

HIGH ALTITUDE  
ENTOMOLOGY  
AND  
WILDLIFE ECOLOGY



Zoological Survey of India

# **HIGH ALTITUDE ENTOMOLOGY AND WILDLIFE ECOLOGY**

PROCEEDINGS OF THE WORKSHOP  
ON HIGH ALTITUDE ENTOMOLOGY AND WILDLIFE  
ECOLOGY HELD AT SOLAN, HIMACHAL PRADESH  
On 14-16 June, 1979



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## F O R E W O R D

High altitude ecosystem provides an exciting avenue of research, specially in India, where a good deal remains to be done. This has been clearly evident of late through the focal theme on high altitude discussed at 72nd Session of Indian Science Congress, held at Lucknow. A workshop on High Altitude Entomology and Wildlife Ecology was held on June 14-16, 1979 at Solan, Himachal Pradesh. This was sponsored by the Zoological Survey of India in collaboration with the Himachal Pradesh Krishi Vishva Vidyalaya. This workshop provided a forum for fellow research workers to discuss fundamental and applied aspect of insects and wildlife, predominant in the high altitude regions of the country. A total of 39 papers, divided into two major groups viz., High Altitude Entomology and Wildlife Ecology were dealt with. Hope, the deliberations presented here will benefit the researchers and planners concerned with the productivity and conservation of high altitude ecosystem.

The entire task of getting it printed at Chandigarh was undertaken by Dr. Asket Singh, Deputy Director and Dr. J. M. Julka, Suptd. Zoologist of the High Altitude Zoology Field Station, Zoological Survey of India, Solan to whom thanks are due.

Calcutta

B. K. TIKADER  
*Director*  
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# ZOOLOGICAL SURVEY OF INDIA

## PROCEEDINGS OF THE WORKSHOP ON HIGH ALTITUDE ENTOMOLOGY AND WILDLIFE ECOLOGY

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## STUDIES ON THE ECOLOGY OF AQUATIC INSECTS OF KUMAON LAKES

By

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### INTRODUCTION

Entomofauna play an important role in an aquatic ecosystem, as it exerts not only a potential but also a real influence on fishes inhabiting it. Some aquatic insects are voracious feeders on fish fry (Champlain, 1923; Ganguly and Mitra, 1961; Julka, 1969; Vazirani, 1971), while others constitute the principal food of fishes. The knowledge of aquatic insects therefore is of prime importance in fishery science. Few records are available on high altitude aquatic entomofauna of India. A few high altitude freshwater insects (above timber line 4000-5400 metres) and their ecology was recorded by Mani *et al.* (1961); while Das (1969) reported the ecology of insect fauna of high altitude lakes of Kashmir. Unfortunately our knowledge of aquatic entomofauna of high altitude Kumaon lakes (alt. 1220—1938 m) is restricted to the scanty taxonomic records by Distant (1910), Hafiz and Ribeiro (1939), Hafiz and Pradhan (1947), Vazirani (1968, 1970), etc. The present investigation, which was carried out under a D. S. T. project (Govt. of India), is the first detailed contribution to our knowledge of the ecology of entomofauna of Kumaon lakes.

### THE HIGH ALTITUDE KUMAON LAKES

The Kumaon lakes are situated in the lesser Himalayas and are intermediate in altitude and coldwater. They may be classified into two types : 1. oligotrophic (e. g. Bhimtal, Naukuchiatal, Sat tal and Khurpatal) 2. eutrophic (e.g. Nainital and Sukhatal). The oligotrophic and eutrophic lakes have been found by the author to differ radically in their physical, physiographical and physicochemical parameters. These data for three largest lakes (during 1977—78) may be summarised as in Table 1

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TABLE I Some physical, physiographical and physicochemical parameters of three major Kumaon lakes

	Oligotrophic		Eutrophic
	Bhimtal	Naukuchiatal	Nainital
Altitude above mean sea level	1700 m	1220 m	1938 m
Longitude	79° 34' E	79° 35' E	79° 23' E
Latitude	29° 21' N	29° 19' N	29° 2' N
Shape of the lake	C shaped	—	bean shaped
Lake area	63.75 ha	45.07 ha	50 ha
Maximum depth	18 m	36 m	24 m
Lake bottom	rocky and sandy	rocky and sandy	muddy
Water temperature	11°-26.5°C	12.5°-27°C	5.5°-23.25°C
Humidity	20-95%	23-95%	30-96%
Turbidity	2.37-3.5 m	2.85-4.25 m	1.0-1.87 m
Dissolved Oxygen	10.32-14.5 ppm	9.2-16.5 ppm	2.3-13.0 ppm
Free Carbondioxide	0-6.1 ppm	0-2.0 ppm	0-22 ppm
Alkalinity (Methyle orange)	12.5-41.0 ppm	10.0-29.8 ppm	97.0-240.0 ppm
pH of water	7.1-8.5	7.0-8.5	7.8-9.0
Hydrophytes	<i>Potamogeton</i> , <i>Polygonum</i> , <i>Ceratophyllum</i> , <i>Myriophyllum</i> , <i>Najas</i> , <i>Hydrilla</i> , <i>Lemna</i> , <i>Gonatozygon</i> , <i>Ulothrix</i> , <i>Spirogyra</i> , etc.	Same as Bhimtal	<i>Potamogeton</i> , <i>Polygonum</i> , <i>Ceratophyllum</i> , <i>Hydrilla</i> , <i>Vallisnaria</i> , <i>Gonatozygon</i> , <i>Ulothrix</i> , <i>Spirogyra</i> , <i>Cladophora</i> , etc.

## LIST OF INSECT SPECIES

Aquatic insects collected and identified during 1977-78 may be listed as under :-

**COLEOPTERA :** *Hypoporus aper* Sharp, *Rhantus taprobanicus* Sharp, *R. punjabensis* Vazirani, *Hyphydrus (Apriophorus) renardi* Severin, *Laccophilus* sp., *Agabus sinuaticolis* Reg., *A. (Dichorectes) nitidus* Sharp, *Eretes* sp., *Cybister tripunctatus asiaticus* Sharp, *C. limbatus* Fabr., *Halipus (Liaphlus) kapuri* Vazirani, *H. (Liaphlus) manipurensis* Vazirani, *Dineutus unidentatus* Aube, *Helochares orenatus* Reg., *Hydrophilus senegalensis* Perch., *Paracymus* sp., *Steronoluphus rufipes* Fabr., *Berosus* sp., *Bagous* sp.

**HEMIPTERA :** *Micronecta merope* Dist., *Micronecta* sp., *Corixa* sp., *Anisops* sp., *Plea pelopea* Dist., *Ranatra filiformis* Fabr., *R. varipes* Stal., *R. elongata* Hafiz and Pradhan.

*Laccotrephes griseus* Guer., *L. ruber* Linn., *Helocoris* sp., *Lethocerus indicus* (Lep. Serv.), *Gerris monticola*, *G. nepalensis* Dist., *Gerris* sp.

ODONATA : *Crocothemis servillia servillia* Drury., *Palpopleura sexmaculata sexmaculata* Fab., *Orthetrum triangulare triangulare* Selys., *Libellula glauca* Brauer., *Sympatrum commixtum* Selys., *Orthetrum taeniolatum* Schnieder, *Pseudagrion decorum* Rambur, *Calicnemis eximia* Selys., *Neurobasis chinensis* Linn.

DIPTERA : *Chironomus*, *Forcipomia*, *Chaoborus*, *Dixa*. *Culex*, *Eristalis* and *Simulium*.

EPHEMEROPTERA : *Ephemerella*, *Ephemera*, *Baetis*, *Cloeon* and *Caenis*.

#### PHYSICOCHEMICAL PARAMETERS OF SOME AQUATIC INSECTS OF BHIMTAL AND NAINITAL LAKES

The physicochemical parameters for some Hemiptera and Coleoptera on average monthly basis are recorded for one year (1977-78) in Bhimtal and Nainital lakes and given in Table-2.

*Corixa* (Hemiptera) collected from waters with temperature, pH, Oxygen and alkalinity values at 5.5 to 26.5°C, 7.1-9.0, 4.3-14.5 ppm, 16-240 ppm respectively has comparatively wider range of physicochemical parameters and is found in all the three lakes. While some other species with comparatively narrow range were found to be completely absent in lake Nainital. These are *Ranatra elongata*, *Laccotrephes ruber*, *Micronecta merope*, *Lethocerus indicus* and *Helocoris* spp.

An abundance of *Hyphoporus* (Coleoptera) was observed in lake Nainital (water temperature 5.5-24°C, pH 7.8-9.0, O<sub>2</sub> 4.3-13 ppm, alkalinity 97-240 ppm) and it was rare in Bhimtal, restricted only to polluted zones of the shallows (water temperature 12.0-26.5°C., pH 7.1-8.5, O<sub>2</sub> 10.32-14.5 ppm and alkalinity 13-41 ppm). This indicates that *Hyphoporus* can be used as a biological indicator of pollution along with other such biota (Das, 1978).

Some coleopterans, viz. *Hyphydrus renardi*, *Cybister limbatus*, *Halipus* spp., *Sternolophus rufipes*, *Hydrophilus* and *Bagous* species were recorded only from oligotrophic waters, being completely absent in conditions prevailing in eutrophic lakes, e. g., lake Nainital. Other insects observed as oligotrophic species are : *Baetis*, *Caenis*, *Ephemera*, *Ephemerella* (Ephemeroptera) ; *Dixa* (Diptera) and *Neurobasis* (Odonata).

TABLE 2. Physicochemical parameters for Hemiptera and Coleoptera on average monthly basis for the year 1977-78

Insect	Temperature of water in C.	Turbidity in cm	Dissolved Oxygen in ppm	Carbon dioxide in ppm	pH of water	Alkalinity in ppm
<b>HEMIPTERA</b>						
<i>R. varipes</i>	16.0-26.5	170-350	10.3-13.6	0-10.5	7.1-8.8	16.0-114.0
<i>L. griseus</i>	16.0-26.5	170-350	10.3-13.6	0- 8.0	7.1-8.8	12.5-102.0
<i>Corixa sp.</i>	5.5-26.0	100-350	4.3-14.5	0-22.0	7.1-9.0	16.0-240.0
<i>Micronecta sp.</i>	11.0-26.5	100-350	10.5-14.5	0-22.0	7.1-8.8	12.5-122.0
<i>Gerris sp.</i>	11.0-26.5	100-350	10.3-14.2	0- 6.1	7.1-9.0	41.0-122.0
<i>L. indicus</i>	20.0-26.5	250-298	10.3-14.5	0- 4.3	8.2-8.5	14.5- 40.0
<i>Helocoris sp.</i>	11.0-26.5	237-350	10.3-14.5	0- 5.5	7.9-8.5	13.0- 39.5
<i>P. pelopea</i>	11.0-26.5	120-350	10.3-13.6	0- 6.1	7.5-8.8	13.5-122.0
<b>COLEOPTERA</b>						
<i>H. aper</i>	5.5-26.5	100-350	4.3-14.5	0-22.0	7.1-9.0	14.5-240.0
<i>R. taprobanicus</i>	5.5-26.5	100-350	4.3-14.5	0-22.0	7.1-9.0	14.5-240.0
<i>R. punjabensis</i>	5.5-26.5	100-350	4.3-14.5	0-22.0	7.8-9.0	13.0-240.0
<i>A. sinuaticolis</i>	5.5-26.5	100-350	4.3-14.5	0-22.0	7.5-9.0	12.5-240.0
<i>A. nitidus</i>	12.5-23.2	100-187	8.1-13.0	0-22.0	7.8-9.0	99.2-170.0
<i>C. libatus</i>	20.0-26.5	237-298	10.3-14.5	0- 4.5	8.2-8.5	13.0- 40.0
<i>C. tri punctatus asiaticus</i>	18.0-23.2	115-187	10.5-13.0	0-19.5	8.6-9.0	99.2-170.0
<i>D. unidentatus</i>	11.0-26.5	100-350	10.5-14.5	0-10.5	7.1-9.0	40.0-170.0
<i>H. kapuri</i>	20.0-26.5	237-350	10.3-14.5	0- 4.3	7.9-8.5	12.5- 41.0
<i>H. manipurensis</i>	20.0-26.5	237-269	10.3-14.5	0- 4.5	8.0-8.5	12.5- 41.0
<i>H. crenatus</i>	11.0-26.5	110-350	10.3-14.5	0- 6.1	7.1-8.8	12.5- 97.0
<i>S. rufipes</i>	11.0-26.5	240-350	10.3-14.5	0- 6.1	7.8-8.8	12.5- 40.0
<i>H. senegalensis</i>	11.0-26.5	240-350	10.3-14.5	0- 5.0	7.8-8.8	12.5- 40.0
<i>Berosus sp.</i>	13.1-26.5	100-350	10.3-14.5	0- 6.0	7.8-9.0	12.5-114.0
<i>Paracymus sp.</i>	11.0-26.5	110-350	10.3-14.5	0- 6.1	7.1-8.8	14.5-122.0
<i>Bagous sp.</i>	11.0-26.5	237-350	10.9-14.5	0- 6.1	7.1-8.4	13.0- 40.0

### HABITATS OF AQUATIC INSECTS

The association of aquatic insects with hydrophytes is very interesting, as they determine the abundance of insect life in a fresh-water ecosystem. Hydrophytes provide the insects with rich oxygen supply, places for hiding, material for cases and cocoons, places to lay eggs, anchorage and food supply. Rich growth of hydrophytes affects the physicochemical conditions of water favourably (Srivastava, 1959). Plants increase the food and oxygen supply, while their paucity decreases these, and insect life becomes less abundant (Frost, 1942).

Nearly all immature and adult aquatic insects with the exception of those which are more affiliated to muddy, sandy or rocky substratum, live among hydrophytes and utilize them as anchorage and places for hiding from their enemies.

Larvae of *Chironomus*, *Simulium* and *Eristalis* (Diptera) which have been considered as pollution indicators (Das, 1978), are more affiliated to the muddy substratum than the hydrophytes. It is also confirmed by the fact that these insect larvae were observed much more abundant in eutrophic lake (Nainital), than the oligotrophic lakes (Bhimtal and Naukuchiatal). Similarly nymphs of *Ephemera* are confined to sand, while others such as *Baetis*, *Caenis*, *Ephemere* and *Cloeon* (Ephemeroptera) dwell under stones or among macrophytes. A few bugs such as *Micronecta merope* and *Helocoris* and beetles such as *Helochaeres* and *Paracymus*, were found more abundantly in rocky substratum than with macrophytes. This is one of the reasons that these species were found to be rare or completely absent from lake Nainital with muddy substratum.

The majority of aquatic insects (nymphs, larvae and adults) such as *Caenis*, *Ephemere*, *Baetis*, *Cloeon* (Ephemeroptera), *Crocothemis*, *Orthetrum*, *Pseudagrion*, *Neurobasis* (Odonata), *Micronecta* sp., *Corixa*, *Anisops*, *Laccotrephes*, *Ranatra*, *Plea*, *Lethocerus* (Hemiptera), *Rhantus*, *Agabus*, *Laccophilus*, *Sternolophus*, *Hyphydrus*, *Cybister*, *Halipus*, *Berosus*, *Hydrophilus* and *Bagous* species were found to be more affiliated to aquatic hydrophytes than any of the substrata mentioned above. It was also observed that aquatic insects were more abundant in oligotrophic lake Bhimtal and Naukuchiatal than in eutrophic lake Nainital. This can be explained due to rich growth of hydrophytes and good quality of water in these oligotrophic lakes.

The bloodworms (*Chironomus*) live abundantly in waters where oxygen is deficient (Frost, 1942) which was also observed by the present authors in lake Nainital, especially during the winter months (Nov.—Feb.) when oxygen was only 2.3-8.11 ppm.

Many hydrophilid beetles, e.g., *Hydrophilus*, *Helochaeres*, *Sternolophus*, and the curculionid *Bagous*, devour the submerged portions of aquatic plants and thus utilize them as their food.

Hydrophytes also provide places to lay eggs of some insects. The eggs of mayflies and trueflies are mostly dropped on the surface of the water where abundant vegetation occurs. The eggs of some aquatic bugs, e.g., *Anisops*, *Laccotrephes*, *Ranatra*, and beetles, e.g., *Cybister* are deposited inside the plant tissue while *Hyphorus* and *Hyphydrus* were observed to lay eggs on macrophytes and algal filaments. The silken cocoons of *Hydrophilus* and *Sternolophus* were

seen to be attached to the aquatic macrophytes *Ceratophyllum* and *Lemna minor*. Dragonflies and damselflies lay their eggs on macrophytes in strings.

In addition to these advantages, rich growth of hydrophytes also checks the rapid disturbances in water which affect the insect life.

## ROLE OF AQUATIC INSECTS IN RELATION TO COLDWATER FISHERIES

### *Predatory aquatic insects*

The predatory action of aquatic insects in the plains of India was discussed by Champlain (1923), Ganguly and Mitra (1961), Julka (1969), Shirgur and Kawalramani (1971) and Vazirani (1971), etc. But no such work has been done on aquatic insects of high altitude Kumaon lakes.

Four major groups of aquatic insects were observed to prey on fish larvae and fingerlings in Kumaon lakes. These are : 1. Nymphs of dragonflies and damselflies (*Libellula*, *Crocothemus*, *Pseudagrion*, and *Neurobasis*); 2. Nymphs and adults of aquatic bugs (*Corixa*, *Anisops*, *Laccotrephes*, *Ranatra*, *Lethocerus*); 3. Larvae of Hydrophilidae (*Sternolophus* and *Helochaeres*); 4. Larvae and adults of Dytiscidae (*Rhantus*, *Agabus*, *Hyphoporus*, *Hyphydrus*, *Hydaticus* and *Cybister*).

Experimental observations under laboratory conditions (water temperature 20 to 21° C) on *Rhantus*, *Agabus*, *Hyphoporus* and *Cybister* revealed that each insect was able to destroy 9,6,2 and 10 fish fry per 24 hours respectively.

It is interesting to note that the breeding period of some high altitude Kumaon lake fishes, e.g., *Schizothorax*, *Cyprinus*, *Puntius*, *Berilius*, etc., coincides with the most favourable period of aquatic insects. The two populations are thus interdependent on each other.

### *Insects as fish-food decimators.*

Besides fish predation these insects devour the valuable food of fishes, e.g., nymphs of Ephemeroptera, Odonata, nymphs and adults of some Hemiptera, larvae of Trichoptera and Diptera, oligochaetes and crustaceans. Under the aforesaid laboratory conditions, it was observed that *Rhantus*, *Agabus*, *Hyphoporus* and *Cybister* were able to devour 8,6,3 and 13 *Chironomus* respectively and 9,7,4 and 15 *Micronecta* respectively in every 24 hours.

### *Insects as food of fishes*

The carnivorous fishes of Kumaon lakes feed on aquatic insects

to a considerable extent. This is true for *Nemachilus rupicola*, *N. botia* and *Channa striatus*. The omnivorous species (*Tor* spp., *Puntius* spp. and *Cyprinus carpio*) also feed to some extent on aquatic insects. Thus aquatic insects form an important part of the food of Kumaon fishes.

### CONCLUSIONS

It can be concluded from the present study that aquatic insects of Kumaon lakes are governed not only by the physicochemical parameters, but also related to hydrophyte density in water. Greater attention should, therefore, be paid to the growth and abundance of aquatic hydrophytes in fisheries. Furthermore, the role of aquatic insects in relation to fisheries is of high significance due to their complex role in the freshwater ecosystem. For a pisciculturist, therefore, both the aspects are of prime importance in order to obtain better production of fishes in the high altitude lakes of Kumaon.

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## BIOLOGY OF PEMPHIGINAE (HOMOPTERA : APHIDIDAE) IN INDIA

By

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### INTRODUCTION

Most of the Pemphigid aphids are heteroecious alternating between specific groups of primary host plants and secondary host plants. Typically, entire cycle is annual as in the tribes Pemphigini and Eriosomatini but in Fordini the cycle is biannual. Usually a gall is initiated on the leaf of primary host by the fundatrix and both the fundatrix and the fundatrigeniae may live within the same gall or the latter may form definitive galls. Plants of Ulmaceae, (Eriosomatini), Salicaceae (Pemphigini) and Anacardiaceae (Fordini) are normally used as primary hosts while Graminae, an array of Dicots and Conifer roots are mostly known as secondary hosts.

The galls of Pemphiginae may be varied in shape, size and site of occurrence. Often galls may be characteristic for a particular genus or even for a species. Galls may be simple pseudo leaf galls, pyriform or spiral closed galls, cylindrical horn like gall or even nest-galls; galls are believed to provide specific nutrient tissue.

### PEMPHIGINAE IN INDIA : DISTRIBUTION

In the region under study, Pemphigid aphids are mostly distributed in areas between *ca* 600—2000 m in the Northern Himalaya, Nilgiri Hills and Ceylon. The two distinct phases of life cycle, often lead to marked morphological changes both in larval and in adult stages. The radicolous forms have been found in a wide range of soil types, from dry sandy to wet clay soil and at different depth upto 15 cm. Most of the radicolous forms are collected in late winter whereas gallicolous forms are found between May to September. A total of 48 species under 20 genera have so far been recorded ; distribution of the Pemphigid genera has been shown in Table—I.

### HOSTS AND MORPHS

The present study indicates an extensive change in the biology and hetero-holocyclic pattern appear to remain far from complete. In most cases, either only gallicolous morphs or radicolous morphs have

been recorded and this may be indicative of a monoecious—anholocyclic pattern. In Eriosomatini, galls on *Alnus* and *Ulmus* have been recorded only in two species, *Eriosoma kashmiricus* Verma and *Schizoneurella indica* H.R.L. but only the latter is known to be definitely heteroecious between *Ulmus* and *Malus*. Almost all other species (a total of 16) are known from Graminae except *E. lanigerum* (Haus.) which lives anholocyclic life cycle in Pomoidea.

In the tribe Fordini, 12 species under 8 genera have been studied and only two, viz. *Baizongia pistaciae* (Linn), and *Kaburagia ailanthi* Chowdhury *et al.*, are known to form galls on *Pistacia* and *Ailanthus* and for rest of the species only radicicolous forms are known.

In the tribe Pemphigini, the situation appears different and out of a total of 20 species studied, 15 species are known from galls of Primary host-plants (*Populus*, *Michelia*, *Brunfelsia*) but only one of these is also known from secondary host, viz. *Pemphigus immunis* Buckton from *Euphorbia*. All the other species (5) are known only from secondary host plants.

#### LIFE CYCLE

The apparent change in the biology may be due to several factors. The temperate hill region in India, where these insects normally occur may be devoid of specific host-plant group due to elimination of the same during geological upheavels. In case, where both the host groups are known, it may be possible that the entire cycle exists and a regular heteroecy occurs, but without being actually noticed; the occurrence of sexuparae on secondary hosts and migrants on the primary hosts which are rather rare, should have special significance and indicative of heteroecious cycle. While considering the first possibility, it is noted that a member of species belonging to primary host plant groups actually occur in N.W Himalayan region; at least 10 species of Salicaceae, 4 species of Ulmaceae and several species of Anacardiaceae occur in high altitudes; similarly a host of plants of *Abies*, *Cedrus*, *Picea*, *Pinus*, *Taxus* and *Tsuga*, which harbour many radicicolous forms of Pemphigini occur in the Himalayan region.

However, geographical paracycles in the Pemphigini is not uncommon and on the basis of our existing knowledge, probable paracycles, as may be occurring in the Indian region may be grouped as follows:

1. Cycle: Ulmus—Monocot		Para cycle
Genera:	1. <i>Eriosoma</i>	— only from Pomoidea
	2. <i>Ghariesia</i>	— only from Monocot root
	3. <i>Schizoneurella</i>	— Heteroecious between Galls of <i>Ulmus</i> & roots of <i>Malus</i>
	4. <i>Tetraneura</i>	— only from Monocot root

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 II. Cycle: *Pistacia*—Monocot
 

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Genera	1. <i>Baizongia</i>	— Heterocious between Galls of <i>Pistacia</i> & roots of Graminae
	2. <i>Chaetogeoica</i>	— only from Monocot root
	3. <i>Forda</i>	— only from Monocot root
	4. <i>Asiphonella</i>	— only from Monocot root

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 III. Cycle: *Pistacia*—Monocot
 

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Genus <i>Smynthuodes</i>	— only from Monocot & Dicot roots
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 IV Cycle: Dicot—Conifers
 

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Genus <i>Prociphilus</i>	— Some only from Galls, others only from roots
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 V. Cycle: *Populus*—Monocot/Dicot
 

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Genera <i>Pemphigus</i>	— Mostly from Galls of <i>Populus</i>
<i>Epipemphigus</i>	— " " " " "

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 VI. Cycle: *Ailanthus*—? Moss
 

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Genus <i>Kaburagia</i>	— only from galls of <i>Ailanthus</i>
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However unless the complete annual life-table is known establishment of definite paracycles can not be ascertained.

### DISCUSSION

The present state of knowledge indicates the need of extensive study of this group of aphids mostly occurring at high altitude areas in temperate region. The formation of galls at high branches of tall primary hosts and the radicolous forms below the surface of earth poses serious problems for collection and often escapes notice. Systematic survey of the areas where most of the host plants grow, with specific objective to collect gall-inhabitants and root-feeders may clear the present problem but biological transfer experiment at suitable field station could also ensure the identity of species and its bio-cycle. Host-plants should be selected for exploration in the more easily accessible areas. Sometimes, as in *Pistacia* several species occur beyond the territorial limit of India but nevertheless the possibility of seasonal migration from these plants to the monocots in the Northern Hills should not be excluded. Besides, study of lifecycle of Pemphigid, more extensive knowledge about their trophobiotic

relationship with ants is needed; specially when it is known that anholocycle may be induced by the myrmecophilous habit during subterranean life.

### ACKNOWLEDGEMENT

The author is thankful to the Director, Zoological Survey of India, for providing necessary working facilities.

TABLE : Life cycle and distribution of Pemphiginae in Indian region

TRIBE : ERIOSOMATINI	CYCLE	ALTITUDE	DISTRIBUTION
1. ERIOSOMA	Monoanholocyclic	1500-2500 m	N.E., N.W., S. India
2. GHARESIA	Heteroholocyclic	4000 m	N.W. India
3. KALTENBACHIELIA	?	?	Ceylon
4. SCHIZONEURELLA	Heteroholocyclic	1800-2000 m	N.W. India
5. TEIRANEURA	Monoanholocyclic	S.L.-2700 m	N.E., & S. India
TRIBE : FORDINI			
6. APLONEURA	?	?	Nepal
7. ASIPHONELLA	Heteroholocyclic	200 m	Pakistan
8. BAIZONGIA	Heteroholocyclic	1000-2000 m	N.W. India
9. CHAETOGEOICA	Monoanholocyclic	600-2000 m	E. India
10. FORDA	Monoanholocyclic	410-2000 m	N.E. & India
11. GEOICA	Monoanholocyclic	1000-2200 m	N.E. & S. India
12. KABURAGIA	Heteroholocyclic	2000-2200 m	N.W. India
13. SMYNTHURODES	Monoanholocyclic	1080-2000 m	N.E. & S. India
TRIBE : PEMPHIGINI			
14. CERATOPEMPHIGUS	? Heteroholocyclic	?	Ceylon
15. CERATOPEMPHIGELLA	Monoanholocyclic	200 m	N. India
16. EPIPEMPHIGUS	? Heteroholocyclic	1800-2400 m	N.E. India
17. FORMOSAPHIS	Monoanholocyclic	1500-2000 m	N.E. India
18. PEMPHIGUS	Monoanholocyclic	1500-2200 m	N.E. & N.W. India
19. PROCIPHILUS	? Heteroholocyclic	1500-2200 m	N.E. & N.W. India
20. THECABIUS	?	1800 m	N.W. India

AN ACCOUNT OF GREENIDEINE APHIDS (HOMOPTERA :  
APHIDIDAE : GREENIDEINAE) IN THE DARJEELING  
DISTRICT OF WEST BENGAL AND SIKKIM

*By*

M. R. GHOSH\* and D. N. RAYCHAUDHURI\*\*

Aphids belonging to the subfamily Greenideinae form about 14% of the total number of aphid species recorded from Darjeeling district of West Bengal and Sikkim. The subfamily is represented by 38 species distributed over 9 genera, a figure which is quite high as compared to 83 species of greenideine aphids found all over the world (Eastop and van Emden, 1973). From the records it has been found that aphids of this subfamily have a strikingly restricted distribution comprising India, far eastern and southern eastern Asiatic countries, Australia and the Philippines. With this restricted distribution the greenideine aphids exhibit striking host-plant relationship and other ecological preferences. The present report forms a part of the analysis of data accumulated through sustained and systematic studies on aphids in the region from 1968 to 1972.

MATERIALS AND METHODS

Aphids were collected through frequent trips to different localities of the region when utmost care was taken to collect all aphids occurring there and to note detailed records on different biological features. Regular collections at monthly interval were, however made from eight localities. These localities were so selected that every two of these localities were distributed in the strata like 150-600 m, 601-1200 m, 1201-1800 m and 1801-2400 m. Host plants of these aphids were also collected when their on-the-spot identity could not be made out and herbaria were prepared for getting them determined by the Botanical Survey of India and Department of Botany, Calcutta University.

Aphids were identified in the laboratory from the microscopic slides prepared in the usual procedure.

RESULTS AND DISCUSSION

The subfamily Greenideinae as treated here comprises two tribes—Cervaphidini and Greenideini. The results obtained by scanning the collection data reveal the following interesting aspects of ecology of this group.

