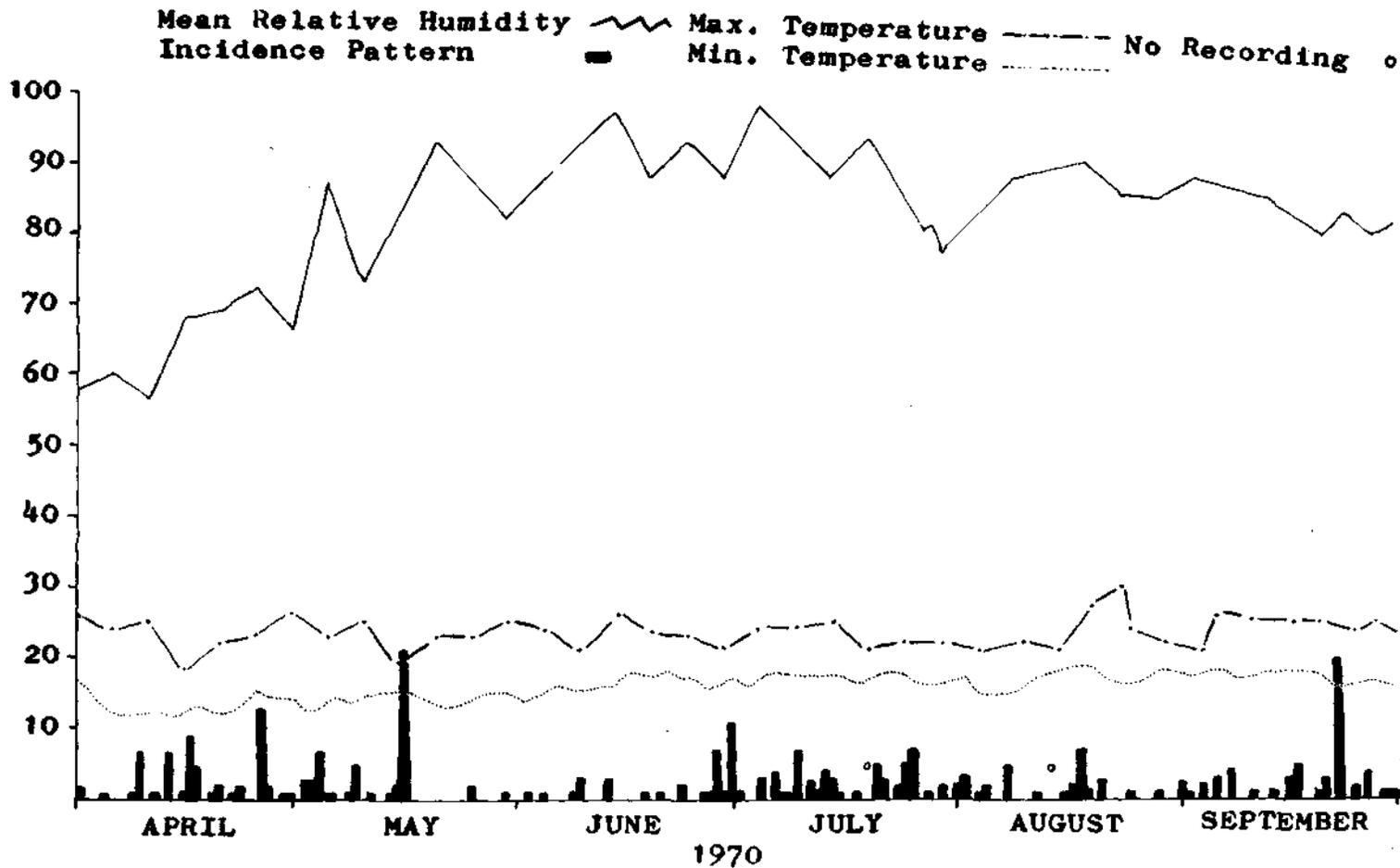


FIG.31: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) griseocens Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1970. Figures on the ordinate indicate quantity

any single night. This peak was attained through a number of rise and fall in incidence, from the beginning of April, and after this peak, the population went down abruptly. In September, however, there was a very small sub-ordinate peak, with 12 specimens on 3.9.70., this being the maximum for any single night of the month. The average nightly catch of the species was 10.53 specimens in April; 10.7 in May; 3.93 in June; 2.13 in July; 1.17 in August; 1.23 in September; in comparison with 5.09 for the whole period.

The population of griseus attained its peak on 16.5.70, with 21 specimens. In the preceding period the incidence was gradual, but irregular. In the succeeding period the population fell down abruptly after the principal peak, and it rose again from the last part of June, and on 22.9.70, a sub-ordinate peak was encountered. The nightly average turn-up of the species was 1.83 specimens in April; 1.63 in May; 1.13 in June; 1.87 in July; 1 in August; 1.77 in September; and 1.53 for the whole period.

The peak of rufibasis was observed in the middle of June, with 26 specimens recorded on 19.6.70. The incidence in April was very high with a number of rise and fall, and it was maintained upto the middle of May. The principal peak was attained almost abruptly. The incidence of the following months was almost constant with a little rise in September, wherein two sub-ordinate peaks - one on 3.9.70, with 11 specimens, and the other

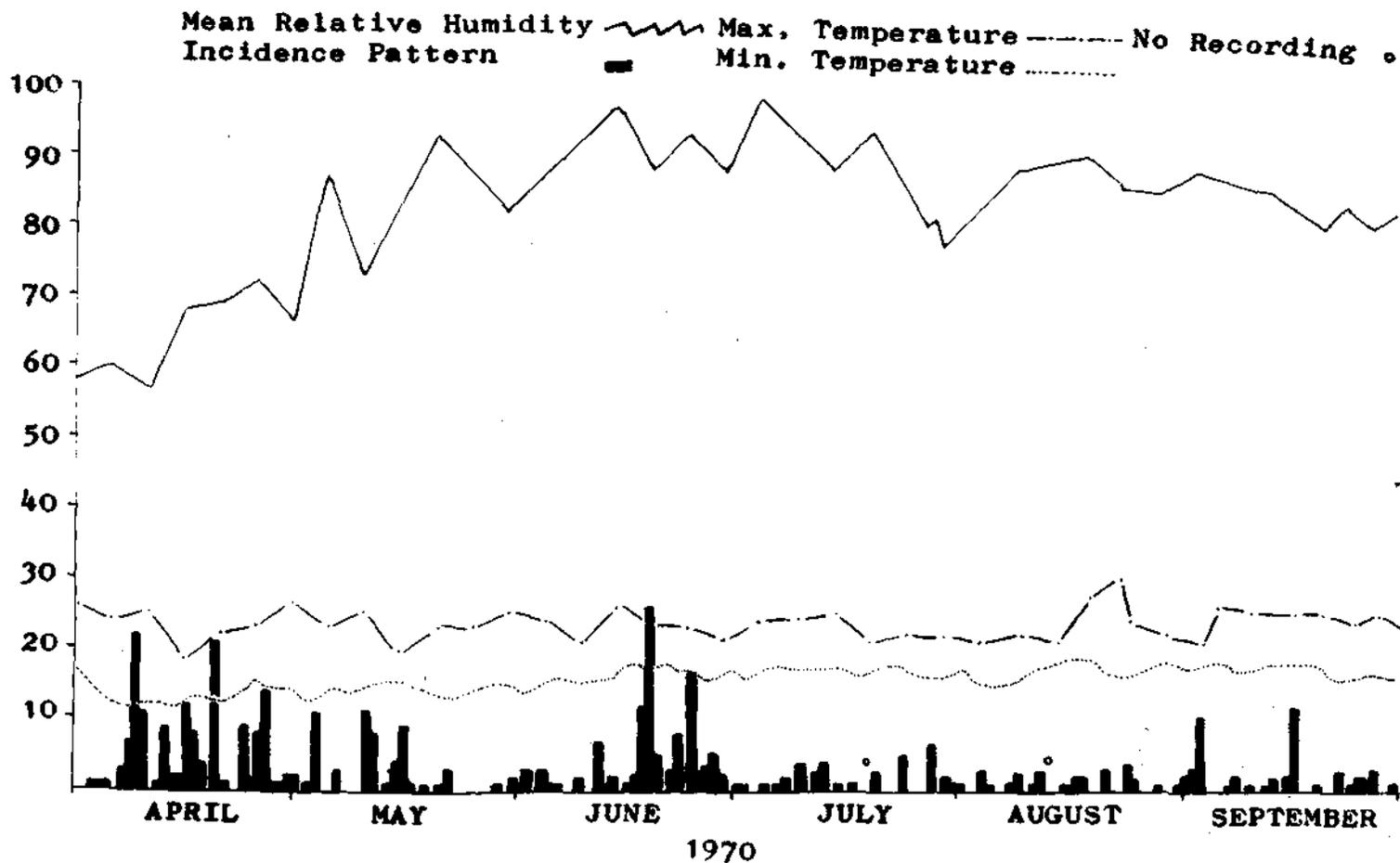


FIG.32: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) rufibasis Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September, 1970. Figures on the ordinate indicate quantity

through the following months. In the preceding period there

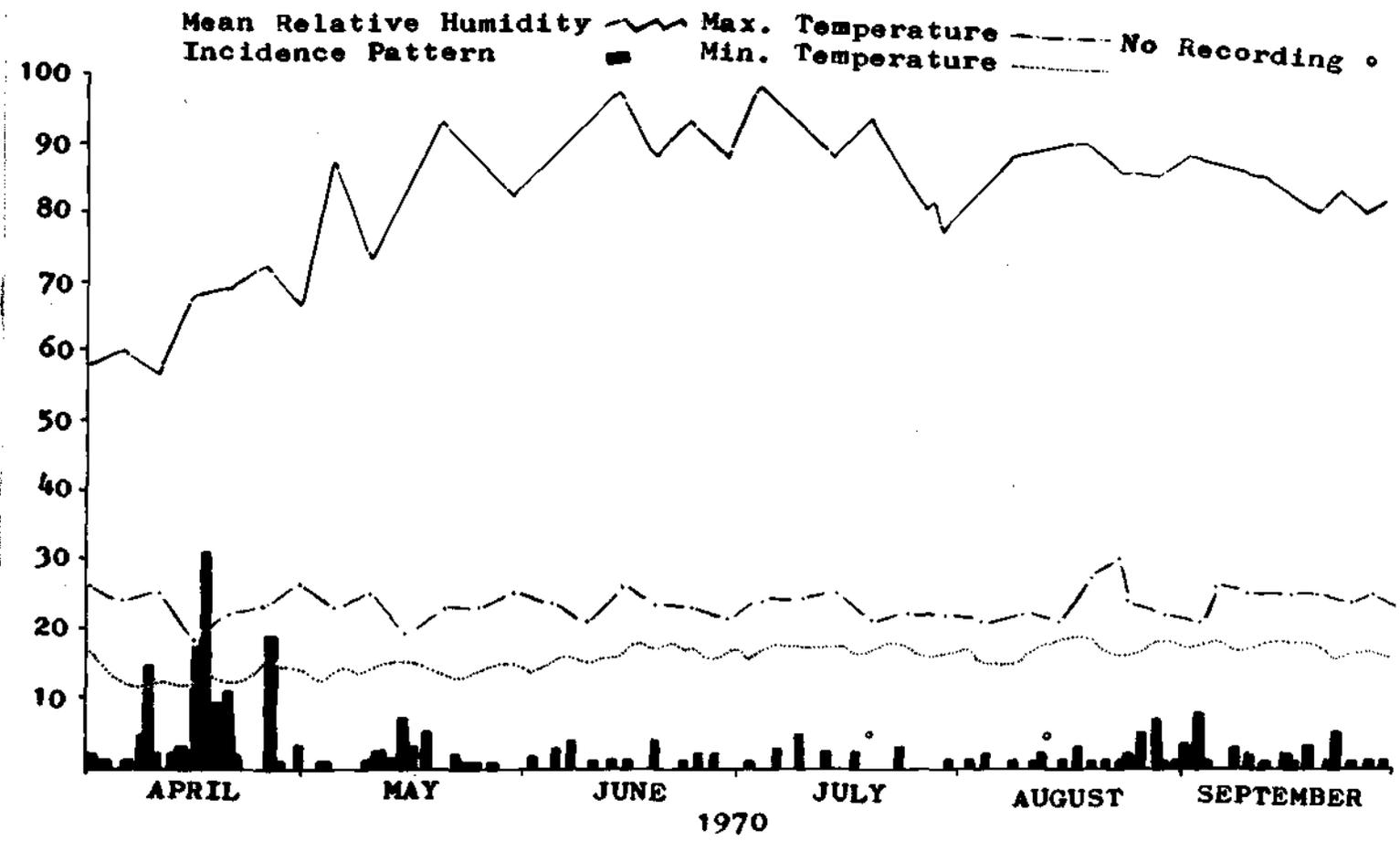


FIG.33: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Gomphostilbia) tenuistylum, n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September, 1970. Figures on the ordinate indicate quantity

on 16.9.70, with 12 specimens, were noticed. The nightly average turn-up of the species was 4.73 specimens in April; 2 in May; 3.53 in June; 1.23 in July; 1 in August; 1.63 in September; and 2.33 specimens for the whole period.

The population of tenuistylum attained its peak abruptly on 17.4.70, with the trapping of 31 specimens, and then the incidence declined steadily. The incidence was very poor both in June and July. There was higher incidence in September than in August with a sub-ordinate peak on 3.9.70., with only 8 specimens. The nightly average catch of the species was 4.4 specimens in April; 0.9 in May; 1 in August; 1.17 in September; and 1.45 in the whole period.

The incidence patterns of the six species of black flies of the study area and within the study period are illustrated along with the patterns of the existing relative humidity and atmospheric temperature in Figs. 28-33.

(d) Seasonal incidence in average

S.(E.) praelargum showed two co-ordinate peaks, with 15.7 specimens on May 11 and May 12, and then the population went down abruptly and maintained itself almost constantly through the following months. In the preceding period there were a number of rise and fall from the beginning of April.

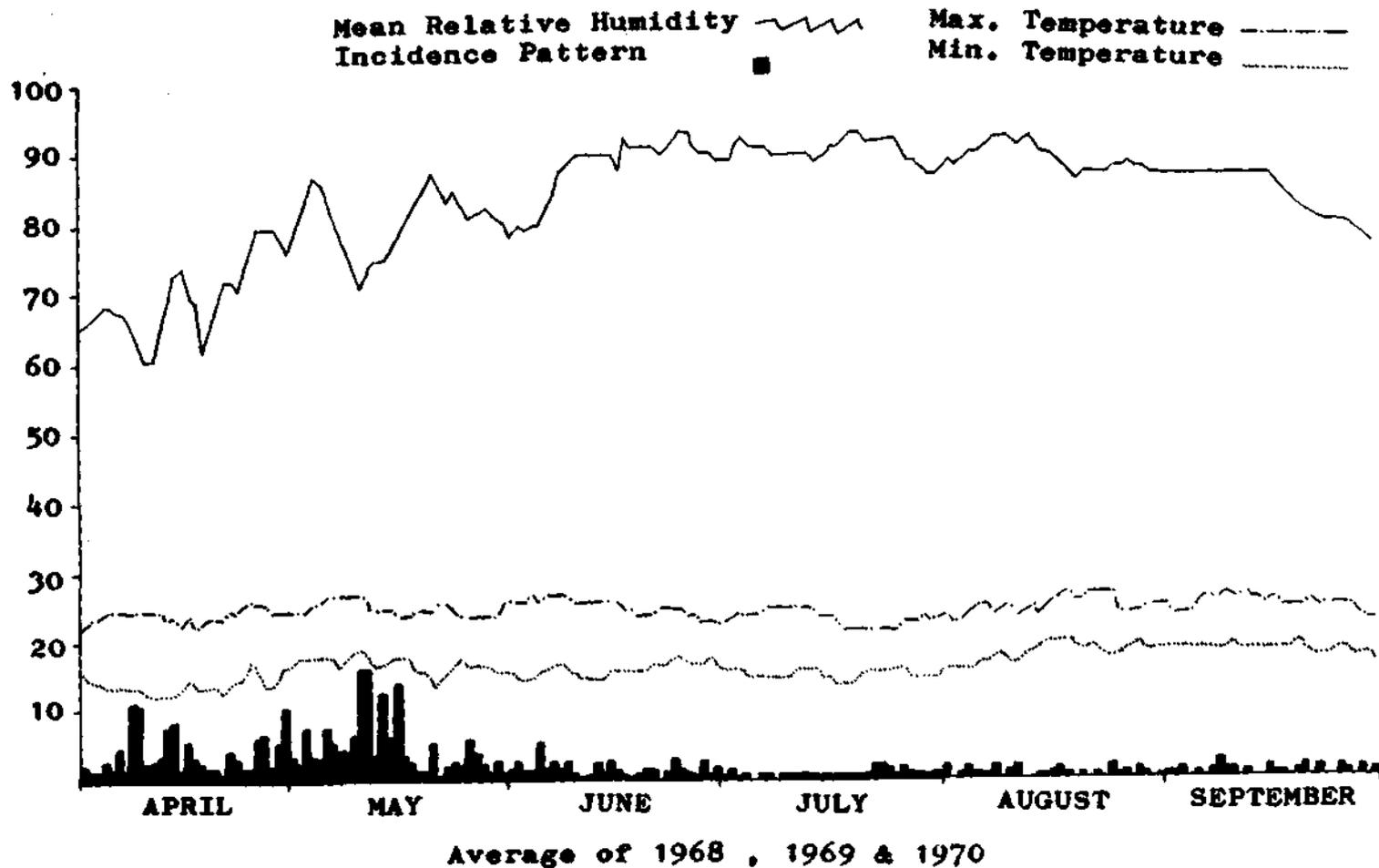


FIG.34: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) praelargum n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