1. **Altitudinal distribution and seasonal occurrence (Fig. 1)**

From the data presented in Table 1 it appears that the four altitudinal strata in the ascending order harbour 14, 24, 18, and 12 species respectively and these are distributed over 6, 9, 6 and 3 genera

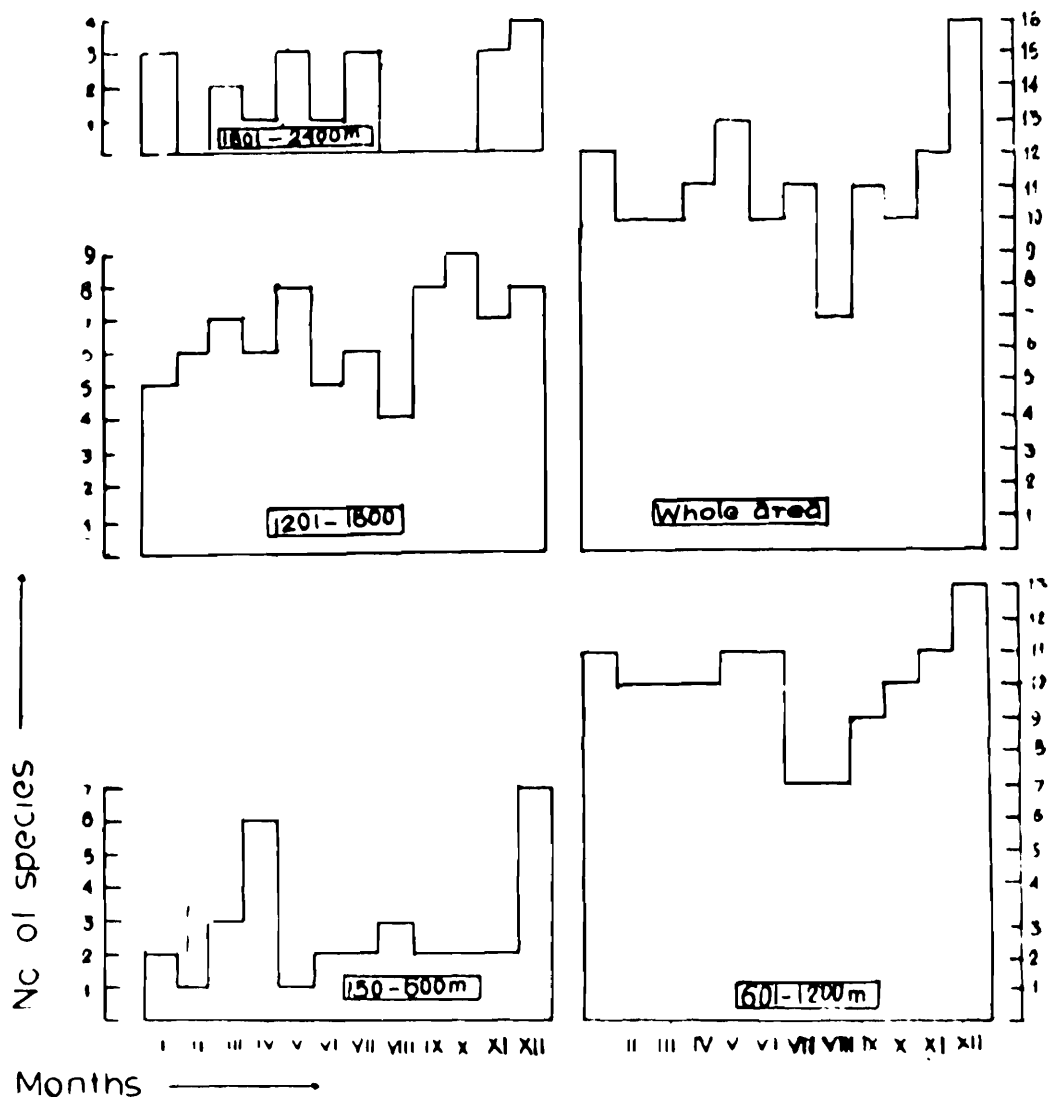
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respectively. It further reveals that out of the total number of species 4 are restricted to only the lowest stratum i.e. 150-600 m, 10 species in the stratum 600-1200 m, 6 species in the stratum 1201-1800m, and only 3 species in the stratum 1801-2400 m, 5 species could be found to occur in all the altitudinal strata. Besides 3 species appear to be distributed up to 1800 m and 1 species up to 1200 m from 150 m.

Consideration of distribution of aphid species from the highest strata downwards reveals that 2 species occur from 2400 m down to 601 m and 2 other species from 1800 m down to 601 m. From this pattern of vertical distribution it appears that these prefer localities situated between 601 and 1200 m or a little below or above the range just mentioned. It is interesting that aphids belonging to tribe Cervaphidini mostly inhabit the low altitude areas. From Table 1 it, however, appears that *Anomalosiphum indigoferae* and *Schoutedenia lutea* belonging to Cervaphidini are found even in the third altitudinal stratum (1201m-1900 m) but it must be pointed out here that these mostly occur along low fringe areas of the stratum.



Greenideine species recorded during different months of a year at different strata and in the whole area

Fig. 1

TABLE 1. Occurrence of greenideine aphids at different altitudes and months of the year (I-XII denote month of a year)

Aphid species	Altitudinal strata and months of occurrence			
	150-600 m	601-1200 m	1201-1800 m	1801-2400 m
<b>A. Tribe Cervaphidini</b>				
1. <i>Anomalosiphon indigoferae</i> Ghosh, Ghosh and Raychaudhuri	IV, XII	I-III, VI, VIII-XII	X	—
2. <i>Cervaphis rappardi indica</i> Basu	I, XI			
3. <i>Schoutedenia lutea</i> (v.d.G.)	IV-XII	I, III-XII	VII-X	—
4. <i>Sumatraphis celti</i> Takahashi		I, IX		
<b>B. Tribe Greenideini</b>				
5. <i>Brevitrichosiphon mukherjii</i> Raychaudhuri, Ghosh, Banerjee & Ghosh		II		
6. <i>Eutrichosiphon davidi</i> Raychaudhuri			III	
7. <i>E. pasanae pseudopasanae</i> Szel.		II-VII, IX-XII	V, XII	VII, XII
8. <i>E. quercifoliae</i> Raychaudhuri, Ghosh, Banerjee, Ghosh		XII		
9. <i>E. sankari</i> Raychaudhuri, Ghosh, Banerjee and Ghosh				V
10. <i>E. taoi</i> Ghosh, Basu and Raychaudhuri	IX			
11. <i>E. (Neoparatrichosiphon)</i> <i>raychaudhurii</i> Ghosh		I-VII, X-XII	I-VII, IX-XII	I, III, V VII, XII
12. <i>E. (Paratrichosiphon)</i> <i>alnicola</i> (Basu)	III	I-VII, X-XII		
13. <i>E. (P.) sikkimense</i> Raychaudhuri, Ghosh, Banerjee and Ghosh	XII			
14. <i>Greenidea ficicola</i> Tak.	IV, XII	I-XII	II-VII, X	XI, XII
15. <i>G. longicornis</i> Ghosh, Ghosh and Raychaudhuri	III			
16. <i>G. longirostris</i> Basu	IV	I-V, XI, XII	II-V, XI, XII	
17. <i>G. neoficicola</i> Ghosh, Ghosh and Raychaudhuri				I
18. <i>G. photiniphaga</i> Raychaudhuri, Ghosh, Banerjee, Ghosh			I	XII
19. <i>G. (Neogreenidea) ayyari</i> Raychaudhuri, Ghosh, Banerjee and Ghosh				

Aphid species	Altitudinal strata and months of occurrence			
	150-600 m	601-1200 m	1201-1800 m	1801-2400 m
20. <i>G. (N.) longisetosa</i> Raychaudhuri, Ghosh, Banerjee and Ghosh				V
21. <i>G. (N.) querciphaga</i> Raychaudhuri, Ghosh, Banerjee and Ghosh		XII		
22. <i>G. (Trichosiphum) bucktonis</i> Ghosh, Basu and Raychaudhuri			VII	
23. <i>G. (T.) formosana heeri</i> Raychaudhuri, Ghosh, Banerjee and Ghosh	I-IV, XII	I-XII	I-VI, IX-XII	II-IV XI, XII
24. <i>G. (T.) gigantea</i> Ghosh and Raychaudhuri				
25. <i>G. (T.) prunicola</i> Ghosh Banerjee and Raychaudhuri			IV	
26. <i>G. (T.) schoutedeni</i> Raychaudhuri, Ghosh, Banerjee and Ghosh	I, VII	I, V		
27. <i>G. (T.) sikkimensis</i> Raychaudhuri, Ghosh, Banerjee and Ghosh			VII	
28. <i>G. (T.) spinotibium</i> Chatterjee and Raychaudhuri		III, XII		
29. <i>G. (Neogreenidea) bengalensis</i> Chatterjee and Raychaudhuri			II	
30. <i>G. (Pentatrichosiphon) ?</i> <i>lambersi</i> (Basu)		VI		
31. <i>G. (P.) luteum</i> (Basu)		IV-VI		
32. <i>Holotrichosiphum dubius</i> (v.d.G.)		II		
33. <i>H. russellae</i> Ghosh, Ghosh and Raychaudhuri			V	
34. <i>Mollitrichosiphum shinjii</i> Raychaudhuri, Ghosh, Banerjee and Raychaudhuri		XII		
35. <i>M. tenuicarpus</i> (Okajima)	X-XII	X-XII	X-XII	XI
36. <i>M. (Metatrichosiphon) alni</i> Ghosh, Ghosh and Raychaudhuri	IV, VI, VIII	I, VI, VIII	I-III, VI-IX, XI-XII	I, VI, VII, XI
37. <i>M. (Meta-) buddlejae</i> Ghosh, Banerjee and Ghosh			X	
38. <i>M. (Meta-) nansii</i> Basu	I-VI, VIII, XII	I-XII		

Notwithstanding the fact that 14 species of greenideine aphids occur in localities lying between 150 m and 600 m it must be stated that not more than 7 species could be found in any month. The highest number of species could be recorded during December. It was followed by April when 6 species could be recorded. During other months of the year 1-3 species could be found. In case of 24 species occurring in localities situated between 601 and 1200 m not less than 7 and not more than 13 could be found in any month of a year and here also the highest number of species was noted during December and the lowest during July and August. In localities between 1201 and 1800 m the find of species through different months of year varied between 4 and 9 and the trend of their occurrence was more or less the same as observed in localities on the stratum just below it. In localities situated between 1801 and 2400 m the pattern of their occurrence does not exhibit any definite trend in relation to season though highest number (4) could be recorded during December and none during February, August, September and October. It may, however, be stated that occurrence of greenideine aphid species was not much abundant during August and in all the altitudinal strata the number of species found during this month was lowest if they occurred at all. It may be worthwhile to mention that during August the number of rainy days is maximum in this region and so also total precipitation. From the foregone account it is apparent that the altitude ranging between 601 and 1200 m is congenial for the diversity of these aphids. It is also evident low temperature and short day length favour their abundance.

## 2. Host plant relationships

The aphids belonging to this subfamily have been found to be restricted to only dicotyledonous angiospermic plants belonging to Magnoliidae, Hamamelidae, Dilleniidae, Rosidae and Asteridae (Table 2). Among these plant groups maximum number of plant families (5) utilised as hosts of this group of aphid belongs to Hamamelidae and Rosidae but the highest number of aphid species could be recorded on plants belonging to Hamamelidae. Though Eastop (1973) reported that high number of plant families used as hosts by this group of aphid belong to Rosidae followed by Hamamelidae and Dilleniidae, the number of aphid species infesting hamamelid plants is much higher than that infesting plants of either Rosidae or Dilleniidae. Higuchi and Miyazaki (1969) also reported that out of 19 species of this subfamily found in Japan 18 infest plants belonging to Hamamelidae and one infests those of Rosidae. Raychaudhuri (1956) also opined that greenideine aphids mostly infest hamamelid plants. It is, therefore, apparent that this group of aphids prefers plants of Hamamelidae which is one of the old groups of angiospermic plants. The rather

higher number of plants belonging to Rosidae used as hosts by this group of aphids may be a case of recent acquisition as Rosidae is believed to be group of plants of rather recent origin.

Analysis of host plants infested by these aphids further reveals that the group is substantially host specific (Table 3). Since as much as 75.8% of the greenideine aphids are restricted to only one plant genus these can be said to be much host specific while only 15.2% of the group may be termed as polyphagous utilising plants belonging to very distantly related families.

TABLE 2. Host association of greenideine aphids

	Number of plant families under					Asteri- dae
	Magnoli- dae	Hamameli- dae	Coryphylli- dae	Dilleni- dae	Rosidae	
Infested by 1 aphid sp.	2	1	—	1	2	1
.. 2-5 ..	—	4	—	1	3	—
.. 6-10 ..	—	—	—	—	—	—
.. many ..	—	1	—	—	—	—
.. one aphid genus	2	2	—	2	4	1
.. more than one aphid genus	—	—	—	—	2	—
<b>Total no. of plant families</b>	<b>2(2)</b>	<b>5(5)</b>		<b>2(5)</b>	<b>5(7)</b>	<b>1(3)</b>
<b>Total no. of aphid species</b>	<b>2(3)</b>	<b>22(38)</b>		<b>3(10)</b>	<b>9(20)</b>	<b>1(5)</b>

Figures in parenthesis are from Eastop (1973).

TABLE 3. Degree of host specificity in greenideine aphids

Host range	Number of aphid sp.	% over total
Restricted to one plant genus	25	75.8
Restricted to 2-5 plant genera of same family	4	12.1
Restricted to one plant family	28	84.8
Restricted to one plant group	29	90.5

It is interesting to mention here that out of 4 species belonging to the tribe Cervaphidini 3 infest plants belonging to Rosidae and the remaining species, *Sumatraphis celti*, however, infests plants belonging to Hamamelidae. On the contrary majority of the species of the tribe Greenideini, for which host plants are known, show preference for plants of Hamamelidae. It may further be added here that of hamamelid plants, the plants under family Fagaceae are utilised as hosts by as

many 11 species belonging to Greenideini. From this discussion it may be visualised that high degree of host specificity is exhibited by greenideine aphids.

### 3. General remarks

Both Raychaudhuri (1956) and Heie (1967) pointed out that there exists fossil record of greenideine aphids from Miocene deposits of Yugoslavia. This fact leads one to assume that aphids of this group were once inhabitants of Europe. The present day records however indicate that the west latitudinal limit of distribution of this group of aphids is almost up to 80°E which is far south-eastward from region of fossil find. The absence of these aphids in the present day aphid fauna of Europe may appear somewhat perplexing. Mordvilko's (1924) postulation that drift and dispersion of fauna may be related with glaciation may possibly explain present day distribution of the greenideine aphids.

Higher concentration of aphids of this group (about 50% of the total world fauna) in a small area like that of the present study is very interesting and it may be surmised that diverse but congenial ecological conditions coupled with its zoogeographical position have led to formation of diverse species. It has however, been inferred by Bodenheimer and Swirski (1957) that moderate warmth, moderate rains and humidity, moderate winds, together with availability of a great variety of herbs, grasses, shrubs and trees, create an optimal condition for abundance of aphid species. The assemblage of diverse aphid fauna in the area of the present study may be attributed to these ecological factors besides the zoogeographical importance of the area, i. e. junction of palearctic and oriental regions. Notwithstanding above, emphasis has to be laid on the ecological factors favouring abundance of greenideine aphids not only in this region but also in Japan, Formosa and South-East Asia which together with the area of present study may be said to form 'Greenidea-zone'. In this zone the common species are *Greenidea ficicola* Tak., *Mollitrichosiphum tenuicarpus* (Okajima) and *Greenidea (Trichosiphum) formosana* Maki, the last named one, however, in this region has probably acquired ecological specialisation needing it to be treated as a subspecies *heeri*. Greenideine aphids have been found to show a great degree of host specificity being restricted to plants belonging to dicotyledonous Angiosperms. Further, these are mostly associated with older groups of plants and a major portion of species utilise plants belonging to Hamamelidae though recently evolved plant groups like Rosidae and Asteridae are also infested by greenideine aphids, the latter plant group has only few of these aphids feeding on them. Deduction on the antiquity of the group basing on association with plant groups is sometimes adventurous as new acquisition of recently evolved plants by older group of insects is not infrequent.

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SEASONAL DIFFERENCES AND RELATIVE ABUNDANCE  
AMONG POPULATIONS OF BENTHIC AQUATIC  
INSECTS IN A MODERATELY HIGH ALTITUDE STREAM

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INTRODUCTION

Available information on the seasonal abundance and other aspects of ecology of lotic insect communities from temperate regions is considerable as reviewed by Hynes (1970), which has subsequently been followed by many major studies in Europe, U.S.A. and Canada (Coffman, 1973, Fahy, 1973, Allan, 1975, Clifford, 1978). On the other hand, studies on running water insect communities in India and other South Asian countries has so far been very limited (Costa and Fernando, 1967; Gupta and Michael, 1978) and the only comprehensive study in South East Asia is that of Bishop (1973).

The Khasi Hills district of Meghalaya, North Eastern India exhibits large number of small streams which flow through woodlands of *Pinus kesiya* Royle, waste pasture and agricultural lands and also through Urban areas. A common feature of these streams is that they flow with a moderate to high current speed, mostly over rubble and gravel beds with occasional shallow, sand-bottomed pools. Most of the streams are perennial, because they receive ground source of water through springs. One such stream, the Umkaliar, near Shillong (Altitude 1500m, Lat. 25°30' N; Longitude 90°30' E) was chosen for the present study to see whether this moderately high altitude accompanied by low temperature regimes (4.5-26°C) as compared to the sub-tropical Indian plains and other tropical areas carried any influence on the patterns of seasonal variations in abundance of the benthic aquatic insect communities. The possible relations of insect abundance to various physico-chemical parameters and the nature of substrate were also investigated.

SITE OF WORK

The sampling site was a small riffle in the stream, where the water flowed uniformly over gravels of *ca* 10-15 cm diameter. A small sandy pool before the riffle stretch was also sampled. The riffle was 6-23 cm deep and 1.2-3.8 m wide and the pool was 35-40 cm deep and 1.1-2.8 m wide. There were considerable amounts of silt and vegetable detritus in the interstices of gravel, whereas the pool was sandy-bottomed with deposition of layers of detritus. At the sampling site the stream flowed through a broad valley with a thick forest of *Pinus*. Near the bank of

streams, small shrubs like *Polygonum* and *Eupatorium* were present which contributed the most towards the allochthonous litter input into the stream.

### MATERIALS AND METHODS

Temperature was measured by an ordinary thermometer calibrated in °C. Current velocity was measured by a stopwatch and float. Depth and width were measured with a metre tape.

pH was recorded in a pH meter (Model CL43 Toshniwal). Conductivity readings were taken in a conductivity meter (Model CM82-Elico). Dissolved oxygen was measured by the modified Winkler's Method. Carbondioxide and total alkalinity were estimated by the methods given in APHA (1971).

Detritus samples were collected by disturbing a known unit area of substratum into a net held downstream and the vegetable detritus was separated from the insects and other invertebrates and the volume measured by displacement method. The insects were sorted and counted (Egglshaw, 1964).

Benthic insects samples were collected in the same way by disturbing unit area of substratum and the insects were washed into a net held downstream. They were sorted and counted in the laboratory. Almost all the samples were always taken in the morning between 0730 and 0900 Hours.

### RESULTS

Based on temperature data, the calender year was divided into four seasons, viz. (1) Spring (February to April). Summer (May to August). Autumn (September to November) and a short winter (December to January). Summer and autumn were characterized by heavy rainfall (127.4-460.1mm), which was moderate during spring (17.7-266.5 mm) and low during winter (0-25.0 mm).

TABLE 1. Seasonal Fluctuations of Physico-Chemical Parameters in Umkaiar Stream, Shillong

Parameters	Fluctuations over the seasons			
	F-A (Spring)	M-A (Summer)	S-N (Autumn)	D-J (Winter)
Mean Max. Air Temperature (O' C)	15.2-23.7	21.9-25.0	18.5-23.1	13.4-17.8
Water Temperature (O' C)	16.5-20 C	20-24.0	16.5-23.0	7.0-12.5
Current velocity (Cm/Sec)	22-72	25-85	60-76	38-58
pH	5.9-6.5	6.1-6.5	6.0-6.5	6.1-6.5
Conductivity (Mmhos/Cm)	31.15-39.9	26.25-46.25	31.5-53.55	46.25-57.75
Dissolved O <sub>2</sub> (mg/l)	7.6-8.4	7.6-8.4	7.2-8.0	7.6-8.2
Dissolved Co <sub>2</sub> (mg/l)	2.0-4.0	2.0-4.0	2.5-4.0	2.5-4.0
Total alkalinity (mg/l)	26-38	30-42	18-44	26-34

The physical and chemical parameters in the four seasons are depicted in Table-1. Definite seasonal variation in water temperature was observed (16.5 to 20.0 C during Spring, from 20-24°C in Summer, from 16.5 to 23°C in Autumn and from 9.0—12.5 in Winter).

Current velocity was more in late spring, summer and early autumn and was comparatively low in late autumn, winter and early spring.

pH and conductance did not show any seasonal patterns in their fluctuations and the same applies to dissolved oxygen and carbon-dioxide which varied from 7.2 to 8.4 mg/l and from 2.0 to 4 mg/l respectively. No phenolphthalein alkalinity was recorded and the methyl orange alkalinity ranged from 18 to 44 mg/l, not showing any seasonal patterns in its variations.

The seasonal variations in abundance and percentage composition of benthic aquatic insects were represented in terms of "Operational Taxonomic Units" (OTUS) (Clifford, 1977) chosen for the present study. Each of the orders Ephemeroptera, Plecoptera, Trichoptera, Coleoptera and Magaloptera were taken as one OTU, whereas larvae of the diptera families Chironomidae and Simuliidae were considered as two separate OTUs. Chironomid pupae were considered as a separate OTU, because their fluctuations were indicative of rate of emergence.

Chironomids and ephemeropterans were the most dominant among the insect groups, followed by trichopterans whose numbers increased in winter. The other groups constituted only a fragment of the total population. The Chironomids were represented by 2—3 distinct species and the ephemeropterans by 3 distinct species at the sampling site.

The seasonal variations in abundance are depicted in Figure 1. Chironomid larvae and ephemeropterans showed two maxima in their populations over the seasons during both the annual cycles, one during spring and the other during autumn; the peak in larval population was observed in autumn for both groups. Chironomid pupae and exuviae were collected throughout the year, but in larger numbers during September and again from February to April. Trichopterans were most abundant during late autumn and winter (November to January) and their number declined through early spring and during summer months. Members of other groups were recorded sporadically and their seasonality cannot be said for certain. However, during the 1st Annual cycle plecopterans were more in January and February whereas in the 2nd, they were more abundant during October, November and January.

The relationship between the detrital volume and abundance of ephemeropterans and chironomids can be observed (Fig. 2). The

numbers of both the groups were directly related to the amount of detritus in most of the samples excepting a few. Apart from this, direct observations revealed that the ephemeropterans were more abundant on the underside of the cobbles and gravel, whereas chironomids colonized the fine gravel, silt and sand in the interstices of the gravels and towards the margin of the stream. The marginal weeds in the pool contained some adult coleopterans and occasional visitors like some gerrids. Coleopteran larvae were more in the weeds and also in the margin.

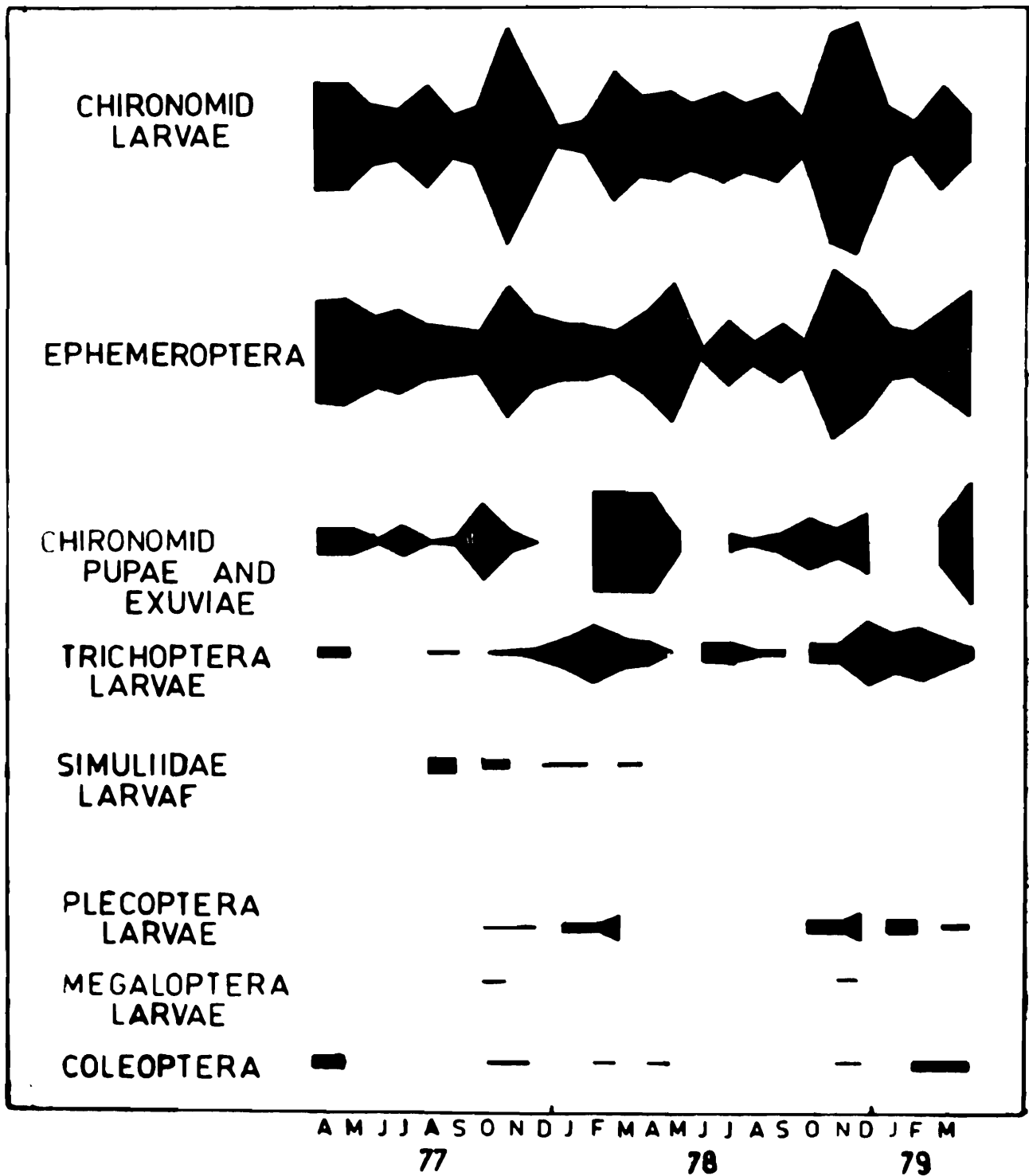


Fig. 1

Seasonal abundance of OTUs from April 1977 to March 1979. Width of spindle is proportional to number of animals for each of the sampling interval.

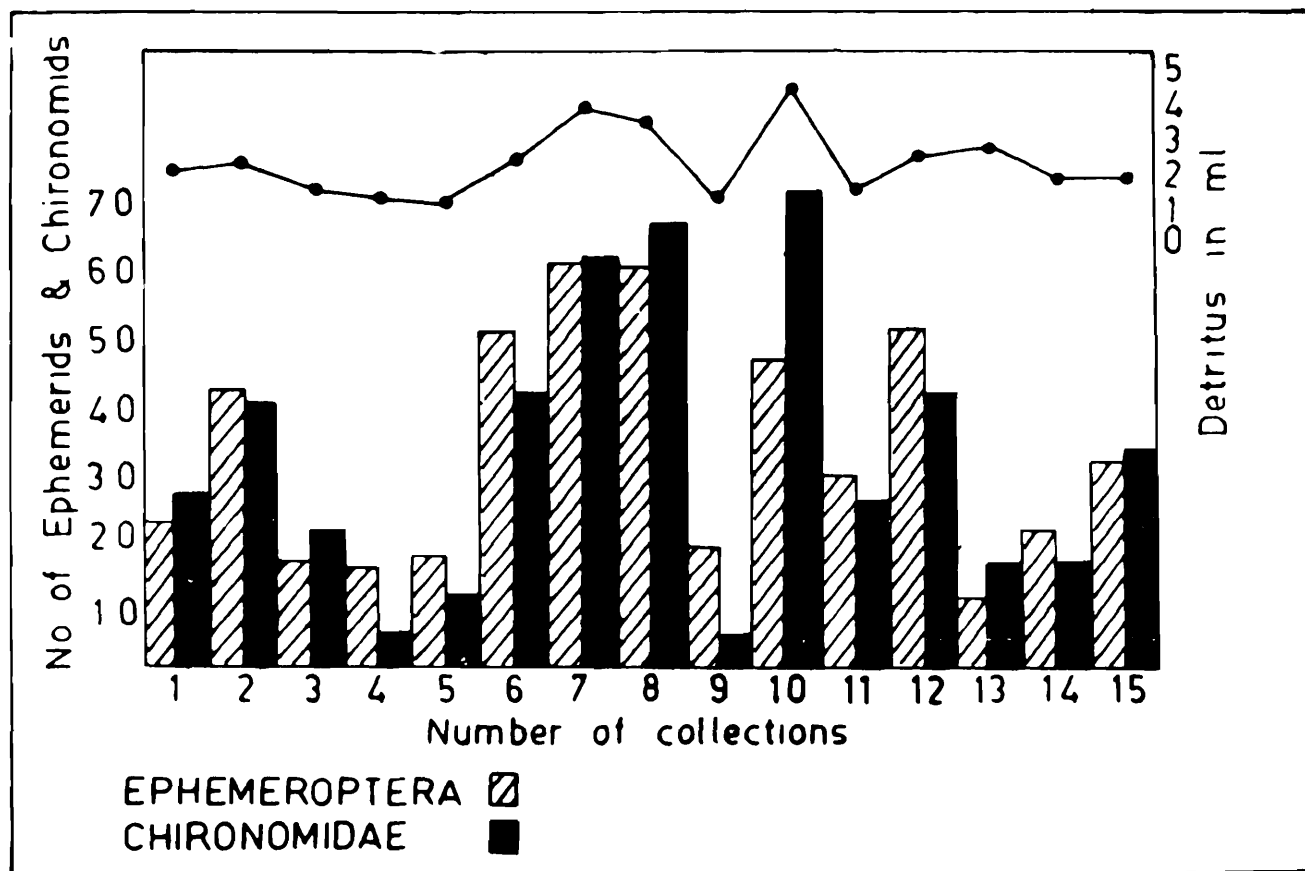


Fig. 2

Showing the relationship between plant detritus and benthic insects.

### DISCUSSION

From the seasonal abundance of different groups, it is obvious that the stream can be described as a Chironomid-ephemerid type stream, but the trichopterans were also abundant in winter. Chironomids and ephemeropterans were present in the system throughout the year, with the other groups disappearing during certain periods.

This type of a community composition dominated by chironomids and ephemeropterans and represented by other groups like Plecoptera, Trichoptera, Simuliidae, Megaloptera and Coleoptera seem to be characteristic of streams with gravel and rubble beds throughout the world, in both tropical and temperate climates. Such a view is supported by studies from different parts of the world like Malayasia (Bishop, 1973), Japan (Tsuda *et al.* 1975), England (Minshall, 1969) and Canada (Clifford, 1977). It appears that the insect community of lotic ecosystems is a remarkably conservative assemblage of analogous families or even genera, which occur in similar biotopes, regardless of geographical location, a fact also pointed out by other workers (Hynes, 1970; Bishop, 1973).

Lieth (1974) defines seasonality as the 'occurrence of certain obvious biotic and abiotic events or group of events within a definite

period or periods of the calendar year' From Fig. 1, it is evident that spring and autumn were periods marked by high reproduction of ephemerids and chironomids and subsequent hatching of small individuals resulting in high densities. The subsequent decline in population densities probably represents the extent of field survivorship for the animals. The seasonal patterns observed in the present study reflects an intermediate situation between non-seasonal, continuous cycles found in tropics (Bishop, 1973) and the clear-cut seasonal rhythms observed in temperate latitudes (Clifford, 1977). Temperature probably is the main factor acting to produce such a seasonal rhythm, but the photoperiod could also be important as pointed out by Hynes (1970). In winter, the water temperature is as low as 8 to 10°C, inhibiting the growth and reproduction of most of the groups. However, the abundance of Trichoptera was found to be more in late autumn and winter. In spring and autumn, water temperature is around 16.5 to 20°C which appears to be the favourable range for increased reproduction and hatching for ephemerids and chironomids. This departure from known seasonal rhythms from other tropical and temperate situations can be appreciated when one compares the range of water temperature of the present study (7-24°C) with a constant range of 20—30°C in a Malaysian stream (Bishop, 1973) with the other extreme (1.1 to 13.0°C) in a stream in Canada (Clifford, 1977).

Other physico-chemical parameters like pH, conductance, dissolved oxygen, carbon-dioxide and total alkalinity values were more or less constant in the stream over the seasons and probably did not markedly influence the fluctuations of the insect communities. The uniform conditions of dissolved oxygen and carbon-dioxide is characteristic of small turbulent streams (Hynes, 1970). These along with other factors in the present study probably did not act as limiting factors.

The fact that the ephemerids were found more in the gravel and the chironomids more in the interstices over fine gravel and sand indicates that the nature of substrate could be an important factor influencing the distribution and abundance of insects within the stream. Habitat and nature of substrate were clearly shown to be major factors controlling the population and production dynamics in certain Trichoptera (Resh, 1977).