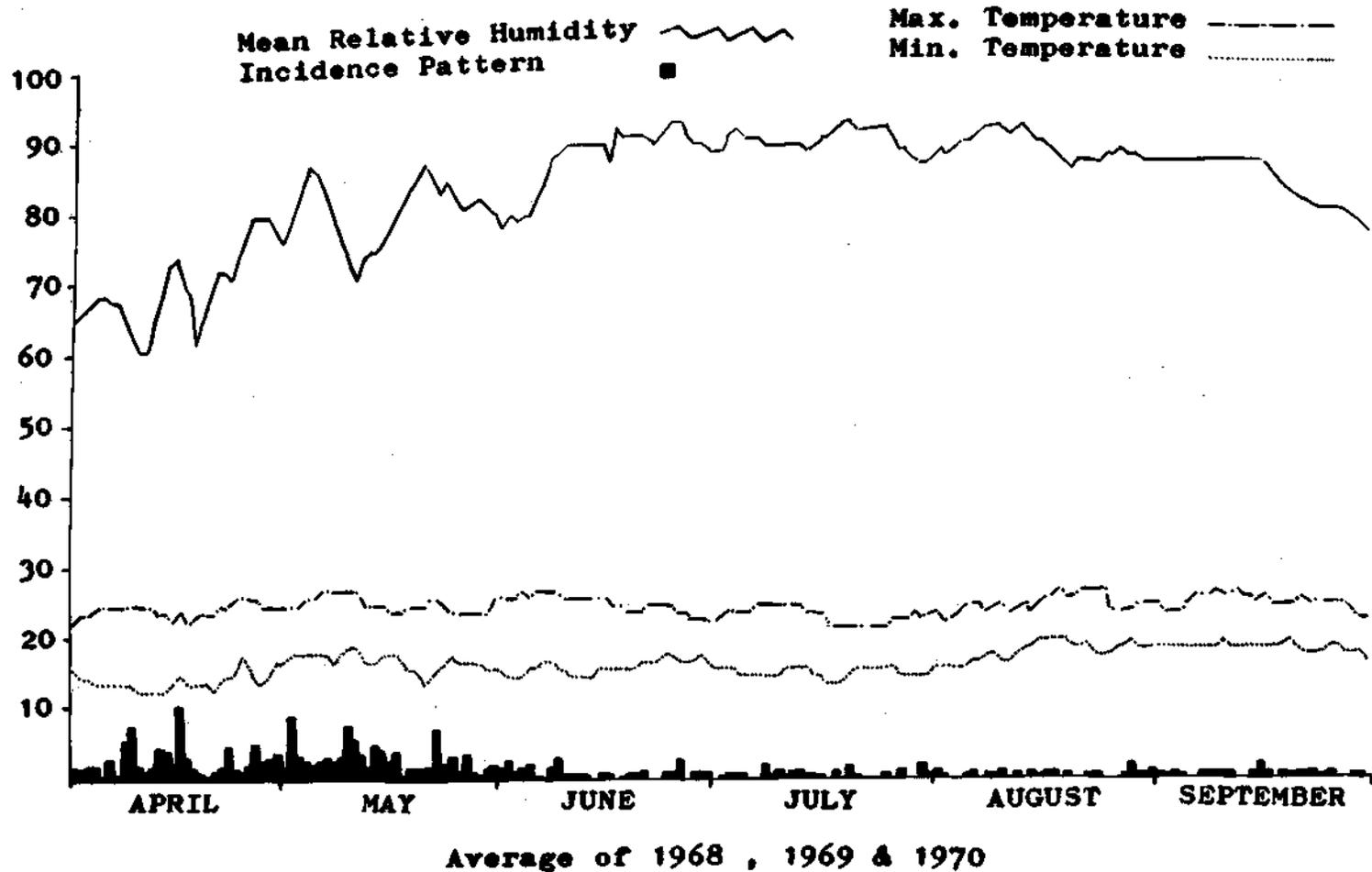


FIG.35: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Eusimulium) gracilis, n.sp. on the abscissa, at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

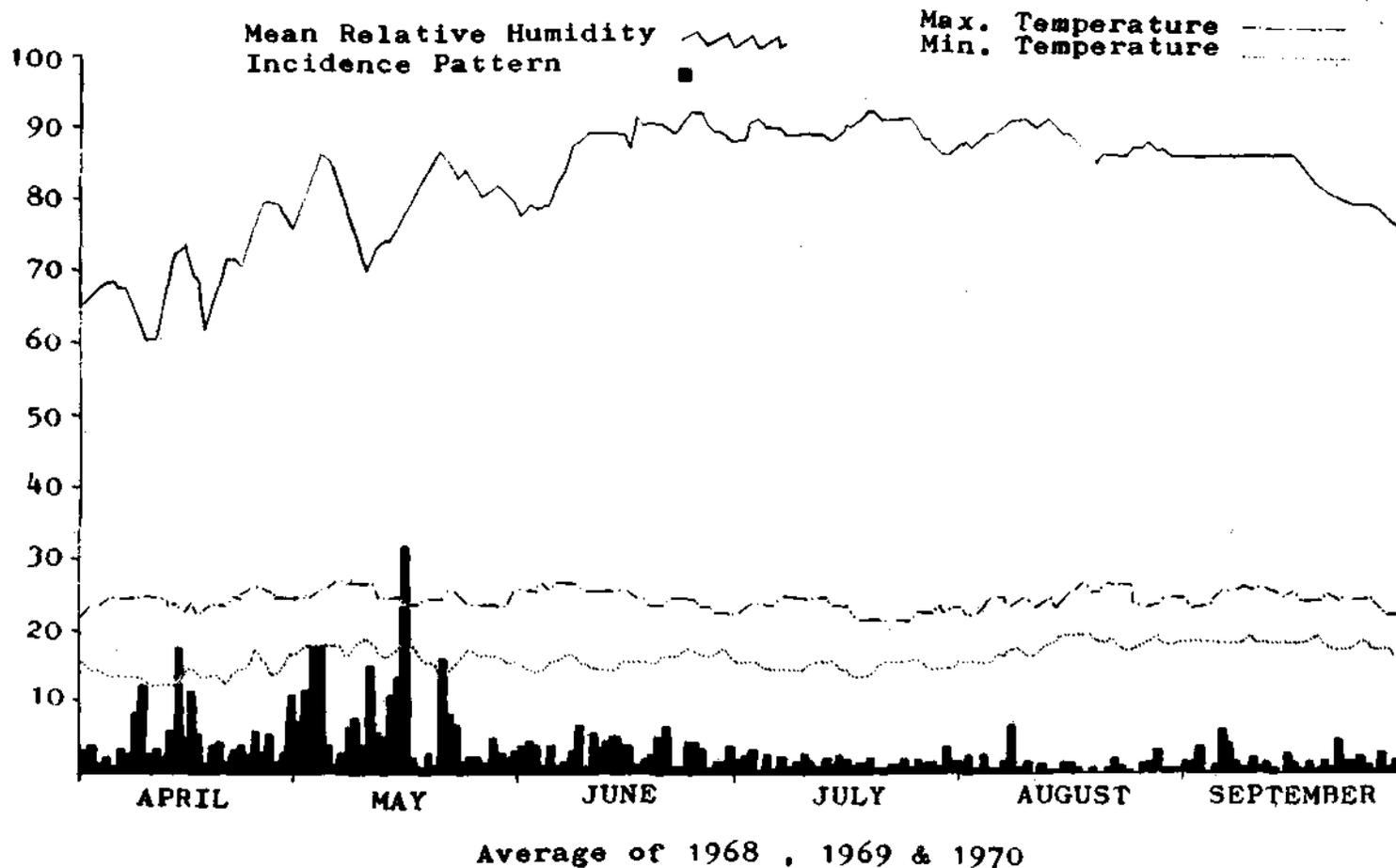


FIG.36: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium)himalayense Puri (1932) on the abscissa, at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

S.(E.) gracilis showed its principal peak on April 16 with only 10.3 specimens. The incidence of the species was higher in April and May, with rise and fall, than in the following months.

The peak of himalayense was observed on May 16, with 31.5 specimens, and this peak was attained through rise and fall from the beginning of April. Subsequent to the principal peak the population declined abruptly and maintained itself almost constantly. In September, however, there was a rise in incidence of the population.

The population of grisescens showed the peak on June 16, with 13 specimens, and then gradually it went down through the following months, except in September, when there was a rise in incidence. The incidence in April was poor, and in May there was a rise in the incidence in the last half of the month.

S.(S.) rufibasis attained its peak with 16.3 specimens on June 13, and then the population gradually declined. In September the incidence was again on the verge of ascent. The incidence, both in April and in May, maintained itself almost constantly.

The peak abundance shown by tenuistylum was on April 17 with 11 specimens, and then the population maintained itself almost constantly upto the first part of June with a little rise

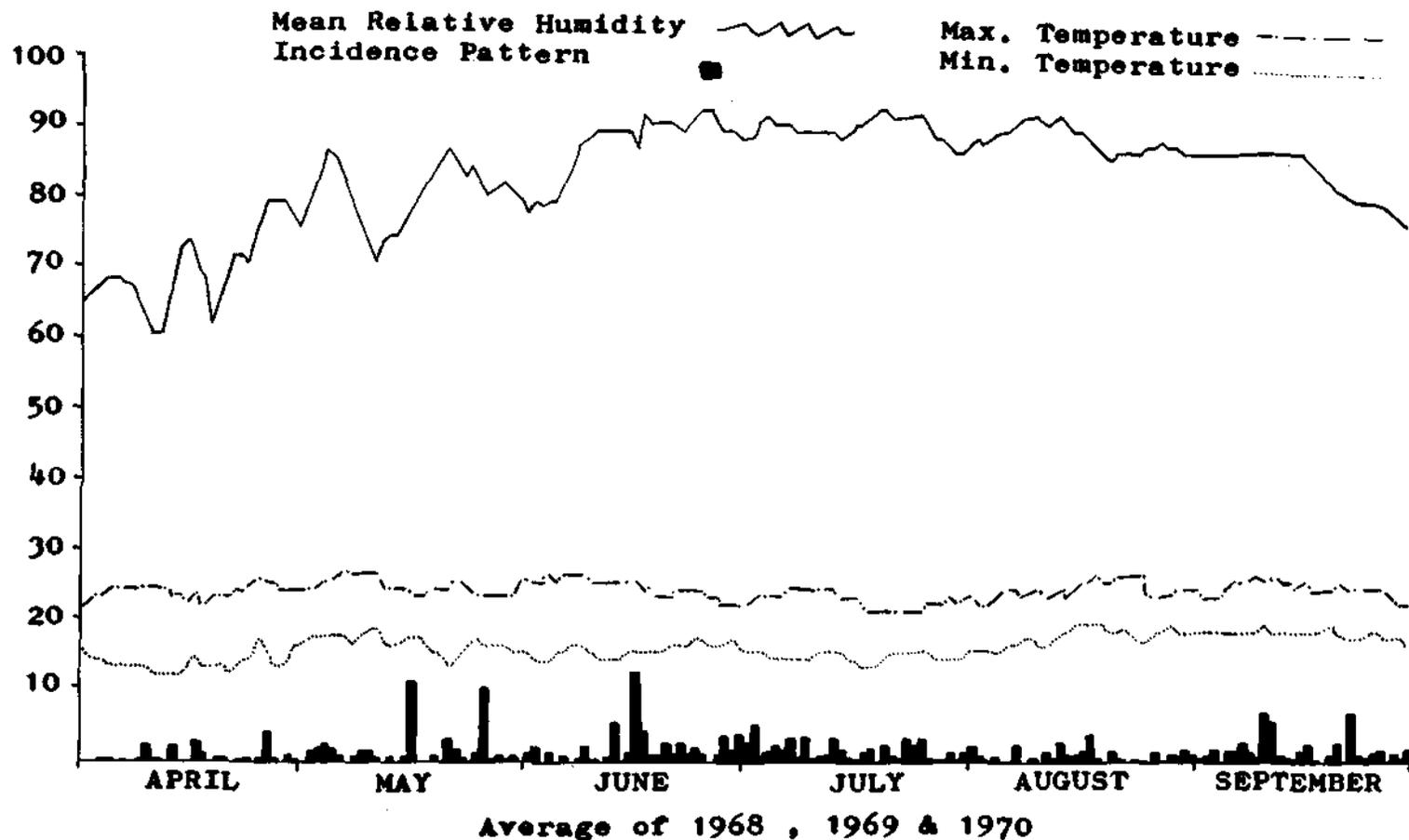


FIG.37: The mean relative humidity, maximum and minimum temperatures, and daily catches of *Simulium* (*Simulium*) *grisescens* Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

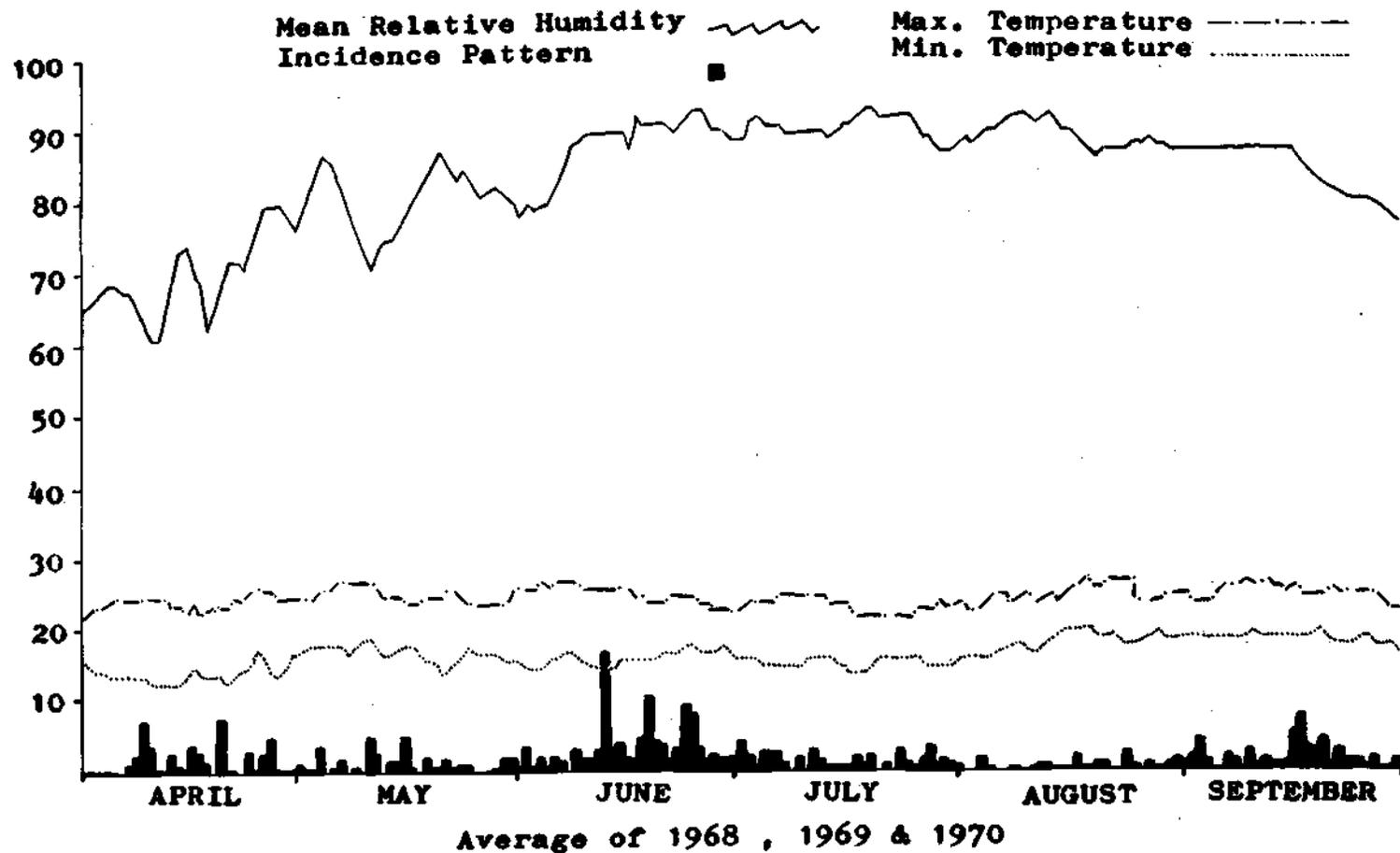


FIG.38: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Simulium) rufibasis Brunetti (1911) on the abscissa, at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

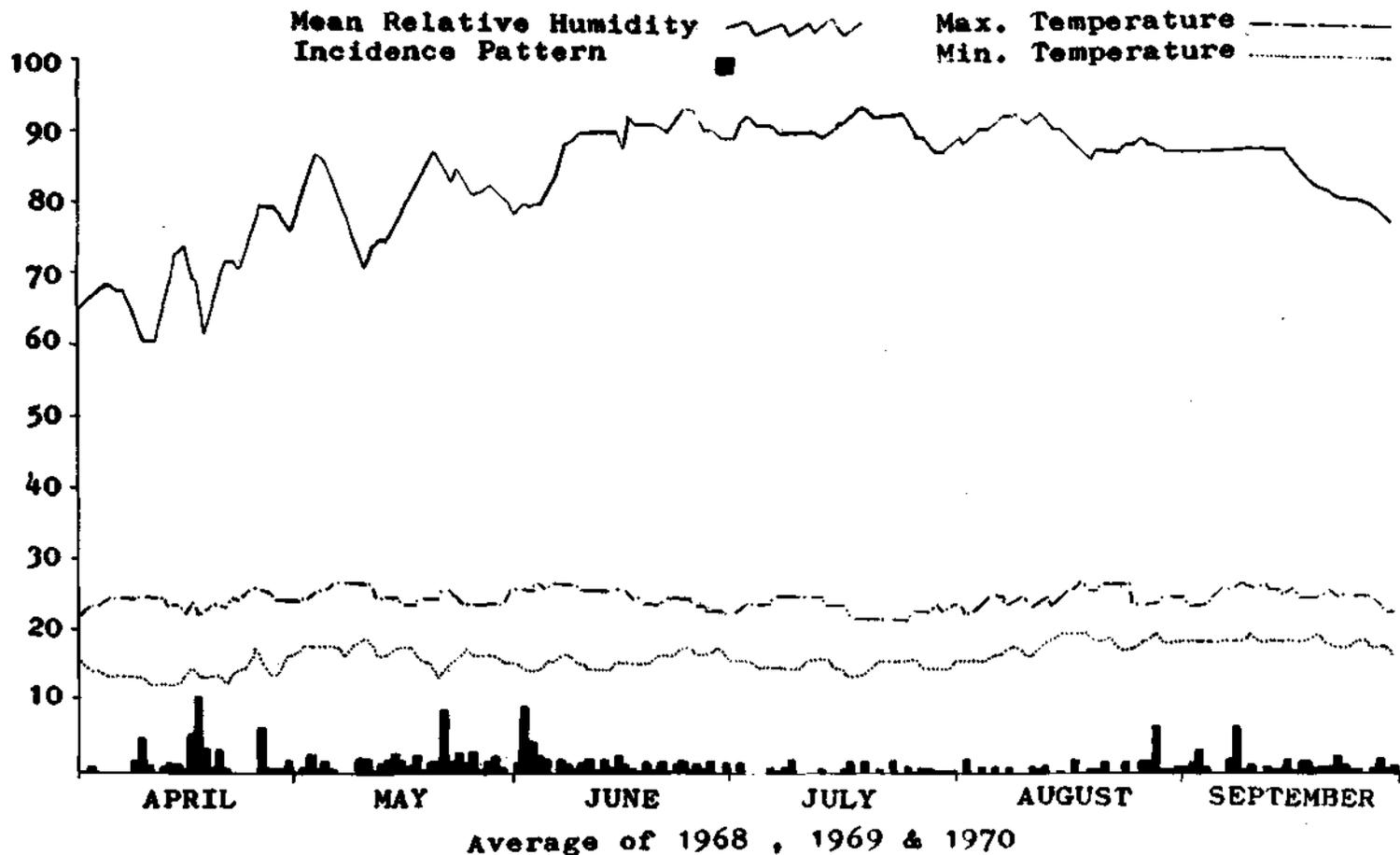


FIG.39: The mean relative humidity, maximum and minimum temperatures, and daily catches of Simulium (Gomphostilbia) tenuistylum n.sp. on the abscissa at Darjeeling Government College collecting Station from April - September of 1968, 1969 and 1970 (in average). Figures on the ordinate indicate the quantity

in incidence though the population was very low. From the end of August the population again began to rise to a considerable extent.

The above incidence patterns of the six species of black flies of the study area and within the whole study period are illustrated along with the patterns of the existing relative humidity and atmospheric temperature (in average) in Figs. 34-39.

Seasonal succession

The peak abundance analysed above showed the seasonal succession of the six species of black flies of the present study. Those months having at least one specimen per day (i.e., 30 specimens for 30 days comprising a month) were considered to be the months of their abundance. In this way in 1968 (Fig.-40) praelargum was abundant from April to June with peak in the early May; S.(E.) gracilis only in May with the peak in the late May; S.(S.) himalayense throughout the study period except August, with the peak in the early May; S.(S.) griseocens from June to September, with the peak in the middle of June; S.(S.) rufibasis in June, July and September, with the peak in the middle of June and tenuistylum in the months of May, June and September, with the peak in late May.

In 1969 (Fig.-41), praelargum showed abundance only in April and May, with the peak in the middle of May; S.(E.) gracilis showed the same type of abundance but the peak was in

the early part of May; S.(S.) himalayense in the whole study period with the peak in late May; S.(S.) griseascens in May, June and September, with the peak in late May; S.(S.) rufibasis in June, July and September, with the peak in late June; and tenuistylum in June and August, with the peak in early June.

In 1970 (Fig.-42), the abundance of praelargum was in April, May, June and August, with the peak in the early April; that of gracilis was in April, May and June with the peak in the middle of April; that of himalayense in the whole study period, with the peak in the middle of May; that of griseascens in the whole study period as of the former species, with the peak in the same period; that of S.(S.) rufibasis in the same period except August, but the peak was in the last part of June; and that of tenuistylum in April, August and September, with the peak almost in the last part of April.

In average (Fig.-43), praelargum showed abundance from April to June with the peak in the early part of May; S.(E.) gracilis only in April and May, with the peak in the middle of April; S.(S.) himalayense in the whole study period, with the peak in the middle of May; S.(S.) griseascens in the whole study period except April with the peak in the middle of June; S.(S.) rufibasis in the whole study period except August, with the peak in about the middle of June, and S.(G.) tenuistylum from April to June and September with the peak in the middle of April.

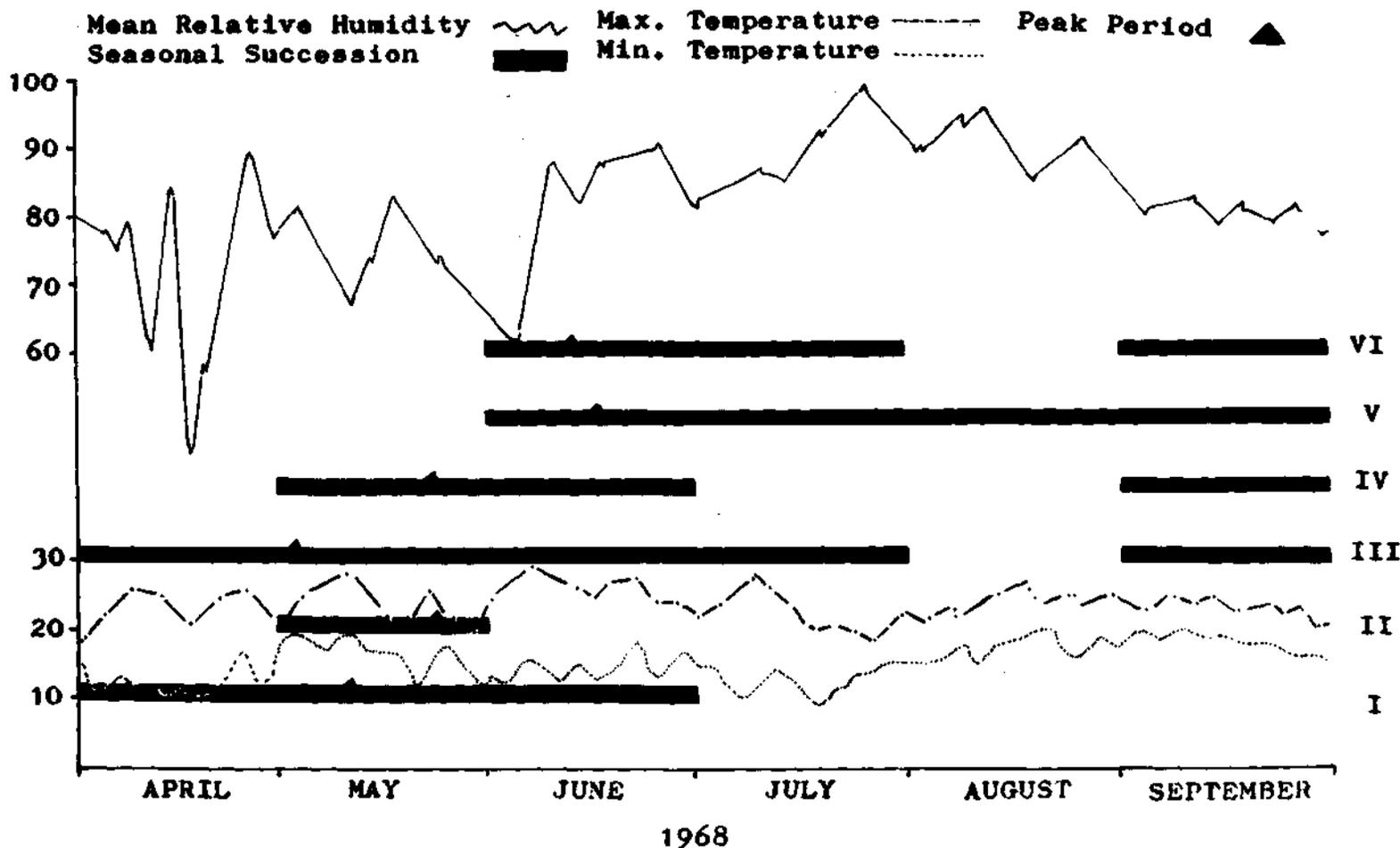


FIG.40: Seasonal succession of black flies, Simulium (Eusimulium) praelargum n.sp. (I), S.(E.) gracilis n.sp. (II), Simulium (Simulium) himalayense Puri(III) Simulium (Gomphostilbia) tenuistylum n.sp.(IV), S.(S.) griseocens Brunetti (V) and S.(S.) rufibasis Brunetti (VI) of the present study in 1968

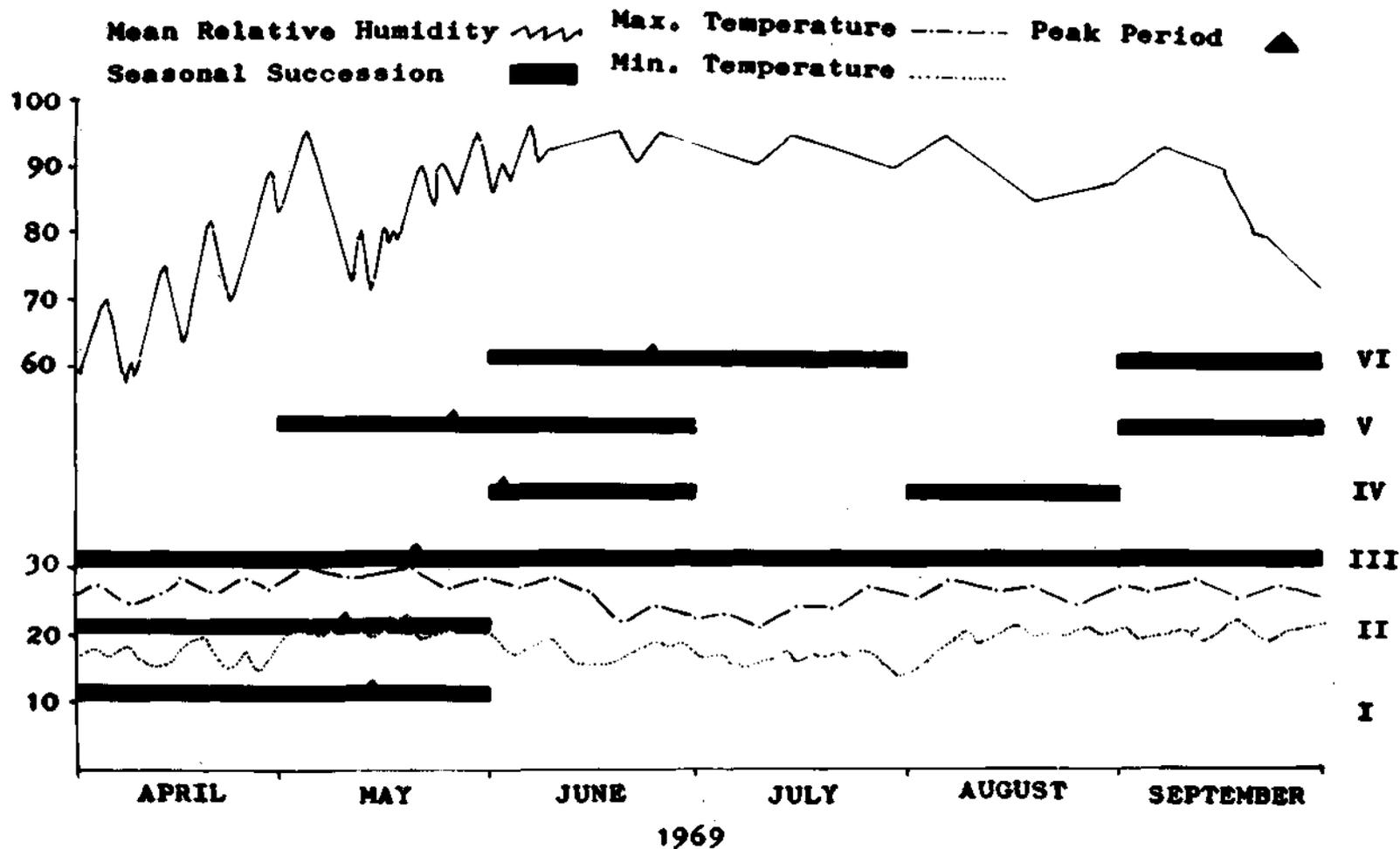


FIG.41: Seasonal succession of black flies, Simulium (Eusimulium) praelargum n.sp. (I), S.(E.) gracilis n.sp.(II), Simulium (Simulium) himalayense Puri (III) Simulium (Gomphostilbia) tenuistylum n.sp.(IV), S.(S.) grisescens Brunetti (V) and S.(S.) rufibasis Brunetti (VI) of the present study in 1969

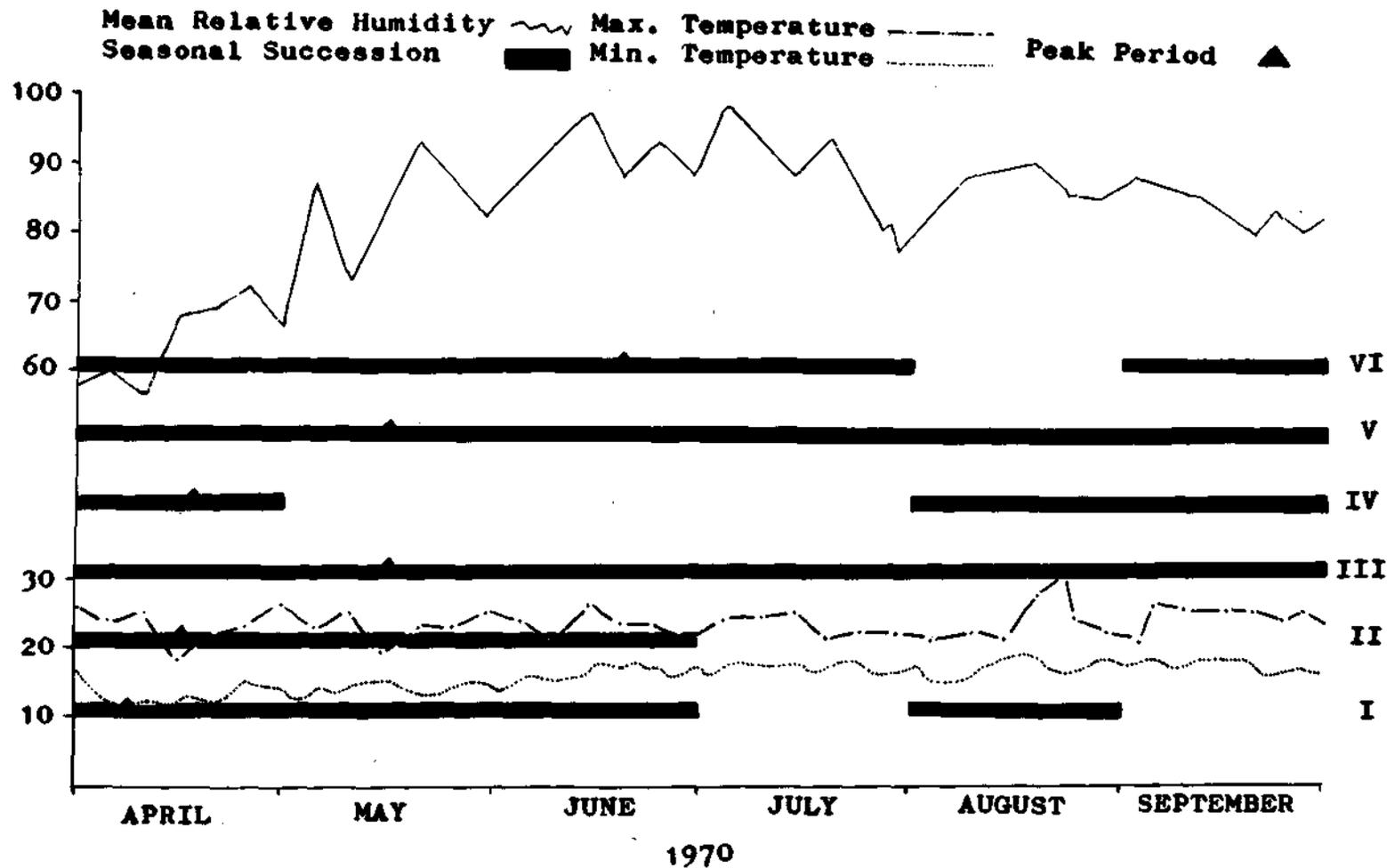


FIG.42: Seasonal succession of black flies, Simulium (Eusimulium) praelargum n.sp. (I), S.(E.) gracilis n.sp.(II), Simulium (Simulium) himalayense Puri (III) Simulium (Gomphostilbia) tenuistylum n.sp. (IV), S.(S.) grisescens Brunetti (V) and S.(S.) rufibasis Brunetti (VI) of the present study in 1970

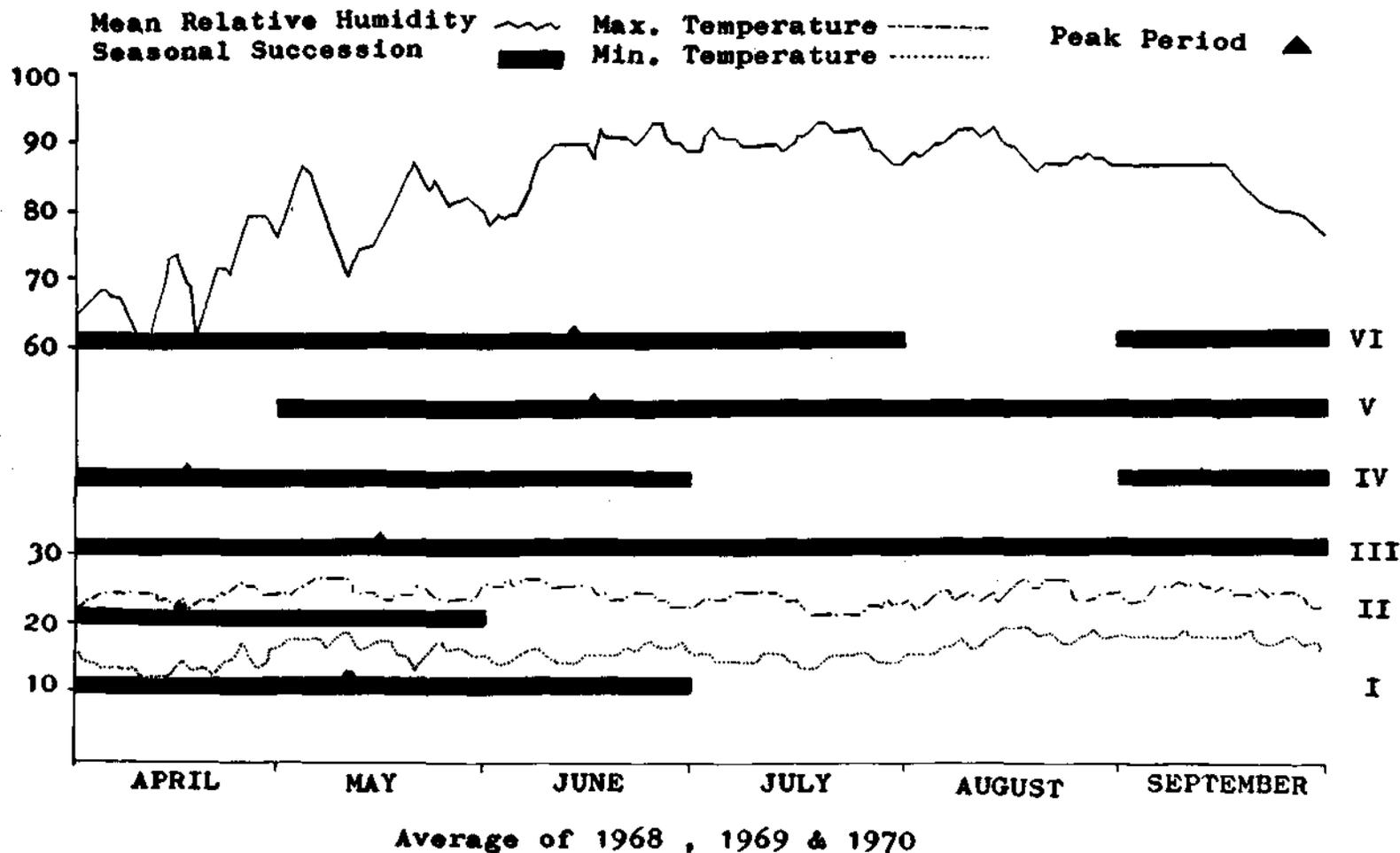


FIG.43: Seasonal succession of black flies, Simulium (Eugimulium) praelargum n.sp. (I), S.(E.) gracilis n.sp. (II), Simulium (Simulium) himalayense Puri(III) Simulium (Gomphostilbia) tenuistylum n.sp.(IV), S.(S.) griseascens Brunetti (V) and S.(S.) rufibasis Brunetti (VI) of the present study in average of 1968, 1969 and 1970.