From Fig. 2 it can be observed that in the majority of the samples the amount of detritus was directly correlated to the number of chironomids and ephemeropterans. The two exceptions, where the number of organisms were less in spite of the fact that detritus was more, were due to high waters in the stream just a day prior to the date of collection. This probably resulted in bringing in large amounts of detritus while at the same time depopulating the habitat.

The increased abundance of insects with increasing amount of detritus can be due to two obvious reasons. Firstly, larger detrital particles, leaves and twigs provided shelter and foothold for the organisms. Second, and the more important reason can be the use of detritus as a food substance by the insect larvae. The importance of detritus as food has been stressed by many workers and some ephemeroptera are known to feed almost exclusively on detritus (Brown, 1961). The relation of detritus to increased abundance of insects has also been shown in streams in Scottish-highlands (Egglisshaw, 1964) and in this region, two species of ephemeropterans were also found to feed more detritus (Gupta and Michael, 1978).

Thus, the seasonal differences and relative abundance of the major insect taxa in the stream appear to be largely governed by temperature and also probably by photoperiod, nature of substrate and the detrital content in terms of shelter and food availability. Detailed investigations on more subtle interspecific differences are being attempted within the taxa when species level identifications are sorted out.

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BIOLOGY OF *FORCIPULA QUADRISPINOSA* (DOHRN)  
(DERMAPTERA: LABIDURIDAE) WITH NOTES ON THE  
EFFECT OF ALTITUDE ON ITS LIFE-HISTORY

By

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INTRODUCTION

Although great deal of work has been carried out on the biology of the European and American species of earwigs (Chapman, 1917; Takahasi, 1926; Worthington, 1926; Beall, 1932; Klostermeyer, 1942; Guppy, 1950; Behura, 1950, 1956; Giles, 1953; Bhardwaj, 1966), yet very little is known on this aspect of the Indian earwigs. The biology of the Indian species is known somewhat from the work of Thiagarajan (1936), Cherian and Basheer (1940), Arora and Bhatnagar (1961), Bhatnagar (1963), Kapoor and Baijal (1968) and Baijal and Srivastava (1974).

*Forcipula quadrispinosa* (Dohrn) commonly inhabits moist places under stones near streams at sea level to an altitude of 2450 m. At present nothing is known about its biology. This article records the results of studies carried out on *Forcipula quadrispinosa* at Jodhpur (approx. altitude 180 m) and Solan (approx. altitude 1500 m) under the laboratory conditions. Some interesting observations on the effect of altitude on the duration of incubation and post-embryonic development period are presented.

MATERIAL AND METHODS

The earwigs were reared in the laboratory under normal room conditions of temperature and humidity in the months of August to October, 1976 at Jodhpur and July to September 1978 at Solan. They were kept in petri-dishes of 15 cm diameter containing sterilized slightly wet soil. Each petri-dish was covered with another petri-dish of slightly larger diameter. Several such petri-dishes were kept under observations with a pair of mature male and female in each container. A few pebbles were also placed inside the petri-dish to provide hiding place for the earwigs. As soon as the nymphs hatched from the eggs, they were transferred to glass tubes of 15x5 cm size containing wet cotton wool at the bottom. A filter paper cut to the size of the diameter of the tube was placed over the cotton wool. A little of sand and a few pebbles were also placed in the tubes.

*Copulation :*

The copulation takes place in the month of August to September at Jodhpur and in June to August at Solan. Prior to copulation, the male touches the female with his antennae and often strikes her with his upturned abdomen. After 3 to 5 minutes of this courtship, the male turns around and backs up against the tip of female's abdomen so that both of them are in a back-to-back position. If the female is non-receptive she moves away. To effect the union, the male pushes his forceps under her abdomen which is slightly raised upwards. They remain *in copula* for 5 to 15 minutes and the position assumed is back-to-back. The pair generally remains passive during the copulation. When the copulation is over, the female starts walking and the male is dragged for some distance before being disengaged.

*Oviposition :*

The female lays eggs about 3 days after the copulation. Before oviposition, the female constructs a neat chamber by digging the soil with the help of mouth. When kept in a jar with 4.5 cm thick soil, she constructs a 'L'-shaped chamber (Fig.1). The chamber is 8 mm wide near the mouth and 4 mm wide at the bend of the 'L'. The vertical limb of the 'L' is 4.5 cm long and the horizontal limb is 3.5 cm long. If the female is kept in a petri-dish with 1 to 1.5 cm thick soil, she does not construct a 'L'-shaped chamber but is forced to construct an oval-shaped chamber due to the non-availability of deeper soil. In the field, the females with eggs were always found in 'L'-shaped chambers. The eggs are laid in the horizontal limb of the 'L' towards the blind end. The female continues to lay eggs for about 8-12 hours till a complete clutch is laid. The average number of eggs per clutch is 60.



FIG. 1

**Maternal care :**

Just after egg-laying, the female collects all the eggs at one place and sits over them. When disturbed, she adopts an offensive posture by raising her forceps upwards. But the persistent disturbance forces her to remove the eggs one by one with the mouth to another place in the chamber. Some of the eggs were transferred to another container without any female. Such eggs failed to hatch.

**Life-history :**

The life-history of *Forcipula quadrispinosa* was traced out at Jodhpur (alt. approx. 180 m) and at Solan (alt. approx. 1500 m) under the laboratory conditions during the months of July to October. There are four intervening nymphal instars. This species takes an average of 36.79 days to complete its life-history at Jodhpur at temperature ranging from 17.8°C, to 36.6°C, relative humidity ranging from 17% to 92%. The average duration of its life-history at Solan is 58.35 days at temperature ranging from 6°C to 32°C and relative humidity ranging from 49% to 99%. A study of the Fig.2 and Table-I reveals that the average incubation period and the duration of the first three nymphal instars is more at higher elevations (Solan) than at lower altitudes (Jodhpur). However, the altitude seems to have no effect on the duration of the fourth instar. The effect of altitude on the developmental period of *F. quadrispinosa* can be indirectly correlated with that of temperature, which is much higher at Jodhpur than at Solan. Behura (1956) also states that the rise in temperature reduces the incubation period and the post-embryonic developmental period in the earwigs.

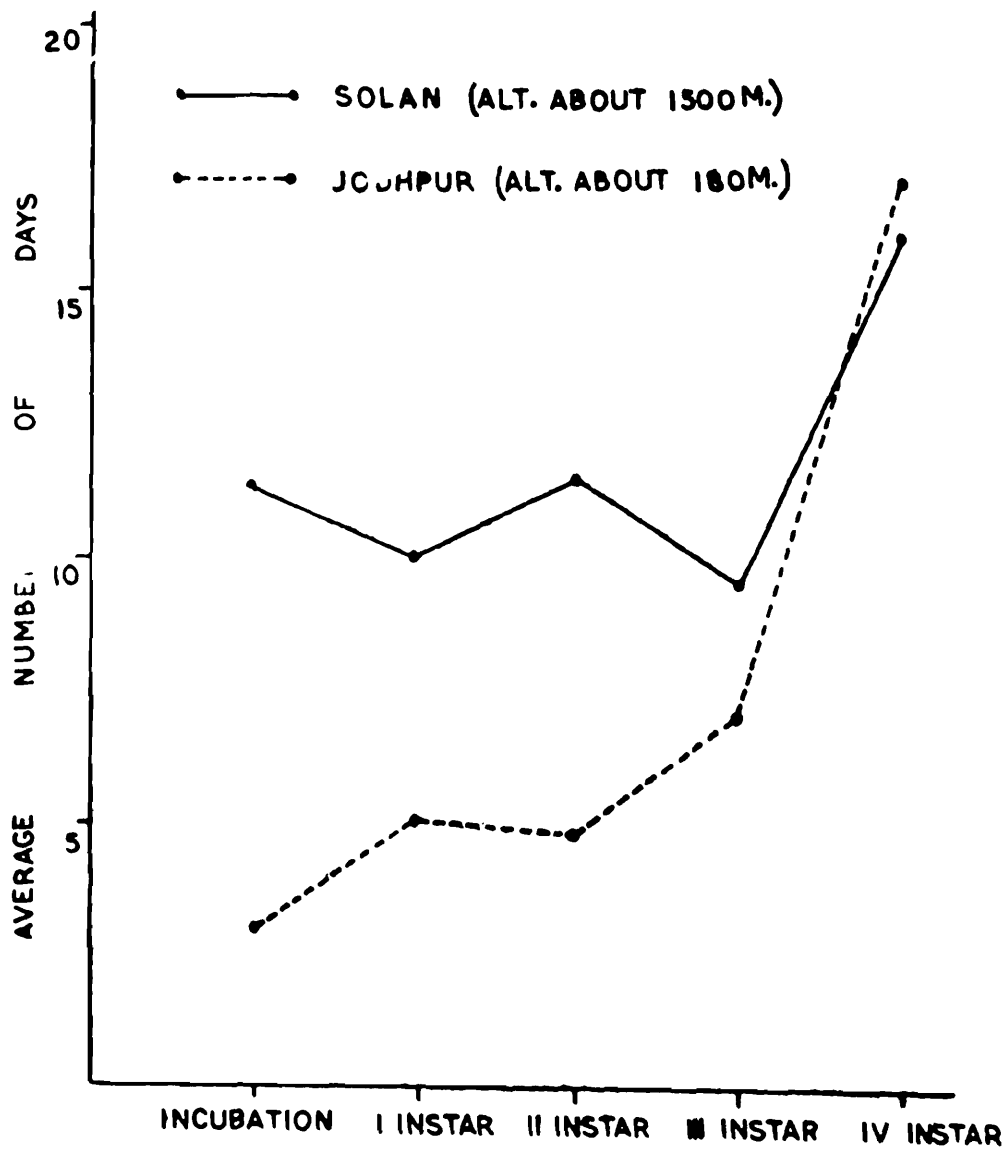


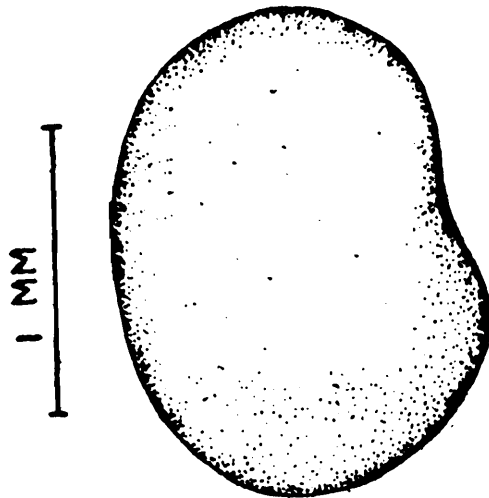
FIG. 2

TABLE-I.—Average incubation period and nymphal instars duration of *F. quadrispinosus*.

Stage	Jodhpur	Solan
Egg	3.00 days	11.25 days
First Instar	5.00 days	10.00 days
Second Instar	4.75 days	11.55 days
Third Instar	7.00 days	9.55 days
Fourth Instar	17.00 days	16.00 days
Total period of development	36.75 days	58.35 days

*Description of egg (Fig.3).*

- Length : Range 0.94-1.02 mm; mean: 0.98 mm.  
Width : Range 0.80-0.88 mm; mean: 0.83 mm.  
Colour : Whitish  
Shape : Oval without any ornamentation.

**FIG. 3**

*Hatching:*— Just before hatching, the eggs are pale brown in colour, eye spots prominent and the rhythmic movements of the embryo can be observed inside the egg shell. The nymph exerts pressure with its head from within. As a result, the egg shell splits towards the narrow end of the egg and larva emerges with the head first. There are no egg bursters. The nymph frees itself from the egg shell by the jerking movements of its legs and forceps. This process of hatching takes about two minutes. The newly hatched nymphs are quite active and devour the empty egg shells. They settle in a cluster under the abdomen of the mother. If a nymph strays away, the mother brings it back to the cluster. The nymphs acquire complete pigmentation in 7-12 hours after hatching.

TABLE II.—Measurements of nymphs and adults of *F. quadrispinosa* in millimetres.

	Head width		Pronotum width		Body length		Forceps length	
	Range	Mean (±.SD)	Range	Mean (±.SD)	Range	Mean (±.SD)	Range	Mean (±.SD)
I Instar	0.875-1.000	0.932 (±.031)	0.687-0.812	0.760 (±.034)	4.875-5.375	5.083 (±.162)	1.437-2.060	1.884 (±.157)
II Instar	1.125-1.250	1.160 (±.047)	0.937-1.062	0.990 (±.040)	5.625-7.625	6.518 (±.693)	2.125-2.625	2.369 (±.171)
III Instar	1.437-1.625	1.525 (±.083)	1.187-1.375	1.299 (±.071)	8.125-9.000	8.612 (±.322)	3.312-3.750	3.549 (±.155)
IV Instar	1.875-2.312	2.110 (±.132)	1.562-2.062	1.769 (±.137)	11.250-12.312	11.874 (±.375)	4.000-4.680	4.322 (±.222)
Adult (Male)	2.250-3.375	2.812 (±.240)	2.000-2.687	2.396 (±.288)	15.750-16.592	16.083 (±.332)	5.500-10.687	7.395 (±2.335)
Adult (Female)	2.812-2.937	2.854 (±.054)	2.187-2.375	2.291 (±.077)	15.625-17.500	16.666 (±.779)	5.187-5.500	5.354 (±.129)

Figures within the brackets denote standard deviation.

*Description of nymphal instars :*

The nymphs shed the skin four times to reach maturity. Before moulting, the nymph stops feeding and becomes sluggish. The cuticle splits along the ecdysial line on the head. The head comes out first followed by the thorax, legs and abdomen. The process of moulting takes about 30 minutes. Table II shows the measurements of different instars.

*First instar* :—Body light brown; legs pale with indistinct light brownish transverse bands on the femur. Antennae 8 segmented. Forceps weak, almost straight with tips slightly curved inwards; surface covered with small fine hair. Thoracic and abdominal segments are furnished with a few delicate spines on their margins. A few scattered spines are present on the anterior and outer surfaces of femur. Wing pads absent.

*Second instar* :—Body brownish; legs pale with indistinct brownish transverse bands on the femur. Antennae 18 segmented. Forceps slightly more sclerotized than in the first instar; straight, with tips slightly curved inwards. Wing pads absent.

*Third instar* :—Body dark brownish; legs pale, femur and tibia with indistinctly marked light brownish bands on anterior and outer margins. Thoracic and abdominal segments densely covered with fine spines. Forceps slightly curved inwards; inner margin slightly serrated. Antennae 28 segmented. Wing pads indistinct.

*Fourth instar* :—General colour and structure as in the previous instar; abdomen with a pair of indistinct longitudinal yellowish bands dorsally. Forceps strongly sclerotized and curved inwards; inner margin slightly serrated; tips sharply pointed. Antennal segments 36. Wing pads well developed; anterior ones reach behind to one-third of mesonotum; posterior ones extend posteriorly upto half of the second abdominal segment.

*Growth :*

According to Dyar's Law (1890), the larval instars of Lepidoptera follow a regular geometrical progression in growth. To ascertain the validity of this law in relation to *Forcipula quadrispinosa*, the relationships between the number of instar and head width as well as pronotum width were calculated. These relationships were found to be linear in the semi-logarithmic form, thereby, supporting the Dyar's Law (Figs. 4 and 5). These relationships are adequately expressed by the following equations :—

(1) *Number of instar and head width.*

$$\text{Log Hw} = -0.1576 + 0.1186 n.$$

(Coefficient of correlation,  $r=0.9879$ )

(2) *Number of instar and pronotum width.*

$$\text{Log Pw} = -0.2488 + 0.1251 n.$$

(Coefficient of correlation,  $r=0.9881$ )

where  $n$  is number of instar.

The high value of  $r$  shows that the correlation is highly significant.

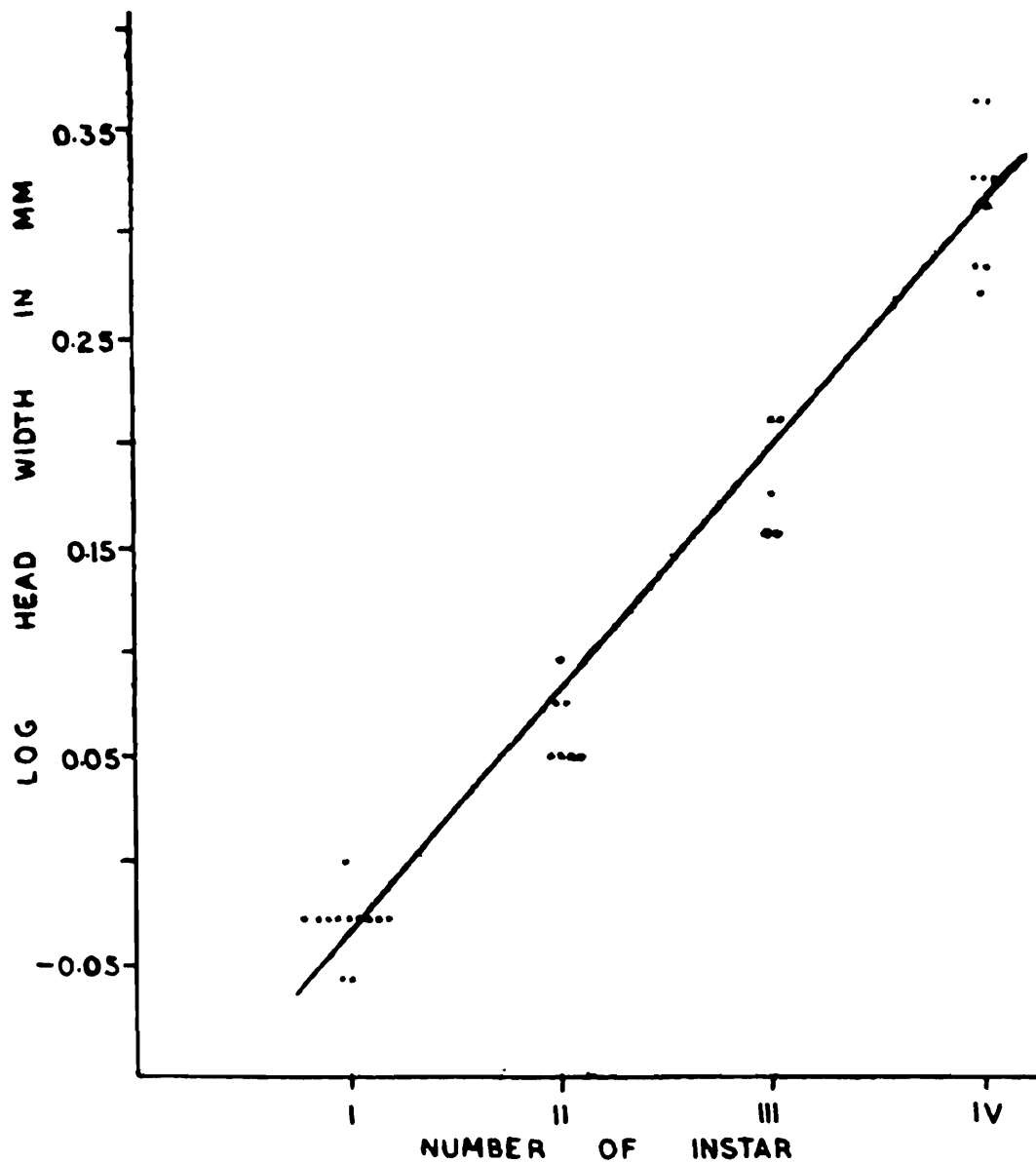


FIG. 4

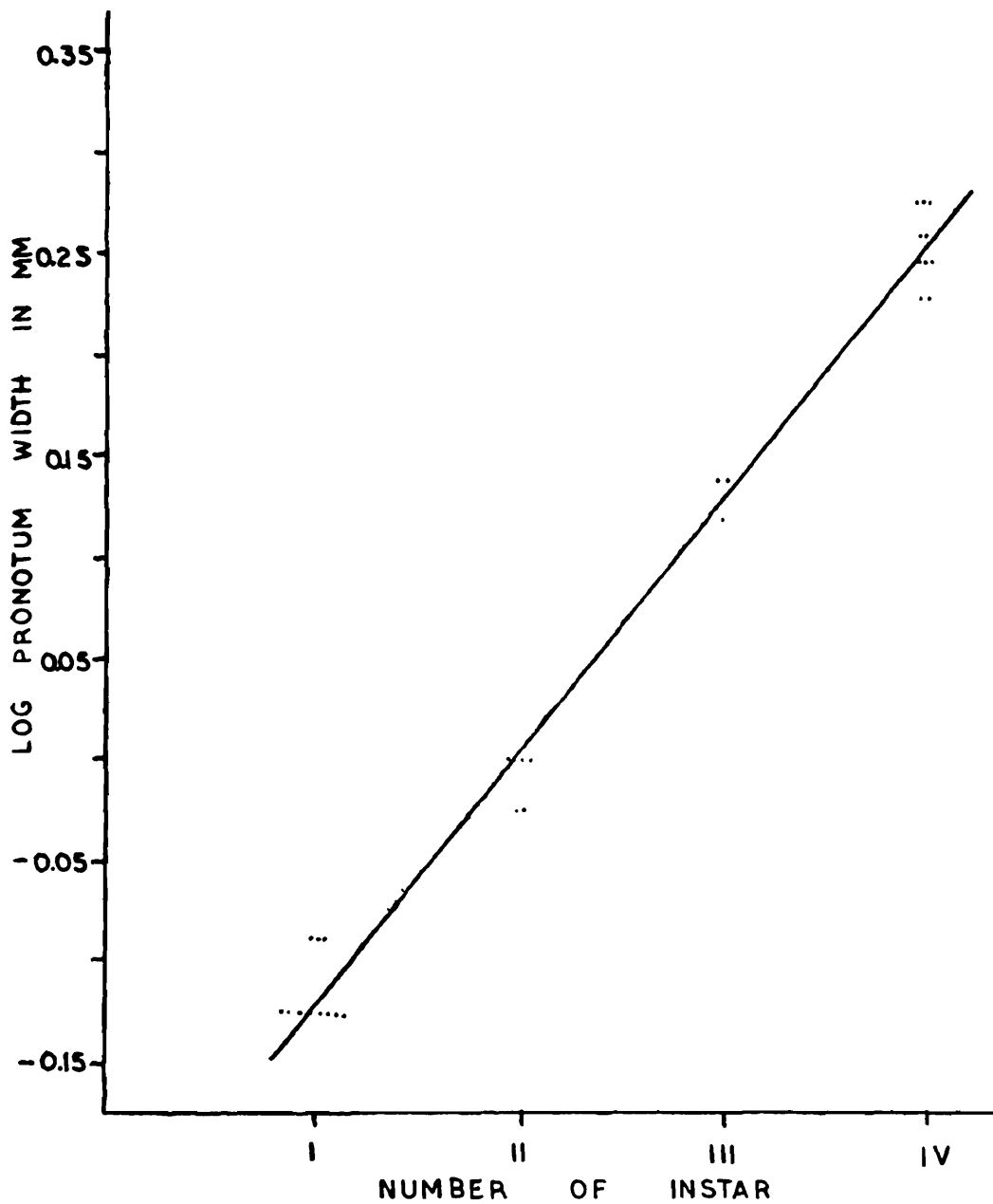


FIG. 5

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## ECOLOGY OF SOME HIGH ALTITUDE RHEATIC ECOSYSTEM DIPTERA OF THE NORTHWEST HIMALAYA

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### INTRODUCTION AND METHODOLOGY

Torrential stream insects have attracted the attention of workers all over the world. The study of the available literature reveals that very little work has, however, been done in India. The insect life in glacial torrents of the Himalaya has been shown by Mani (1968) to present many unsolved problems of ecology, adaptation and evolution. Of the torrential insects, the Diptera constitute one of the most highly specialized forms. Not only are they dominant in all torrential communities, but many of these communities are composed almost exclusively of Diptera. A detailed field survey of the torrential stream Diptera was carried out in the R. Beas system (Fig. 1) at its source glaciers in the Northwest Himalaya. The R. Beas and its tributaries, viz. R. Solang, R. Alhni, R. Manalsu, R. Jagatsukh and R. Parvati are surveyed and 24 survey stations established on random faunal sampling basis. The difference in altitude of the lowest and highest station is 2000 m. Most of the feeder streams were surveyed from their joining with R. Beas at the valley upto their source glaciers. The extensive area drained by hundreds of melt water feeder-streams could only be surveyed by the well known technique of 'Faunal sampling'. Each station extended approximately over 500 m of the stream and was separated by at least 3 km. Nearly all the stations included diverse ecological niches, associated with waterfalls, cataracts, cascades, extremely turbulent vortices, relatively shallow gentle currents, and rock surfaces below waterfall, constantly wetted by spray and by dripping water. The flow of water is violently impeded by enormous fixed boulders and massive loose stones, in addition to smaller or larger rolling pebbles. Regular collections of the larvae, pupae and adults of Diptera, records of hydrological and other ecological factors were made in each station in the morning and again in the evening. A set of uninterrupted 10 days period observations were recorded, after a preliminary period during which the observations methods were tested and standardized. The velocity of water is measured by floatation and pigment drop method. The fluctuations in the water level are recorded by fixing the graduated poles in the stream (Fig. 2).

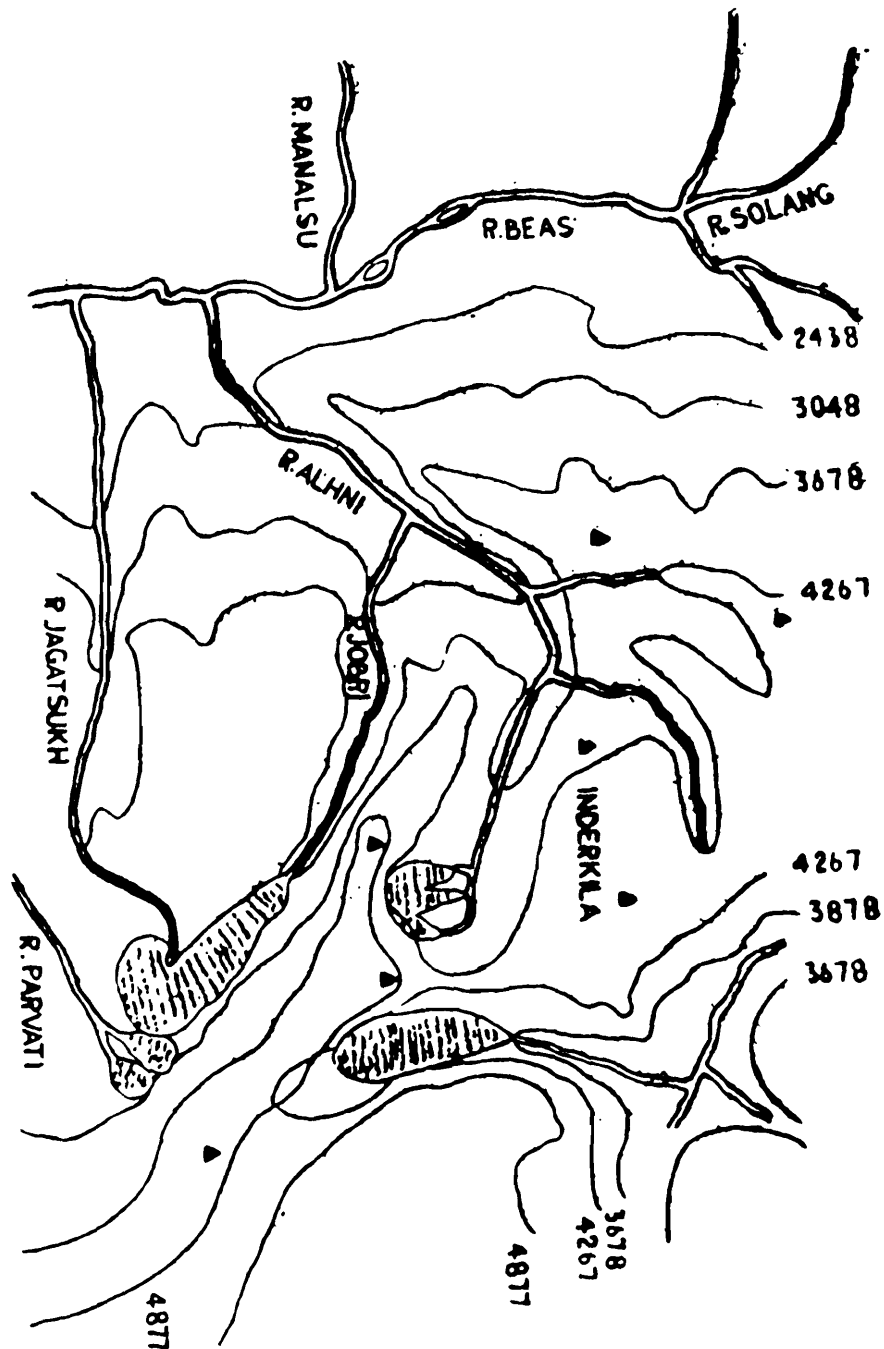


Fig. 1 Sketch map of the Beas river source glaciers and streams in the Northwest Himalaya.

### BEAS RIVER SYSTEM

The Beas river system, at its source glaciers mainly include the main R. Beas, R. Solang, R. Alhni, R. Manalsu, R. Jagatsukh and R. Parvati. These streams lie at the end of Kulu Valley on the southern slopes of the Pir Panjal Range in the Northwest Himalaya. These may be considered as representative of scores of feeder streams, the confluence of which form the R. Beas.

The R. Beas is exclusively fed at its source by the Rohtang glaciers, permanent snowfields at elevation 4600 m above mean sea-level. Just at its source it flows south for about 3 km below Marhi and then

takes a sharp turn to the west over a number of waterfalls and cataracts. Rushing wildly on the mountain spur among the alpine meadows it abruptly spills over gigantic rocks forming a huge, roaring cascading waterfall. Just on its left bank above this cascade a small tributary from the Rahandhar spur empties itself in a steep waterfall. At Rahla it receives one small stream on the left and one on the right bank. Within this short distance of about 10 km the river descends about 1500 m from its source. It flows down the Rahla camping grounds in subalpine meadows along the mountain spur and enters the upper spruce forest zone. After flowing for about 3 km it forms a deep gorge and then appears in an open meadow in village Kothi. Soon after about 1.5 km distance it again disappears in a relatively deeper and narrower gorge to reappear after 5.6 km at the village Palchan and receives R. Solang at its right bank. Now the river becomes wide and flows through pleistocene glacial moraine towards Manali village, where it receives the R. Manalsu at its right bank. A little below Manali, it receives the R. Alhni on the left. Further below the R. Jagatsukh and R. Parvati joins the R. Beas. R. Solang is the first main right bank tributary of the R. Beas and originates in the glaciers and snowfields of the Beas Kund, in Pir Panjal Range, at an elevation of 5000 m above mean sea-level. R. Alhni is the first main left bank tributary of the R. Beas. Its course, about 36 km long, lies wholly within the narrow gorge between the Rahandhar and Hamta spurs of the Pir Panjal Range. There are extensive snowfields and moderately large valley glaciers at its source, which lies at an elevation of about 4,000 m above mean sea-level in a vast boulder strewn amphitheatre, surrounded by mighty Himalayan Peaks of Dev Tibba and Inder Kila, with the Hamta Pass in between. The R. Parvati originates at an altitude of 3600 m from the glaciers and snowfields of Dev Tibba. It flows east-west throughout its course of about 35 km, in a narrow deep channel throughout its soft rocks. Most of its course is through the forest zone. Due to the dissolution of soft rocks its water is always turbid. It joins R. Beas at Bhuntar just at the foot of the famous Bijali Mahadeva Temple Hill of Kulu valley.