Discussion

The great abundance of himalayense in contrast to other species of the subgenus Simulium taken in the light trap was probably due to the occurrence of a good number of suitable breeding centres along with certain other favourable conditions in the vicinity of the trapping site. The very low catch recorded in August, 1968 was due to the disturbance of the breeding centres on account of heavy rainfall and extensive land-slides in 1968. The abundance of rufibasis was slightly higher than that of grisescens. Both these species showed the tendency to become abundant after himalayense, except in 1970, when there was almost a similar distribution pattern. The pattern for 1970 might be accepted as the normal pattern as in this year there was no natural disaster. The year 1969 might be called the preparatory year for the high incidence recorded in 1970 following the natural calamity in 1968, when practically all of the breeding sites were destroyed during the rainy season and this might explain the variation in population-size during the whole study period. A similar situation was also reported by Wolfe and Peterson (1959) during their field studies in Quebec.

S.(E.) praelargum and gracilis were apparently the earlier species to occur, having appeared presumably in the last part of March or in early part of April. S.(G.) tenuistylum probably appeared later than the former two species. The devious nature

of incidence shown by all these species of black flies was perhaps responsible for the irregularity in the attainment to a certain population level in the area of trapping. The actual dates of the first appearance of these flies could not be pinpointed due to lack of information regarding the overwintering stages of these flies.

Davies and Williams (1962) in Scotland held that a light trap would not be expected to produce the same time-distribution picture in a given species as that from observations on the aquatic stages, and that such a trap would be expected to show some indications of successive generations by the presence of peaks and troughs in the catch size. As recorded in 1970, the adults of all the species, which showed the first peak abundance from April to June, might be the product of the overwintered larvae, and the adults showing second peak abundance in August or September, or later, might produce the overwintering larvae in the species of the subgenera Simulium and Gomphostilbia. The species of those subgenera, therefore, might be the bivoltine species, while those of the subgenus Eusimulium were probably univoltine.

According to Grenier (1949), adults of Simulium ornatum Mg. in France produced from the earliest hatched eggs out of the egg-batch laid might oviposit before others had hatched in the field. This phenomenon was also found to be true by Peterson

and Wolfe (1956) and, Fredeen (1959) in Canada. The complicated nature of incidence of some species of black flies taken in the light trap in the present study might be caused by such "pipe-line effect" as discussed by Davies and Williams (1962), and the relationship of the peak abundance to voltinism in fields would hardly hold good in all the cases.

The incidence of black flies during trapping was certainly dependent upon the preceding and current weather conditions as was also reported by Williams (1951, 1961, 1962) in Scotland. According to him (Williams, 1962) the highest night-activity of black flies was effected in the minimum temperature above 6°C , in falling barometer, particularly when the pressure was already low, in the absence of rain or with quite heavy rain. In the present investigation the highest incidence was found to occur mostly in the minimum temperature above 14°C and in the maximum temperature below 26°C . Absence of wind and little or no rainfall accompanied by the relative humidity of 65%-80% were most suitable for highest incidence, though deviation was also experienced. Rubtsov (1939) observed the optimum activity in $20\text{-}23^{\circ}\text{C}$ temperature, 75%-90% relative humidity with the absence of rain and high wind in day light during his field studies in Central Asia. In Canada, Davies (1952) found that most black flies were on the wing at $24^{\circ}\text{C}\text{-}26.6^{\circ}\text{C}$ and in the moist air; but not when it was close to saturation point. The low wind velocity was favourable. From the records of the present

investigation it was often difficult to explain the incidence of these insects in relation to all the meteorological conditions within the study period. The presence of other factors of unknown nature acting upon the incidence of these insects in the study area could not also be ruled out in the absence of evidence to the contrary.

Summary

The seasonal distribution and succession of six major species of black flies in Darjeeling were shown with the help of a simple light trap device. From the trend of incidence it was indicated that both Simulium (Eusimulium) praelargum n.sp. and S.(E.) gracilis n.sp. were the earliest species to occur almost with the departure of the winter. Simulium (Gomphostilbia) tenuistylum n.sp. was apparently found to appear just after the former two species almost simultaneously with Simulium (Simulium) himalayense Puri (1932a). The other two species, S.(S.) grisescens Brunetti (1911) and S.(S.) rufibasis Brunetti (1911) were the later species to show their peak abundance in last part of May or June.

All the species except the species of the subgenus Eusimulium showed a little rise in incidence before the advent of the winter indicating the bivoltine nature of the species.

The highest incidence was recorded mostly in the minimum temperature above 14°C and in the maximum temperature below 26°C . Absence of wind and little or no rainfall accompanied by the relative humidity of 65%-80% were most suitable for highest incidence.

The relationship of incidence of black flies taken in the light trap with their life-cycles in fields, and their deviations from the normal pattern are discussed in details.

SEX-RATIO

Introduction

Notwithstanding the behavioural variations in both sexes of insects it is customary to study the sex-ratio of insects obtained by light trapping in order to show certain aspects of insects' life intimately associated with the proportions of sexes of a species of insects. Davies and Williams (1962), in Scotland, showed the heterogeneity of sexes for seven species of black flies belonging to the family Simuliidae (Diptera) taken in a light trap, whereas Rubtzov (1939), during his ecological studies of black flies in some Russian localities, observed the homogeneity of sexes of each of the species studied. In Canada, Judd (1957) and Fredeen (1961) studied the bionomical phenomena of Simulium vittatum Zetterstedt and S.arcticum Malloch and held that the females consistently outnumbered the males. Even the results obtained by Williams (1964) in Scotland from light trapping data were found to tally with the above trend in average.

Method

Black flies were collected by continuous light trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights from April 1, 1968 to September 30, 1968; in 1800 trap-hours of 180 nights from April 1, 1969 to September 30, 1969; and in 1810 trap-hours of 181 nights from April 1, 1970 to September 30, 1970 with the help of a simple light trap device described in the page no.132. Male and female specimens of each of the major species of black flies trapped were assorted and counted in order to find out the sex-ratios of the trapped series.

Result

Black flies collected by the above method were found to consist of six major species, namely, Simulium (Eusimulium) praelargum n.sp., S.(E.) gracilis n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum n.sp., and a few rare species.

The frequencies of the appearance of male and female of all species of the major group are shown in the following tables (Tables XIV-XVII).

Table-XIV

Estimated sex-ratios of six species of black flies captured in the study site during April 1 - September 30, 1968

Species-population:	Male-Female:	% data		χ^2 -value
:	frequency :	Male	Female :	
Whole population	815 : 826	49.66	50.34	0.07 *
<u>praelargum</u>	145 : 119	54.92	45.08	2.56 *
<u>gracilis</u>	59 : 72	45.04	54.96	1.29 *
<u>himalayense</u>	215 : 245	46.74	53.26	1.95 *
<u>grisescens</u>	130 : 172	43.05	56.95	5.84 **
<u>rufibasis</u>	146 : 130	52.90	47.10	0.92 *
<u>tenuistylum</u>	120 : 88	57.70	42.30	4.92 **

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

* Insignificant at both the levels.

Table-XV

Estimated sex-ratios of six species of black flies captured in the study site during April 1 - September 30, 1969

Species-population:	Male-Female:	% data		χ^2 -value
:	frequency :	Male	Female :	
Whole population	651 : 728	47.21	52.79	4.50 **
<u>praelargum</u>	120 : 163	42.40	57.60	6.53 **
<u>gracilis</u>	116 : 76	60.42	39.58	8.33 ***
<u>himalayense</u>	147 : 206	41.64	58.36	9.86 ***
<u>grisescens</u>	103 : 80	56.29	43.71	2.90 *
<u>rufibasis</u>	90 : 105	46.15	53.85	1.15 *
<u>tenuistylum</u>	75 : 98	43.35	56.65	3.05 *

*** Significant at both 5% and 1% levels

** Significant at 5% level but insignificant at 1% level

* Insignificant at both the levels.

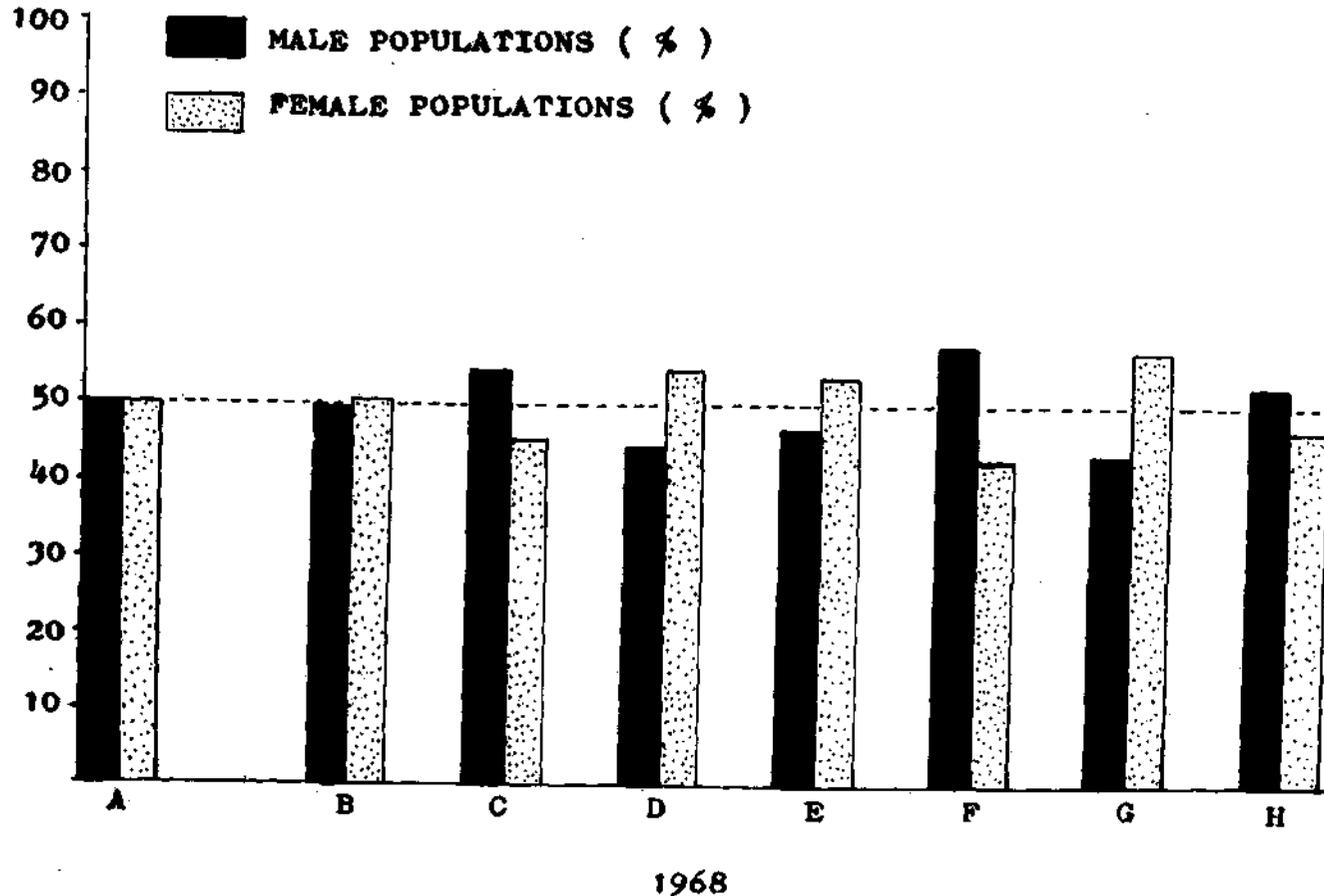


FIG.44: Histograms showing comparative catches of specimens of whole populations (B) and of Simulium (Eusimulium) praelargum n.sp. (C), S.(E.) gracilis n.sp. (D), Simulium (Simulium) himalayense Puri (E), Simulium (Gomphostilbia) tenuistylum n.sp. (F), S.(S.) griseescens Brunetti (G) and S.(S.) rufibasis Brunetti (H) of the present study in 1968, in relation to the balanced state of sex-ratio (A)

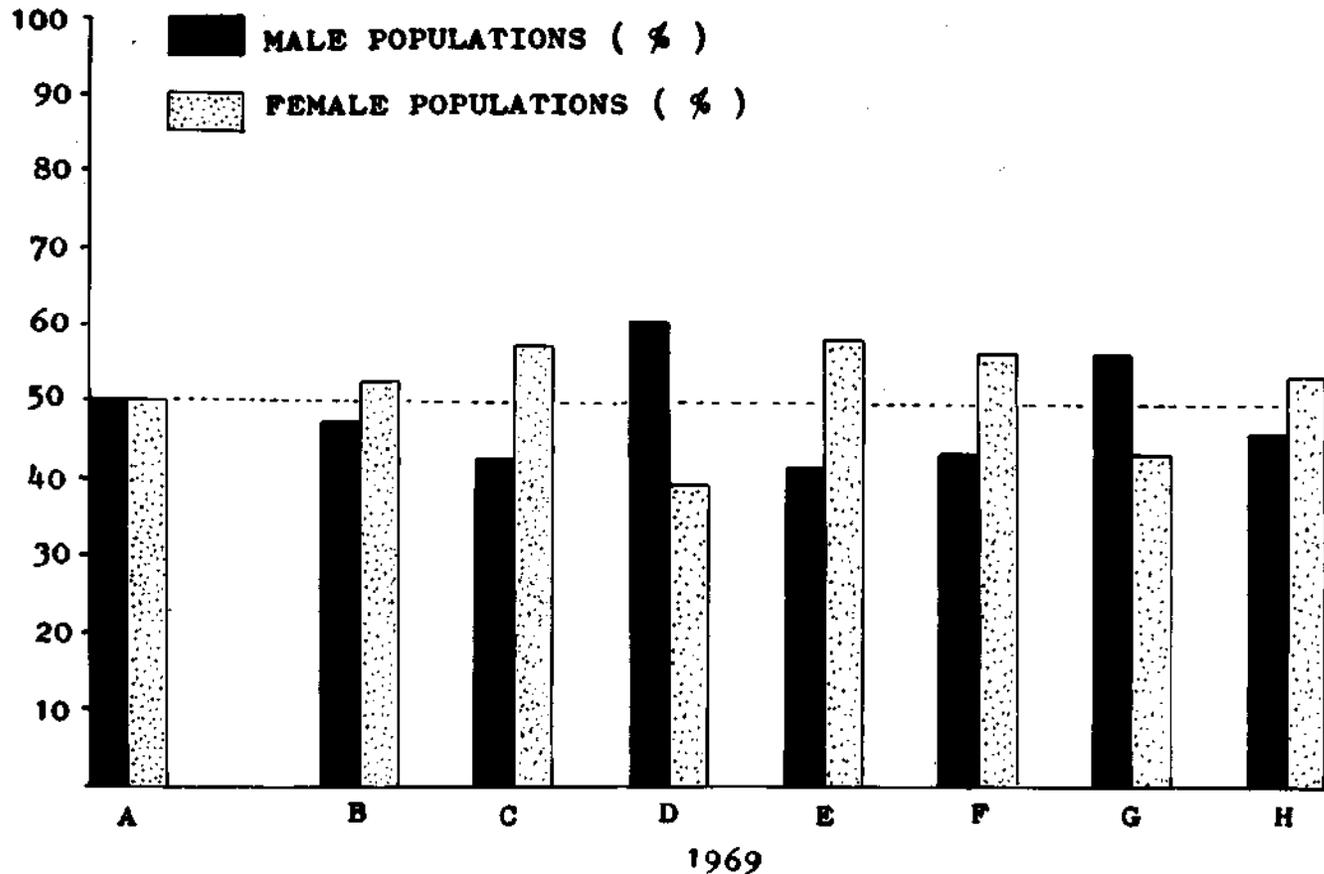


FIG.45: Histograms showing comparative catches of specimens of whole populations (B) and of Simulium (Eusimulium) praelargum n.sp.(C), S.(E.)gracilis n.sp. (D), Simulium (Simulium) himalayense Puri (E), Simulium (Gomphostilbia) tenuistylum n.sp.(F), S.(S.)grisescens Brunetti (G) and S.(S.) rufibasis Brunetti (H) of the present study in 1969, in relation to the balanced state of sex-ratio (A)

Table-XVI

Estimated sex-ratios of six species of black flies captured in the study site during April 1 - September 30, 1970

Species-population:	Male-Female:	% data		X ² -value
: frequency :	Male : Female :	Male	Female	
Whole population	1189 : 1639	42.04	57.96	71.29 ***
<u>praelargum</u>	204 : 377	35.11	64.89	51.51 ***
<u>gracilis</u>	205 : 160	56.16	43.84	5.54 **
<u>himalayense</u>	410 : 511	44.52	55.48	11.08 ***
<u>grisescens</u>	171 : 106	61.74	38.26	15.25 ***
<u>rufibasis</u>	107 : 315	25.35	74.65	102.50 ***
<u>tenuistylum</u>	92 : 170	35.12	64.88	23.22 ***

*** Significant at both 5% and 1% levels.

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

Table-XVII

Estimated sex-ratios of six species of black flies captured in the study site during April 1 - September 30 of 1968, 1969 and 1970 (in average)

Species-population:	Male-Female:	% data		X ² -value
: frequency :	Male : Female :	Male	Female	
Whole population	885 : 1064	45.40	54.60	16.44 ***
<u>praelargum</u>	156 : 220	41.49	58.51	10.90 ***
<u>gracilis</u>	127 : 103	55.22	44.78	2.50 *
<u>himalayense</u>	257 : 320	44.54	55.46	6.88 ***
<u>grisescens</u>	135 : 119	53.15	46.85	1.00 *
<u>rufibasis</u>	114 : 183	38.38	61.62	16.04 ***
<u>tenuistylum</u>	96 : 119	44.65	55.35	2.46 *

*** Significant at both 5% and 1% levels.

* Insignificant at both the levels.