All these glacial torrents and other smaller tributaries which were explored by me are remarkable for the fact that each one of them may be described as a series of violent cataracts, glistening cascades and roaring waterfalls, in which relatively quiet or slow zones are virtually absent. It is characterized by great irregularity of cross-section area, depth, nature and slope of the bottom etc. The bed is strewn with loose stones of all sizes, but mostly large enough not to be moved by the current of water. The fall in gradient is irregular and very abrupt. In most of the glacial torrents of the Himalaya the fall in gradient amounts to nearly 2000—2500 m 20-25 km or

100 m per km There are no rooted higher plants, but there is great profusion of diatoms, algae and moss on all submerged surfaces. The temperature of the water is typically not much above that of the atmospheric temperature. In view of the fact that there is no fixed water surface and also because the water is violently churned, the glacial stream water is rich in dissolved oxygen, indeed it has been shown by Mani (1968) that the water is supersaturated with oxygen. The observations of Brodskii (1972) in the R. Issyk also confirm this finding.

### DIPTERA OF GLACIAL STREAMS

The Diptera of torrential streams differ from other Diptera in that their immature stages live only in the water of the stream. The aerial life of the adult is relatively very short. The families which breed in streams include Tipulidae, Blepharoceridae, Deuterophlebiidae, Chironomidae, Simuliidae and Psychodidae. The families Blepharoceridae and Deuterophlebiidae are strictly confined to the torrential streams and are never found even in slow flowing water. Deuterophlebiidae appear in particular to be confined to glacial and semi-glacial streams. Blepharoceridae occur both in the glacial and non-glacial habitats, but the generic and species compositions differ. My studies have mainly been on these little known families, viz. Blepharoceridae and Deuterophlebiidae. The family Blepharoceridae is represented in these streams by the genera *Blepharocera* Macquart (1843), *Philorus* Kellogg (1903), and *Manaliella* Kaul (1976). *Blepharocera* include the species *B. autumnalis* Kaul (1971) and *B. tertia* Kaul (1971). Genus *Philorus* include *P. thorus* Kaul (1971), *P. novem* Kaul (1971) and *P. dubeyi* Kaul (1971). A new genus *Manaliella* was described by the author in 1976 which include *Manaliella manaliella*. In addition to these species some more new species have been collected from these streams. The study of this family revealed the presence of the genus *Horaia* in these streams. Family Deuterophlebiidae is represented by its only genus *Deuterophlebia*. The species is *D. mirabilis* Edw. (1922). In addition to the Diptera, the members of Ephemera, Plecoptera and Trichoptera are also abundant in these streams. Ephemera is the widely distributed member of the torrenticole community. Plecoptera is abundant in the upper reaches in subalpine and alpine areas. The Trichoptera is a minor group and seems to be restricted in distribution to areas of optimal conditions.

### ECOLOGICAL FACTORS

The major ecological factors, which determine the characteristic of the insect communities, may be enumerated as follows:

1. The velocity of flow or current velocity.

2. Fluctuations in the level of water.
3. Water temperature.
4. Dissolved oxygen.
5. Biotic factors including food.

#### 1 *Water velocity*

The constant motion of water effects all other ecological factors so that in some cases their effects may even be completely neutralized. The current velocity effectively obliterates temperature stratifications, stratification of the dissolved gases, and ensures a constant supply of oxygen and food.

The following is the summary of measurements of water velocities at different altitudes in the R. Beas, R. Alhni and R. Solang.

TABLE 1. Current velocity m/sec

River	Altitude	Morning	Evening	Mean
Alhni	4000m	1.623	1.905	1.764
	3700m	1.569	1.806	1.688
Beas	3300m	1.026	1.110	1.068
	2700m	0.860	0.902	0.881
Solang	2500m	1.600	1.800	1.700
Mean		1.336	1.504	1.420

Minimum velocity recorded : 0.61m/sec

Maximum velocity recorded : 3.04m/sec

The velocities summarized above, represent the velocity of flow on the surface of the stream. The maximum velocity recorded is at the waterfall while the minimum velocity is near the banks of the river. It is apparent from the table that the flow is swifter in R. Alhni, and R. Solang than the R. Beas. These differences are readily reflected in the marked difference in the distribution of Diptera, the principal torrenticole families of which seem to be confined to zones with velocities exceeding 1.42m/sec. The mean current velocity decreases with fall in elevation, and is associated with increase in cross section area of the stream and rise in total discharge. Thus at lower reaches, though glacial streams are wider, deeper and carry also more water than higher above, they also flow relatively more slowly. With this lowering of velocity there is also a rise in water temperature. These correlations readily explain the total absence of typical forms like *Deuterophlebiidae* in the lower reaches.



Fig. 2. Observation of the water level in Alhni river with the help of a fixed graduated pole. The boulder strewn river bed can be seen on the right.

## 2. *Water level*

During summer, considerable melting of the surface layers of snow and ice takes place. This has two readily recognizable effects in glacial streams, viz regular diurnal rise in water level in the late afternoon and pronounced increase in turbidity from the load of the dust on snow and glacier surface. The measurements of percentage diurnal increase in water level, made at different altitudes in the rivers Alhni, Beas and Solang are summarized in the table below:

TABLE II. \*Mean water level in cm

River	Altitude	Morning	*Evening	Percentage increase
Alhni	4000	53.30	49.39	7.40
	3700	44.18	37.69	14.60
Beas	2700	101.88	94.50	7.20
Solang	2500	69.08	68.60	0.69
Mean		67.11	62.54	7.475

\*The above water level records refer to readings from the top (Zero mark) of poles graduated at 10 cm intervals, so that the rise of level in the evenings reads less in the datum pole. The level is minimum in the early part of the day and late in the night. These periods of fluctuations in water levels bear great relevance to times of movements of larvae for pupation, emergence of adults and deposition of eggs.

3. *Water temperature*

The water temperature measurements are summarized in the following table :

TABLE III. Mean water temperature in C

River	Altitude	Morning	Evening	Fluctuation
Alhni	4000m	6.80	8.00	+1.20
	3700m	4.48	6.36	+1.88
Beas	3300m	5.40	7.25	+1.95
	2700m	5.30	7.25	+1.95
Solang	2500m	7.75	10.10	+2.35

Minimum recorded at snow field : 0.5°C

Maximum recorded at Manali : 12.0°C

The above data is interesting in showing that the diurnal variations of temperature are slight. The variation, if any, is correlated with the slowing down of velocity of flow and increase of volume of water. The maximum difference between the highest and the lowest points in the stream, involving a distance over 40 km, and difference in altitude of 2000 m, is only 11.5°C. It follows that the temperature of water is not the decisive factor in the nature, composition and occurrence of insects in the stream.

## GENERAL ECOLOGY

Steinmann (1907), has given an interesting account of the ecology of stream Diptera from the Alps. *Liponeura* occurs according to him, in the wildest part of very swift flowing streams. He also records *Simulium*, *Tanytarsus*, *Chironomus* and other forms. In the Himalayan glacial torrents these groups constitute minor elements, at least at higher altitudes and in glacier zone.

In order to understand the general ecological peculiarities of the Diptera of glacial torrents, and to explain the remarkable behaviour and reactions of the larvae and pupae and their relations to the conditions prevailing, it is necessary to briefly consider at the outset the theory of drag experienced by bodies in running waters.

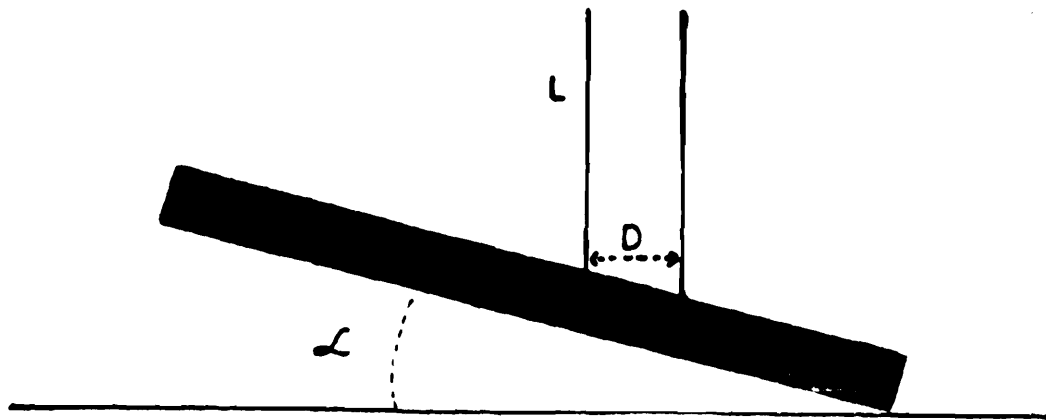


Fig. 3. Diagrammatic representation of the lift  $L$  and drag  $D$  experienced by a flat plate kept at an angle.

#### *Drag on body*

When a submerged body moves along a straight line with a uniform velocity through a liquid which is at rest, the body experiences a force opposite in direction to that of its motion. This force is called drag or resistance. Similar drag is experienced by a body at rest in a mass of flowing water. The another force which is experienced by the bodies in water is the lift. If a flat plate (Fig.3), even if slightly lifted up to form a small angle to the direction of flow of water, it will experience a lift. The ratio  $L/D$  depends not only on this angle of attack but also on the aspect ratio. A rectangular aspect ratio for example 6:1 (the sides are 6/1) shows a larger  $L/D$  ratio than a square plate. Better  $L/D$  ratio results if the plate is slightly curved. Such a body tends to be lifted up and rolled over. This explains why no immersed stone or the body of an insect is flat. Flattened insect cannot remain in equilibrium in water, because first their body will be lifted up and secondly folded backwards.

The submerged rocks in a torrent are always moulded by mechanical and physical action of running water and turned into streamlined bodies, conforming to aeorofoil shape. It is necessary that the front end be rounded off and top surface curved very smoothly and tail profile has a sharp edge. Such streamlined shapes of the bodies of stones (Fig.4) minimise the lift and turbulence. In such a case  $L/D$  ratio is optimal and the water flows very smoothly over such surfaces without forming any turbulence. *It is on such stones that the maximum number of eutorrenticole insects larvae occur, because of the thickness of the boundary layer being optimal over a wide range and because of the absence of turbulence.*

In a glacial stream, as the constant current of water effectively ensures continual replenishment of the supply of the respiratory oxygen, removal of carbon dioxide and other matabolic waste from the

neighbourhood of the larvae and in some cases even brings in food particles. The glacial larvae effectively utilize the high current velocity. This eliminates the necessity of large and specialized respiratory organs like gills and gill lamellae. Even where gills are present, gill movements are unnecessary. The only movements of the body are associated with the scrapping of the food diatomaceous and algal slime from the stone. Some locomotion is also necessary to the location of pupation. Movements of the body under the conditions of pressure drag, explained above, are affected because of the weighting of the anterior end of the body to minimise lift. *From this it is evident that the wide-spread assumption that torrential Dipterous larvae inhabit areas of fastest velocity of current is wholly unjustified.* The larvae occur consistently only on stones of appropriate size, which have suffered streamlining erosion by water. On these stones the larvae also take advantage of the existence of moderate velocities in the boundary layer, where the drag and lift ratio is also optimal. From this it is evident that the larvae and pupae selectively avoid excessive current velocity itself in creating the necessary optima in their niches. These peculiarities underlie the complete absence of larvae on numerous submerged stones covered with abundant growth of the food algae. Although the conditions seem otherwise extremely favourable, the thickness of the boundary layer, the drag and lift ratio, the nature of streamlined shape of the stone exclude the possibility of occurrence of larvae. It therefore happens that the ecology of the Diptera itself acts as limiting factor so that the population of larvae are generally broken into small and greatly isolated pockets.

Another peculiarity of the general ecology may be mentioned here. Although only the immature stages are necessarily exposed to the special conditions and must therefore be expected to show ecological modifications, it is nevertheless true that ecologically even the aerial adult is not completely emancipated from the ecology of torrential streams. The factors which operate on the larval forms are reflected in the organization and behaviour of the adult also.

## SPECIAL ECOLOGY

### Adults

*Emergence* : The emergence of most adult Diptera from the pupae is effected in about 5-6 minutes. The pupal integument splits down in the normal orthorrhaphous manner and the adult works its way out slowly from the pupal skin, progressing to the water surface while still holding on to the pupal skin by the long, strong hind legs. While thus holding on to the rigidly anchored pupae by the legs, the adult rests chiefly on the water surface, spreads out the wings and allows them to expand. It then releases the foothold, rises above the water and takes

flight. The emergence always takes place in *calm and sunny weather*, in the morning hours only, when the water level is, *low*. If the pupae happen to be submerged too deeper, *emergence is suppressed* till the level falls to the extent that the length of legs of adult enables the body to be in air and claw holding to pupal skin under water. Even a brief interval of sunshine acts as a trigger for emergence.

*Flight* : All the torrential Diptera are extremely poor and clumsy fliers and never fly very far from the stream. The adults of Blepharoceridae if there is no large obstruction in their way, may for example cover on wings a maximum of 100 m from the stream. They are also low fliers. The flight in the case of Deuterophlebiidae is even more irregular and haphazard ; the wings are simply fluttered in the air

*Feeding* : The adults of Deuterophlebiidae do not eat. In family Blepharoceridae the males feed upon plant juices and nectar and females are predaceous. They prey upon the smaller Diptera including adult Chironomidae and Psychodidae.

*Resting* : The adult flies generally avoid strong sunlight and thus mostly seek shelter in the shaded areas, under overhanging rocks and boulders, in minicaves and under the leaves of the herbs and low shrubs growing near the stream. The Blepharoceridae rest in early morning with their wings swept back behind 40° to the body horizontal axis in the relaxed position. During the later hours of the day wings are held stretched at right angle to the body axis, in ready position for flight. They rest under leaves and curiously enough always clinging to the tip of a leaf, with all legs directed forward, keeping the body at right angle to the leaf surface. They remain thus resting for a considerable time unless disturbed.

*Swarming* : Swarming usually occurs in the evening hours. Except for one swarm of a Blepharocerid, which was collected from under a overhanging rock the other adults were collected while devouring their prey. Probably the swarm is formed at the resting places and after the copulation the male dies. The female survives for about 4-5 days and dies, after laying eggs. The Deuterophlebiidae swarm in the morning hours, flying low over the surface of water, not rising more than about half a metre high. After emergence the adults rest for sometime under rocks near the stream and then swarm. The male dies after copulation and the female after laying eggs.

*Oviposition* : Oviposition occurs during sunny weather always before noon, when the water level is low. The Blepharoceridae female hovers on the stone surface near the water surface. It rests on the stone 30-40 cm above the water level. It then starts tapping the stone

surface with the tip of abdomen, at the same time gradually sliding downward, towards the water surface, deposits the eggs in shiny white patches immediately above the water surface, in the splash line zone where the stone surface is consistently wetted by the water but not submerged at the time of oviposition. In the late noon the eggs are submerged. According to Steinmann (1907) some species from the Alps lay eggs on the underside of the submerged stones where it would be necessary for the adult to dive under and remain in water while egg laying.

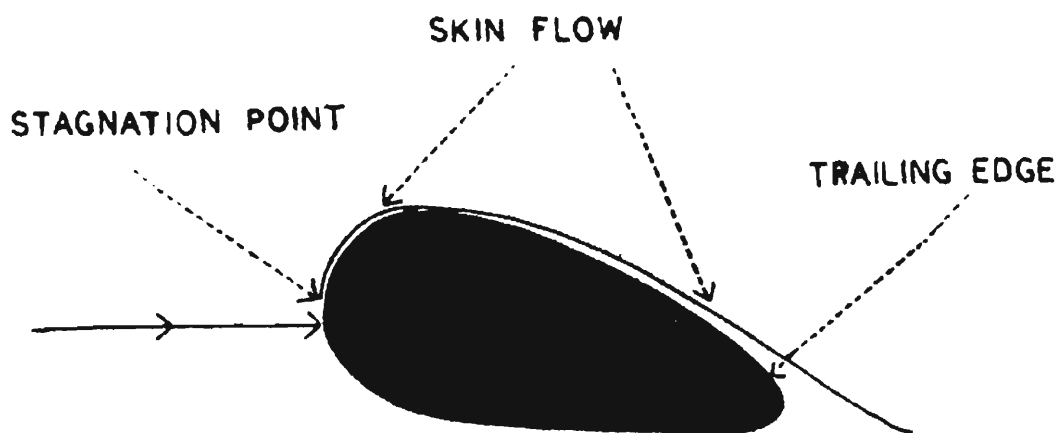


Fig. 4. Skin flow of the boundary layer around a streamlined submerged stone, seen in profile, on which larvae of torrential insects occur.

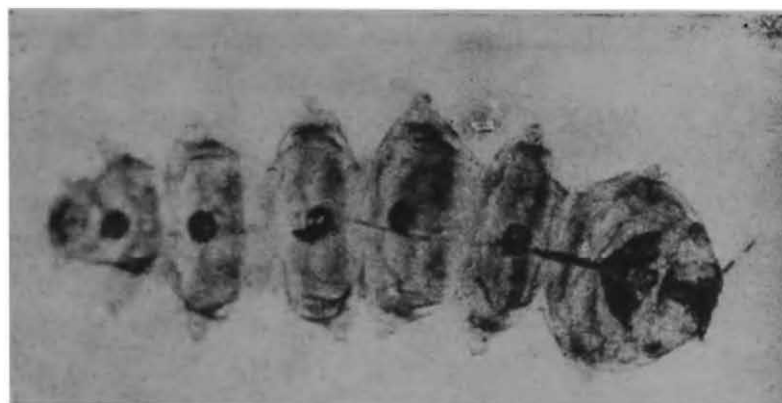
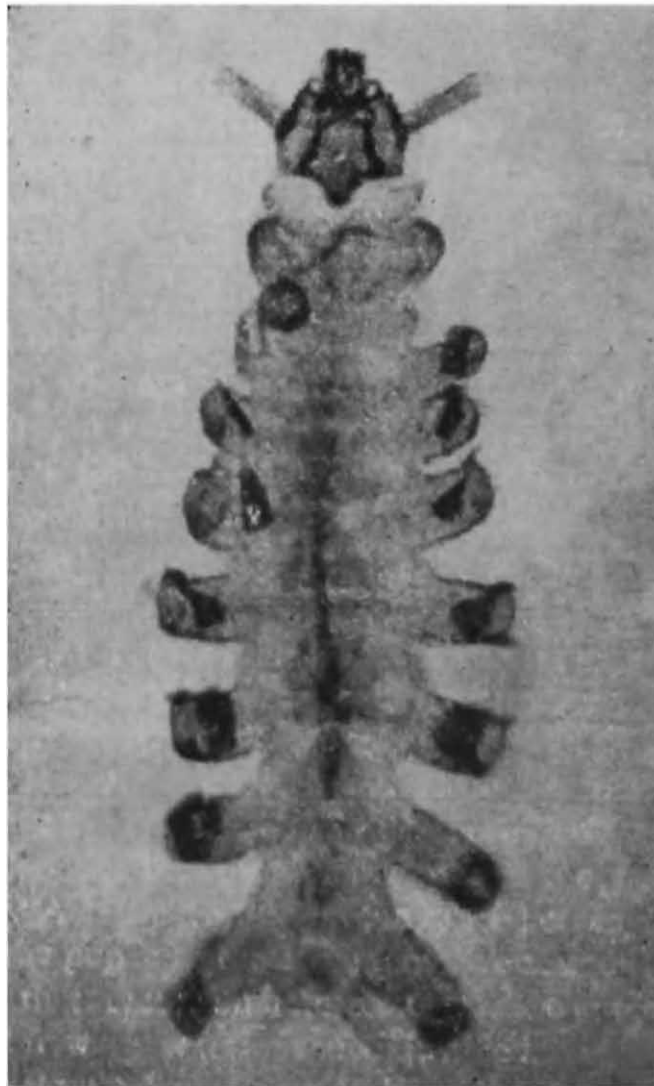


Fig. 5. Larva of *Blepharocera*. Six suckers and the parapodia are clearly visible.

### Larvae

The larvae of Blepharoceridae (Fig. 5) occur gregariously on rocks and stones submerged in water in torrential stream, at the cascade and edge of the waterfalls. They are always confined to the region of reduced velocity in the boundary layer. Younger larvae occur deeper in water while the larger and older ones are found closer to the water surface. This peculiarity is correlated with the differences in the thickness of the boundary layers in deep and shallow water (deep water



**Fig. 6. Larva of Deuterophlebiidae (dorsal view).**

velocity is higher than the shallow water velocity). They are abundant only on the streamlined surface of the stones and are never found at the trailing edge. A typical full grown larva (Fig. 5) measures 4-6.5 mm in length. It is greyish brown or black and has three segmented antennae. Some workers like Tonnoir (1930) described the larvae as bearing two segmented antennae. The head complex is globose and large. The respiration occurs with the help of gill tufts present on the ventral surface. The number of gill filaments in each tuft varies from instar to instar and also from species to species. Constant character of the larvae is the presence of suckers, one in each segment in the mid-ventral line of the body. Each sucker consisted of an outer rim of fringe, a layer of rods followed by sclerotic blocks, a valvular opening and a piston. In addition to these structures there are six thick spines and a number of spinules. It forms a sort of cup like structure which remain fixed to the substratum while the larva is at rest. Larvae of Deuterophlebiidae (Fig. 6) is 4-5.5 mm in length and strongly arched dorsally (Singh, 1961). Head, thorax and abdomen are distinct. The head

is wider than long and bears long branched antennae. The thoracic segments are separated by a conspicuous lateral constriction. The abdomen consists of eight distinct segments, each of the first seven bearing a pair of stout and large lateral prolegs. The distal ends of the prolegs are provided with numerous concentric rings of crochets. The last abdominal segment is produced into paired terminal process, reduced apically. This process bears ventrally five soft, obtuse blood gills.

My collection of the larvae and adults of this family was the first record of its presence on the southern slopes of Pir Panjal Range. This family is always found in the vicinity of melting snow in association with Blepharoceridae. The food of these larvae consists of diatomaceous algae.

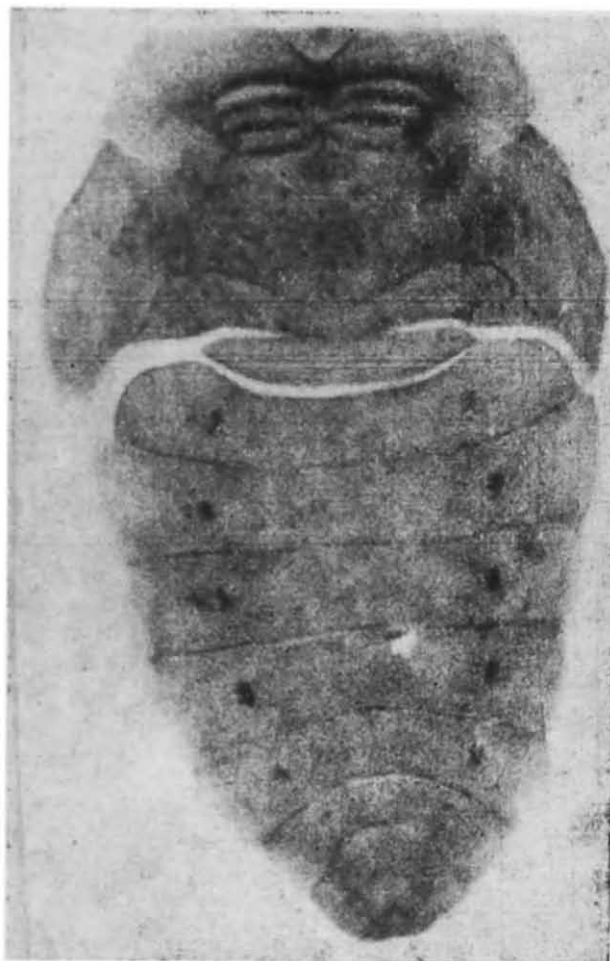


Fig. 7. Pupa of Blepharoceridae (dorsal view). The respiratory organs on the head complex and the peculiar pattern of the tubercles on the body are visible.

#### **Pupae**

Pupae are fixed on the stones and rocks. At the time of pupation the Blepharocerid larvae move towards the water surface on the stones and arrange themselves at depth of 3-4 cm gregariously, mostly taking advantage of the surface irregularities on the stone.

They are found soldered to the rock surface by some secretion below the splash line. The orientation of the pupae with reference to the direction of flow seems to be unrelated. Previous workers (Hora, 1930 and Tonnoir, 1932) have reported that the pupae orientated with the head upstream, others (Alexander, 1958, 1963) record that the pupae are orientated with head downstream. I have found that while many pupae face upstream, other downstream, there are still others which are placed diagonally to the direction of flow. The pupae apparently seem to occur in zones of lower current velocities, than the larvae. The pupa (Fig. 7) is 4-5 mm in length. It bears four pairs of elongated lamellae as respiratory organs on the head. These respiratory organs and tubercles on the body differ in their pattern and distribution in different genera and are of taxonomic importance.

### CONCLUSION

A field survey of the R. Beas system at its source glaciers in the Kulu Valley of Himachal Pradesh in Northwest Himalaya, conducted on random faunal sampling basis gave interesting results, with respect to the distribution, ecology and character-communities of some Dipterous families. The little known families, viz. Blepharoceridae and Deuterophlebiidae are found distributed in the fast flowing water of the streams. A concentration on the special ecological niches where the larvae and the pupae of these families are found revealed that earlier assumption that these immature stages are subjected to the high pressure of fast flowing water is not justified. It is shown here that they inhabit the slow velocity zone of boundary layer on the only streamlined submerged stones. The high velocity of water which does not allow the stratification of water temperature, concentration of the carbon dioxide, oxygen, itself creates the optimum conditions for these insects. The oviposition, the movement of the fully grown larvae for pupation and emergence of the adults are directly correlated with the fluctuations of the water level and the conditions of the atmosphere. The emergence always occurred in a sunny and calm weather at the morning hours when the water level is low.

The current velocity, the water level and the streamlined surfaces of the submerged stones are the only decisive factors in the distribution and abundance of the members of these families. The structural organizations in the immature stages and also in the adult have directly been influenced by the general ecological factors operating in the torrential streams.

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ALTITUDINAL STRATIFICATION OF DERMAPTERA IN THE  
HIMALAYA FROM BHUTAN IN THE EAST TO LADAKH  
IN THE NORTHWEST

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INTRODUCTION

Our knowledge of the Dermaptera from the Himalaya is undoubtedly far from complete and it will take a concerted effort over large number of years before a true picture of the faunal composition emerges. But, from whatever is known, it is possible to analyse the altitudinal succession of different taxa. The results of the analysis, outlined here, merely aim at presenting the general average most likely to be observed in the biome of the treeless montane tundra above the timber line. This average should indicate the broad central tendencies of more or less cyclic fluctuations and oscillations of the insect communities, their structure and faunistic composition. The environmental factors and insect communities are constantly changing and yet a certain seemingly unchanging pattern of factors and communities continues to exist over long periods. This pattern enables us to study the stratification of certain species at a given time. An effort is made here to describe the composition of different earwig species and their altitudinal succession.

FAUNAL COMPOSITION OF THE HIGH ALTITUDE SPECIES

The analysis of the taxa presented hereunder is based on the taxonomic and ecological contributions of Burr (1910), Singh (1955), Mani (1962, 1968), Kapoor (1966), and Srivastva (1976). So far seventy-four species belonging to twenty-seven genera of five families of Dermaptera viz., Apachyidae, Pygidicranidae, Labiduridae, Labiidae, and Forficulidae have been described from the Himalayan region under discussion. Family Forficulidae with Palaearctic affinities exhibits a pronounced dominance over all the remaining families by constituting about 60.8% of the total Dermaptera of the region. The dominant genera are *Guanchia*, *Forficula*, *Anechura*, *Allodhalia*. A reference to Fig. 1, will reveal that families Labiduridae (17.6%), and Pygidicranidae (13.5%) represent the other important component of high altitude Dermaptera. Families Labiidae with only 6.8% and Apachidae with 1.3% of the total Dermaptera known in the region comprise relatively insignificant element which is generally confined to valleys and lower elevations.

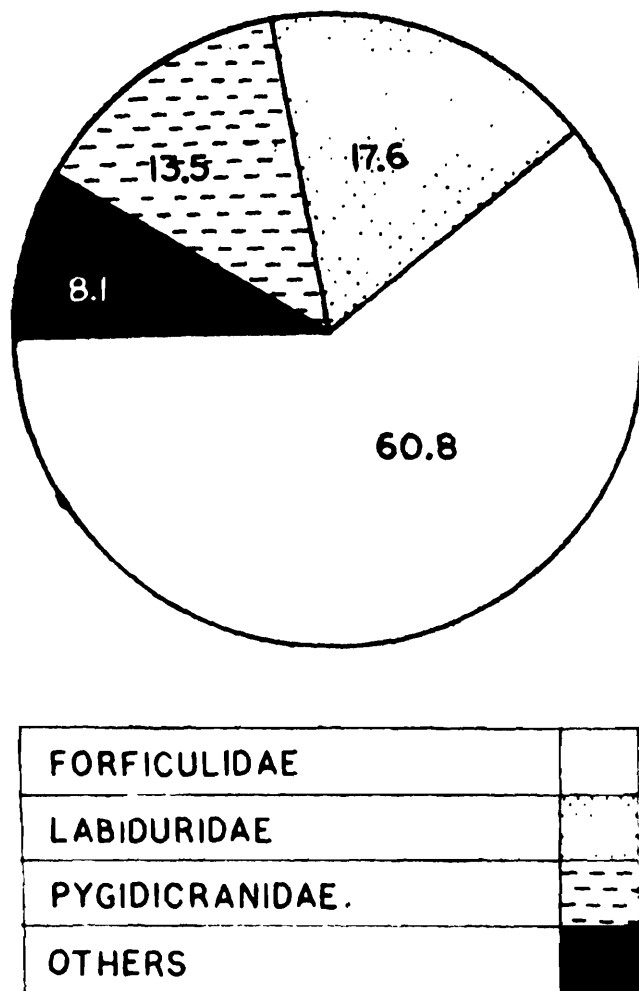


Fig. 1. Relative percentage abundance of different families.

#### ALTITUDINAL STRATIFICATION OF DIFFERENT FAMILIES

Of the five families of the Dermaptera, Apachyidae is restricted to an altitude below 1,500 metres above the mean sea level. Family Pygidicranidae extends from about 250 metres to about 2,500 metres above the mean sea level. Similarly family Labiduridae extends from below 500 metres to about 3,250 metres above the mean sea level. The family Labiidae comprising a tropical group of Dermaptera has not extended to beyond 2,000 metres above the mean sea level. A study of Fig.2, makes it abundantly clear that the dominant family Forficulidae is extended from about 800 metres to about 4,350 metres above the mean sea level. Apart from showing a wide range of altitudinal succession this family also represents the only Dermaptera so far known above 4,350 metres above the mean sea level. This apparently indicates that high altitude Forficulidae represents a truly hypsobiont element of the Dermaptera fauna. Labiduridae and Pygidicranidae represent the cryophile element of the Dermaptera from the Himalaya. It will not be out of place to remark here that a great preponderance of hypsobiont species are endogeous in their habits, whereas some of the Apachyidae and Labiidae are quite frequently met with below the timber line in the logwood or decaying conifer tree trunks.