The patterns of sex-ratios estimated above of the trapped black flies are illustrated in the figures 44-47.

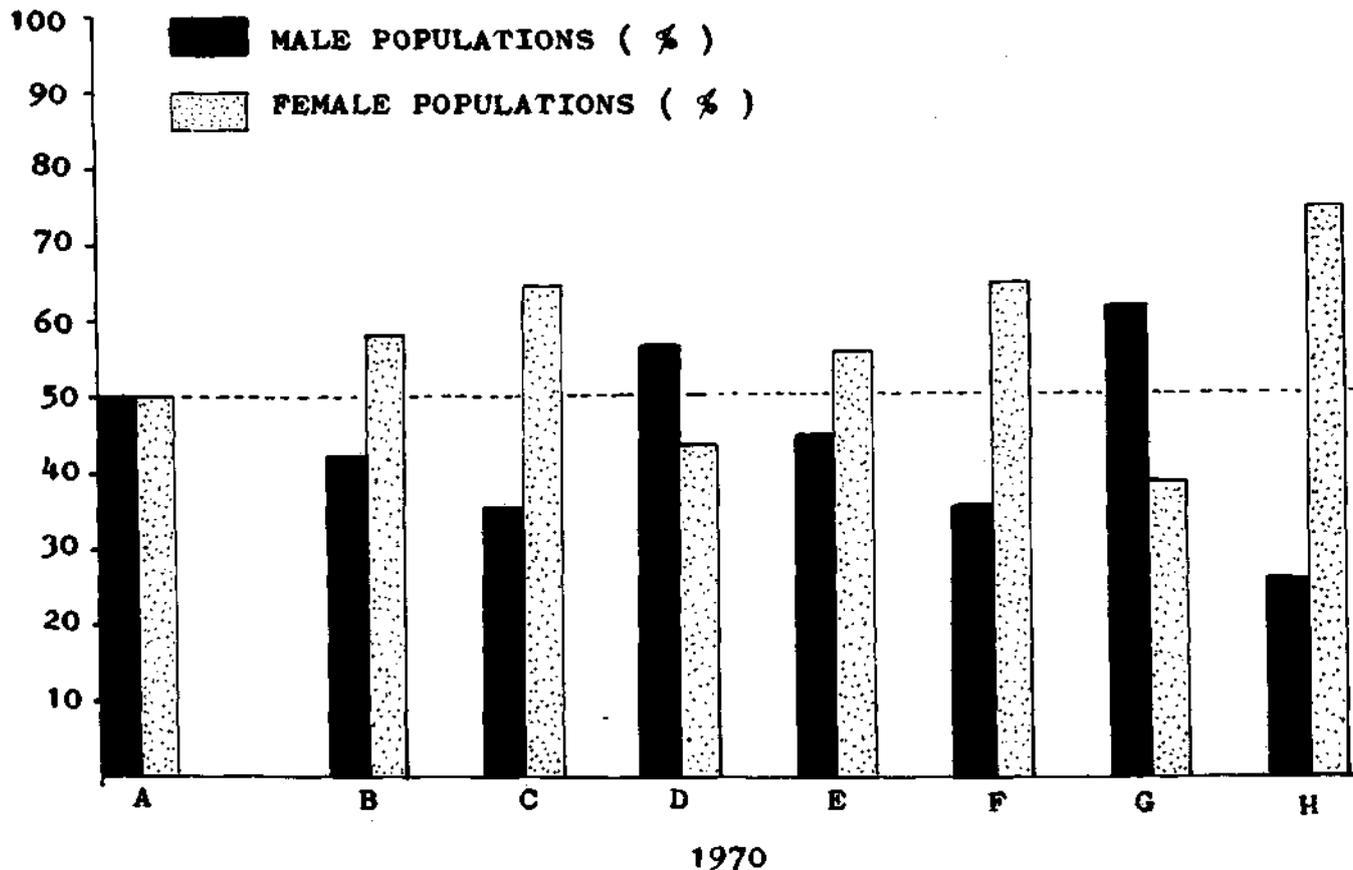


FIG.46: Histograms showing comparative catches of specimens of whole populations (B) and of Simulium (Eusimulium) praelargum n.sp.(C), S. (E.) gracilis n.sp. (D), Simulium (Simulium) himalayense Puri (E), Simulium (Gomphostilbia) tenuistylum n.sp.(F), S. (S.) grisescens Brunetti (G) and S. (S.) rufibasis Brunetti (H) of the present study in 1970, in relation to the balanced state of sex-ratio (A)

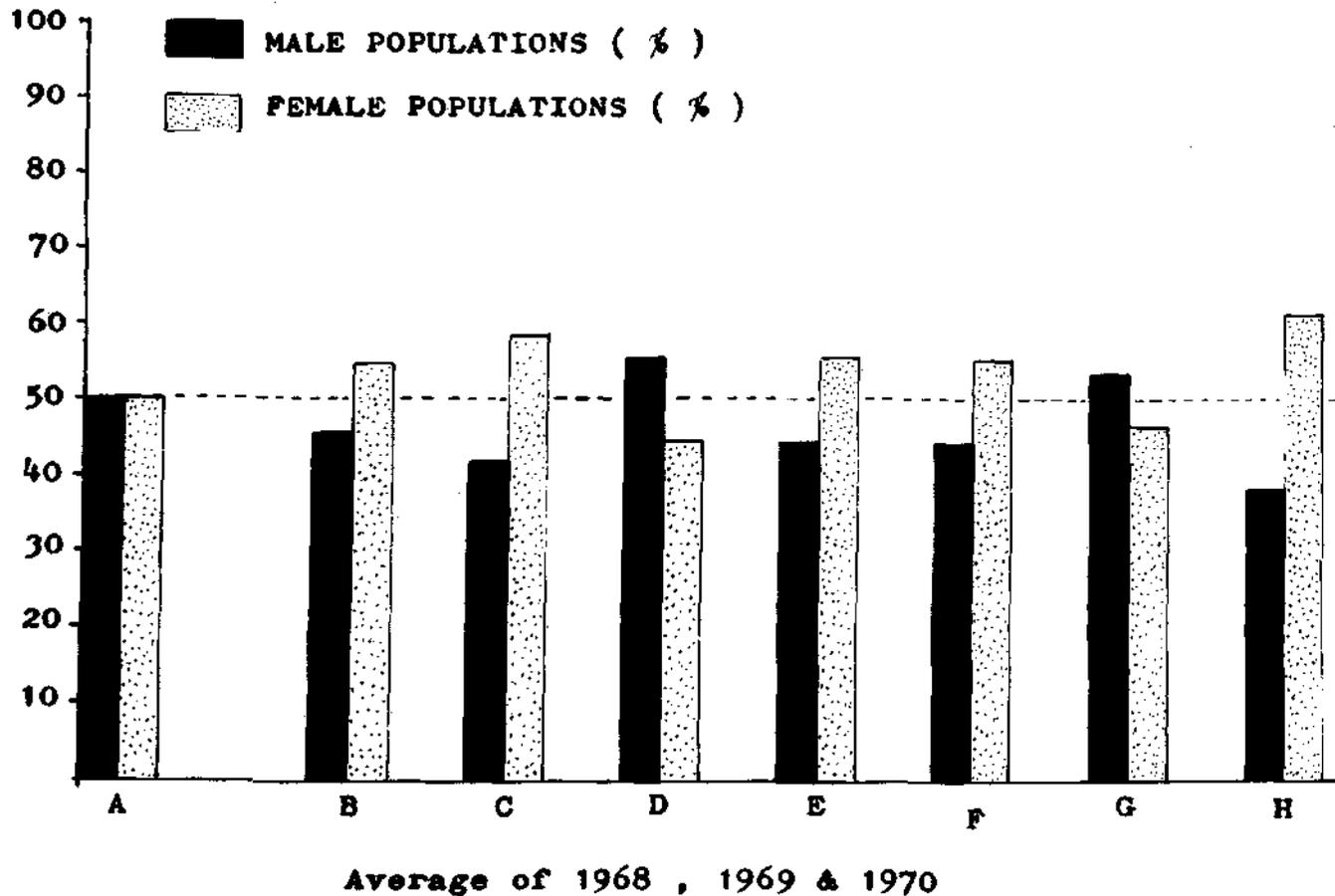


FIG.47: Histograms showing comparative catches of specimens of whole populations (B) and of Simulium (Eusimulium) praelargum n.sp.(C), S. (E.) gracilis n.sp. (D), Simulium (Simulium) himalayense Puri (E), Simulium (Gomphostilbia) tenuistylum n.sp.(F), S. (S.) grisescens Brunetti (G) and S. (S.) rufibasis Brunetti (H) of the present study in average of 1968, 1969 and 1970, in relation to the balanced state of sex-ratio (A)

Discussion

The observations made during the three years' period indicated that there were real differences in the sex-ratio among the species of black flies in Darjeeling if the method of light trapping could be relied upon for the purpose of such study. In the whole populations in each year the proportion of females was always higher than that of males and this tendency was found to maintain itself at all nights when the abundance of these insects was very low irrespective of species. The differing values of the whole populations for those years were evidently significant, except in 1968, when it was really insignificant. Williams (1964) also obtained significantly high numbers of females of black flies from a light trap in Scotland.

In the course of discussion on the results of the sex-ratios shown by the black flies taken in a light trap in Scotland, Davies and Williams (1962) held that the two sexes of different species of black flies might be differentially attracted to a light trap. In a similar way a specieswise estimation of the present investigation revealed that in himalayense the females consistently outnumbered males, and this was also the case in praelargum, except in 1968, when the proportion of males was much higher than that of females. Both rufibasis and tenuistylum showed an excess of females

over males in 1969 as well as in 1970. But in 1968 males of both the species exceeded females. Both in gracilis and griseescens the males predominated over females, except in 1968 when in both these two species females outnumbered males. The deviation from an indicated trend of sex-ratio of a given species in 1968 was noteworthy, and this deviation was thought to be due to the natural calamity of 1968 in the form of heavy rainfall and extensive land slides which disturbed the breeding sites of one or other or both sexes of black flies which flourished during the pre-autumnal period in the study site.

Fredeen (1961) working with different types of traps always obtained a significantly high number of females of Simulium arcticum Mall in each trial. Kettle (1955) observed the differences in the sex-ratios of the British Gulicoidea obtained through various means. Williams (1939) also showed that in tipulids the sex-ratio varied from species to species, and even the closely related species showed opposite results. To correlate the behaviour of these insects it may be stated that the differences were due to the differential sensitivity of the sexes to factors such as weather conditions, involving the emergence of adults, and the death-rate of one sex, or the influence of factors governing the night activity of one sex that were largely independent of those affecting another sex.

Davies, D.M. (1950) and Davies, L. (1957) found that black flies ceased biting and oviposition with the onset of

darkness. There were, however, records of biting in darkness by black flies in Guatemala (Dalmat, 1955), in the high altitudes of Utah (Peterson, 1956) and in Sudan (Lewis, 1957). It is to be noted that at least a few species of black flies are found to bite at night in Darjeeling, if not all. Males of those species might outnumber females, if the latter are thought to travel to other parts in search of appropriate hosts. A parallel situation might exist with males, since male swarms of black flies are often said to occur at considerable distances from breeding sites (Davies & Williams, 1962) resulting in the alteration of incidence picture as revealed by light trap. Again, as Wolfe and Peterson (1959) experienced in Quebec, floods, logging and fire which frequently occur in or nearabout the natural habitats of black flies in Darjeeling, might affect one or the other sex of a species population causing an arbitrary and abrupt change in the incidence pattern of that sex of black flies. Thus, the sex-ratio of black flies taken in the light trap was really the outcome of the interplay of several factors of unknown nature which would require further investigation.

Summary

The present investigation deals with the sex-ratios of six species of black flies taken in a light trap in Darjeeling for three consecutive years 1968, 1969 and 1970. In the whole

populations of black flies in each year the proportion of females was always higher than that of males. In a species-wise estimation it was observed that in himalayense, the females consistently outnumbered the males, while in praelargum, rufibasis and tenuistylum, the females exceeded males in 1969, as well as in 1970; but in 1968, the males of these species showed an excess over females. Both in gracilis and grigescens the males outnumbered the females except in 1968, when the females of both these species outnumbered the corresponding males. The deviation from an indicated trend of sex-ratio of a given species is discussed in details in the light of several possible factors governing the same.

INTERNAL CONDITION OF TRAPPED FEMALES

Introduction

Females of almost all the species of black flies belonging to the family Simuliidae are blood-suckers, attacking mostly homeothermous animals in order to gain energy for ovarian development and oviposition (Cameron, 1922; Wu, 1931; Rubtsov, 1936; Lewis, 1953; Davies and Peterson, 1956). These females are found in nature in different internal conditions. Taking advantage of their positively photophilic habit (Williams and Davies, 1957) the incidence of unfed, blood-fed and gravid females was studied by Davies and Williams (1962) in Scotland using the Rothamsted light trap (Williams, 1948). The purpose of this present work is to assess statistically the incidence of unfed, blood-fed and gravid females of black flies in Darjeeling by light-trapping.

Methods

Females of all the six species of black flies investigated here, namely, Simulium (Eusimulium) praelargum, n.sp., S.(E.) gracilis, n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp.

were collected by continuous light-trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights, from April 1, 1968 to September 30, 1968; in 1800 trap-hours of 180 nights, from April 1, 1969 to September 30, 1969; and in 1810 trap-hours of 181 nights, from April 1, 1970 to September 30, 1970 with the help of a simple trap device described in the page no. 132.

After the assortment of females and males of a given species, females of different internal conditions were identified by means of a stereoscopic binocular microscope following the method of Davies and Williams (1962). The female specimens engorged with blood were recognizable by the black colour of the blood-mass which was visible through the transparent ventral wall of the abdomen. Specimens having swollen abdomen with yellowish or light brown colour due to mature eggs and with or without the remnant of blood in the gut were considered to be the gravid females, while others having normal abdominal texture and neither with blood nor with mature eggs were taken to be the non-replete females. The placement of the intermediate specimens were, however, not always perfect.

Observations

The proportion of non-replete, replete and gravid females of the six major species of black flies in the annual incidence and in average are shown in the tables XVIII-XXI.

Table-XVIII

Estimation of the trapped females of black flies
in the different internal conditions during
April 1 - September 30, 1968

Female population	Unfed-fed-gravid ratio	χ^2 -value
Whole population	284 : 235 : 307	9.83 ***
<u>praelargum</u>	45 : 38 : 36	1.12 *
<u>gracilis</u>	28 : 18 : 26	2.33 *
<u>himalayense</u>	78 : 72 : 95	3.48 *
<u>grisescens</u>	61 : 45 : 66	3.17 *
<u>rufibasis</u>	44 : 31 : 55	7.02 **
<u>tenuistylum</u>	28 : 31 : 29	0.17 *

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

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

* Insignificant at both the levels.

Table-XIX

Estimation of the trapped females of black flies
in the different internal conditions during
April 1 - September 30, 1969

Female population	Unfed-fed-gravid ratio	χ^2 -value
Whole population	240 : 247 : 241	0.11 *
<u>paelargum</u>	60 : 42 : 61	4.22 *
<u>gracilis</u>	37 : 19 : 20	8.09 **
<u>himalayense</u>	68 : 94 : 44	18.20 ***
<u>grisescens</u>	15 : 27 : 38	10.12 ***
<u>rufibasis</u>	37 : 24 : 44	5.89 *
<u>tenuistylum</u>	23 : 41 : 34	5.03 *

*** Significant at both the levels.

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

* Insignificant at both the levels.

Table-XX

Estimation of the trapped females of black flies
in the different internal conditions during
April 1 - September 30, 1970

Female population	Unfed-fed-gravid ratio	χ^2 -value
Whole population	530 : 506 : 603	9.35 ***
<u>praelargum</u>	145 : 128 : 104	6.74 **
<u>gracilis</u>	62 : 43 : 55	3.47 *
<u>himalayense</u>	164 : 153 : 194	5.30 *
<u>grisescens</u>	16 : 42 : 48	16.39 ***
<u>rufibasis</u>	99 : 84 : 132	11.49 ***
<u>tenuistylum</u>	44 : 56 : 70	5.97 *

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

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

* Insignificant at both the levels.

Table-XXI

Estimation of the trapped females of black flies
in the different internal conditions during
the whole study-period (in average)

Female population	Unfed-fed-gravid ratio	χ^2 -value
Whole population	351 : 329 : 384	4.31 *
<u>praelargum</u>	83 : 69 : 67	2.08 *
<u>gracilis</u>	42 : 27 : 34	3.29 *
<u>himalayense</u>	103 : 106 : 111	0.30 *
<u>grisescens</u>	31 : 38 : 51	5.15 *
<u>rufibasis</u>	60 : 46 : 77	7.90 **
<u>tenuistylum</u>	32 : 43 : 44	2.23 *

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

* Insignificant at both the levels.

It was found that the proportion of the unfed females of the whole population was higher than that of the fed females, but lower than that of the gravid ones, except in 1969, when the proportion of the fed females was higher than both the unfed and gravid females; the gravid ones being slightly greater in proportion than the unfed ones.

The incidence shown by different species in different years was variable, but the frequency of a particular condition was not significantly low in each species. It was further observed that the feeding of all the species continued throughout all the seasons of the study period and that the decline started with the advent of the winter. Blood-fed females of a given species were captured in larger numbers when the catch was small. The cumulative percentage of the total catch of the females of all the species in different internal conditions for the year and the average showing the trend of incidence is given in Table XXII.

Table-XXII

Percentage compositions of unfed, blood-fed and gravid specimens in the total annual and in average incidence of females of black flies

Species	Unfed				Blood-fed				Gravid			
	1968:	1969:	1970:	Average:	1968:	1969:	1970:	Average:	1968:	1969:	1970:	Average:
<u>praelargum</u>	37.8	36.8	38.5	37.8	31.9	25.8	33.9	31.6	30.3	37.4	27.6	30.6
<u>gracilis</u>	38.9	48.7	38.7	40.8	25.0	25.0	26.9	26.2	36.1	26.3	34.4	33.0
<u>himalayense</u>	31.8	33.0	32.1	32.2	29.4	45.6	29.9	33.2	38.8	21.4	38.0	34.6
<u>grisescens</u>	35.4	18.7	15.1	25.8	26.2	33.8	39.6	31.7	38.4	47.5	45.3	42.5
<u>rufibasis</u>	33.9	35.2	31.4	32.8	23.8	22.9	26.7	25.1	42.3	41.9	41.9	42.1
<u>tenuistylum</u>	31.8	23.5	25.9	26.9	35.2	41.8	32.9	36.1	33.0	34.7	41.2	37.0

Discussion

The incidence of the females of black flies in different internal conditions was found to vary from time to time, from night to night, from month to month and even from year to year. Davies and Williams (1962) working in Scotland also observed this variation and held that females in different physiological conditions would react differently either to the stimulus of the light trap or to the meteorological conditions that were likely to influence their incidence in a given night. Moreover, the variable nature of the incidence shown by the females in different internal conditions could be correlated to the heterogeneity of these insects.

Although the ratio among three groups, unfed, fed and gravid females, considering the whole population, showed a significant departure from the hypothesis 1:1:1, in 1968 and also in 1970, but it was not significantly different statistically from the hypothesis when the average over the whole study period was considered. So, leaving the cases of a particular year or years, for which a lot of studies would be required to reveal the essence of the incidence, the average over the whole study period was taken into account. In fact, for the whole population, as well as for the different species, with the only exception of rufibasis, which at 5% level showed a ratio significantly different from the hypothesis on the basis of

average over the entire study period, the hypothetical ratio 1:1:1 was tenable, that is, the females in different internal conditions, namely, blood-fed, unfed and gravid ones appeared at the light trap almost in equal proportions.

Summary

The trapped females of six species of black flies taken in a light trap in Darjeeling for three consecutive years 1968, 1969 and 1970 were broadly categorized into three groups, namely, unfed, blood-fed and gravid ones depending upon their internal conditions, in order to examine the essence of their incidence patterns through statistical procedure. It was observed that the hypothetical ratio of the groups was tenable for the whole population as well as for most of the species, considering the average over the entire study period. However, the departure from the hypothesis in a given species or in the whole population in a given year has been shown critically by statistical evaluation.

HOST PREFERENCE

Introduction

Both male and female black flies feed on the nectar of flowers mainly to provide energy for flight (Strong et al., 1934; Hocking, 1953) and the females of almost all species feed on the blood of most homiothermous animals to provide energy for ovarian development and oviposition (Cameron, 1922; Wu, 1931; Rubtzov, 1936; Lewis, 1953 and Davies and Peterson, 1956). The information on the feeding by black flies on man and domestic animals are numerous, but that on birds and wild animals are rather meagre. The poikilothermous animals are rarely fed on by black flies. The feeding activities of black flies are, however, closely related to the four variables, namely, temperature, relative humidity, wind velocity and changing light intensity (Peterson and Wolfe, 1956).

For the identification of the host blood from biting flies the precipitin test was widely used as an entomological tool (Lloyd et al., 1924; Johnson and Rawson, 1927; Rice and Barber, 1935; Rempel et al., 1946; Riddell et al., 1947; and Schubert and Kelley, 1950) and this technique was employed also for the study of black flies by several workers (Downe, 1957;

Downe and Morrison, 1957 and Davies et al., 1962) in different countries. In India records of blood-sucking by black flies are scanty (Becher, 1884; Senior-White, 1922 and, Perti and Lopez, 1962). A preliminary work on the identification of blood meals of black flies was first undertaken by Das Gupta et al. (1969) in Darjeeling. In order to augment the knowledge on the host preference of the Indian Simuliidae this investigation was undertaken in Darjeeling with numbers of blood engorged specimens available from the light trap device.

Methods

The materials for the precipitin test were only the blood engorged live female specimens of black flies (Simuliidae; Diptera) consisting of the six major species, namely, Simulium (Fusimulium) praelargum, n.sp., S.(E.) gracilis, n.sp. Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp., out of the total collection made by continuous light-trapping between 7 P.M. and 5 A.M. at Darjeeling Government College campus in 1790 trap-hours of 179 nights from April 1, 1968 to September 30, 1968 with the help of a simple light trap device described in page no. 132.

The method adopted in this study for the preparation of blood smears was based on the essential principles of Eligh

(1952). The blood engorged specimens of a given species were pressed against heavily by means of the thumb and forefinger round the periphery of the filter paper and then the remnant of the insect body was wiped clean off the paper. The smears were then allowed to dry slowly within a dessicator to get satisfactory results (Boreham in personal communication, 1968).

Following the method of Weitz (1956) the blood smears were subjected to the precipitin test. Those smears were extracted in 1 c.c. of physiological saline (P^H 7) for a considerable period at room temperature. The extracts thus obtained were layered in 0.05 c.c. amounts over an equal volume of appropriate antiserum in small serological tubes which were kept under observations for precipitin rings. Both positive and negative controls were tried, wherever possible, for the series of tests.

The procedure adopted was to test first of all with general mammalian anti-serum and anything that did not react was tested against general avian and general reptilian antisera. Any positive mammal feed was tested for man, bovid, horse, pig, rodent and carnivore, and all positive bovid feeds for sheep/goat.

Observations

Out of 97 blood-meals 73 reacted with appropriate antisera in a positive way. The sources of blood-meals of the six major species of black flies are shown in the table XXIII.

Table-XXIII

Blood-meals of black flies reacted positively

Hosts	<u>praelargum</u>	<u>gracilis</u>	<u>himalayense</u>	<u>grisea</u>	<u>rufibasis</u>	<u>tenuistylum</u>
Bird	-	-	4	-	-	-
Man	1	-	1	-	-	-
Carnivore	-	-	1	-	-	-
Rodent	-	-	-	1	-	-
Horse	-	-	3	-	1	1
Pig	-	-	3	-	-	-
Cow	-	-	18	9	4	3
Sheep/goat	-	-	1	1	-	-
Unidentified bovid*	1	-	2	2	3	-
Unidentified mammal**	1	1	4	4	3	-

* Weak feeds derived from the bovids and could include Sheep/goat.

** Weak feeds derived from the mammals and could include the species tested for.

The following is a specieswise description of host-preferences of the black flies of Darjeeling.

Simulium (Eusimulium) praelargum, n.sp.: This species was found to bite man in dull weather during collection in the field. In the precipitin test one blood-meal was found to have been taken from man. This species was also found to feed on some unidentified member of the bovidae and other mammalia.

Simulium (Eusimulium) gracilis, n.sp.: A single blood meal was found to have been taken from a mammal which could not be identified.

Simulium (Simulium) himalayense: The largest single group of blood-meals in this species was from the cow (18 out of 37). This species was also found to take its blood-meals from man, a carnivore, horse, pig, sheep or goat. It was also found to have fed on other bovids or some other mammals as shown by the test. However, an additional category of blood source for this species was from birds.

Simulium (Simulium) grisescens: This species was found to take its major blood-meals (over 50%) from the cow. It was found to feed on sheep or goat. It also fed on unidentified bovids or other mammals. This species also fed on an unidentified rodent.

Simulium (Simulium) rufibasis: This species fed predominantly on cows and also fed on the horse. It also fed on some other bovids excluding the cow, and also on some unidentified mammals.

Simulium (Gomphostilbia) tenuistylum, n.sp.: Only the cow and the horse were found to be the hosts of the species as revealed by the precipitin test; but this species is known to bite man in nature.

Discussion

In course of the present study himalayense was found to have a very wide range of hosts including birds and mammals. This species showed a preference for the cow, though other mammals including man, a carnivore, horse, pig, sheep or goat were also not spared. The carnivore could be a dog, a tiger, a leopard, a civet cat or a bear which occurred in the Zoological Park beside the trapping site.

Shewell (1955) suggested the presence of the large basal tooth on the tarsal claw of several species to be an adaptation for feeding on birds. Four, out of the six species, namely, himalayense, praelargum, gracilis and tenuistylum actually possessed toothed tarsal claw. The former species having very small sub-basal tooth (Puri, 1932a) was found to have bird-feeding habit, but the latter three species having large basal tooth indicated no ornithophilic habit within this brief trial of the investigation. Hargreaves (1925), le Roux (1929), Fain (1950), and Fallis and Bennet (1958), as stated by Fallis (1964), however, noted exceptions to the rule among the Ethiopian black flies. S.(E.) praelargum, n.sp. and S.(S.)

himalayense fed on man while no other species did so. S.(G.) tenuistylum, n.sp. and S.(S.) rufibasis were found to feed on horse and cow. S.(S.) grisescens was unique in feeding on rodent which might be a flying squirrel or an unstriped squirrel occurring in the locality. This species as well as himalayense fed on sheep or goat. All of these species, excepting tenuistylum, fed on other unidentified mammals as indicated by the precipitin test. Moreover, there should be some composite blood-meals of black flies but those could not be differentiated in these studies. However, it might be noted, as pointed out by Bates (1949) and also by Glasgow et al. (1958), that the identification of simuliid blood-meals were often subject to a strong bias produced by several potential factors influencing these flies.

Studies were made in other countries on the feeding period of black flies (see Fallis, 1964). It was of interest to note that the fed flies entered the light trap throughout the dark period, as was also recorded by Davies and Williams (1962). Peterson (1956) also recorded feeding of some flies at night at high altitude in Utah. In Darjeeling more fed females were trapped at the beginning and at the end of the night when the incidence of these flies was much poorer than in the middle phase of the night.

Black flies were found to show their feeding activity during occasional drizzle with over 55%-95% of relative humidity.

Rubtzov (1939) found greatest activity to occur in 75%-90% relative humidity. Underhill (1940) observed feeding at the relative humidity as low as 42% with a peak between 65%-75%, but later he (Underhill, 1944) held that there was no definite relationship between relative humidity and blood-sucking and, observed that active feeding would occur between 52% and 94% relative humidity. According to Davies (1952) most flying activity occurred in moist air, i.e., at 70%-90% relative humidity but not when it was close to saturation point. Wolfe and Peterson (1960) noticed feeding of Simulium venustum say at 25%-95% relative humidity and a remarkable decline if it was raining. Anderson and de Foliart (1961), however, reported little effect of humidity on the ornithophilic species.

Temperature was important in influencing the activity of black flies. Activity was noted at temperatures of 10-30°C in Darjeeling. Rubtzov (1939) noted that the activity of black flies was normal at temperatures between 10-29°C with the optimum at about 20-23°C. Underhill (1939, 1940) observed more flies to feed between 24°C and 29.4°C, and few to feed below 21°C or above 32.2°C. According to Davies (1952) more flies were on the wing between 15.5°C and 26.6°C, with most possibly at 24°C-26.6°C. Dalmat (1954, 1955) from extensive studies of three species concluded that the optimum temperature for feeding of those species was about 34-35°C. Abreu (1960) recorded activity of Simulium damnosum Theobald at 27-30°C but not below 18°C or above 40°C.

Strong winds interrupted the activity and feeding as was also observed by several workers in different countries (Edwards, 1920; Edwards et al., 1939; Rubtzov, 1939; Underhill, 1940, 1944; Ogata, 1954; Davies, 1952; Peterson and Wolfe, 1956; Wolfe and Peterson, 1960; Anderson and de Foliart, 1961), and most active flying was found only when the air was calm or almost so as was remarked by Uvarov (1931).

The barometric change (Rubtzov, 1935; Underhill, 1939, 1940; Crisp, 1956), altitudinal effect (Strong et al., 1934; Fain, 1950; Dalmat, 1954, 1955; Peterson, 1956, 1959), and the physiological state of the individual fly (Rubtzov, 1951; Sailer, 1953; Davies, 1955, 1957 and Lewis, 1960 a, b) have a direct bearing on the activity of these insects. In fact, so far as the observations were concerned, the most active flying and feeding of black flies in Darjeeling were indicated during the period of occasional drizzle and in almost calm air accompanied by dull cloudy weather.

Summary

The present investigation deals with the host preferences of six species of black flies (Simuliidae) of Darjeeling from the blood-meal identification by precipitin test. S.(E.) praelargum, n.sp., sucks blood from man. S.(S.) himalayense Puri (1932a) has a very wide range of hosts from birds to mammals, the latter included man, a carnivore, horse, pig, cow and sheep or

goat. S.(S.) *grisescens* Brunetti (1911) feeds on a rodent, cow and sheep or goat. S.(S.) *rufibasis* Brunetti (1911) sucks blood from horse and cow. All these species show also to have fed on some other members of mammalia including other bovids. S.(E.) *gracilis*, n.sp., is the blood-sucker of a mammal other than the member mentioned above. S.(G.) *tenuistylum*, n.sp., feeds on horse and cow as shown by the test, but it also bites man in nature.

The feeding period of these flies continued throughout the night but more fed flies were trapped at the beginning and at the end than at the middle phase of the night. The most active feeding was enhanced by occasional drizzle and by almost calm air accompanied by dull cloudy weather which has been discussed in details.

NOCTURNAL PERIODICITY

Introduction

Black flies belonging to the family Simuliidae (Diptera) exhibit considerable night activity (Williams and Davies, 1957) and according to Williams (1964) their activities continue for a long period in the night. Rubtzov (1936) and Ussova (1961) on the other hand believed that daylight would be an essential factor for adult activity. Nocturnal activity of Tipulinae (Diptera) was earlier demonstrated by Pinchin and Anderson (1936) using a light trap, and similar work was reported on heleid midges (Diptera) by Sen and Das Gupta (1959). The present investigation was undertaken to find out the nocturnal activity of adult black flies in Darjeeling, a hilly area of the eastern Himalayas.

Methods

Specimens of black flies were collected by continuous trapping at Darjeeling Government College campus from 7 P.M. to 5 A.M. for a total of 45 hours between May 10, 1969 and August 28, 1969, with the help of a simple light trap device described in page no.132, and data were obtained to estimate the nocturnal periodicity of these species of insects. During

a particular night collection was made in three shifts, each of three-hours' duration. The first shift was between 7 P.M. and 10 P.M., the second shift between 10.30 P.M. and 1.30 A.M. and the third or the last shift between 2 A.M. and 5 A.M. A half-an-hour time period between the shifts was permitted for sorting out different species trapped in the previous shift.

Observations

All the major six species of black flies, namely, Simulium (Eusimulium) praelargum, n.sp., S.(E.) gracilis, n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp., were studied and incidence of these flies is shown in the Table XXIV.

The incidence of black flies was marked by hourly variation and the peak (except for rufibasis) was attained during the middle of the night when the flies accounted for 60.9% of the total catch. The incidence was at its lowest during the first shift, with 17.2% of the total catch; while the third shift yielded 21.9% only.

In a species-wise estimation, praelargum showed a varying periodicity with the incidence in three shifts as 25%, 60.7% and 14.3% in succession, and this was unlike the general trend of the insect, but gracilis was found to maintain the

Table-XXIV

Prevalence of black flies at different
hours of the night in Darjeeling

Date of collec- tion	Species	Number of specimens in diff- erent shifts						Total
		Shift I		Shift II		Shift III		
		♀	♂	♀	♂	♀	♂	
10.5.69	<u>praelargum</u>	1	0	3	1	1	1	7
	<u>gracilis</u>	0	3	5	7	3	1	19
	<u>himalayense</u>	0	0	3	0	1	0	4
	<u>grisescens</u>	1	0	0	2	0	1	4
	<u>rufibasis</u>	0	0	0	0	0	0	0
	<u>tenuistylum</u>	0	0	1	0	1	0	2
21.5.69	<u>praelargum</u>	2	1	7	2	1	0	13
	<u>gracilis</u>	0	0	1	0	0	0	1
	<u>himalayense</u>	3	2	17	15	1	4	42
	<u>grisescens</u>	2	0	3	2	3	0	10
	<u>rufibasis</u>	1	0	0	0	0	0	1
	<u>tenuistylum</u>	1	0	1	0	0	0	2
2.6.69	<u>praelargum</u>	1	0	1	0	0	0	2
	<u>gracilis</u>	0	1	1	0	1	0	3
	<u>himalayense</u>	1	0	3	2	1	0	7
	<u>grisescens</u>	0	0	1	0	0	0	1
	<u>rufibasis</u>	1	0	1	0	0	1	3
	<u>tenuistylum</u>	3	1	7	12	1	1	25
24.6.69	<u>praelargum</u>	0	1	2	0	0	0	3
	<u>gracilis</u>	0	0	2	0	0	0	2
	<u>himalayense</u>	1	0	3	0	1	0	5
	<u>grisescens</u>	0	0	1	1	0	0	2
	<u>rufibasis</u>	2	1	4	2	9	6	24
	<u>tenuistylum</u>	0	0	0	0	1	0	1
28.8.69	<u>praelargum</u>	1	0	1	0	1	0	3
	<u>gracilis</u>	0	1	0	0	1	0	2
	<u>himalayense</u>	0	2	3	1	1	0	7
	<u>grisescens</u>	0	0	1	0	1	0	2
	<u>rufibasis</u>	0	0	0	1	0	0	1
	<u>tenuistylum</u>	0	2	5	3	1	1	12
TOTAL		21	15	77	51	30	16	210

general trend with the incidence during the three shifts as 18.5%, 59.3% and 22.2% in succession. The incidence patterns shown by himalayense during the three shifts were 13.8%, 72.4% and 13.8%, the sequence in the first shift and the last shift being equal, while grisescens obeyed the general trend of the insect with the incidence in three shifts as 15.8%, 57.9% and 26.3% in succession. S.(S.) rufibasis showed completely different periodicity in that the species was at its peak during the end of the night with the percentage of incidence as 17.2%, 27.6% and 55.2% in the three respective shifts. S.(G.) tenuistylum showed the trend of praelargum in periodicity with the sequence of incidence in three shifts as 16.6%, 69.1% and 14.3% respectively.