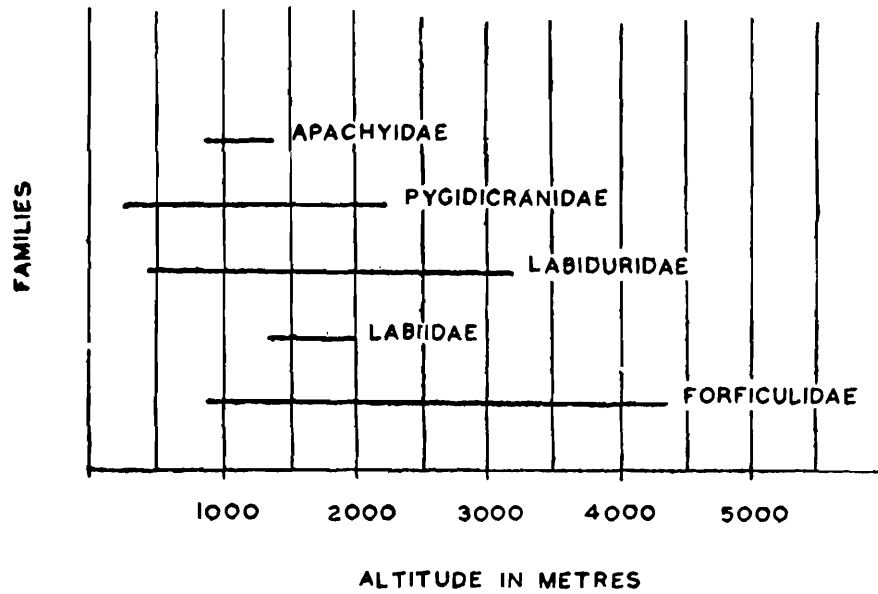


Fig. 2. Altitudinal range of distribution of different families.

### HYSOMETRIC DISTRIBUTION OF SPECIES

A study of the Table I given below and Fig. 3, will show that maximum number of species viz., 56 are met with between 1000—2000 metres above the mean sea level; 25 species between 2000-3000 metres; 7 species between 3000—4000 metres and only a small fraction represented by 3 species viz., *Guanchia chirurga*, *Anechura himalayana*, and *A. pirpanjalae* have succeeded in colonizing higher altitudes above 4,000 metres above the mean sea level.

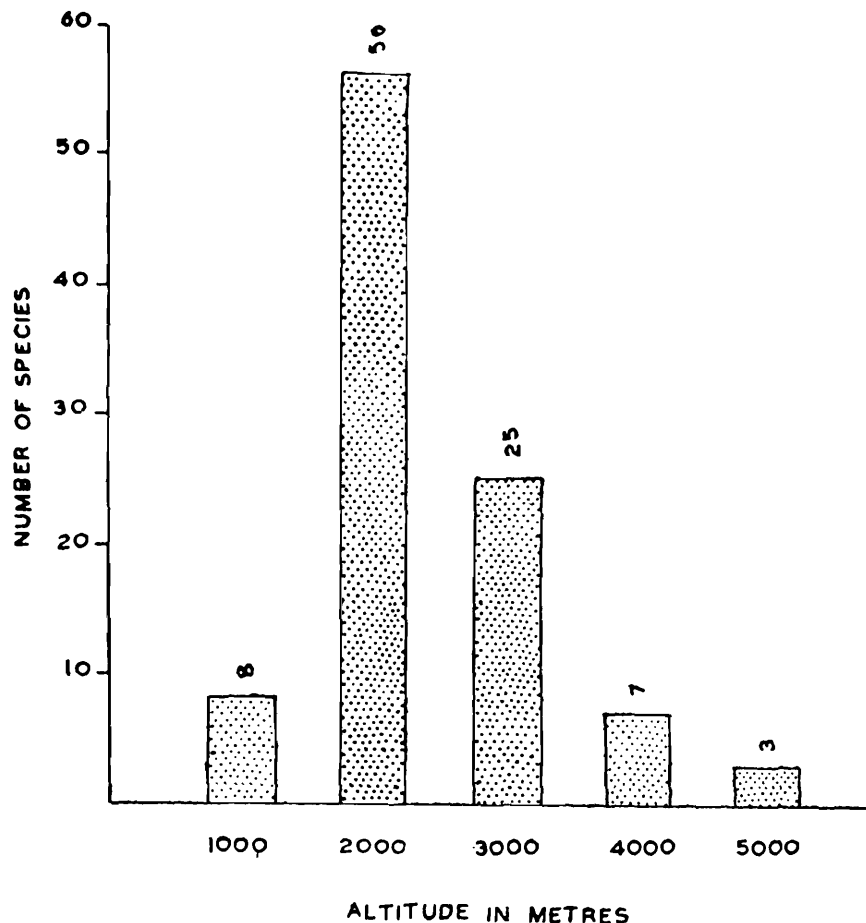


Fig. 3. Hypsometric distribution of the Dermaptera species in the Himalaya.

TABLE I

Altitudinal Range in Metres	Number of Species
300-1000	8
1000-2000	56
2000-3000	25
3000-4000	7
4000-4350	3

## REGIONAL SUCCESSION OF HIGH ALTITUDE SPECIES

### A. Species confined to Sikkim and Bhutan

A great preponderance of Dermaptera representing about 43.2% of the known species is confined to Sikkim and Bhutan regions. The important species being *Apachus feae*, two species of *Diplatys*, three species of *Cranopygia*, *Anisolabis gaudens*, *Euborellia femoralis*, *Forcipula quadrispinosa*, *Nala lividipes*, *Chaetospania kurseongae*, *Labia fulleri*, *Proreus cunctator*, *Hamaxas melanocephalus*, three species of *Allodhalia*, six species of *Forficula* and seven species of sub-family Opisthocosmiinae. It is significant to point out that out of the nine species of sub-family Opisthocosmiinae seven are confined to this region. All of the species of this region are relatively found at moderate heights. Further it is interesting to note that dominant Palaearctic element of the Northwest Himalaya represented by Anechurinae has not penetrated into the Eastern Himalaya. The only eastern Palaearctic species *Guanchia chirurga* of sub-family Forficulinae is confined to higher altitude of Sikkim.

### B. Species between west of Nepal and Sutlej Profile

Before discussing the composition of species of this region, it is worthwhile to point out that our knowledge about Dermaptera of Nepal region is very fragmentary and we know only a single species viz., *Forficula ornate*, which is confined to Nepal Himalaya and it does not extend beyond 3000 metres above the mean sea level.

Out of seventy-three known species of the high altitudes of the Himalaya 13 species viz., *Diplatys glenis*, *D. simlaensis*, *D. himalayanus*, *Euborellia kumaonensis*, *Parisolabis immsi*, *Spongiophora nainitalensis*, *Chaetospania jeolikotensis*, *C. lakhanmandiensis*, *Allodhalia dineshi*, three species of *Elauon* and *Forficula kumaoniensis* are confined to this region.

### C. Species confined to Northwest Himalaya

The earwigs of this region are predominantly represented by family Forficulidae with seven species out of the total eight species that we know of at present. The species are *Adiathetus nigrocastaneus*,

*Hamaxas singhi*, *Oreasiobia fedtschenkoi* sub sp. *calciatii*, *O. stoliczkae*, *Anechura himalayana*, *A. nayyari*, and *A. pirpanjalae*. The only other species viz., *Isolaboides burri* belongs to the family Labiduridae. It is not surprising to find family Forficulidae particularly sub-family Anechurinae with Palaearctic affinities constituting the dominant element in this region.

#### D. Species distributed all along the Himalaya

Besides the species restricted to different Himalayan regions about 27.1% of the Dermaptera species (20 species) are found in more than one region. A careful study of the Table II will reveal a very significant situation regarding such widespread elements. Of the 20 species 80% are confined to the east of Sutlej profile thus indicating the tremendous limiting influence of the R. Sutlej, which cuts across the Himalayan Mountain from north to south, on the westward dispersal of endogenous forms of Dermaptera. There are only four species viz., *Forcipula indica*, *Labidura riparia*, *Forficula beelzebub*, and *F. schlagintweiti* which are common in the Northwest Himalaya and have penetrated to the east of Sutlej Valley.

#### ALTITUDINAL STRATIFICATION OF THE SPECIES

The altitudinal stratification and succession of all the known species is presented figuratively in Figs. 4a and 4b. A careful study of these Figures will reveal that subfamily Anechurinae represented by only two species viz., *Anechura himalayana* and *A. pirpanjalae* have reached the highest elevation in the Himalaya. The other sub-family Forficulinae represented by a single species viz., *Guanchia chirurga* has also attained the highest altitude in Sikkim.

Darlington (1943), Singh and Mani (1961) and Mani (1962, 1968) have emphasized the marked tendency towards the abbreviation and gradual loss of wings under the impact of high altitude ecological conditions in the mountain forms. The typically hypsobiont Dermaptera like *Anechura himalayana*, *A. pirpanjalae* and *Guanchia chirurga* provide very convincing evidences for loss of flight and consequently the development of very sturdy and transverse sternal plates, which enable them to successfully lead an endogenous life.

#### ACKNOWLEDGEMENTS

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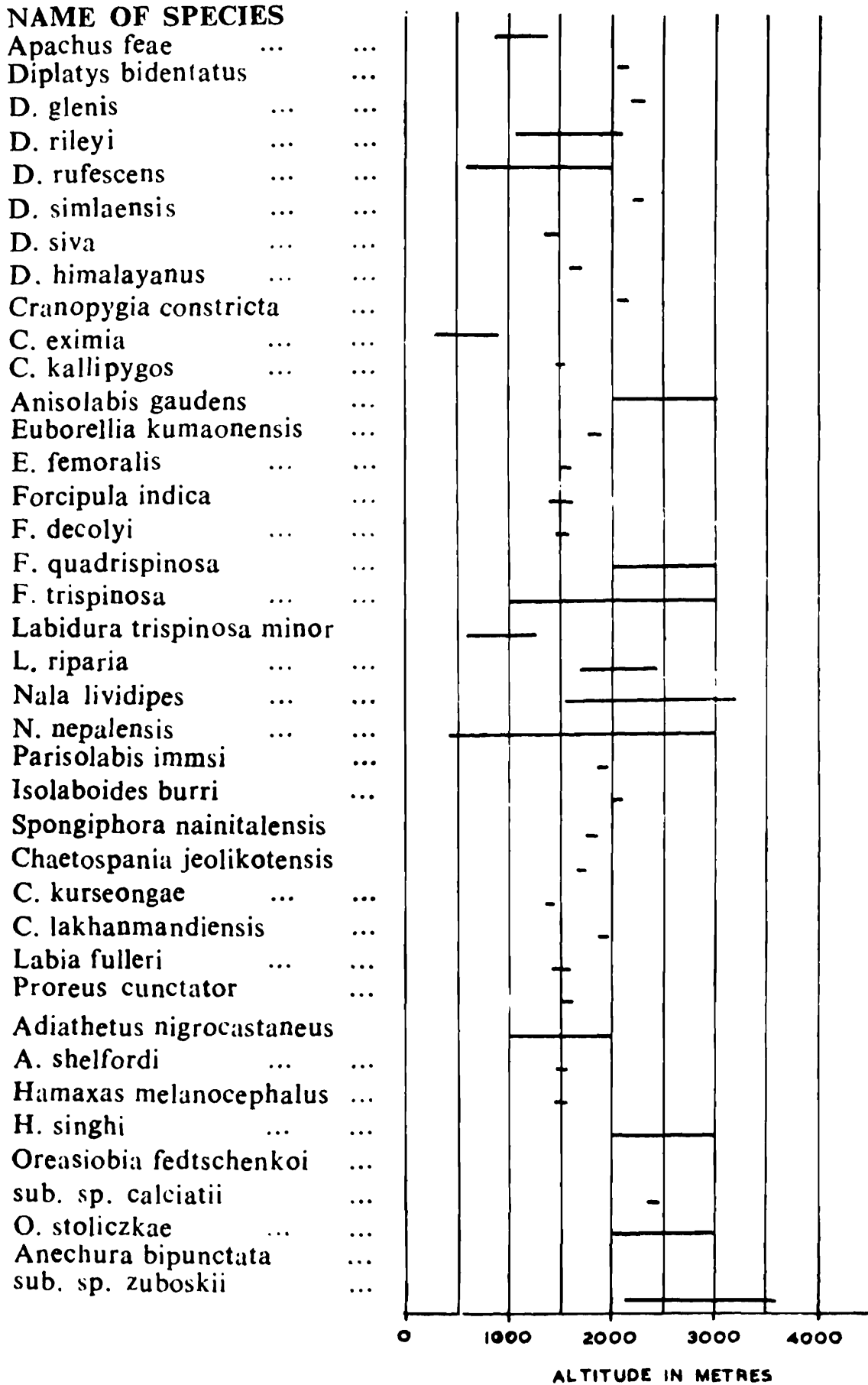


Fig. 4a. Altitudinal range of distribution of the species

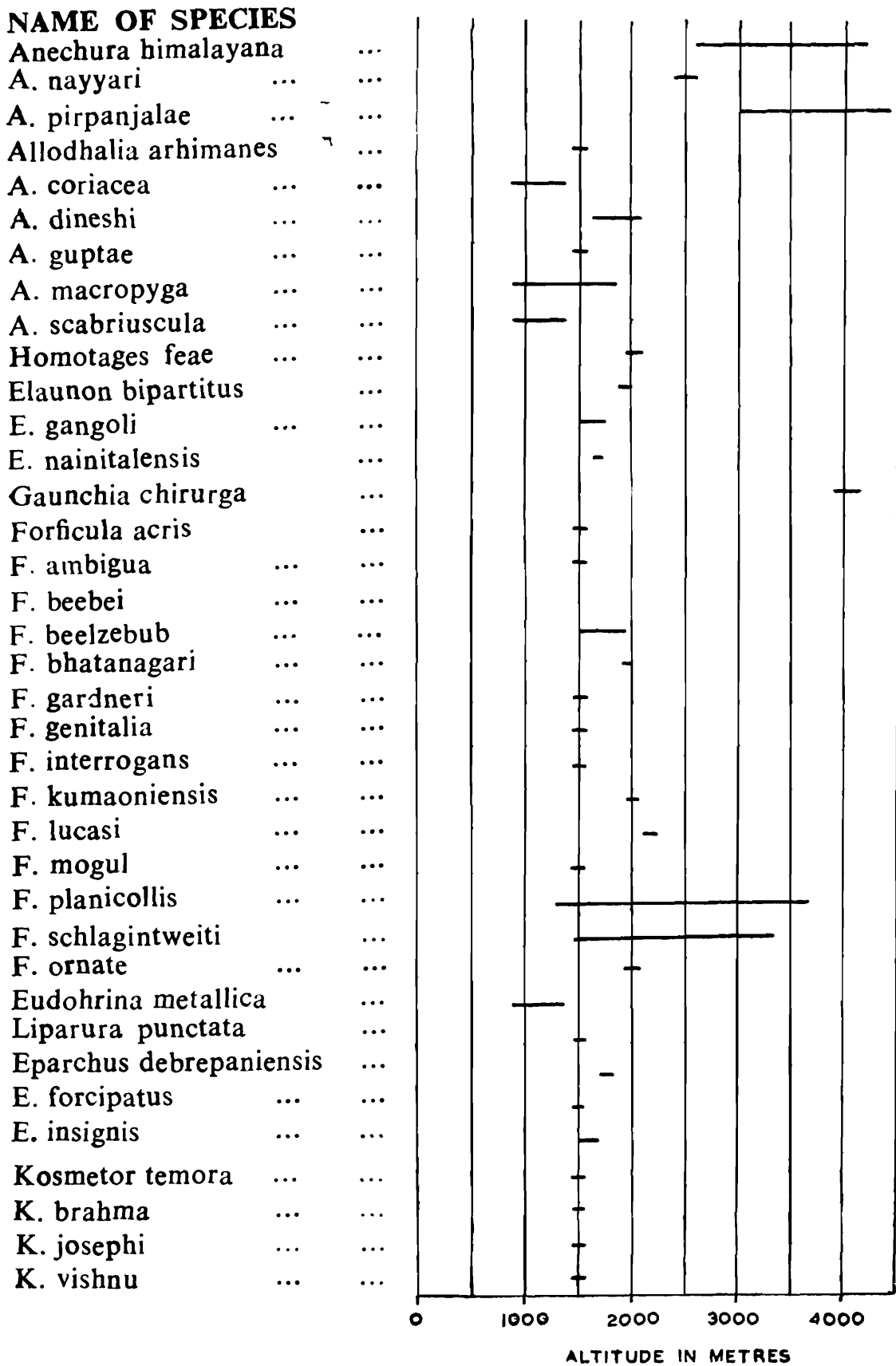


Fig. 4b. Altitudinal range of distribution of the species.

TABLE II

Name of Species	Northwest Himalaya	East of Sutlej & West of Nepal	Nepal	Sikkim & Bhutan
<b>APACHYIDAE</b>				
<b>Apachyinae</b>				
<i>Apachus feae</i>	—	—	—	+
<b>PYGIDICRANIDAE</b>				
<b>Diplatyinae</b>				
<i>Diplatys bidentatus</i>	—	—	—	+
<i>D. glenis</i>	—	+	—	—
<i>D. rileyi</i>	—	—	—	+
<i>D. rufescens</i>	—	+	—	+
<i>D. simlaensis</i>	—	+	—	—
<i>D. siva</i>	—	+	—	+
<i>D. himalavanus</i>	—	+	—	—
<b>Pygidicraninae</b>				
<i>Cranopygia constricta</i>	—	—	—	+
<i>C. eximia</i>	—	—	—	+
<i>C. kallipygos</i>	—	—	—	—
<b>LABIDURIDAE</b>				
<b>Carcinophorinae</b>				
<i>Anisolabis gaudens</i>	—	—	—	+
<i>Euborellia kumaonensis</i>	—	+	—	—
<i>E. femoralis</i>	—	—	—	+
<b>Labidurinae</b>				
<i>Forcipula indica</i>	+	—	—	+
<i>F. decolyi</i>	—	—	+	+
<i>F. quadrispinosa</i>	—	—	—	+
<i>F. trispinosa</i>	—	+	+	+
<i>Labidura trispinosa minor</i>	—	+	+	+
<i>L. riparia</i>	+	+	—	+
<i>Nala lividipes</i>	—	—	—	+
<i>N. nepalensis</i>	—	+	+	+
<b>Parisolabinae</b>				
<i>Parisolabis immsi</i>	—	+	—	—
<i>Isolaboides burri</i>	+	—	—	—
<b>LABIIDAE</b>				
<b>Labiinae</b>				
<i>Spongiphora nainitalensis</i>	—	+	—	—
<i>Chaetospania jeolikotensis</i>	—	+	—	—
<i>C. kurseongae</i>	—	—	—	+
<i>C. lakhanmandiense</i>	—	+	—	—
<i>Labia fulleri</i>	—	—	—	+
<b>FORFICULIDAE</b>				
<b>Chelisochinae</b>				
<i>Proreus cinctator</i>	—	—	—	+
<i>Adiathetus nigrocastaneus</i>	+	—	—	—
<i>A. shelfordi</i>	—	—	—	+
<i>Hamaxas melanocephalus</i>	—	—	—	+
<i>H. singhi</i>	+	—	—	—

Name of Species	Northwest Himalaya	East of Sutlej & West of Nepal	Nepal	Sikkim & Bhutan
<b>Anechurinae</b>				
<i>Oreasiobia fedtschenkoi</i>				
sub sp. <i>calciatii</i>	+	—	—	—
<i>O. stoliczkae</i>	+	—	—	—
<i>Anechura bipunctata</i>				
sub sp. <i>zuboskii</i>	+	+	—	—
<i>A. himalayana</i>	+	—	—	—
<i>A. nayyari</i>	+	—	—	—
<i>A. pirpanjalae</i>	+	—	—	—
<i>Allodhalia arhimanes</i>	—	—	—	+
<i>A. coriacea</i>	—	+	—	+
<i>A. dineshi</i>	—	+	—	—
<i>A. guptae</i>	—	—	—	+
<i>A. macropyga</i>	—	+	—	+
<i>A. scabriuscula</i>	—	—	—	+
<i>Homotages feae</i>	—	+	+	+
<b>Forficulinae</b>				
<i>Elaunon bipartitus</i>	—	+	—	—
<i>E. gangoli</i>	—	+	—	—
<i>E. nainitalensis</i>	—	+	—	—
<i>Gaunchia chirurga</i>	—	—	—	+
<i>Forficula acris</i>	—	+	—	+
<i>F. ambigua</i>	—	—	—	+
<i>F. beebei</i>	—	—	—	+
<i>F. beelzebub</i>	+	+	+	+
<i>F. bhatanagari</i>	—	+	—	+
<i>F. gardneri</i>	—	—	—	+
<i>F. genitalia</i>	—	—	—	+
<i>F. interrogans</i>	—	—	—	+
<i>F. kumaoniensis</i>	—	+	—	—
<i>F. lucasi</i>	—	+	—	+
<i>F. mogul</i>	—	—	—	+
<i>F. planicollis</i>	—	+	—	+
<i>F. schlagintweiti</i>	+	—	—	+
<i>F. ornate</i>	—	—	—	—
<b>Opisthocosmiinae</b>				
<i>Eudohrina metallica</i>	—	+	+	+
<i>Liparura punctata</i>	—	—	—	—
<i>Eparchus debrepaniensis</i>	—	—	—	+
<i>E. forcipatus</i>	—	—	—	+
<i>E. insignis</i>	—	+	—	+
<i>Kosmetor temora</i>	—	—	—	+
<i>K. brahma</i>	—	—	—	+
<i>K. josephi</i>	—	—	—	+
<i>K. vishnu</i>	—	—	—	+

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RAINFALL AND ITS RELATION TO ENTOMOFAUNA  
AT MODERATELY HIGH ALTITUDE ECOSYSTEMS  
WITH PARTICULAR REFERENCE TO PINE  
(*PINUS KESIYA* ROYLE)

By

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INTRODUCTION

Rainfall is one of the commonest factors of atmospheric precipitation and the most important meteorological element being the only source of fresh water. It is the falling of water in drops, through the atmosphere. In tropical climates, rainfall is of convectional type as it is caused by the vertical movement of warm humid air and rapid cooling as it rises. Among conifer forests in tropical climates, rainfall is the important factor regulating the size of the insect population in both natural and near to natural ecosystems. Though rainfall is an important factor of the abiotic environment of the tropical coniferous ecosystem, very little is known about its influence on the entomofauna inhabiting such ecosystems. This report discusses the variation in total monthly rainfall during the period 1976-78 and its effect on various groups of entomofauna such as sapsucking, chewing and mining consumers, and soil and litter inhabiting decomposers.

STUDY AREA

The study was conducted at an altitude of range 1000 to 1200 metres MSL near Shillong (Latitude 25°34' N and Longitude 90°56'E) on the site of old Gauhati-Shillong Road. The area covers pine plantation of various age groups ranging from seedling beds of one year old to the plantations of thirty years old. Pine (*Pinus kesiya* Royle) is the predominant primary producer. *Schima wallichii* was also present at random. The undergrowth vegetation is characterised by various herbs like *Eupatorium adenophorum*, *Hedychium coronarium* Koeing, shrubs like *Lantana camara*, *Setaria glauca* P. Beauvand, grasses like *Imperta cylendica*, *Paspalum dilatatum*.

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## MATERIALS AND METHODS

The rainfall was measured by a simple rain gauge and confirmed by meteorological data. The sap-sucking consumers mainly represented by aphids, were sampled following the method of Gray and Schuch (1941). The chewing and mining consumers were sampled with the help of a light trap (Reddy and Alfred, 1977a). The soil arthropods were sampled following the methods of Macfadyen (1962) and the litter arthropods were sampled following the method of Crossley and Hogland (1962).

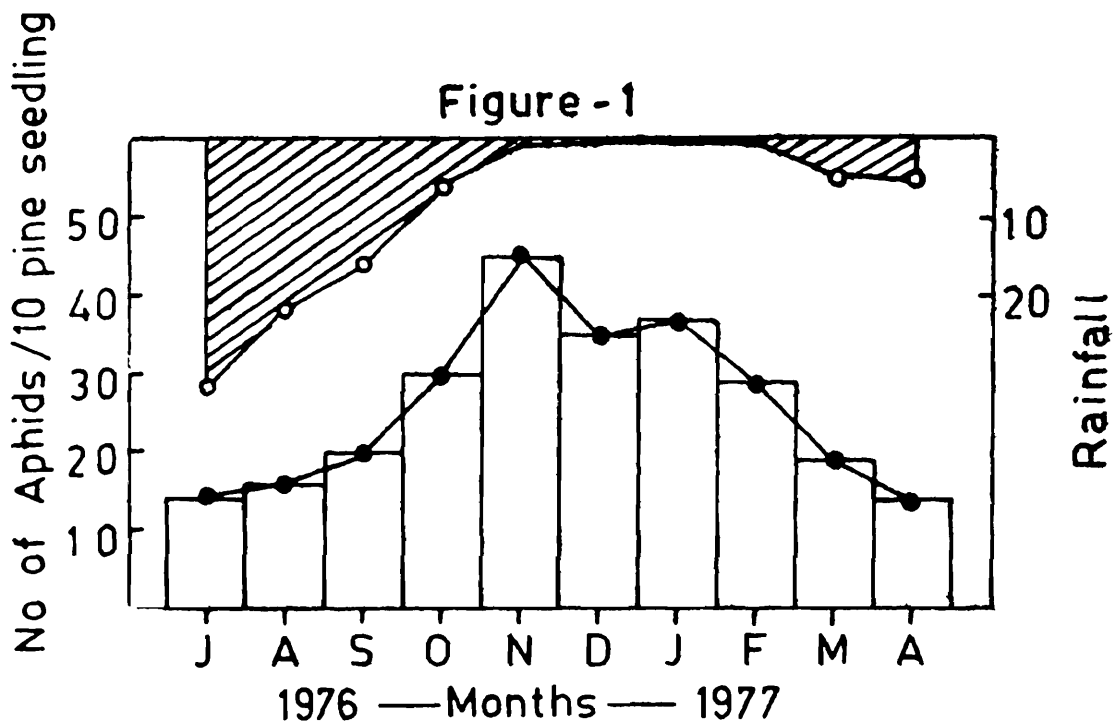
## RESULTS AND DISCUSSION

The monthly fluctuation of total rainfall (cm) revealed that the rainfall ranged from 0-72.08 cm during 1976-77 and 0-64.45 cm during 1977-78. The rainfall was recorded nil in the month of January 1976. Then it gradually increased from the month of February with a sudden rise in May, 1976 reaching the peak in June, 1976. Thereafter it gradually decreased reaching nil in January, 1977. From February, 1977 onwards it gradually increased with a sudden upsurge in April, reaching a peak in May, 1977. Then it gradually decreased with a small peak of increase in August, to zero in January, 1978. The coefficient correlation between the monthly rainfall of the two annual cycles is presented in Table-I. The correlation was statistically positively highly significant. This indicates that the rainfall on a future year follows the rainfall pattern of the present year

TABLE I. Coefficient correlation between monthly rainfall (1976-77 and 1977-78)

	<i>Statistical Values</i>
Coefficient correlation	+0.8156
Computed value of "t"	6.610
Degree of freedom	22
Level of significance	P < 0.01

The effect of rainfall on entomofauna of any natural or near to natural ecosystems may be of two types (1) Regulatory (2) favourable. In regulatory type of effect, any excess rainfall reduces the size of the insect population. Reddy and Alfred (1979a,b) reported that the rainfall was negatively significantly correlated with the population of sap-sucking consumer (aphids) feeding on pine (Table-II). During the peak periods of rainfall, i.e. in May-June, not a single aphid was recorded. When the rainfall started decreasing from July the aphid population started increasing and when the rainfall was in a low ebb during winter months, the aphid population reached the peak period of abundance (Fig. 1). This study clearly indicates the regulatory effect of



Monthly abundance of total number of *Neomyzus circumflexus* (Buckton) / 10 pine seedling in relation to monthly rainfall

rainfall on an aphid population. Similar results were obtained by many other aphidologists. The causes for reduction in aphid population level by rainfall by merely washing them (Hodek *et al.*, 1972) and by dislodging them (Dunn and Weight, 1955; Lewis and Siddorn, 1972) from the plants were evident. Besides the mechanical effect of rainfall on aphid population, rainfall may also regulate the population by being favourable to aphids infecting pathogenic fungi.

The favourable effect of rainfall becomes evident when the insect population of an ecosystem increases with the upsurge of the rainfall. Reddy and Alfred (1978a) reported a highly positively significant correlation between the total monthly rainfall and the abundance of different groups of chewing and mining insect consumer. With the sudden increase in rainfall in May, 1976, these insect orders were increased and trapped maximum in the light trap. The rainfall reached its maximum in June. Thereafter when the rainfall started decreasing the entomofaunal population also decreased and reached the minimum in the month of January, 1977 when the rainfall was nil (Fig. 2). Many investigators reported this type of effect of rainfall on insect population in different ecosystems (Banerjee, 1967; Graham *et al.*, 1971; Cantelo, 1973; Firth, 1975). This is because rainfall forms the basis for insect multiplication, stimulating the plant growth, which in turn provides food for insect development.