The two sexes of a species occasionally showed different periodicities. However, both the sexes of all the species excepting rufibasis were dominant during the middle of the night. S.(S.) rufibasis was, in fact, dominant in the last part of the night with the percentage distribution at 22.3%, 27.7% and 50% in females, and at 9%, 27.3% and 63.7% in males. Only in the females of grisescens the incidence assumed the general trend of the insect on the whole with 23.1%, 46.2% and 30.7% of the total catch of the sex, while the males of the species were unrepresented in the first shift of the night and accordingly the percentage compositions of the middle and

the last shifts were 83.3% and 16.7% respectively for males. The females of gracilis were also unrepresented in the first part of the night and the incidences of the second and the third shifts of the night were 64.3% and 35.7% respectively, for females, while in males the incidence was 38.5%, 54% and 7.5% in succession, the lowest being registered in the last shift of the night. Both the females and males of praelargum and the males of tenuistylum showed an incidence pattern similar to that shown by the males of gracilis. The percentage distributions in three shifts of the night in succession were at 22.8%, 63.6% and 13.6% for the females of praelargum, at 33.3%, 50% and 16.7% for the males of praelargum and at 15%, 75% and 10% for the males of tenuistylum respectively. In the females of tenuistylum, however, the incidence was equal in the first shift and in the last shift of the night and comprised of 18.2% in both the cases and there was a peak with 63.6% during the middle shift of the night. Both males and females of himalayense showed the above trend with the percentage distribution at 15.4% in both the first and the last shifts and 69.2% in the middle of the night for the former, and at 12.8% in both the first and the last shifts and 74.4% in the middle of the night for the latter, respectively.

The Chi-square analyses of the 19-patterns of nocturnal periodicity encountered involving the six species of black flies are shown in the Table XXV.

Table-XXV

Chi-square analyses of the incidence frequencies
of black flies at different parts of night
(based on Table XXIV)

Types of incidence	: Frequency in three shifts	: Chi-square value
1. Total population of six species	36 : 128 : 46	55.06 ***
2. <u>praelargum</u> -population	7 : 17 : 4	9.96 ***
3. <u>gracilis</u> -population	5 : 16 : 6	8.22 **
4. <u>himalayense</u> -population	9 : 47 : 9	44.35 ***
5. <u>grisescens</u> -population	3 : 11 : 5	5.50 *
6. <u>rufibasis</u> -population	5 : 8 : 16	6.66 **
7. <u>tenuistylum</u> -population	7 : 29 : 6	24.14 ***
8. Female-populations	21 : 77 : 30	42.37 ***
9. Male-populations	15 : 51 : 16	30.88 ***
10. <u>praelargum</u> -females	5 : 14 : 3	9.40 ***
11. <u>himalayense</u> -females	5 : 29 : 5	29.53 ***
12. <u>grisescens</u> -females	3 : 6 : 4	1.08 *
13. <u>rufibasis</u> -females	4 : 5 : 9	2.33 *
14. <u>tenuistylum</u> -females	4 : 14 : 4	9.13 **
15. <u>praelargum</u> -males	2 : 3 : 1	1.00 *
16. <u>gracilis</u> -males	5 : 7 : 1	4.34 *
17. <u>himalayense</u> -males	4 : 18 : 4	15.02 ***
18. <u>rufibasis</u> -males	1 : 3 : 7	5.04 *
19. <u>tenuistylum</u> -males	3 : 15 : 2	15.62 ***

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

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

* Insignificant at both the levels.

Discussion

Observations on the nocturnal periodicity of the six species of black flies revealed that there was a significant difference in the activities of these insects at different hours of the night and all of them with the exception of rufibasis showed the highest incidence in the middle of night, i.e., between 10.30 P.M. and 1.30 A.M. However, rufibasis showed its peak abundance during the last part of the night, i.e., between 2 A.M. and 5 A.M. Minář (1962), working with five species of Simuliidae, observed that black flies showed their maximum activity at 6 A.M. and upto 6 to 7 P.M. but the activity ceased in the middle of the day. In Kenya, McMahon (1947) noted that Simulium neavei Roubaud showed its maximum activity from 9 A.M. to 11.30 A.M. and from 3 P.M. to 6.30 P.M. According to Wolfe and Peterson (1960) black flies were most active in the morning, one to two hours after dawn, and in the evening, half-an-hour to one hour before sun-set, and at night they moved to resting places in the tops of the trees, probably because of the more suitable light intensity at higher levels just before darkness. Peterson (1956) recorded activity of some species at night in Utah at high altitudes. Bennet (1960) recorded more flies from woodland birds late in the evening. In the Palaearctic region, Helodon ferrugineus Wahlberg was caught in the light trap during night by Kureck (1969). Thus, the activities of black flies are not restricted in day time only. Williams (1964)

experimentally proved that the activity of these insects continued throughout the night and that the activity became dominant during the middle of the night, when conditions were favourable. These suggestions made by him confirm the results of this investigation. In a similar type of experiments with Tipulinae Pinchin and Anderson (1936) observed that these insects showed the maximum activity at dusk and, Sen and Das Gupta (1959) found that the heleid midges were most active in the early hours of the night and according to them different periodicities might be shown by the two sexes of a given species.

In the present investigation both sexes of all the species showed the peak abundance as represented for the given species in the same time-period, but no distinctive conclusion could be made from these brief trapping data as to whether the two sexes of a species would show different periodicities, as was shown by Pinchin and Anderson (1936) in the case of Tipulinae in which females were on the wing at dusk while the males appeared an hour later. The present investigation, however, indicated that the percentage distribution of the females of a given species in every shift was significantly higher than that of the males of the same species and this was true for most of the species, as was shown earlier by Williams (1964) in Scotland. However, the two sexes of a species might respond to the different hours of the night differently even in the favourable meteorological conditions for both of the sexes of black flies.

Summary

The nocturnal periodicity of six species of black flies of Darjeeling was found out from the data of light-trapping made in three equal shifts for each of the five nights selected in 1969. The incidence of these flies was marked by hourly variation. Each of S.(E.) praelargum, n.sp., S.(E.) gracilis, n.sp., S.(S.) himalayense Puri (1932), S.(S.) griseescens Brunetti (1911) and S.(G.) tenuistylum, n.sp., showed its peak abundance in the middle of night, while S.(S.) rufibasis Brunetti (1911) was at its peak at the end of the night. The percentage composition of gracilis and griseescens in the last shift was higher than that in the first shift, and this was the general trend of the species of these flies taken together. The incidence of praelargum and tenuistylum in the first shift was higher than that in the last shift. In himalayense the distribution was similar in any of the two shifts, while in rufibasis it was found to rise gradually, thereby attaining itself to its peak at the end of the night. The incidence shown by the two sexes of a species did not always obey the general trend and this is discussed in details.

PHOTOPHILIC BEHAVIOUR

Introduction

Black flies belonging to the family Simuliidae (Diptera) are known to be positively phototropic insects (Williams and Davies, 1957). Kohler and Fox (1951) performed an experiment on the Puerto Rican Culicoides (Ceratopogonidae) by means of the New Jersey light trap (Headlee, 1932) using chrome yellow and green lights to ascertain the relative attractiveness of the insects to these colours. Observations on the landing of black flies depending on the colour of their hosts were also recorded by Davies (1951, 1961) and Vargas (1945). A study was undertaken to find out the photophilic behaviour of black flies of Darjeeling using some desirable coloured lights.

Methods

A Chinsura light trap (Banerjee and Basu, 1956) was operated simultaneously for the control experiment beside the regular light trap device (see page no.132) meant for the treated experiments. A 200 wattage lamp was used as the light source of each of the trap which were made operational by turning on its light source daily at 7 P.M., and the trapping continued till

5 A.M. of the following day. The experiment was conducted at Darjeeling Government College campus for 68 nights during the months of March and October of 1968, 1969 and 1970. The light source of the treated trap was wrapped around by a transparent cellophane paper of a desirable colour, while that of the control trap was white as usual for all the series of performance. The incidence of black flies taken in the treated series was compared with that of the control ones in order to find out the colour preference of these insects.

Observations

Black flies collected by the above method were found to consist of the six major species, namely, Simulium (Eusimulium) praelargum, n.sp., S.(E.) gracilis, n.sp., Simulium (Simulium) himalayense Puri (1932a), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp. The incidence of these flies in the traps are shown in the following Tables XXVI-XXX..

Table-XXVI

Black flies taken in the treated trap with
chrome yellow light source as against the
control trap tested for 14 days

Species	: Number of specimens taken:		Percentage of inci- dence in Chrome yellow light
	: _____ : Control	: _____ : Treated	
<u>praelargum</u>	14	12	46.1
<u>gracilis</u>	10	11	52.4
<u>himalayense</u>	20	16	44.4
<u>grisescens</u>	7	4	36.4
<u>rufibasis</u>	13	12	48.0
<u>tenuistylum</u>	5	5	50.0

The incidence of black flies in the control trap was slightly greater than that of the treated trap excepting in the case of gracilis and tenuistylum. The former species taken in the treated trap showed a slightly higher proportion of incidence, while the latter occurred in equal proportions in both the traps.

Table-XXVII

Black flies taken in the treated trap with dark red light source as against the control trap tested for 17 days

Species	: Number of specimens taken:		Percentage of incidence in dark red light
	: _____ in light trap	: _____	
	: Control	: Treated	: light
<u>praelargum</u>	20	15	42.9
<u>gracilis</u>	12	9	42.9
<u>himalayense</u>	22	17	41.0
<u>grisescens</u>	10	7	41.2
<u>rufibasis</u>	11	9	45.0
<u>tenuistylum</u>	4	2	33.3

The incidence of all the black flies taken in the treated trap using dark red light source was always lower (much below 50%) than that taken in the control trap. S.(G.) tenuistylum, n.sp., however, showed the incidence only above 30% level.

Table-XXVIII

Black flies taken in the treated trap with forest green light source as against the control trap tested for 15 days

Species	: Number of specimens taken:		Percentage of incidence in forest green light
	: _____ in light trap _____ :		
	: Control	: Treated	
<u>praelargum</u>	20	7	26.0
<u>gracilis</u>	14	6	30.0
<u>himalayense</u>	31	14	31.1
<u>grisescens</u>	15	7	31.8
<u>rufibasis</u>	18	8	30.8
<u>tenuistylum</u>	7	2	22.2

The incidence of black flies excepting praelargum and tenuistylum, taken in the treated trap with forest green light source was found to be 30% or just above 30% level, while praelargum and tenuistylum showed lower percentage of incidence below 30% level. In all cases, however, the appearance of females in the treated trap was scarce.

Table-XXIX

Black flies taken in the treated trap with dark blue light source as against the control trap tested for 12 days

Species	: Number of specimens taken:		Percentage of inci- : dence in dark blue : light
	: _____ : Control	: _____ : Treated	
<u>praelargum</u>	17	7	29.2
<u>gracilis</u>	11	2	15.4
<u>himalayense</u>	24	9	27.3
<u>grisescens</u>	15	5	25.0
<u>rufibasis</u>	18	6	25.0
<u>tenuistylum</u>	7	1	12.0

The incidence of black flies taken in the treated trap using dark blue lamp as the light source was very poor. The two species gracilis and tenuistylum showed the incidence at 15.4% and 12.5% level respectively, while the others registered this incidence between 25% and 30% level. The most important feature of this experiment was that the treated trap captured only the female specimens instead of admixture of both the sexes as evidenced in other experiments.

Table-XXX

Black flies taken in the treated trap with snow white light source as against the control trap tested for 10 days

Species	: Number of specimens taken:		Percentage of inci- : dence in snow : white light
	: _____ : in light trap	: _____ : Treated	
	: Control	:	
<u>praelargum</u>	12		58.6
<u>gracilis</u>	8		63.6
<u>himalayense</u>	27		55.7
<u>grisescens</u>	9		57.1
<u>rufibasis</u>	15		51.6
<u>tenuistylum</u>	6		53.8

The picture of incidence of black flies taken in the trap with snow white light source was quite different in that all the species showed higher incidence in the treated trap than in the control one and the percentage of females captured was always above 50.

The incidence percentage for all the species of black flies taken in the treated series of experiments tried for five desirable colours with which the relative attractiveness of these insects was tested is shown in the following table (Table XXXI).

Table-XXXI

Incidence-percentage of black flies taken
in the treated trap tried for 5-coloured
light sources in 68 nights

Species	: Chrome : yellow	: Dark : red	: Forest : green	: Dark : blue	: Snow : white
<u>praelargum</u>	46.1	42.9	26.0	29.2	58.6
<u>gracilis</u>	52.4	42.9	30.0	15.4	63.6
<u>himalayense</u>	44.4	41.0	31.1	27.3	55.7
<u>grisescens</u>	36.4	41.2	31.8	25.0	57.1
<u>rufibasis</u>	48.0	45.0	30.8	25.0	51.6
<u>tenuistylum</u>	50.0	33.3	22.2	12.5	53.8

Discussion

The photophilic behaviour of the species of black flies in Darjeeling was very interesting as evidenced from the series of experiments with light traps, in which, as it was revealed, black flies were more attracted to snow white light than any other coloured light and the ordinary white light. The incidence percentage of a given species varied from colour to colour and the sequence of attractiveness for all but praelargum followed in this way: snow white, chrome yellow, dark red, forest green and dark blue. Only praelargum was least attracted to forest green light. The incidence of tenuistylum was obtained in equal proportions taken in the control and the treated traps with

chrome yellow light source, probably because of the scanty populations of the species, and this sort of variation in incidence was also shown by Kohler and Fox (1951) who experimented with Culicoides in Puerto Rico and demonstrated that the yellow trap made consistently higher catches than the forest green one, if the populations were not extremely low.

The reason of decreasing incidence with the declining sequence of attractiveness of black flies might be correlated with the limited dispersion of light rays from the coloured envelope of the treated trap which could be restricted beyond the span of these insects' activity in nature, if not to speak of their natural sensivity to different chromatic lights.

Moreover, two sexes of a species behaved in an opposite way. Thus, as the incidence of a species began to decline with the above trend of attractiveness, more and more female specimens were to appear in the treated trap excepting in the case of green light. According to Davies and Williams (1962) two sexes of a given species or two species of a given population of black flies might be attracted to light differentially. The results of the present investigation confirmed this view. Davies (1951, 1961) held that females of Simulium venustum Say were attracted more to dark blue cloth than to other coloured cloth. It might be possible that females of a species would be influenced by the

excitement to one colour and not to another, which might be preferable to the other sex, depending upon the criteria of wavelength, intensity and purity of the colour chosen.

Summary

The photophilic behaviour of the six species of black flies (Simuliidae:Diptera) of Darjeeling, namely, Simulium (Eusimulium) praelargum, n.sp., S.(E.) gracilis, n.sp., Simulium (Simulium) himalayense Puri (1932), S.(S.) grisescens Brunetti (1911), S.(S.) rufibasis Brunetti (1911) and Simulium (Gomphostilbia) tenuistylum, n.sp., was tested with five different coloured lights. Black flies were more attracted to snow white light than by any other coloured light. The incidence percentage of a given species varied from colour to colour, and the sequence of attractiveness for all but praelargum followed in this way: snow white, chrome yellow, dark red, forest green and dark blue. Only praelargum was least attracted to forest green light. The relative attractiveness of both sexes differed to a considerable extent. The reason of decreasing incidence with the declining sequence of attractiveness of black flies is discussed.

REFERENCES

- Abreu, M.M.M. de Araujo (1960). Contribuicao para o estudo dos Simuliidae de Angola (Diptera:Nematocera). Alguns dados sobre a sua ecologia, biologia e relacoes com a epidemiologia da oncocercose. Ann. Int. Med. Trop. 17:113-171.
- Anderson, J.R. and de Foliart, G.R. (1961). Feeding behaviour and host preferences of some black flies (Diptera: Simuliidae) in Wisconsin. Ann. Entomol. Soc. Amer. 54:716-729.
- Andrews, H.L. (1931). Moth trap experiences in Dorset. Entomologist. 64:86-90 and 104-106.
- Banerjee, S.N. and Basu, A.C. (1951). On the suitability of light trap for quantitative studies on insect population. Proc. 38th Ind. Sci. Cong. (3):215.
- (1956). The Chinsura light trap. Proc. Zool. Soc. Calcutta. 9:27-32.
- Bates, M. (1949). The natural history of mosquitoes. New York. 1-379.
- Becher, E. (1884). A new species of Simulium from Assam. Jour. Asiat. Soc. Beng. 53(2): 199-200.
- Beck, E.C. (1958). A population study of Culicoides of Florida (Diptera:Heleidae). Mosq. News. 18(1):6-11.
- Bennett, G.F. (1960). On some ornithophilic blood-sucking Diptera in Algonquin Park, Ontario, Canada. Can. J. Zool. 38:377-389.
- Brunetti, E. (1911). New Oriental Nematocera (Simuliidae). Rec. Ind. Mus. 4(7):282-288.