Figure-2

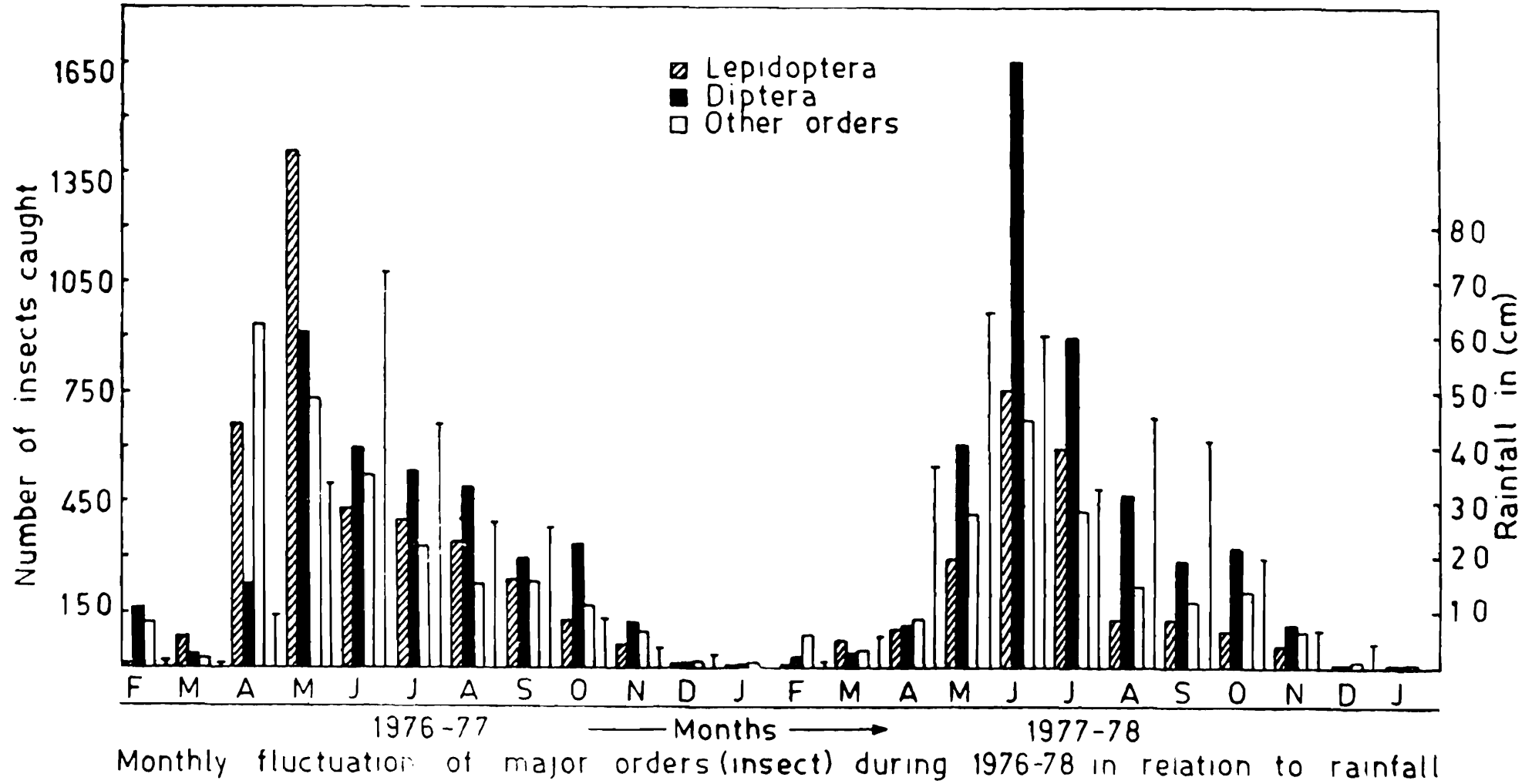
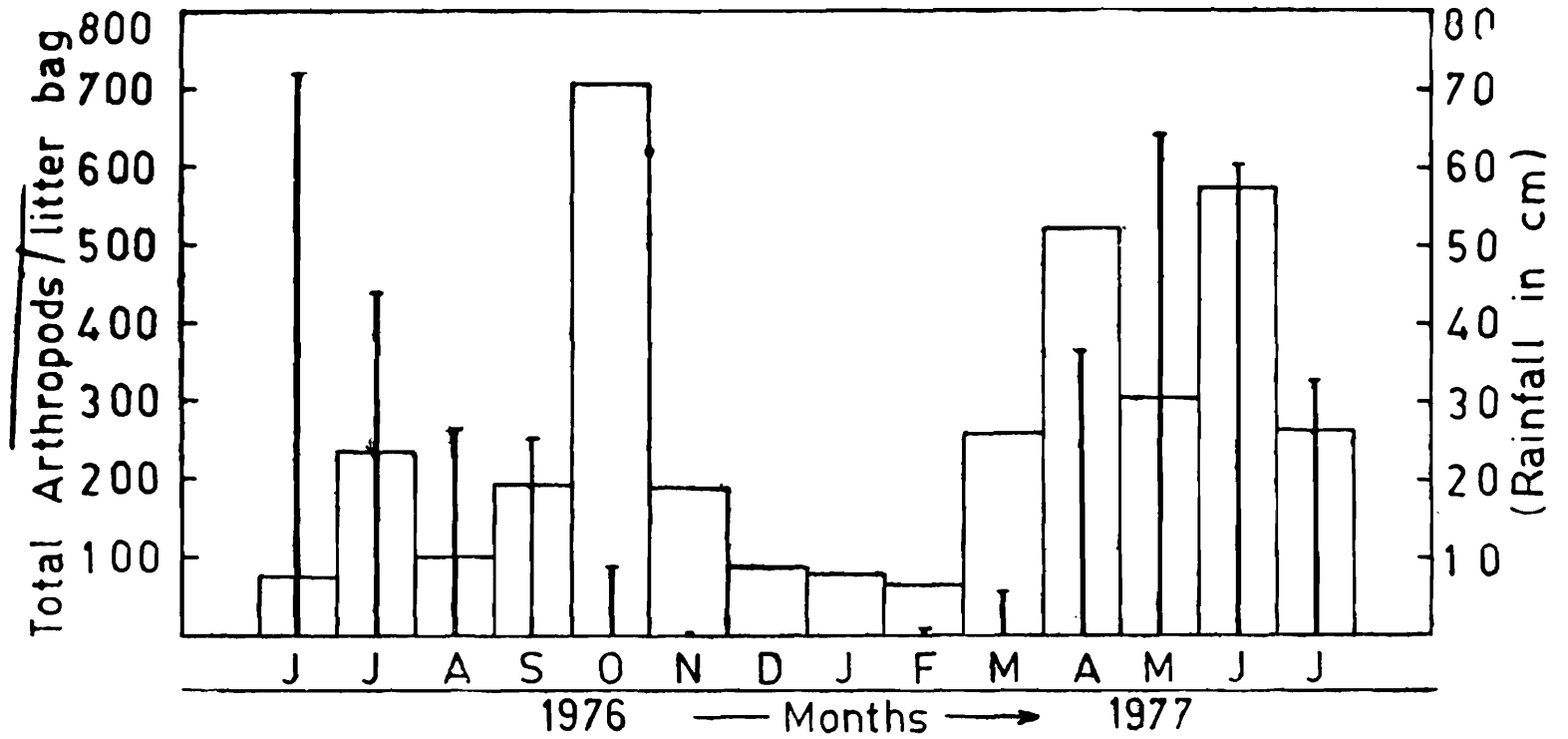


Figure -3



Seasonal abundance of litter Entomofauna in relation to rainfall.

The litter entomofauna were negligibly influenced by the rainfall when compared to the epizoic entomofauna. Reddy and Alfred (1978a) could not find any significant correlation between the rainfall and litter inhabiting entomofauna. The seasonal abundance of litter entomofauna fluctuated considerably. The population showed four peaks of abundance during the annual cycle i.e. in July and October, 1976 and April, June, 1977 (Fig. 3). Reddy and Alfred (1977b) reported a positively significant correlation between the seasonal abundance of soil inhabiting arthropod fauna and the fluctuation in total monthly rainfall. They could record a higher population of soil arthropods during the rainy months of the year, the maximum being in July and lower population during the winter months when the rainfall was recorded minimum (Fig. 4). Similar results were reported by many workers (Choudhuri and Roy, 1967; Gupta and Mukherji, 1978) who reported the occurrence of peak population during rainy season.

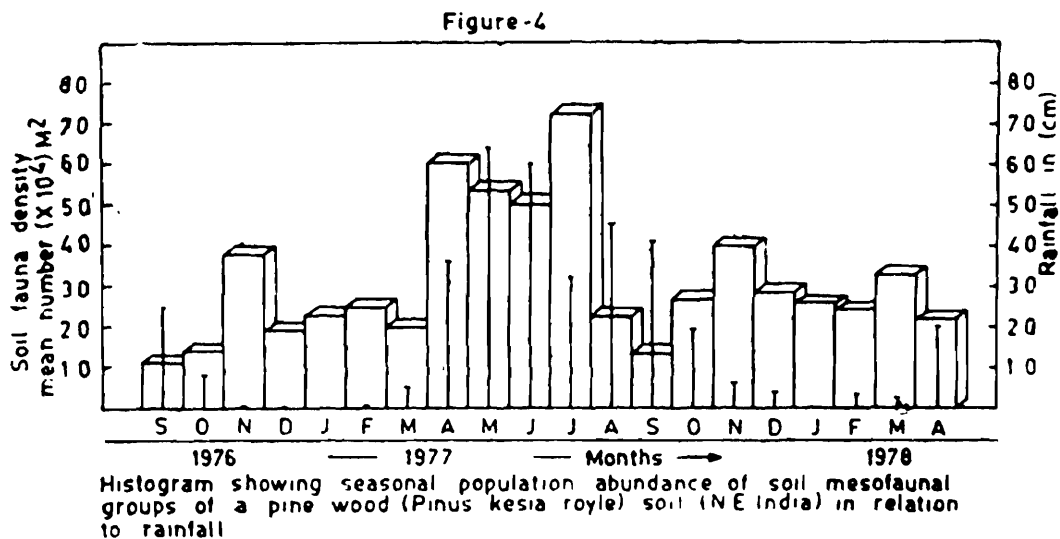


TABLE II. Coefficient correlation between the monthly abundance of different entomofaunal groups and the monthly variation in rainfall

Different parameters	Coefficient Correlation	Computed value of "t"	Degree of freedom	Level of significance
Sap-sucking consumers	-0.7956	3.719	8	$P < 0.01$
Chewing and mining consumers	0.7989	3.719	10	$P < 0.01$
Litter inhabiting entomofauna	0.2467	0.852	11	Not significant.
Soil inhabiting	0.4580	2.188	18	$P < 0.05$

Rainfall is one of the important factors of the abiotic environment and the entomofauna is one of the groups of consumer of the pine forest ecosystems of North-Eastern India. It became evident from the above study that these two fractions of different components of the

ecosystem interacted with each other, the entomofauna being influenced by the rainfall. It was seen that the rainfall was not always favourable for all the groups of insects. Sometimes it regulated the entomofaunal population and sometimes it favoured it.

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AN ADDITION TO THE SPIDER FAUNA OF THE  
JAMMU AND KASHMIR STATE

By

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INTRODUCTION

There was practically no work in the past on the spider fauna of the Jammu and Kashmir State although spiders are quite abundant throughout the State. Recently, Sharma and Sharma (1976) made a survey of spider fauna of this State and reported 32 species of spiders belonging to 15 families and 23 genera. The author undertook collection trips in this State for over two years and collected a number of spiders from various localities. The spiders were preserved in 70% alcohol.

The examination of collection revealed an enumeration of 20 species of spiders referable to 10 families and 17 genera which have been systematically embodied below. All the species except *Tetragnatha mandibulata* Walck., the families Eresidae and Selenopidae and the genera *Neoscona*, *Singa*, *Stegodyphus*, *Labulla*, *Lepthyphantes*, *Selenops*, *Pardosa*, and *Phidippus* are new records from the State. With the addition of this fauna to the existing record, the number of spider species now known from the Jammu and Kashmir State stand at 52 referable to 17 families and 32 genera. It is hoped that further extensive survey of this State will yield many interesting records as an addition to the volume of araneid fauna so far known.

OBSERVATIONS

The spider species collected during the survey from the Jammu and Kashmir State are arranged below systematically together with collection data.

I. Family ARGIOPIDAE

*Araneus nympa* Simon, 3♀♀, needles of pine trees, Pehlgam, Srinagar 22. VI. 77 and 2♀♀, Pampore (Srinagar), 8. VI. 78.

*Araneus himalayensis* Tikader, 2♀♀, web among shrubs, Chattbal, Srinagar, 23. VI. 77 and 2♀♀, Shalimar Garden (Srinagar), 10. VI. 78.

*Neoscona mokerjei* Tikader & Bal, 3♀♀, web among shrubs, Gulmarg (Srinagar), 24. VI. 77 and 1♀, Srinagar, 11 VI. 78.

*Singa chota* Tikader, 2♀♀, web among shrubs, Gulmarg (Srinagar), 24. VI. 77 and 1♀, Chhattbal (Srinagar), 11 VI. 78.

## II. Family ERESIDAE

*Stegodyphus sarasinorum* Karsch., 4♀♀, an extensive web on the branches of *Acacia* trees, web composed of an extensive sheet in form of a net with a central irregular ball like mass of silk threads with tunnels, Nagrota (Jammu), 15. VI. 76, 3♀♀, Pacca Danga (Jammu), 6. VI. 78.

## III. Family LINYPHIIDAE

*Labulla nepula* Tikader, 3♀♀, web among needles of pine trees, Gulmarg (Srinagar), 24. VI. 77 and 2♀♀, Srinagar, 10. VI. 78.

*Lepthyphantes lingsoka* Tikader, 2♀♀, sheet web among leaves of shrubs, Pehlgam (Srinagar), 22. VI. 77 and 2♀♀, Gulmarg (Srinagar), 24. VI. 77.

## IV Family SELENOPIDAE

*Selenops* sp., 2♀♀, crevices of wall of an old house. Jammu, 18. VI. 77.

## V Family LYCOSIDAE

*Hippasa olevacea* (Thorell), 1♀, tube web among stones, Jammu, 18. VI. 77, 1♀, Nagrota (Jammu), 6. VI. 78.

*Pardosa oakleyi* Gravely, 5♀♀, leaf litter, Jammu, 16. VI. 76, 2♀♀, Nagrota (Jammu), 6. VI. 78.

## VI. Family SALTICIDAE

*Marpissa ludhianaensis* Sadana & Kaur, 6♀♀, citrus plants, Jammu, 18. VI. 77.

*Marpissa mandali* Tikader, 4♀♀ old house. Jammu, 18. VI. 77.

*Marpissa tigrina* Tikader, 7♀♀, grapevine plants, Jammu, 16. VI. 76.

*Myrmarachne lacta* Thorell, 3♀♀, brinjal plants, Jammu, 17. VI. 77.

*Phidippus* sp., 2♀♀, citrus plants, Jammu, 16. VI. 77

## VII. Family PLATORIDAE

*Plator indicus* Simon, 3♀♀, walls of an old house, Jammu, 17. VI. 77.

VIII. Family PHOLCIDAE

*Aratema atlanta* Walck., 6 ♀♀, web under an old bridge, Nagrota (Jammu), 16. VI. 77.

*Crossopriza lyoni* Blackwall, 10 ♀♀, an extensive web in an old house, Pacca Danga (Jammu), 6. VI. 78.

IX. Family TETRAGNATHIDAE

*Tetragnatha mandibulata* Walck., 2 ♀♀, rice plants, Jammu, 16. VI. 76.

X. Family THOMISIDAE

*Xysticus minutus* Tikader 2♀♀ flower heads of an unidentified wild plant, Jammu, 18. VI. 77.

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**USE OF ECOLOGICAL BIOENERGETICS TO STUDY THE  
PRODUCTIVITY OF HIGH ALTITUDE ECOSYSTEM—AN  
INTERPRETIVE ARTICLE**

*By*

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The sun releases energy through the thermonuclear reactions involving nuclear transmutation of hydrogen to helium, upon which life on earth depends. Solar energy is in the form of electromagnetic waves capable of bringing about a rhythmic exchange between potential and kinetic energy. Heat energy results from the random movement of molecules possessing kinetic energy. The evolution of heat is caused when all other forms of energy are transformed and the work is done. The physiological activities of all living organisms represent such energy transformations involving heat production (exergonic processes). On the contrary, the endergonic processes occurring in an ecological unit require an outside source of energy for their operation. Because the quantum of heat energy evolved by any exergonic process is not completely utilized by the endergonic process, a part of it still remains as heat when the work is done. This, obviously, means that increase or decrease in the internal energy of a system ( $\Delta E$ ) equals the heat ( $Q$ ) evolved or absorbed and the work ( $W$ ) done according to the first law of thermodynamics.

$$\Delta E = Q + W \dots \dots \dots (i)$$

This law also includes principles of Constant Heat Sums which means that the total energy transformation as heat is the same no matter what pathway the reaction has followed. Secondly, the energy transformations will never occur unless there is a degradation of non-random forms of energy (energy other than heat) to a random form (Heat).

These principles of thermodynamics hold good in the energy transformation in nature also. Solar energy enters the earth's atmosphere at the rate of  $15.3 \times 10^8$  Cal/m<sup>2</sup>/year. Much of this energy is lost in evaporation of water from the land, or is scattered by atmospheric particles (Fig. 1). The actual availability of energy to photosynthetic plants varies with the location of the ecosystems (Fig 1). While some study has been carried out on the average amount of radiant energy available (Phillipson, 1974) in Michigan, U. S. A. ( $4.7 \times 10^8$  Cal/m<sup>2</sup>/year) ; Georgia, U. S. A. ( $6.0 \times 10^8$  Cal/m<sup>2</sup>/year) and Britain ( $2.5 \times 10^8$

Cal/m<sup>2</sup>/year); no such information is available on the high altitude ecosystems of our country. The photosynthetic plants (autotrophs) lose approximately 95-99% of available energy as heat and use only 1-5% to transform it into chemical energy which is termed as primary production.

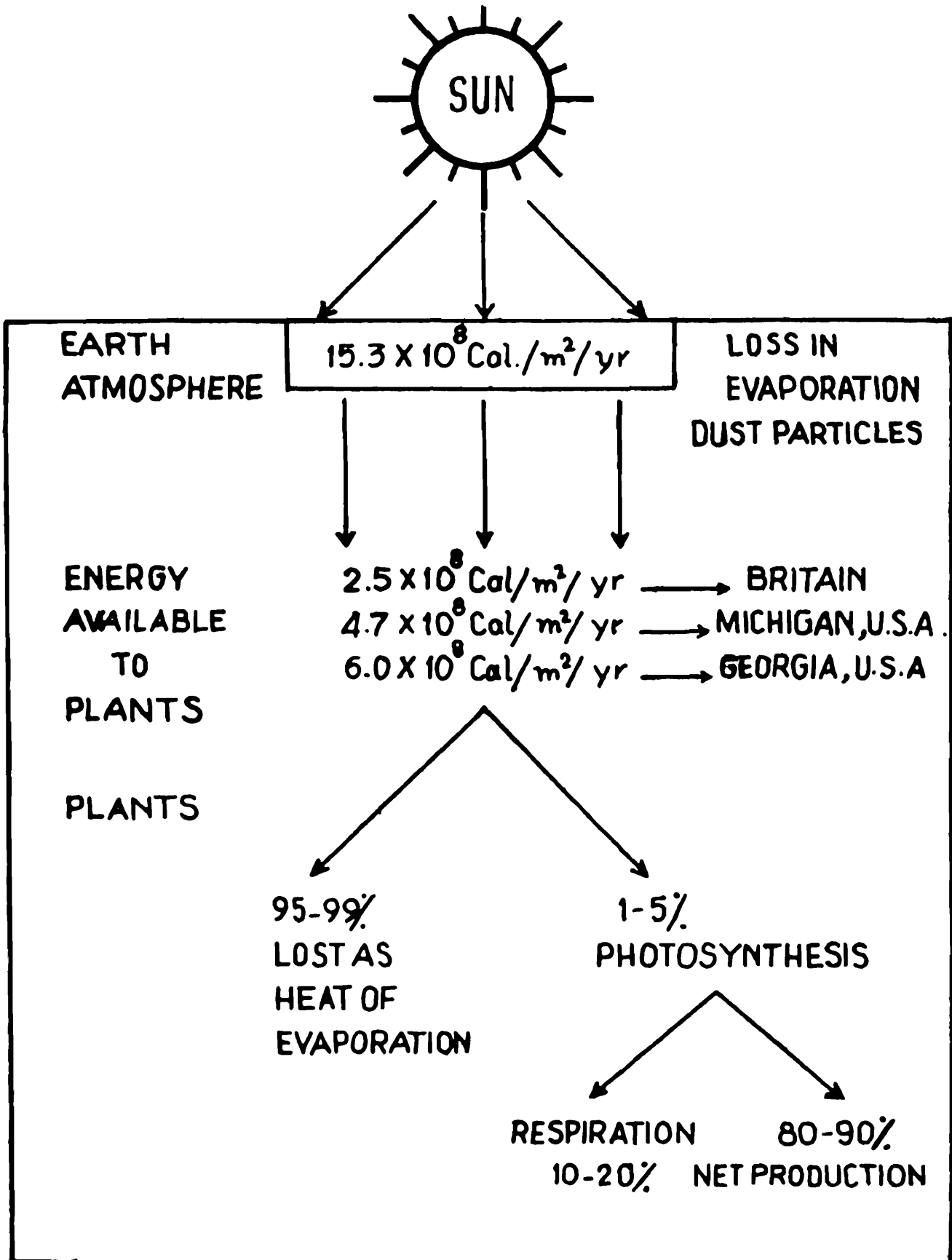


Fig. 1. Fate of solar energy in a grassland ecosystem (Data from Golley, 1960; Phillipson, 1974).

The gross primary production is the total energy stored by the autotrophs per unit time per unit area. In the process of synthesis of organic matter autotrophs utilize energy released in the oxidation of food. The food energy stored by the autotrophs which is potentially available to heterotrophs is called net primary production and can be quantified by subtracting energy loss through respiration from Gross primary production. Golley (1960) studied the net productivity of a grass-herb ecosystem of U. S. A. and reported that it varies between 80-90% of the gross productivity.

In nature life of heterotrophs depends on the net productivity of the autotrophs and in fact there exists an equilibrium between the net production and the food assimilated by the heterotrophs. The energy ingested by the heterotrophs is not completely utilized and its fate can be traced, according to the laws of thermodynamics, in the following equations used by Klekowski *et al.* (1967); Petruszewicz and Macfadyen. (1970); Singh *et al.* (1976).

$$C = P + R + FU \dots \dots \dots (ii)$$

$$A = C - FU \dots \dots \dots (iii)$$

$$R = A - P \dots \dots \dots (iv)$$

Where C = the energy content of ingested food.

P = the energy content of the biomass growth (production in heterotrophs).

R = the energy used in respiration.

FU = the energy loss through egestion.

A = total energy assimilated.

In an ecosystem the energy used in production of heterotrophs is transferred to other heterotrophs of the food chain and in each transfer heat is evolved. While a number of studies on bioenergetics of the food chains of different ecosystems have been carried out elsewhere (Lindeman, 1942; Weigert, 1965, Smalley, 1960; Gyllenberg, 1969; Van Hook Jr., 1971; Bailey and Riegert, 1973; Singh *et al.*, 1976; Campbell *et al.*, 1976 and Bailey and Singh, 1977), no study has been or is being, conducted in India on the trophic dynamic aspects of any high-altitude ecosystem either to quantify the productivity of autotrophs or heterotrophs. It has been earlier established (Odum and Smalley, 1959) that energetics is a better indicator of a trophic-level's significance in an ecosystem than either its population density or biomass. On the basis of these facts it is recommended that researches on the following aspects of the high-altitude ecosystem may be undertaken.

(i) *Primary productivity of the autotrophs*: The habitats of North Western Himalaya have been classified (Mani, 1962) into tow

major life zones. The zone immediately above the timber line is termed Alpine zone or the Montane Tundra. On the contrary the conifer zones below the timber line are called Taiga. Babler (1910) preferred to use the term Nival Zone for the entire biotic province above the timber line. The life zones below Taiga are inhabited by the sclerophyll oak-rhododendron forests and broad-leaved monsoon forests.

To study the autotroph-productivity both above and below Taiga zone of Himalaya, the techniques used by Crow (1978) in Wisconsin, U. S. A. may be followed. His methods involve the use of destructive sampling procedures followed by the measurement of plant dimensions and plant biomass. A correlation factor may be worked out between the plant dimension (Crown diameter crown length, diameter-breast length etc.) and plant mass for various plant species (trees and shrubs). As such the standing crop biomass and annual biomass increments may be estimated after determining the population levels and measuring the dimensions of the standing trees and shrubs in the study area. The data on biomass increment can be transformed into calorific values using the calorific contents of the sampled plant materials. The calorific contents can be determined in an oxygen microbomb calorimeter (Phillipson, 1964). Annual net production may, thus be presented as :

$$\text{Net production} = \Delta B - (L + H) \dots \dots \dots (v)$$

Where  $\Delta B$  = the annual calorific increments in biomass,

L = calorific values of buds, inflorescence, seeds, leaf-shedding, and

H = plant losses (Cal) due to herbivore consumption.

The productivity of ground vegetation may be similarly studied by clipping ground vegetation periodically and determining the maximum biomass (Cal.) accumulation per year.

(ii) *Food chain and heterotroph productivity* : A series of pioneering entomological studies have been carried out and published on the insects of Nival zones of Himalaya by Drs. M. S. Mani and Santokh Singh (Mani, 1962) of St. John's College Agra. These authors reported the occurrence of a variety of insects in the Nival zone and only 30% of the total insect were phytophagous; rest of them being either predators or carion feeders (Carabidae, Staphylinidae, Diptera). Phytophagy was common on the Alpine meadows with insects such as grasshoppers, caterpillars of butterflies, Heteroptera, and a few Coleoptera. Some Collerabola, Diptera and the caterpillars of Lepidoptera thrive on Algae, Lichens and moss on the rocks.

Keeping in view the geographical and ecological limitations, studies on bioenergetics of various stratified life zones in the high-altitude ecosystem (both above and below timber lines) may be initially undertaken with reference to insect orders such as Orthoptera, Coleoptera, Dermaptera, Heteroptera, Neuroptera, Trichoptera, Lepidoptera, Diptera, Thysanura, Collembola, Hymenoptera etc. which are linked with a variety of food chains and occur at almost all heights (Mani, 1962).

The food chains and feeding relationships of animals and plants of life zones above and below timber lines may be a very complex one and the generalized expression: Plant  $\rightarrow$  Herbivore  $\rightarrow$  Carnivore<sub>1</sub>  $\rightarrow$  Carnivore<sub>2</sub>  $\rightarrow$  Carnivore<sub>3</sub>  $\rightarrow$  Carnivore<sub>n</sub> may be applicable. But this expression does not account for the loss of primary productivity as fuel by the human inhabitants in and around the ecosystem, its loss in soil erosion and log-harvesting. These factors should be quantified before tracing the Trophic-dynamic aspects (Lindeman, 1942) of the high-altitude ecosystem as detailed in Fig. 2.

In the High-altitude ecosystem the cumulative (calorific) production and absolute daily growth in various heterotrophs may be determined by gravimetry and calorimetry using the following equations (Klekowski *et al.*, 1967; Petruszewicz and Macfayden, 1970; Singh *et al.*, 1976; Bailey and Singh, 1977).

$$Pt = (Bb)t - (Bb)O + \sum_{K=O}^t (Bex) K \dots \dots \dots (vi)$$

$$V = \frac{W_2 - W_1}{t_2 - t_1} \dots \dots \dots (vii)$$

Where Pt = Cumulative Production (Cal)

(Bb)t = Instantaneous Biomass (Cal)

(Bb)O = Initial Biomass (Cal)

$\sum_{K=O}^t (Bex) K =$  Cumulative Exuvia production (Cal)

V = Absolute daily growth

W<sub>1</sub> and W<sub>2</sub> = Mean biomasses (Cal) of the individuals at time t<sub>1</sub> and t<sub>2</sub> respectively.

To trace the fate of energy ( $\lambda$ , Fig. 2) obtained by a trophic level from producers is a tedious and time-consuming job which involves the use of respirometry and other suitable techniques (Brody, 1964) required in the quantification of energy flow through different pathways. While such studies must be undertaken to know the community

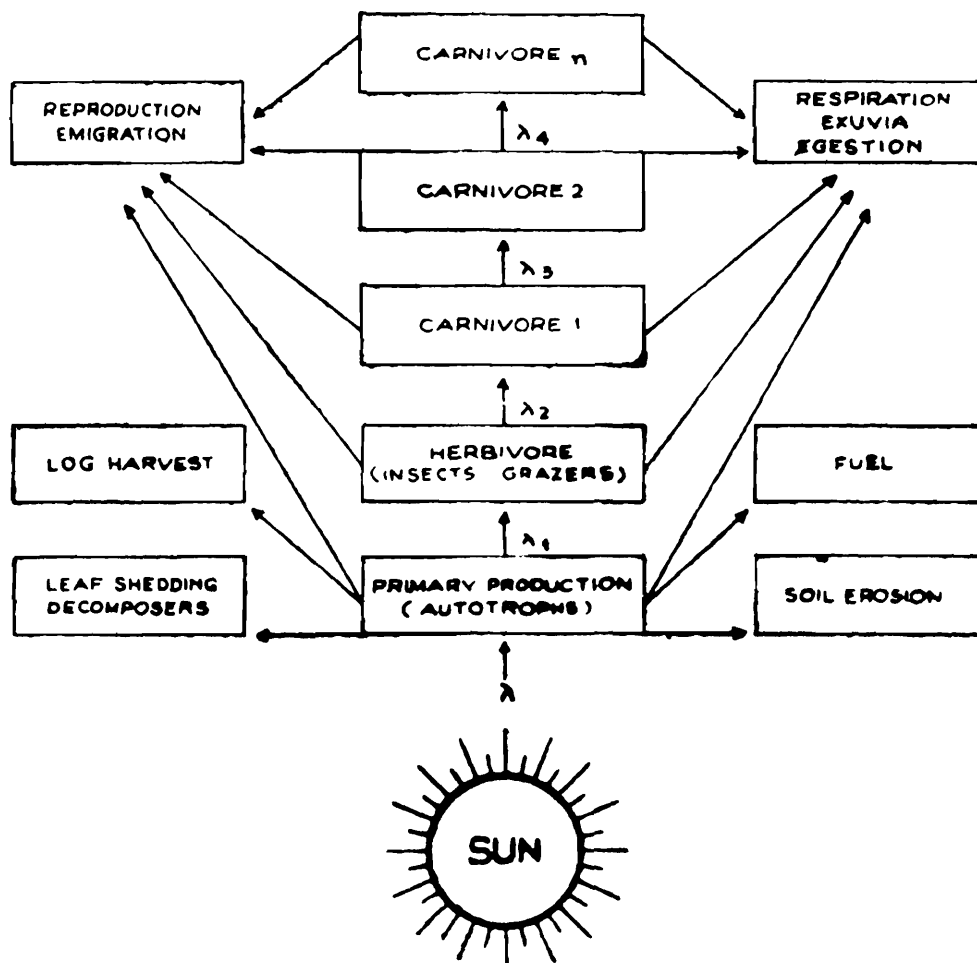


Fig. 2. A schematic presentation of the concept of community dynamics.  $\lambda$  (Lambda) indicates the contribution of energy per unit time.

interaction of various stratified life zones of the high-altitude ecosystems of our country: it is easier to explore the share and fate of energy procured by the phytophagous insects from the commercially important crops, trees, shrubs and herbs of Alpine, Taiga, and below taiga zones of Himalaya. If the population levels of all, or some, phytophagous insects and their feeding habits are known, their bioenergetics can be worked out under simulated laboratory conditions as presented in Fig. 3 in case of bertha army worm, *Mamestra configurata* (Walker) which is a serious pest of rape crop in Canada. *M. configurata* larvae consume 2124.3 cal of rape plant (35-days old plant is equivalent to 5169.3 cal). Of this ingestion, approximately 1266.4 cal is egested as feces, 661.0 cal are used in respiration of all stages, 486.0 cal are used in production in the larval stages, 49.7 cal are shed as exuvia and 67.0 cal are converted into eggs by the adult in 12 days (Bailey and Singh, 1977).

From the data on the bioenergetics, various ecological efficiencies (Odum 1959; Kozlovsky, 1968; Randolph *et al.*, 1976; Bailey and Singh, 1977) of the different trophic levels may be determined to understand any serious economic stress caused by them on the total community behaviour, using the following equations :

1. Assimilation Efficiency =  $A/C \times 100$ .....(viii)
2. Ecological Growth Efficiency =  $P/C \times 100$ .....(ix)
3. Tissue Growth Efficiency =  $P/A \times 100$ .....(x)
4. Utilization Efficiency =  $R/A \times 100$ .....(xi)
5. Respiration Efficiency =  $R/C \times 100$ .....(xii)

Where : C = the energy content of ingested food.

P = the energy content of the biomass growth (production).

A = total energy assimilated.

R = the energy used in respiration.

The information collected on all the trophic dynamic aspects of different life zones along with data on ecological parameters of the various high-altitude ecosystems may be analysed using a computer to construct energy flow models and plan a better management strategy for the geographically vital part of our country—the Himalaya.

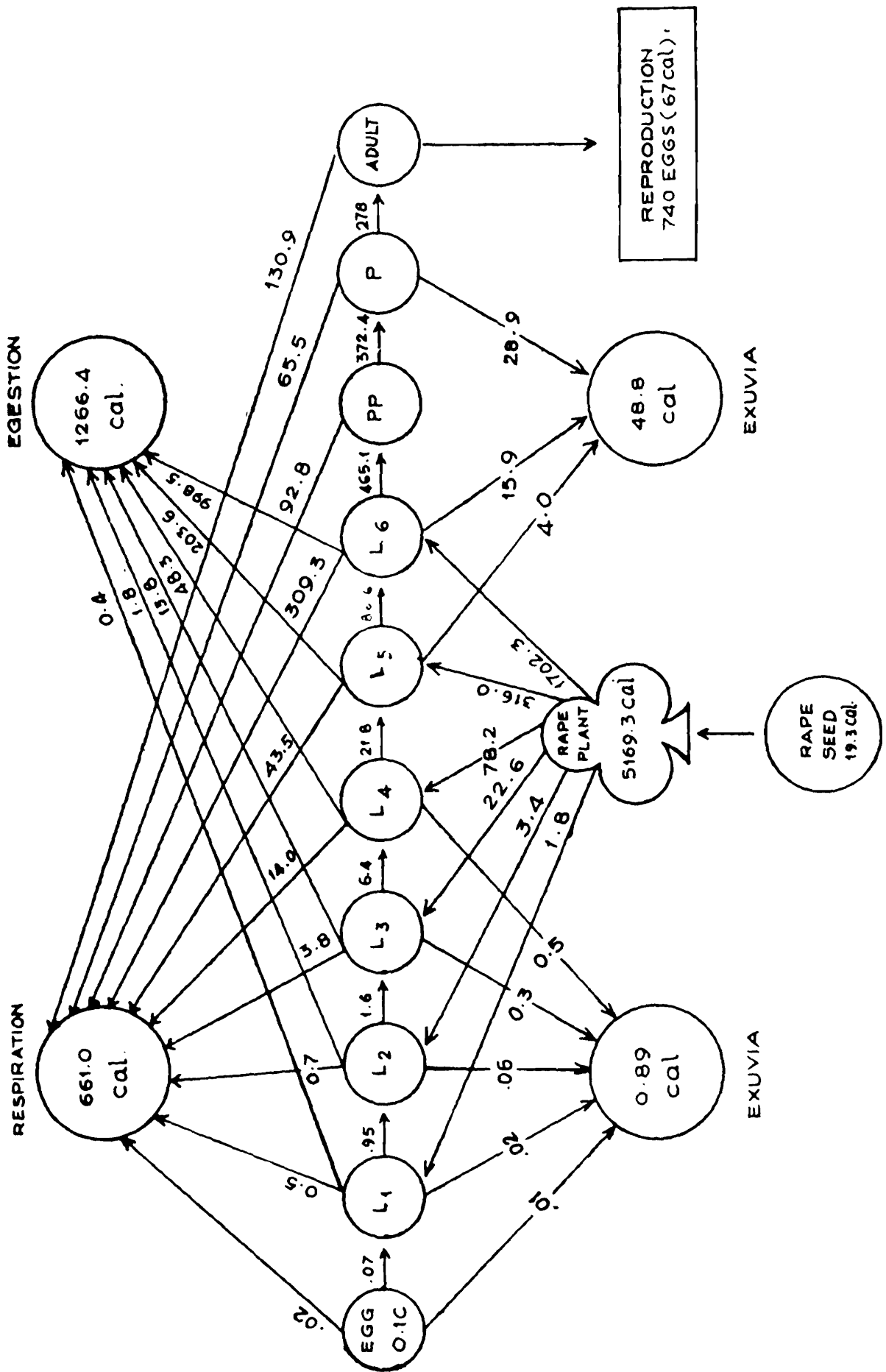


Fig. 3. The energy flow from food sources (35-day-old rape plant) through the different developmental stages and adult of *M. configurata*. L1-L<sub>6</sub>, Larval instars 1-6; PP, prepupa; P, Pupa. (Data source Bailey and Singh, 1977).

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## HIGH ALTITUDE ENTOMOLOGY IN INDIA AND ITS SCOPE

By

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### INTRODUCTION

The earliest collections of high altitude insects of the Himalaya were probably made by von Hugel in the first half of the last century. His collections, comprising several hundred species, were identified by various eminent European specialists like Kollar and Redtenbacher around 1848. The credit for next important attempt at collecting high altitude insects must undoubtedly go to the untiring labours of the renowned naturalist and geologist Col. Stoliczka, who was a member of the Yarkand Mission in 1872, and who gave his life in the North-west Himalaya. To him should really go the chief credit for discovering a veritable mine of insect life in the extremely inaccessible and inhospitable areas. Since then many professionals as well amateurs have made collections in different parts of the mountain chain, the important of them being Guy Babault Yale University North India Expedition, Italian Karakoram and German Naga Parbat Expeditions and the successive Everest Expeditions. Practically all these collections provided adequate raw material for describing and listing new taxa, a very significant step in its own right. But none of these studies paid any attention to the numerous complex and inter-acting ecological factors that govern the distribution and existence of such a fantastic variety of insect life at extreme elevation. Also no serious effort was made to uncover the biographical affinities and evolutionary tendencies of the high altitude insect fauna.

The credit for coining the term "high altitude entomology" must go to Mani (1954), who has rightly been called the "Dean of High Altitude Entomologists" by the late Prof. Gordon Alexander, of Colorado University. He and his associates organised many entomological expeditions during the last twentyfive years or so and published a series of papers on the faunistics, systematics, field ecology and geography of the high altitude insects. Significance of Mani's (1962, 1968, 1974, 1978) monumental contribution in this field can never be over emphasized or ignored.

Though a massive volume of literature and knowledge of the subject has been accumulated by Mani, he would be the first to admit that these contributions touch upon only the fringes of the problem

which requires intensive efforts over many more years to come. There are numerous fundamental problems dealing with the eco-physiology, zoogeography, mechanism of speciation, origin and evolution of high altitude fauna, etc. which still await the attention of scientific world. In recent years a tendency, based on fallacious assumptions, has started leading to erroneous comparisons between the high altitude ecology and the arctic ecology. Such thinking, completely divorced from the reality of high altitude ecology, is likely to lead to some unsound deductions and illogical conclusions. The importance of rarefaction of the atmosphere seems to have been completely ignored in these comparisons. It would be nearer the truth to compare high altitude ecology with the "outer space" ecology rather than with the arctics. In tune with the massive dimensions of Himalaya, the problem of high altitude insects is truly Himalayan.

### WHAT IS HIGH ALTITUDE ?

A great deal of confusion exists about what actually constitutes "high altitude" For review of divergent views one may refer to recent publications by Mani (1973, 78). In accordance with the concept, by high altitude it is meant in biology the elevated regions on high mountains, above the tree line or the timberline. It may be defined as region of open vegetation above the upper limits of closed forest, where the general environment, the flora and the fauna are markedly different from those of the forests or steppes. It is highly specialized zone, which is characterized by the absence of trees. As compared to the closed forests the high altitude zone is characterized by stunted shrubs, low growing herbs, grassy meadows, cushion like growth of not only Bryophytes but even Angiosperms like *Thylacospermum rupifragrum* (Caryophyllaceae). The mere absence of trees or forests which may be absent even at very low latitudes and may disappear even very near sea level in north latitudes, as a criterion for determining the lower limits of high altitude zone can be misleading if emphasis is not laid on the altitude. Thus it is only above a timberline altitude of about 3000 m above m. s. l. that significant differences in the environment appear Aynomin & Gupta (1955), Larsen (1975), Schweinfurth (1957) and Troll (1967) have given detailed accounts of timberline in general and on mountains in particular. The timberline is by no means a sharply defined line but represents an oscillating zone altitude, in which summer mean atmospheric temperature generally fluctuates about 10-12°C Directly related to the high altitude is the progressive intensity of cold and aridity that characterise the higher altitudes.

In defining the high altitude zone biologists often fall into the error of overemphasizing the role of only the atmospheric temperature, by completely ignoring other ecological factors. This approach

inevitably leads them to erroneous comparisons between the high altitude ecology and the high latitude ecology. They appear to be greatly impressed by the apparent parallelism between the fall in temperature at high altitudes and high latitudes. These workers have apparently overlooked the fundamental difference in the causative factors which underlie the atmospheric cold in the two cases. Mani (1973) has drawn pointed attention to the fact that the arctic zones of the north latitudes are basically *lowland* areas of low temperatures and dense atmosphere, but the high altitude is a region of low temperatures of gradually thinner atmosphere. For these reasons, and because of the great significance of snow-cover at high altitudes for organisms, Mani (1954-1978), Janetschek (1956), Mani & Singh (1961-63) and Singh (1957-1967) have recognised the elevated regions above the timberline on the Himalaya as the *nival* zones, with particular reference to insects.

Though the scope of this paper precludes a detailed discussion of the ecology of the high altitude zone, it will not be out of place to make a passing reference to some of the dominant ecological factors which operate in these regions.

These factors include the atmospheric cold, aridity, intense insolation and radiation and the snow cover, which actually represent the chain effects of progressive attenuation of air with rise in altitude. The thin air and low atmospheric humidity present in the high altitude atmosphere accentuate the rapid desiccation of bodies exposed to the air and bright sunshine. A paradoxical factor worth recording is the extremely high temperature, sometimes as high as 40°C and above, experienced during the periods of bright sunshine. This is because the rarefaction of air at high altitudes apart from bringing about the fall in temperature, deficiency of oxygen etc., also at the same time increases the intensity of insolation and radiation. This explains the peculiarity that at high altitudes when the temperature in the shade may be as low as 0°C the temperature in the sun may be as high as 50°C. It is thus literally possible for a man to freeze on one side (shady side) and become roasted on the other side (exposed to the sun).

#### SOME AVENUES FOR EXPLORATION

The fields of investigations suggested hereunder are based on author's 25 years of association with the high altitude entomology of the Northwest Himalaya. The faunistic data primarily from the Northwest Himalaya, referred here, merely aims at presenting the general average most likely to be observed in the biome of the treeless nival zone above an elevation of 3000 metres above mean sea level. This average should serve as a fairly accurate index of the faunistic conditions prevailing in the rest of the Himalaya. Before the High Altitude Entomology is able to hold its position as an important field

of scientific exploration, amongst a mosaic of scientific disciplines, it is imperative that serious efforts are made to gather more fundamental informations about various aspects of the problem. To achieve the desired results it is absolutely necessary to initiate researches along some of the important avenues proposed here.

**1. Extensive and Intensive Surveys, and preparation of Distributional Maps :** Nature has been extremely kind to India that it has presented to the country the highest, youngest and the most youthful mountain system in the world. Though, as pointed out in the introductory remarks, naturalists have been making insect collections since the first half of the last century, yet these attempts have fallen far short of what should have been accomplished by this time. This observation is firmly supported by the fact that we know the occurrence of not more than about 500 insect species only from the nival zone of the North-west Himalaya (Mani & Singh 1961-63). Recent experiences have shown that this figure represents hardly one tenth of the insect wealth that still awaits discovery. The situation in the rest of the Himalaya also cannot be any different.

The Indian taxonomists have not yet grasped the opportunities that the Himalaya, as a most fruitful region, has offered. A careful perusal of the available literature will reveal in no uncertain terms that we know practically nothing about the fauna of a large number of insect orders. For instance, to name a few, our knowledge of high altitude Thysanura; Collembola; Ephemera; Plecoptera; Thysanoptera; Corrodentia; Trichoptera; Diptera particularly Blepharoceratidae, Chironomidae, Deuterophlebiidae, and many Brachycera families; many families of Coleoptera; many families of Hymenoptera, etc., is confined to only stray publications. It is, therefore, absolutely necessary that top priority be given to extensive and intensive survey, according to a well coordinated and time bound programme, which should place in the hands of specialists a major portion of the insect wealth of the higher altitudes. On the basis of the study of this immense material it should be possible to prepare distributional maps of the insect fauna. Such maps, along with the vegetation maps, have been prepared in countries like U.S.S.R., Austria and Scandinavia. These maps would also serve to pin-point the "ecological indicators" of different parts of the mountain. The ecological indicators should prove useful in planning and minimising the adverse effects of massive invasion of technology that is bound to come in the name of economic development.

It may not be out of place to remark here that if our naturalists had fanned out, after the independence, into the wilderness of the remote Himalayan regions, we would not have learnt about the ignominy of the Aksai Chin only after it was perpetuated. Naturalists

may not have been in a position to prevent it but would certainly have forewarned the authorities.

**2. Fauna of High Altitude Lakes, Springs and Torrential Streams :** The position of our knowledge of high altitude aquatic insect fauna is even more deplorable than the terrestrial insects. Himalaya which is the source of all the north Indian rivers is the most ideal region for the study of aquatic insect life. Without the risk of being accused of exaggeration one can say that not even one river has so far been entomologically explored. In recent years some attempts have been made to study the Ephemera, Plecoptera & Chironomidae (Diptera) of the R. Beas in its upper reaches only (Khan & Sahni, 1978) and (Kulshrestha, 1978). These studies are however of exploratory nature, as is inevitable in any pioneering attempt. Since the river system is antecedent to the Himalaya, the study of the rivers and torrential streams fauna is bound to yield some far reaching evidences for the evolution of the high altitude insect life.

Besides the rivers and torrential streams the high altitude lakes like Pangong Tso, Tso Morari, Tso Kar, Spangur Tso, Chandar Tal, Suraj Tal, Sarkund, Rupkund, etc. should also yield entomological results of considerable significance.

**3. Insects and Plant Association :** The vegetation of the open nival zones as already mentioned is devoid of trees, and consists of stunted shrubs, grasses, Bryophytes, etc. The mosses and lichens being the pioneers of the high altitude colonisation, their association with insect fauna and the study of interaction between the latter and other vegetation should prove most useful in uncovering the intricacies of the altitudinal stratification of insect communities.

**4. Glaciers and their Entomological Importance :** Glaciologists believe that some of the present day glaciers in the Himalaya are the remnants of the Pleistocene Glaciations. Even if they do not represent the remnants of the last Ice Age, their antiquity can never be doubted. In their successive strata lie buried and refrigerated remains of countless forms of insect life, either deposited there passively by the upper air currents or by active migrations. The existence of such depositions have been established in the Grasshopper Glacier of Montana, U.S.A. (Gurney, 1952), wherein remains of grasshopper species occurring a long distance away have been reported. A systematic exploration of these glaciers for insect and other organic remains would open up a most fascinating field of study in relation to not only the seasonal succession of species but also the distribution of insects in both time and space. These explorations may not be an easy task to perform, nevertheless the difficulties likely to be encountered are not unsurmountable. Drilling of glaciers at randomly selected spots should yield

adequate material for analysing the deposits of the insect remains. There are numerous gigantic glaciers in the Himalaya awaiting some enthusiastic entomologists with drive and dedication. Some of the important glaciers in the Northwest Himalaya are listed below.

No.	Name of the glacier	Length in kilometres	River into which drains
1.	Tuan	16.0	Chenab
2.	Brama	16.0	Chenab
3.	Sissu	11.2	Chandra
4.	Sonapani	11.2	Chandra
5.	Milang	13.0	Bhaga
6.	Rupal North	16.0	Indus
7.	Rupal South	17.7	Indus
8.	Phugatori	12.9	Indus
9.	Diamir	11.0	Indus
10.	Biafro	62.0	Braldo
11.	Baltoro	58.0	Braldo
12.	Gasherbrum	34.0	Shyok
13.	Remo	24.0	Shyok
14.	Five glaciers in Zaskar between 12 and 17 kilometres		

**5 "Nunataks" or "Massifs de Refuge".** In European countries where extensive studies have been carried out on the survival of the Pre-Pleistocene elements by workers like Holdhaus (1912, 1933), Lindroth (1948, 1953), Franz (1950), Janetschek (1956), Kurienzov (1959) in relation to insects, and by Chandeler (1935) in relation to plants, the importance of "nunataks" (glacier free islands within the glaciated region: from Eskimo Language) or "Massifs de refuge" has been emphasized. Mani & Singh (1961-63) and Mani (1962, 1968 and 1978) have also referred to such ice-free islands in the midst of ice and snow which represented ecologically optimal islands or survival centres for flora and fauna, at present and during the pleistocene. The pronounced massing of the nival species, especially the endemite, around high peaks and ridges, above present permanent snow-line and in areas such as for example, the Pangong Valley (N. W. Himalaya), which were formerly heavily glaciated, and the concentrations in the neighbourhood of the present day glaciers are indications that these were the centres of the origin and evolution, and pleistocene survival of the nival insect fauna.

This is one field, where in collaboration with botanists, geologists and glaciologists, great deal can be learnt about the existence of numerous Pleistocene relict species both in the animal and plant kingdoms in the Himalaya.

**6. Physiology of the Hypsobiont Insects :** The physiology of the typical and exclusively high altitude species or hypsobiont forms presents a most promising and almost a virgin field for investigations. The physiology of various metabolic activities with reference to their low temperature environment, deficiency of oxygen and the capacity to withstand arid conditions etc. can be profitably studied. Though considerable amount of work is in progress on the adaptability of man to higher altitude practically no attempts have been made in regard to insects and other poikilotherm organisms.

**7. Ecophysiology of Mass Assemblage of Insects :** Van Dyke (1919), Dobzhansky (1925), Hawkes (1926), Mani and Singh (1955), Edward (1957) and Mani (1962) have recorded the phenomenon of mass assemblage of insects, particularly Coccinellidae, on the high mountain slopes, ridges and snow-fields. They have made observations on the likely factors influencing this tendency. But our knowledge is far from complete about the physiological conditions that induce this migration from the lowlands to the higher altitudes. Similarly we have yet to learn a great deal about the effects of high altitude ecological factors on these mass assemblages.

**8. Migration and its International Aspects, Derilicts of Aeolian Zone and their Importance :** The man-made political boundaries are not recognised by migrating animals, whether they are mammals, birds, fishes or insects. Elton (1925), Cave (1926), Felt (1926), Hardy and Milne (1938), Mani and Singh (1955), Mani (1962, 1968) and Swan (1961, 1963) have discussed various aspects of the active migrations over high mountains by many Butterflies, Moths, Aphids, etc. or passive drift over long distances and high mountain ranges by the agency of upper-air currents. Collines & Baker (1934) explored the upper-air currents as a physical basis for wind-borne gypsy moth larvae. In Himalaya a great variety of organic material like spores, pollen, seeds, insects like aphids, moths, butterflies, hover-flies, etc. are deposited on the aeolian zone from the lower valleys or from the distant plains. These derilicts generally do not survive in the higher altitudes where they are deposited by the courtesy of upper-air currents, and as Mani & Singh (1955) and Swan (1963) have reported they serve as refrigerated food for the nival insect species. Chapman, Romer & Stark (1955) have reported that ladybird beetles and army cutworm adults serve as food for grizzly bears in Montana.

Some of these active migrants cross the high Himalayan ranges from across the international borders in the north. The international aspects of such migrations merit thorough investigations.

**9. Cosmic Radiations and their Influence on High Altitude Insects :** In this age of space travel the studies on the effects of cosmic radiations

on the living organisms have assumed paramount importance. A great deal of work is being carried out in different parts of the world in the field of radiation biology, but generally within the confines of a laboratory. It is high time that the radiation biologists widen the horizon of their chosen field of specialisation so as to include the high altitude insects in their stride. The high altitude insects offer wonderful opportunities as raw material, for the studies of the effects of cosmic radiations.

**10. Genetics of High Altitude Insects :** Botanists studying the high altitude plants in India have paid some attention to the study of genetics of some plants like *Artemisia* spp. and discovered very interesting results. Genetics of high altitude insects has, however, not yet been able to attract any worker. I know of only one person Dr J. Wahrman, of the Hebrew University, Jerusalem, Israel, who exhibited a keen interest to study the genetics of *Blaps ladakensis* (Tenebrionidae : Coleoptera) from the Ladakh region of the Northwest Himalaya. He even undertook a visit to Ladakh, about two years ago, to collect the specimens for his study. His efforts at collecting the specimens, however, failed and he returned disappointed. If a scientist can come all the way from Israel to collect material for his study, there is no reason why some of the Indian geneticists cannot do the same. The study of genetics of high altitude insects is bound to prove most rewarding.

**11. Isolating Mechanism, Speciation and Centres of Speciations :** Various isolating mechanisms that operate in the high altitudes of the Himalaya include the ecological, geographical and topographical besides altitudinal isolation. Mani & Singh (1961-63) and Mani (1962, 68) have discussed in detail the influence of these mechanisms on the speciation of high altitude insect fauna. The combined effect of all these isolating mechanisms has accelerated the rate of speciation which is evidenced by the high endemism and the occurrence of large numbers of local subspecies. This high degree of endemism provides an evidence of the high phylogenetic plasticity and the intense speciation in the nival insect fauna of N. W. Himalaya. The role of glaciation as an isolating factor in speciation has been discussed in detail by Rand (1948). There are indications to suggest that major centres of speciations have been high massifs and peaks which became isolated from one another during Pleistocene Glaciations.

The studies on the population structures of insects around these peaks which remain covered with permanent snow, and in the vicinity of present day glaciers are bound to uncover the forces that are currently operating in speciation.

PLEA FOR A HIGH ALTITUDE ENTOMOLOGY LABORATORY  
IN THE NORTHWEST HIMALAYA, PARTICULARLY IN  
HIMACHAL PRADESH

During the last 25 years or so the students of High Altitude Entomology in India felt their ideas being stifled and their confidence eroded by the lack of properly equipped and suitably located High Altitude Entomological Laboratory. We owe our knowledge of the High Altitude Entomology of the Himalaya to the sheer grit and determination of a small band of dedicated pioneers led by Mani, who laboured under extremely harsh conditions of inadequacy of financial resources, the only resource being their personal purses which amounted to nothing more than a pittance. To undertake the study of any Himalayan problem, with meagre personal resources, is something like inviting frustration. But the enthusiasm and zeal of the workers was so infectious and sustained that frustration and the thought of a defeat were never allowed to dictate terms. Whatever research programmes were taken up, had to be executed during brief and repeated field trips. During these field trips if any single factor crippled the initiative, it was the absence of a field laboratory. The need for such a laboratory can neither be ever over emphasized nor an alternative be recommended. The establishment of such a laboratory is, therefore, strongly pleaded.

A detailed study of the various aspects of High Altitude Entomology, described in the preceding paragraphs, can only be accomplished by stationing properly trained research staff in the laboratory located somewhere above the timberline, who should be available to observe various complex and intricate insect activities throughout the year. The location of such a laboratory is most important. It should be located in the real "high altitude" zone, and not in the "lipstick-altitudes" of Simla, Mussoorie, Nainital or Darjeeling. While discussing this problem with friends I have often been confronted with the question "How to maintain the staff, considering their human requirements, under such inhospitable and harsh conditions of life?" My only answer to this question is a counter question "How do the Americans, Russians, Britishers and others maintain their research stations, under still harsher conditions of life, in the Antarctica?"

I have been fortunate in having opportunities of visiting practically all the major sectors of the Himalaya, like Assam, Bhutan, Sikkim, Nepal, Kumaon & Garhwal, Himachal Pradesh and Jammu & Kashmir including Ladakh region, during the last two decades or so. According to my experiences, the most ideal situation for the establishment of High Altitude Entomology Laboratory, should be somewhere in the Lahaul Valley of the Himachal Pradesh.

## WHY THE HIGH ALTITUDE ENTOMOLOGY LABORATORY IN HIMACHAL PRADESH

In connection with the research on High Altitude insects life in the Himalaya, there are numerous considerations which should clinch the issue of establishment of High Altitude Laboratory in favour of Himachal Pradesh. Some of the more important factors supporting the claim of H. P. are discussed in the succeeding paragraphs.

- (i) Northwest Himalaya, of which the Himachal Pradesh constitutes an important sector, is the biggest mass of elevated region in the world. Apart from its massiveness this sector possesses a larger number of more or less parallel ranges than the rest of the Himalaya. i.e. starting from south the ranges of the N.W Himalaya comprise the Siwaliks, Nagtiba Range, the Dhauladar, the Great Pir Panjal, the Great Himalaya, Zaskar the Ladakh Range and the trans-Himalayan Karakorm. Further, while the rest of Himalaya lies between 27° and 30' North Latitude, the N.W Himalaya stretches from 30° to nearly 36° North Latitude, and has thus a greater width.
- (ii) The Himachal Pradesh occupies a middle position in the longest portion of the Indian Himalaya. i.e. from the western border of Nepal to the Indus Valley and beyond in the Northwest. This situation will be an asset to the researchers who should be able to cover the western-most regions, as easily as the eastern parts, by using H.P. as their base.
- (iii) Thirdly for the investigations of the influences of the Pleistocene Glaciations on the high altitude insect life the Northwest Himalaya will be most ideal. As is well known this part experienced more extensive glaciations than the rest of the Himalaya (de Terra and Peterson, 1939, Wadia, 1940).
- (iv) The contiguity of the Northwest Himalaya with the Pamir knot to the north and the Hindukush to the west further adds to the suitability of this region for establishment of the research laboratory.
- (v) Himachal Pradesh is the only region in the Himalaya which is bisected into eastern and western parts by one of the three important antecedentary rivers, viz. R. Sutlej. Of the three important antecedentary rivers, i.e. Indus, Brahmaputra and Sutlej which after originating in the north of the

Himalaya flow into the southern plains of the Indian sub-continent, the Sutlej is the only one that cuts the Himalaya at almost right angles to emerge on its southern side. Rivers Indus and Brahmaputra have to flow for long distances in longitudinal valleys before finding gaps near the Gilgit syntax and north of Dibrugarh respectively to enter the Indian plains. The significance of Sutlej Valley as an important physiographical feature has long been recognised by the students of Himalayan geology and geography. Its importance as a major factor in the biogeography of the Himalaya has also been emphasized by the competent authorities. Himachal Pradesh, therefore, presents an ideal situation for investigating the impacts of this unique valley on the faunistics, biogeographical relationships and evolutionary tendencies of the High Altitude insect life.

It is earnestly hoped that if and when a decision is taken for the establishment of a high Altitude Laboratory, the arguments cited above will be given serious considerations.

#### CONCLUDING REMARKS

In conclusion it is gratifying to remark that "High Altitude Entomology", which has so far been treated as nobody's child, has come to be recognised as a fruitful field of study. To the organisers of this "Workshop", Zoological Survey of India and Himachal Pradesh Krishi Vishvavidyalya, I offer my congratulations and sincere thanks for drawing the attention of the Indian community of scientists to this hitherto neglected sphere of scientific exploration. It is hoped that this Workshop will generate a great deal of interest leading to a larger number of biologists becoming involved in High Altitude Entomological research.

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## ON THE HIGH ALTITUDE DERMAPTERA OF INDIA

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Those species which extend above 3000 m or timber line in Himalayas, constitute essentially high altitude forms, have been dealt with in the present paper. These comprise 20 species including a new species under 10 genera, five families and seven subfamilies. Besides *Anechura filchneri* Burr, is reported for the first time from India and *Anechura pirpanjalae* Kapoor is treated as synonym of *Anechura zubovskii* Semenov. Out of these three genera viz., *Diplatys* Serville; *Cranopygia* Burr and *Echinosoma* Serville, though mainly distributed in tropical and subtropical parts of the world are represented by one species each. The genera *Anechura* Scudder, *Guanchia* Burr and *Forficula* L., which are mainly Palaearctic, are represented by three, two and seven species, respectively, some of which have been able to reach upto an elevation of 4370 m. The preponderance of species belonging to these genera reveals the marked Palaearctic affinities of the high altitude fauna of Himalayas.

The present study is mainly based on the material from different parts of the Himalayas collected by the various survey parties of the Zoological Survey of India, Calcutta as well procured through other sources. It has been noted that the number of species at higher altitudes is sparse but generally rich in number of specimens. A large number of specimens (approx. 200 to 300 or more) for one or more species from same or different localities in the various collections examined, further corroborates, the well known phenomenon of congregation of individuals at high altitude. Besides other peculiarities noted are high altitude melanism in the majority of species and brachypterism in some only. Hitherto *Allodahlia martensi* Brindle; *Homotages tawangensis* Srivastava; *Guanchia bicarinata* Hincks; *Guanchia chirurga* Burr and *Forficula lucens* Brindle are known from brachypterous forms only. In *Forficula beebei* Burr and *Forficula schlagintweiti* (Burr), both fully winged and brachypterous forms are met with whereas as in remaining 12 species only fully winged forms have been so far reported excepting *Aborolabis pervicina* (Burr) which is apterous. On the basis of the material examined for various species it may be stated that incidence of brachypterism amongst high altitude Dermaptera is low.

Brief diagnostic characters and a key to all the known species is provided.

## LIST OF SPECIES

	Family	DIPLATYIDAE	Altitude range	in m
	Subfamily	DIPLATYINAE		
1.	<i>Diplatys stemmleri</i>	Brindle	— 1700	— 3100
	Family	PYGIDICRANIDAE		
	Subfamily	PYGIDICRANINAE		
2.	<i>Cranopygia constricta</i>	Hincks	— 1400	— 3100
	Subfamily	ECHINOSOMATINAE		
3.	<i>Echinosoma convolutum</i>	Hincks	— 100	— 3200
	Family	CARCINOPHORIDAE		
	Subfamily	CARCINOPHORINAE		
4.	<i>Aborolabis pervicina</i>	(Burr)	— 150	— 3400
	Family	LABIIDAE		
	Subfamily	SPONGIPHORINAE		
5.	<i>Homotages tawangensis</i>	Srivastava	—	3200
	Family	FORFICULIDAE		
	Subfamily	ANECHURINAE		
6.	<i>Allodahlia macropyga</i>	(Westwood)	— 1680	— 3100
7.	<i>Allodahlia martensi</i>	Brindle	— 2650	— 3400
8.	<i>Anechura stoliczkae</i>	Burr	— 1680	— 4200
9.	<i>Anechura zubovskii</i>	Semenov	— 1600	— 4000
10.	<i>Anechura filchneri</i>	(Burr)	— 2593	— 3777
11.	<i>Oreasiobia calciatii</i>	(Borelli)	— 1600	— 2900
	Subfamily	FORFICULINAE		
12.	<i>Guanchia bicarinata</i>	Hincks	— 2000	— 3657
13.	<i>Guanchia chirurga</i>	Burr	— 2706	— 4270
14.	<i>Forficula beelzebub</i>	(Burr)	— 1067	— 3400
15.	<i>Forficula planicollis</i>	(Kirby)	— 1500	— 3400
16.	<i>Forficula schlagintweiti</i>	(Burr)	— 1900	— 4370
17.	<i>Forficula bhutanensis</i>	Brindle	— 2600	— 3400
18.	<i>Forficula beebei</i>	Burr	— 443	— 3657
19.	<i>Forficula lucens</i>	Brindle	— 2150	— 3300
20.	<i>Forficula tawangensis</i>	sp. n.	— 3200	

**Key to the species (on males only)**

- 1(8). Male genitalia with paired distal lobes
- 2(7). Both distal lobes directed backwards at rest
- 3(6). Femora carinate, body devoid of thick setae
- 4(5). Size small (10.9—11.9 mm), slender, virga paired—*Diplatys stemmleri* Brindle
- 5(4). Size larger (26—28.5 mm), stout, virga single —*Cranopygia constricta* Hincks
- 6(3). Femora ecarinate, body covered with short and thick setae —*Echinosoma convolutum* Hincks
- 7(2). One distal lobe directed backwards and the other directed forwards at rest —*Aborolabis pervicina* (Burr)
- 8(1). Male genitalia with a median single distal lobe
- 9(10). 2nd tarsal segment simple —*Homotages tawangensis* Srivastava
- 10(9). 2nd tarsal segment lobed
- 11(22). Mesosternum broader than long
- 12(15). Elytra with a raised carina along the costal margin
- 13(14). Elytra and wings perfect; pygidium produced medially into a sharp point —*Allodahlia macropyga* (Westwood)
- 14(13). Elytra abbreviated with hind margin obliquely truncate, wings absent, pygidium longer than broad —*Allodahlia martensi* Brindle
- 15(12). Elytra devoid of any carina along the costal margin
- 16(17). Body provided with long, dense hairs especially on forceps —*Oreasiobia calciatii* (Borelli)
- 17(16). Body without long dense hairs
- 18(19). Elytra and wings with a yellow spot ; ultimate tergite with a raised oblique fold extending from middle to postero-lateral angles which project strongly; forceps undulate —*Anechura jubovskii* Semenov
- 19(18). Elytra and wings unicolourous ; ultimate tergite without any raised oblique fold extending from middle to postero-lateral angles, not projecting, above the bases of forceps often provided with sharp sub-vertical hooks; forceps horizontal
- 20(21). Pygidium transverse, depressed in middle, raised in posterior half, laterally triangular with a minute point, hind margin above subtruncate and below obtusely rounded, postero-lateral angles above with a minute point; forceps near base with a tooth below and another above —*Anechura filchneri* (Burr)
- 21(20). Pygidium about as long as broad, narrowed posteriorly, hind margin emarginate in middle ; forceps at extreme base with a triangular tooth —*Anechura stoliczkae* Burr
- 22(11). Mesosternum as long as broad
- 23(26). Elytra strongly abbreviated, hind margin obliquely truncate; wings wanting
- 24 (25). Body impunctate; pronotum transverse, sides of abdominal segments 6th to 8th obtuse ; ultimate tergite lacking inverted V-shaped carina—*Guanchia chirurga* Burr

- 25 (24). Body punctate; pronotum about as long as broad or weakly transverse; sides of abdominal segments 6th to 8th rounded; ultimate tergite with an inverted V-shaped carina—*Guanchia bicarinata* Hincks
- 26 (22). Elytra and wings generally perfect; rarely former shortened with hind margin straight or faintly oblique and latter wanting.
- 27 (30). Pygidium distinct, longer than broad
- 28 (29). Size larger (11.9-17.9mm); pronotum weakly transverse; abdomen strongly punctate, almost parallel sided; pygidium hidden by forceps, tongue shaped with hind margin convex; forceps deplanate internally in basal half or a little less—*Forficula beelzebub* (Burr)
- 29 (28). Size smaller (9.3-10 mm); pronotum strongly transverse; abdomen impunctate or sometimes faintly and sparsely punctate, strongly dilated in middle; pygidium subvertical, narrowed in middle, postero-lateral angles with minute tubercles and margin straight, with a faint tubercle in middle; forceps with branches gently dilated at base with a faint tubercle above, afterwards gradually tapering to pointed incurved apices—*Forficula beebei* Burr
- 30 (27). Pygidium small broader than long, generally obtuse or pointed posteriorly
- 31 (32). Legs with femora black and remaining parts testaceous brown; forceps deplanate internally in a little beyond basal half, afterwards strongly bowed—*Forficula tawangensis* sp. n.
- 32 (31). Legs unicolourous; forceps deplanate internally in basal half or less, often with a depressed lobe at base, afterwards strongly bowed or gradually curving enclosing an elliptical space
- 33 (34). Elytra shortened, wings concealed, forceps deplanate in basal half only—*Forficula lucens* Brindle
- 34 (33). Elytra and wings generally perfect, latter rarely concealed or wanting; forceps deplanate at extreme base to basal one fourth only
- 35 (36). Forceps at base with a rounded, depressed lobe internally with fine crenations—*Forficula schlagintweiti* (Burr)
- 36 (35). Forceps deplanate internally in basal one fourth only with inner margin crenate or dentate
- 37 (38). Pronotum strongly transverse, narrowed posteriorly; abdomen impunctate or sometimes with faint and sparse punctures; inner basal lamellation of forceps with fine and distantly placed crenations, branches in cross-section quadrangular—*Forficula bhutanensis* Brindle
- 38 (37). Pronotum weakly transverse, parallel sided; abdomen deeply and densely punctate; inner basal lamellation of forceps closely dentate internally; branches in cross-section rounded—*Forficula planicollis* (Kirby)

#### DIPLATYIDAE

##### *Diplatys stemmleri* Brindle

*Diplatys stemmleri* Brindle, 1975, *Ent. Basil.*, 1 : 10, figs. 4-6 (Male : Bhutan).