- Cameron, A.E. (1922). The morphology and biology of a Canadian cattle-infesting black fly, Simulium simile Mall. (Diptera:Simuliidae). Can. Dept. Agr. Bull. 5 (N.S.), Entomol. Bull. 20: 1-26.
- Chaudhuri, P.K. (1970). Studies on Systematics and Distribution of Alluaudomyia and Stilobezzia species of biting midges (Ceratopogonidae:Diptera) of India. D.Phil. Thesis in Zoology, Burdwan University.
- Cook, W.C. (1921). Studies on the flight of nocturnal Lepidoptera. St.Ent.Minnesota 1920 Rep. 18:43-56.
- (1923). Studies on the physical ecology of the Noctuidae. Minnesota Agr. Exp. St. Tech. Bull. 12.
- (1930). Field studies of the Pale Western cutworm. Bull. Montana Agr. Exp. St. 225.
- Crisp, G. (1956). Simulium and onchocerciasis in the Northern Territories of the Gold coast. Lond. Brit. Emp. Soc. Bld., Lond.:1-171 (Rev.App.Ent.(B)45:191. 1957).
- Dalmat, H.T. (1954). Ecology of simuliid vectors of onchocerciasis in Guatemala. Amer.Midl.Natur. 52:175-196.
- (1955). Black flies (Diptera, Simuliidae) of Guatemala and their role as vectors of onchocerciasis. Smith. Misc. Coll. 125(1):1-425.
- Das Gupta, S.K. (1961). Studies on the incidence of some Indian Culicoides (Diptera:Ceratopogonidae). Ind. Agric. 5(2):189-206.
- (1967). Notes on a blood-sucking Culicoides (Diptera: Ceratopogonidae) from India. Proc.Rajasthan Acad.Sci. 11:58-60.
- , Sharma, T., Mitra, A. and Dasgupta, B. (1969). On the incidence and blood meal of biting insects (Diptera, ceratopogonidae, Simuliidae) of Darjeeling, India. Entomol. Obozr. 48(4):770-773.

- Davies, D.M. (1950). A study of the black fly population of a stream in Algonquin Park, Ontario, Canada. Trans. Roy. Canad. Inst. 28:121-160.
- (1951). Some observations of the number of black flies (Diptera, Simuliidae) landing on coloured cloths. Canad. J. Zool. 29:65-70.
- (1952). The population and activity of adult female black flies in the vicinity of a stream in Algonquin Park, Ontario, Canada. Ibid. 30:287-321.
- (1961). Colour effects the landing of blood sucking black flies (Diptera:Simuliidae) on their hosts. Proc. Ent. Soc. Ont. 91:267-270.
- and Peterson, B.V. (1956). Observations on the mating, feeding, ovarian development and oviposition of adult black flies (Simuliidae:Diptera). Can. J. Zool. 34:615-655.
- and Syme, P.D. (1958). Three new Ontario black flies of the genus Prosimulium (Diptera:Simuliidae). Part II. Can. Entomol. 90(12):744-759.
- Davies, L. (1951). Some field observations on Simuliidae (Diptera) at Holandsfjord, Norway. Oikos 3(2):193-199.
- (1955). Behaviour of young and old females of the black fly, Simulium ornatum Mg. Nature 176:979-980.
- (1957). A study of the black fly Simulium ornatum Mg. (Diptera) with particular reference to its activity on grazing cattle. Bull. Ent. Res. 48:407-424.
- , Downe, A.E.R., Weitz, B. and Williams, C.B. (1962). Studies on black flies (Diptera:Simuliidae) taken in a light trap in Scotland. Part II. Trans. R. ent. Soc. Lond. 114(1):21-27.

- and Williams, C.B. (1962). Studies on black flies (Diptera:Simuliidae) taken in a light trap in Scotland. Part I. Ibid. 114(1):1-20.
- Downe, A.E.R. (1957). Precipitin test studies on rate of digestion of blood meals in black flies (Diptera:Simuliidae). Can. J. Zool. 35:459-462.
- and Morrison, P.E. (1957). Identification of blood meals of black flies (Diptera:Simuliidae) attacking farm animals. Mosq. News. 17:37-40.
- Edwards, F.W. (1920). On the British species of Simulium. Part II. Bull. Ent. Res. 11:211-246.
- , Oldroyd, H. and Smart, J. (1939). British blood sucking flies. Lond. Brit. Mus. (Nat. Hist):1-156.
- Eligh, G.S. (1952). Factors influencing the performance of the precipitin test in the determination of blood meals of insects. Can. J. Zool. 30(4):213-218.
- Fain, A. (1950). Simulies nouvelles du Ruande-Urundi. Rev. Zool. Bot. Afr. 43:101-123. (Rev. App. Ent. (B)41:29. 1953).
- Fallis, A.M. (1964). Feeding and related behaviour of female Simuliidae (Diptera). Exptl. Parasitol. 15:439-470.
- and Bennett, G.F. (1958). Transmission of Leucocytozoon bonasae Clarke, to ruffed grouse (Bonasa umbellus L.) by the black flies Simulium latipes Mg. and Simulium aureum Fries. Can. J. Zool. 36:533-539.
- Fox, I. (1953). Notes on Puerto Rican Simuliidae from a light trap. Proc. Ent. Soc. Wash. 55:135-140.
- Fredeen, F.J.H. (1959). Collection, extraction, sterilization and low-temperature storage of black fly eggs (Diptera:Simuliidae). Canad. Ent. 91:450-453.
- (1961). A trap for studying the attacking behaviour of black flies, Simulium arcticum. Ibid. 93(1):73-78.

- Frost, S.W. (1949). Simuliidae of Pennsylvania. Ent. News 60:129-131.
- (1957a). The Helicidae of the Tennessee river basin. Jour. Tennessee Acad. Sci. 52(1):18-36.
- (1957b). The Pennsylvania light trap. J. Econ. Ent. 50(3):287-292.
- (1962). Winter insect light-trapping at the Archbold Biological Station. Florida Ent. 45(4):175-190.
- (1963). Winter insect light-trapping at the Archbold Biological Station, Florida. Ibid. 46(1):23-43.
- (1964a). Insect taken in light traps at the Archbold Biological Station, Highlands County, Florida. Ibid. 47(2):130-161.
- (1964b). Killing agents and containers for use with insect light traps. Entomol. News. 75(6):163-166.
- Glasgow, J.P., Isherwood, F., Leejones, F. and Weitz, B. (1958). Factors influencing the stable food of tsetse flies. J. Anim. Ecol. 27:59-69.
- Grenier, P. (1949). Contributions a l etude biologique des Simuliidae de France. Physiol. Comp. 1:165-330.
- Hanna, H.M. (1968). On the time of flight of certain nocturnal Lepidoptera as measured by a light trap. Bull. Soc. Entomol. Egypte. 52:535-545.
- Hargreaves, H. (1925). Annual report of the Government Entomologist Uganda. Ann. Rep. Dept. Agric. 21-28. (Rev. App. Ent. (B) 13:167. 1925).
- Headlee, T.J. (1932). The development of mechanical equipment for sampling the mosquito fauna and some results of its use. Proc. Ann. Meet. New Jersey Mosquito Extrem. Assoc. 106-126.

- Hocking, B. (1953). The intrinsic range and speed of flight of insects. Trans. Roy. ent. Soc. Lond. 104:223-345.
- Johnson, W.B. and Rawson, P.H. (1927). Use of precipitin test to determine the food supply of tsetse flies; a preliminary note. Trans. Roy. Soc. Trop. Med. Hyg. 21:135-149.
- Judd, W.W. (1957). Studies of the Byron Bog in South Western Ontario. Part IV. Entomol. News 68(10):263-265.
- Kettle, D.S. (1955). Sex ratio among British Culicoides. Proc. R. ent. Soc. Lond. (A). 30:70-72.
- Kohler, C.E. and Fox, I. (1951). The relative attractiveness of New Jersey light traps painted (a) green and (b) yellow to Puerto Rican Culicoides. J. Econ. Ent. 44(1):112-113.
- Kundu, H.L., Datta Gupta, A.K. and Gupta, B.B. (1964). A study of the abundance of certain insects of Pilani with the help of a light trap. Proc. Rajasthan Acad. Sci. 8:79-87.
- Kurashige, Y. (1970). Nocturnal succession of the mosquitoes captured by a light trap in Utsunomiya city (in Japanese). Jap. J. Sanit. Zool. 20(4):236-239.
- Kureck, A. (1969). Diurnal rhythms in Lapland Simuliidae (Diptera). (In German). Oecologia 2(4):385-410.
- Lewis, D.J. (1953). Simulium damnosum and its relation to onchocerciasis in the Anglo-Egyptian Sudan. Bull. Ent. Res. 43:597-644.
- (1957). Simuliidae and their relation to onchocerciasis in the Sudan. Bull. World Health Org. 16:671-674.
- (1960a). Observations on the Simulium neavei complex at Anami in Tanganyika. Bull. Ent. Res. 51:95-113.
- (1960b). Observations on Simulium damnosum in the southern Cameroons and Liberia. Ann. Trop. Med. Parasitol. 54:208-223.

- Lloyd, R.B., Napier, L.E. and Smith, R.O.A. (1924). The blood meal of Phlebotomus argentipes identified by precipitin anticera. Ind. J. Med. Res. 12:811-817.
- Mazokhin-Porshnyakov, G.A. (1956). The night catch of insects with a mercury light trap, and its application in Applied Entomology (In Russian). J.Zool. 35(2):238-244.
- McMahon, J.P. (1947). Simuliidae of Kenya. E.Afr.Med.J. 24(1):51-56.
- Minář, J. (1962). Observations on the effect of meteorological factors on some parasitic Diptera (Ceratopogonidae, Simuliidae, Tabanidae). (In Czeck). Op. Cit. 9:331-342. (Rev.App.Ent.(B) 52:163-164. 1964).
- Ogata, K. (1954). Studies on the diurnal rhythm of biting activity in Simulium venustum Say. Jap.J.Appl.Zool. 19:136-141.
- Perti, S.L. and Lt.Col.Lopez, W.A. (1962). Bionomics and control of Simulium flies in NEFA area. Part I. Armed Forces Med.Jour. 18(4):536-544.
- Peterson, B.V. (1956). Observations on the biology of Utah black flies (Diptera:Simuliidae). Can.Ent. 88:496-507.
- (1959). Observations on mating, feeding and oviposition of some Utah species of black flies (Diptera: Simuliidae). Ibid. 91:147-155.
- Peterson, D.G. and Wolfe, L.S. (1956). The Biology and control of black flies (Diptera: Simuliidae) in Canada. Proc. Xth Int.Cong.Entomol. 3:551-564.
- Pickard, E. and Snow, W.E. (1955). Light trap collections of punkies (Family Heleidae, Genus Culicoides) McMinn County, Tennessee, April-September, 1952. Jour. Tennessee Acad. Sci. 30(1):15-18.

- Pinchin, R.D. and Anderson, J. (1936). On the nocturnal activity of Tipulinae (Diptera) as measured by a light trap. Proc. R. ent. Soc. Lond. (A) 11:69-75.
- Puri, I.M. (1932a). Studies on Indian Simuliidae. Part I. Ind. J. Med. Res. 19(3):883-897.
- (1932b). Studies on Indian Simuliidae. Part III. Ibid. 19(4):1125-1143.
- Rempel, J.G., Riddell, W.A. and McNelly, E.M. (1946). Multiple feed habits of Saskatchewan mosquitoes. Can. J. Res., E, 24:71-78.
- Rice, J.B. and Barbar, M.A. (1935). Malaria studies in Greece. A modification of the Uhlenhuth-Weidanz precipitin test for determining the sources of blood meals in mosquitoes and other insects. J. lab. Clin. Med. 20:876-883.
- Riddell, W.A., Rempel, J.G. and McNelly, E.M. (1947). The specificity of the precipitin reaction as used in the study of mosquito feeding habits. Can. J. Res., E, 25:210-215.
- Roux, le P.L. (1929). Onchocerciasis of cattle with special reference to its possible life-cycle and control. Pan-Afr. Agric. Veter. Conf., Pretoria 1929.
Par. Veter. Sec. 107-112 (Rev. App. Ent. (B) 18:213.1930).
- Rubtzov, I.A. (1935). Data on the Biology and Ecology of Simuliidae (In Russian). Bull. Inst. Sci. Biol. Geogr. Univ. Irkoutsk 6(2-4):109-133. (Rev. App. Ent. 25:56-57.1937)
- (1936). On the Biology and Ecology of the Simuliidae of Eastern Siberia. (In Russian). Mag. Parasitol. (Leningrad) 6:169-200.

- (1939). Factors of outbreaks of the black flies (In Russian). Trav. Acad. Milit. Méd. Kiroff Armée Rouge 19:177-207. (Rev.App.Ent.34:42-44. 1946).
- (1951). Contribution to the biology and ecology of the midges (Simuliidae) of Central Asia (In Russian) Parasitol. Sbornik. 13:328-342. (Rev.App.Ent.(B) 42:68. 1954).
- Sailer, R.I. (1953). The black fly problem in Alaska. Mosq. News. 13:232-235.
- Schubert, J.H. and Kelley, M.H. (1950). The precipitin technique for determining species of host blood in mosquitoes - modifications and improvements. J.Natl.Malaria Soc. 9:341-348.
- Sen, P. and Das Gupta, S.K. (1959). Nocturnal periodicity of biting midges (Diptera: Ceratopogonidae). Science and Culture. 25:374-375.
- Senior-White, R. (1922). Notes on Indian Diptera. Mem. Dept. Agric. India Ent. Ser. 7(9):126-131.
- Service, M.W. (1969). Light trap catches of Culicoides spp. (Diptera: Ceratopogonidae) from Southern England. Bull. Ent. Res. 59(2):317-322.
- Shewell, G.E. (1955). Identity of the black fly that attacks ducklings and goslings in Canada (Diptera: Simuliidae) Can. Ent. 87:345-349.
- Sinharay, D.C., Hajra, D.P. and Das Gupta, S.K. (1969). A survey of Darjeeling insects by periodic light-trappings. Jour. Beng. Nat. Hist. Soc. 35(2):76-85.
- Smart, J. (1936). Notes on the Simuliidae occurring at Fortingal, Perthshire. Scot. Nat. 22-26.
- Smith, S.G. (1923). Records of experiments with light for attracting British moths. Chester 1923:1-33.

- Snow, W.E. and Pickard, E. (1954). Observations on the seasonal activity of some night-biting Diptera. Jour. Tennessee Acad. Sci. 29(1):17-22.
- Strong, R.P., Sandground, J.H., Bequart, J.C. and Ochoa, M. (1934). Onchocerciasis with special reference to the Central American Form of the disease. Contr. Dept. Trop. Med., Harv. Univ. 6:175-224. (Rev. App. Ent. (B) 23:172-173. 1935).
- Stukolkina, N.N. (1939). Studies on the Biology of black flies in Transbaikalia (In Russian). Trav. Acad. Milit. Méd. Kiroff Armée Rouge 19:49-60. (Rev. App. Ent. (B) 34:42. 1946).
- Underhill, G.W. (1939). Two simuliids found feeding on turkeys in Virginia. J. Econ. Ent. 32:765-768.
- (1940). Some factors influencing feeding activity of simuliids in the field. Ibid. 33:915-917.
- (1944). Black flies found feeding on turkeys in Virginia, (Simulium nigroparvum Twinn and Simulium glossosae Dyar and Shannon). Virg. Polyt. Inst. Agric., Exp. St. Tech. Bull. 94:1-32.
- Ussova, Z.V. (1961). Flies of Karelia and the Murmansk region (Diptera: Simuliidae). (In Russian). Izdatel'stvo Acad. Nauk SSSR: 1-267.
- Uvarov, B.P. (1931). Insects and climate. Trans. Entomol. Soc. Lond. 79:1-247.
- Vargas, L. (1945). Simulidos del nuevo mundo. Monog. Inst. Salubridad Enferm. Trop. Mexico 1:1-241.
- Weitz, B. (1956). Identification of blood meals of blood sucking arthropods. Bull. World Hlth. Org. 15:474-490.
- Williams, C.B. (1923). A new type of light trap for insects. Tech. Bull. Minist. Agric. Egypt 28:1-2.

- (1924). An improved light trap for insects.
Bull. Ent. Res. 15:57-60.
- (1936). The influence of moon light on the activity of certain nocturnal insects, particularly the family Noctuidae, as indicated by a light trap. Phil. Trans. (B) 226:357-387.
- (1939). An analysis of four years' captures of insects in the light trap. Part I. Trans. R. ent. Soc. Lond. 89:79-132.
- (1940). An analysis of four years' captures of insects in light trap. Part II. Ibid. 90:227-306.
- (1948). The Rothamsted light trap. Proc. R. ent. Soc. Lond. (A) 23:80-85.
- (1951). Changes in insect populations in the field in relation to preceding weather conditions. Proc. R. Soc. Lond. (B) 132:130-156.
- (1961). Studies in the effect of weather conditions on the activity and abundance of insect populations. Phil. Trans. R. Soc. Lond. (B) 224(713):331-378.
- (1962). Studies on black flies (Diptera: Simuliidae) taken in a light trap in Scotland. Part III. Trans. R. ent. Soc. Lond. 114(1):28-47.
- (1964). Nocturnal activity of black flies (Simuliidae). Nature 201 (4914):105.
- and Davies, L. (1957). Simuliidae attracted at night to a trap using ultra-violet light. Ibid. 179:924.
- , French, R.A. and Hosni, M.M. (1955). A second experiment of testing the relative efficiency of insect traps. Bull. Ent. Res. 46(1):193-204.
- Wolfe, L.S. and Peterson, D.G. (1959). Black flies (Diptera: Simuliidae) of the forests of Quebec. Can. J. Zool. 37:137-159.

- (1960). Diurnal behaviour and biting habits of black flies (Diptera: Simuliidae) in the forests of Quebec. Ibid. 38:489-497.
- Worms, de C.G.M. (1930). A season's collecting with an electric light trap during 1929 near Egham, Surrey. Entomologist 63:226-234.
- (1931). Moth trap notes for 1930. Ibid. 64:147-149.
- (1932). Moth trap results, 1931. Ibid. 65:230-231.
- (1933). Moth trap records at Egham for 1932. Ibid. 66:140-141.
- Wu, Y.F. (1931). A contribution to the biology of Simulium (Diptera). Papers Mich. Acad. Sci. 13:543-599.
- Zahar, A.R. (1951). The ecology and distribution of black flies (Simuliidae) in South-east Scotland. J. Anim. Ecol. 20:33-62.
-