General colour blackish brown; pubescent.

*Male* : Head transverse, post-ocular ridge wanting. Elytra and wings normal. Penultimate sternite with hind margin emarginate in middle. Genitalia as seen in fig. 1C.

*Female* : Not known.

	Male
Length of body	10-11mm
Length of forceps	9 mm

*Distribution*— BHUTAN (between alt. 1700 to 3100 m).

*Remarks*— The members of the genus *Diplatys* are mainly distributed in tropical and subtropical parts of world but a few species has been able to just reach Palaearctic Region in N. E. Africa, Himalayas and China. Although the present record of species *D. stemmleri* Brindle (1975) from Dorju-la, 3100 m in Bhutan suggest its inclusion under high altitude forms, it is not primarily adapted to higher elevations. This is further confirmed from the relative abundance of specimens of allied species at lower altitudes only.

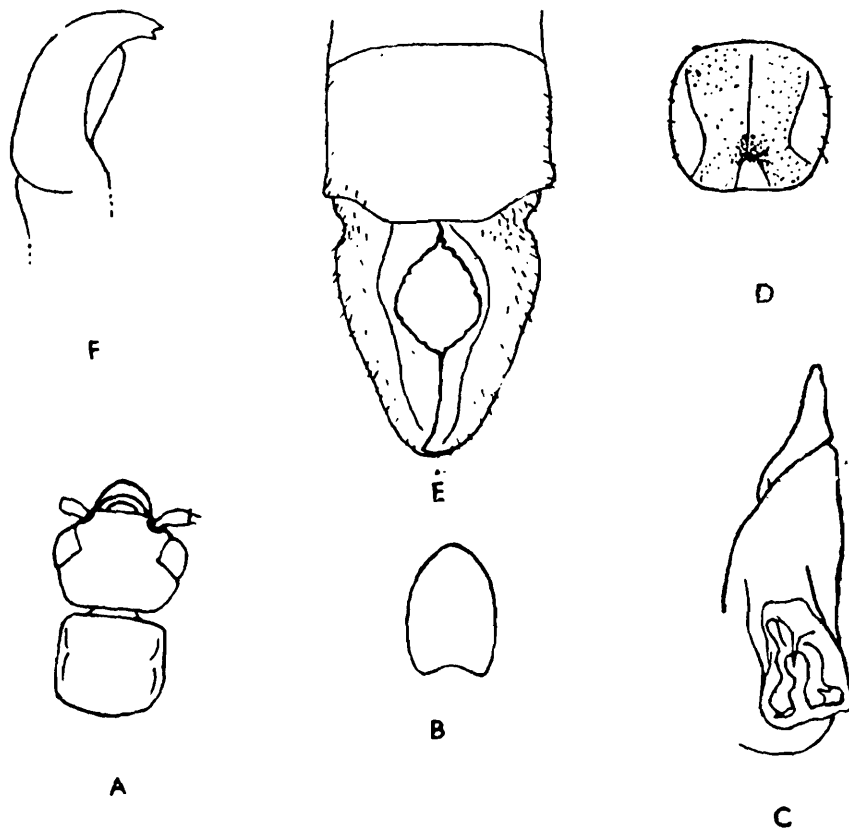


Fig. 1 A-C *Diplatys stemmleri* Brindle ♂ A. Head and Pronotum, B. Penultimate sternite C. A portion of genitalia (redrawn from Brindle, 1975); D-F, *Cranopygia constricta* Hincks ♂ D. Pronotum, E. Ultimate tergite and forceps and F. Paramere.

## PYGIDICRANIDAE

## PYGIDICRANINAE

**Cranopygia constricta** Hincks

*Cranopygia constricta* Hincks, 1955, *Ann. Mag. nat. Hist.*, (12) 8 : 822.

General colour dark blackish brown; basal part of antennae yellowish; pronotum yellow on sides; elytra with a narrow yellow spot extending from shoulder to middle and another smaller one medially; wings yellow, blackish along the external margin; legs black with tarsi yellow.

*Male* : Penultimate sternite transverse, posterior margin rounded with slight emargination in middle. Genitalia with parameres broader at base, apical portion narrowed, curved with apex bifurcated. virga simple, very long. Forceps with branches stout, depressed, internal margin below dentate, in basal half enclosing an elliptical space afterwards margin straight, tips pointed and hooked. In female penultimate sternite obtuse posteriorly and forceps simple and straight.

	Male	Female
Length of body	21-22.5 mm	3 mm
Length of forceps	5-6 mm	4.5 mm

*Material examined*—India : W B., Darjeeling dist., Chunabhati, 1 male 1 nymph, 27. xii. 73 (*G.K.S. and P.K.M.*); Jalpaiguri Dist., Jamduar, Sundari Nala, 1 male 2.xi.73 (*H.K. Bhowmik*).

*Distribution*—INDIA : SIKKIM and WEST BENGAL (Darjeeling Dist.) and BHUTAN.

*Remarks*—This species commonly occurs under bark of dead and decaying logs. It is more common at lower altitudes in Himalayas but Brindle (1975) has reported 1 male from Gonga, 3100 m in Bhutan. The members of the genus *Cranopygia* Burr, are well distributed in tropical and subtropical parts of the world.

## ECHINOSOMATINAE

**Echinosoma convolutum** Hincks

*Echinosoma convolutum* Hincks, 1959, *Syst. Mon. Derm*, 2 : 152,

General colour blackish brown, 1st and 2nd antennal segments, mouth parts and lateral margin of pronotum yellow, legs yellow with femora and tibiae banded with black, wings yellow with a blackish spot in middle, often diffused; forceps blackish to reddish brown. Body covered with thick setae and fine pubescence.

*Male* : Pronotum transverse. Tegmina and wings normal. Abdomen punctate, sides of segments 6th and 7th occasionally obtuse and ecarinate. Pygidium short, transverse, concave posteriorly. Forceps curved, apices pointed. Genitalia with virga long and convoluted. In female pygidium broad and truncate or acute posteriorly.

	Male	Female
Length of body	9.5-12.6 mm	8.4-14.5 mm
Length of forceps	1.5-2.2 mm	1.6-2.8 mm

*Material examined*—India : Arunachal Pradesh. Kameng dist., Tawang, 1 male, 27. vii. 1966, 3200 m (*A. N. T. Joseph*), Sangtichu, 1 female, 12.iv.1961, 1676 m, Rahung Village, 1 nymph, 8. iv. 1961, 1828 m. (*K. C. Jayaramakrishnan*); Lohit dist. Dambuk, Roing, 2 males, 1 nymph, 5. iii. 1969 (*S. K. Tandon* and Party); Siang dist., Rotung, 2 nymphs, 2 males, 23-28.xii.1911, 429 m under bark, Above Panji, 1 female, 16.i. 1912, 1210 m under bark, Dosing, 1 female, 25.i.1912 (*S. W. Kemp*); Assam : Siliguri, Cachar, 1 male (without further data) (*J. W. Mason*), Kobo, 1 female, 30.xi. 1911, 121 m. (*S. W. Kemp*); West Bengal : Darjeeling dist., Kalimpong, 2 males (one specimen broken), 24.iv.1910, 10.v.1915 (*F. H. Gravely*); Andaman Isls. : Port Blair, 1 male, 15.ii.-, 15.iii.1915 (*S. W. Kemp*).

*Distribution.*—INDIA : ARUNACHAL PRADESH, ASSAM, WEST BENGAL (Darjeeling Dist.) and ANDAMAN ISLS.; BURMA and VIETNAM.

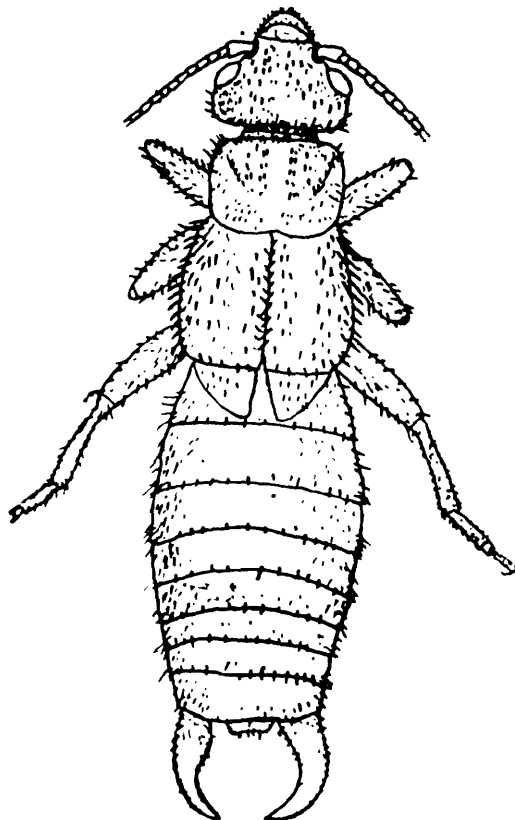


Fig. 2. *Echinotoma convolutum* Hincks, ♂, Dorsal view.

*Remarks*— This species commonly occurs under the bark of dead and decaying logs as well of standing trees. It is more common at lower altitude in Himalayas and in plains as well. The single record of this species from Tawang at an altitude of 3200 m in Arunachal Pradesh reveals the great adaptive powers of this insect at such an altitude and clearly represents the Indo-Malayan element in Himalayan fauna.

CARCINOPHORIDAE

CARCINOPHORINAE

**Aborolabis pervicina (Burr)**

*Anisolabis pervicina* Burr, 1913, *Rec. Indian Mus.*, 8 : 137.

*Paralabis pervicina* : Burr, 1915, *J.R. Micr. Soc.*, 1915 : 540.

*Aborolabis pervicina* : Srivastava, 1969, *Ent. Rec. J. Var.*, 81 : 246.

General colour shining reddish brown to brownish black, legs yellowish brown, femora banded with black.

*Male* Pronotum almost square, hind angles and margin rounded. Elytra and wings wanting. Sides of abdominal segments 5th to 9th acute, rugulose and carinate. Penultimate sternite with hind margin in middle truncate. Forceps with branches remote at base, strongly asymmetrical. Genitalia with parameres three times longer than broad, at base armed with a triangular tooth of same size; distal lobes provided with longitudinal rows of minute teeth. In female forceps simple and straight.

	Male	Female
Length of body	13-16 mm	7-18 mm
Length of forceps	2-3 mm	2.35 mm

*Material examined*— India : Arunachal Pradesh, Kameng dist., Dunn Bridge, 3 males, 2 nymphs, 21. iv. 1966, 1524 m., Pinjuli, 1 female, 4. v. 1966, Tipi, 1 male, 4 females, 6.v. 1966 (*A.N.T Joseph*), Pobrangchu, 2 males, 1 female, 22. iv. 1966, 1828 m., Chug Village, 8 males, 6 females, 14. iv. 1961, 2133 m., Chug, 1 male, 1 female, 17. iv. 1961, 1828 m., Ankling, 1 female, 12. iii. 1961, 609 m., Rahung village, 2 females, 8, 25. iv. 1961, 1828m., Siggon, Dupla R., 2 females, 31. iii. 1961, 2011 m., Siggon, 1 male, 31. iii. 1961, 2011m, Rupa, 4 males, 4 females, 12 nymphs, 1,2. iv. 1961, 1554-2133 m., Dirong Dzong village, 10 males, 15 females, 4 nymphs, 10, 11. iv. 1961, 1600 m., 20 males, 21 females, 8 nymphs, 29. iii. 1961, 2011 m., Dikangko River, 5 males, 7 females, 3 nymphs, 13, 14. iv. 1961, 2133m., Kalaktang, 6 males, 3 females, 2 nymphs, 17. iii. 1961, Shergaon, 1 male, 2 females, 2. iii. 1961, Sangtichu, 2 female, 11. iv. 1961, Bomdila Pass, 1 male, 2 females, 7. iv. 1966, 2936 m., Milankang, 20 males, 10

females, 5 nymphs, 18, 19. iv. 1961, 2133 m., Milankang and Digien, 2 males, 3 females, 2 nymphs, 20. iv. 1961, 1981 m. (*K. C. Jayaramkrishnan*); Subansiri dist., Pakha Camp, 1 male, 4 females, 2 nymphs, 26. x. 1966, 150 m. (*S. K. Tandon & party*), Ziro, 27 males, 28 females, 9 nymphs, 13, 14. v. 1966 (*A. N. T. Joseph*); Siang dist., Rotung, Nomotype male, 1 male; 2 females, 26, 28, 23. vii. 1911, under bark and rotten wood, Puding, 1 male, 1911-12, Bank of Dhiong River below Pasighat, 1 female, 16. xii. 1911 (*S. W. Kemp*), Tappi, 1 male (abdomen broken), 3 females, 23. x. 1966, 600 m., Jeep Camp, 1 female, 6. x. 1966, 140 m., Lekhabali, 1 female, 7. x. 1966, 50 m. (*S. K. Tandon and party*); Lohit dist., Manbhum, Tengapani forest, 4 nymphs, 100 m., Namsai, 7 nymphs, 15. iii. 1969, 100 m., Tezu, 1 female, 10. iii. 1969, 150m., (*S. K. Tandon & party*); Tirap dist., Miao, 2 females, 26. i. 1962 (*C. B. Srivastava*); Assam : Dibrugarh, 1 nymph, 17-19. xi. 1911, Assam—Bhutan Frontier, Mangaldai dist., N. E., Deshnoi river bed, 1 male, 1 female, 31. xii. 1910, Sadiya, 1 female, 26. xi. 1911, under bark, Kobo, 2 nymphs, 7. xii. 1912, 122 m. (*S. W. Kemp*).

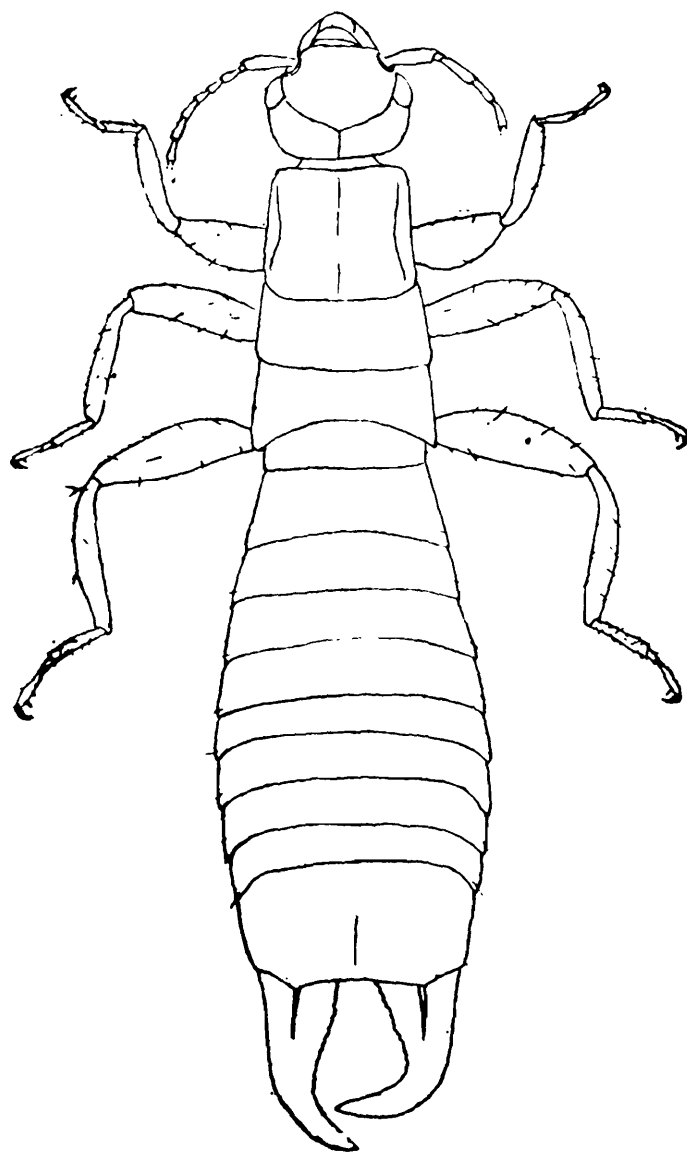


Fig. 3. *Aborolabis pervicina* (Burr), ♂, Dorsal view.

*Distribution*—N. E. INDIA (Himalayas).

LABIIDAE

SPONGIPHOGINAE

**Homotages tawangensis** Srivastava

*Homotages tawangensis* Srivastava, 1977, *Ceylon J. Sci. (Bio. Sci.)*, 12 (2) : 19.

General colour reddish black; head orange red, laterally blackish; tibiae and tarsi reddish testaceous.

*Male* : Elytra smooth, abbreviated, about as long as pronotum, wings absent. Forceps stout, somewhat depressed, gradually curving and tapering from base to apex, finely crenulate at base internally, armed above in apical one third with a stout, triangular tooth directed upwards and backwards, in lateral view branches undulate. Genitalia with parameres broader at base, narrowed apically with tip pointed, virga stout. In female penultimate sternite rounded posteriorly; pygidium subvertical and truncate posteriorly and forceps with branches simple and straight.

	Male	Female
Length of body	11.6-14.1 mm	12.1-12.8 mm
Length of forceps	4.2-4.5 mm	3.6-3.9 mm

*Material examined* : India : Arunachal Pradesh : Kameng Dist., Tawang, Holotype male, Allotype female and paratypes 2 males, 3 females and 1 nymph, 3200 m. (S. K. Bhattacharya).

*Distribution*—Known only from type locality.

*Remarks*—In some specimens upper tooth of forceps is weakly developed.

The genus *Homotages* Burr, is known by two species viz., *H. feae* (Bormans) and *H. tawangensis* Srivastava, distributed all along the Himalayas in India, Nepal and Bhutan and mountains of Burma and China. It belongs to family Labiidae in having simple 2nd tarsal segment but its stout build and general facies are suggestive of its closeness with the members of Forficulidae. Perhaps it may represent a transitional stage when detailed studies on these specie are taken up.

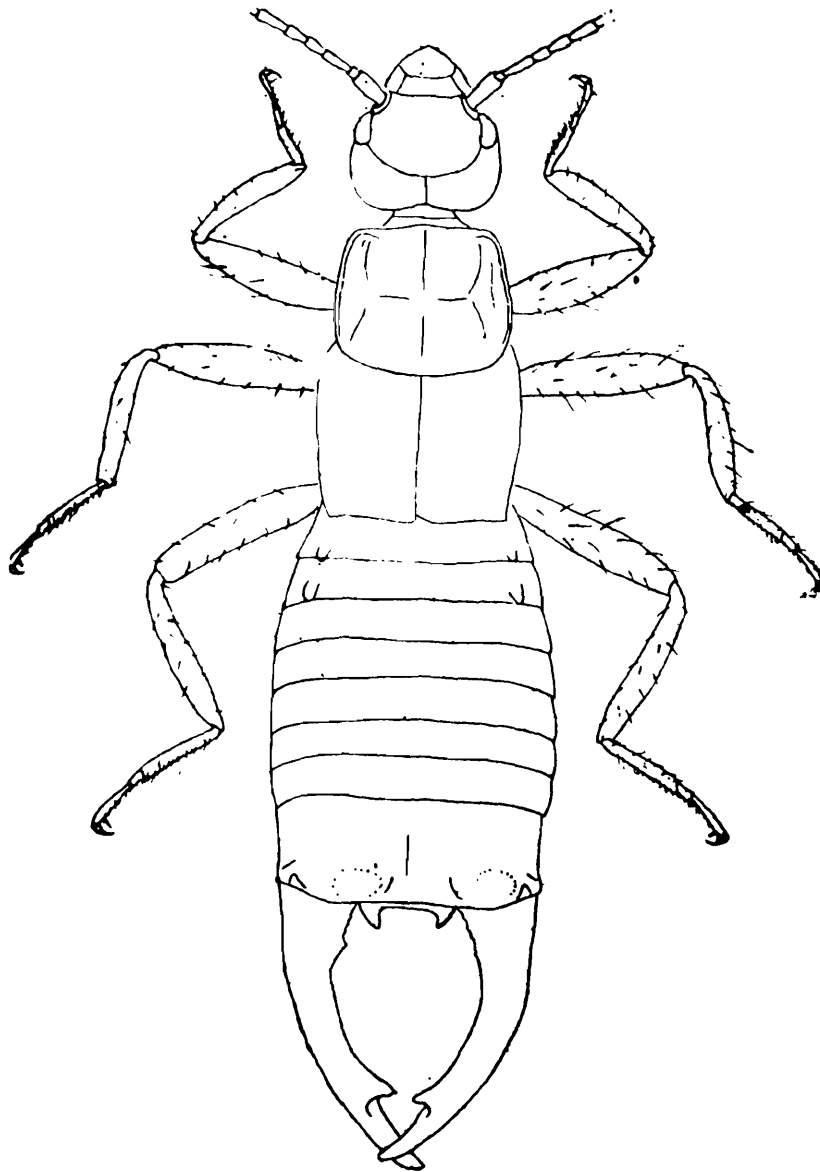


Fig. 4. *Homotages tawangensis* Srivastava, ♂, Dorsal view.

FORFICULIDAE

ANECHURINAE

***Allodahlia macropyga* (Westwood)**

*Forficula macropyga* Westwood in Royle, 1836, *III*s. *Himalayas*, 2 : iii.

*Allodahlia macropyga* : Burr, 1910, *Fauna Brit. India Dermaptera* : 151.

General colour reddish brown, head shining black: inner wing tip with a patch of yellow: legs somewhat reddish.

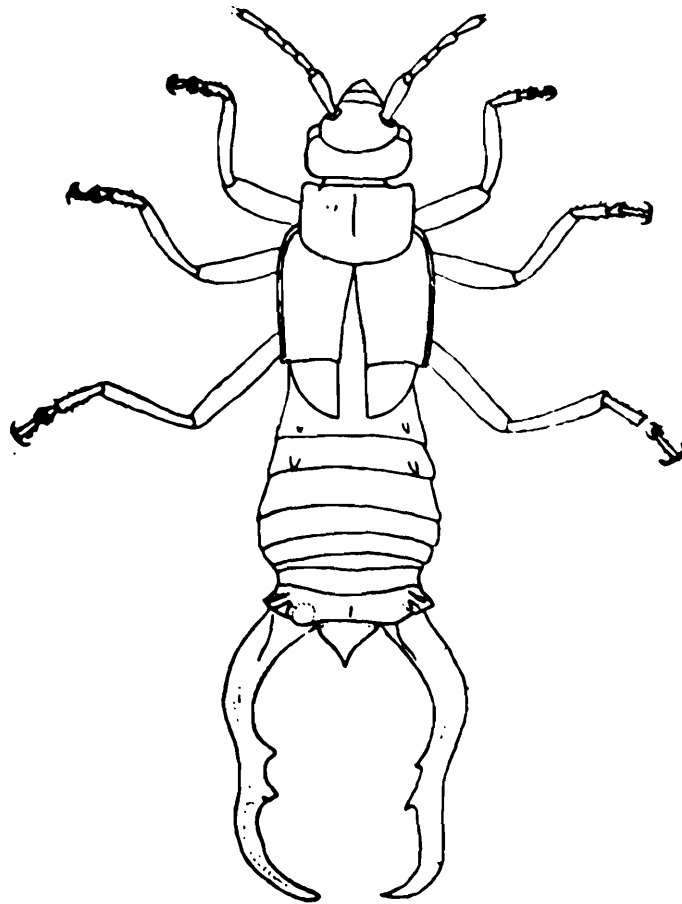
*Male* Elytra with distinct costal keel and punctation deep, coalescing. Wings present. Abdomen punctate but punctures widely separated. Forceps stout, branches undulate with a pair of teeth. Pygidium triangular with a median, strongly pointed spine posteriorly. In female pygidium small, weakly produced into a lobe posteriorly; forceps simple, contiguous and straight.

	Male	Female
Length of body	9.2-11.5 mm	12.0-13.3 mm
Length of forceps	5.8-7.0 mm	5.1-5.8 mm

*Material examined*—India : Arunachal Pradesh : Kameng dist., Pobrang Chu, 2 males, 22. iv. 1961, 1833 m., Moshing village, 2 females, 26. iii 1961, 2286 m., Milankang, 2 females, 18. iv. 1961, 2286 m. (*K.C Jayaramakrishnan*) ; Uttar Pradesh : Dehra Dun dist., Jabaharket, on Mussorie Tehri Road, ca. 4 miles from Mussorie, 1 male, 20, 25. vi. 1930, found in damp places in jungle under stones near water trickling from spring (*B.N Chopra*).

*Distribution*—INDIA, NEPAL and BHUTAN (all along the Himalayas); BURMA, CHINA (Yunnan), THAILAND, VIETNAM and PHILIPPINE ISLANDS.

*Remarks*—The altitudinal range between 1000 and 2000 metres appears to be most favourable but it can be easily collected at higher elevations as well along the banks of streams under stones. At comparatively lower altitudes it occurs under bark. It is essentially a montane species.



**Fig. 5.** *Allodahlia macropyga* (Westwood), ♂, Dorsal view.

***Allodahlia martensi* Brindle**

*Allodahlia martensi* Brindle, 1974, *Senckenbergiana biol.*, 55(1/3) : 154  
(male, female; Nepal).

General colour black with head partly or entirely reddish; antennae dark brown; tibiae and tarsi brown to dark brown.

*Male* : Pronotum transverse, straight laterally with hind margin briefly rounded, punctate, rugose in posterior half only. Elytra abbreviated, costal margin convex and carinate, hind margin obliquely truncate, punctate. Abdomen finely and sparsely punctate. Pygidium directed dorsally, transverse, hind margin concave. Forceps gradually tapering and curving from base to apex, internally armed at basal one third with a median tooth and with another ventro-median tooth at a little beyond basal two thirds. Genitalia with parameres broad; virga long undulate. In female pygidium broadly triangular; forceps short, simple and straight.

	Male	Female
Length of body	10—11 mm	10—11 mm
Length of forceps	3—4.5 mm	1.5 mm

*Distribution*—Known only from its type locality in Nepal.

*Remarks*—It appears to be essentially a high altitude species being more common above 3000 m.

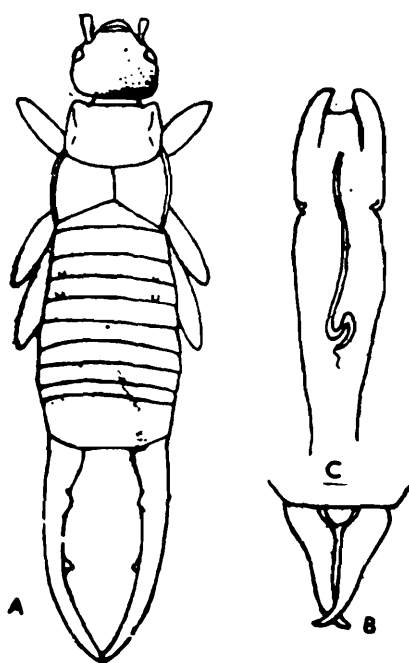


Fig. 6. *Allodahlia martensi* Brindle, ♂, A. Dorsal view, C. genitalia; ♀, B. Ultimate tergite and forceps (redrawn from Brindle, 1975).

***Anechura stoliczkae* Burr**

*Anechura stoliczkae* Burr, 1911, *J. Asiat Soc. Bengal*, (N. S.), 7 : 792.

*Anechura himalayana* Santokh Singh, 1955, *Agra Univ. J. Res. (Sci.)*, 4 : 180.

*Himanechura lahaulensis* Santokh Singh, 1955, *Agra Univ. J. Res. (Sci.)*, 4 : 183 (nymphs).

General colour brownish black with head occasionally orange, sometimes abdominal tergites lighter in colour.

*Male* : Head transverse, eyes small. Pronotum strongly transverse, sides straight, hind margin briefly rounded. Elytra and wings normal. Abdomen gently widened in middle, smooth. Ultimate tergite transverse, above the roots of forceps with tumid elevation, often weakly developed. Pygidium about as long as broad, subvertical gently narrowed posteriorly, hind margin faintly emarginate. Forceps long and cylindrical, gradually curving from base to apex, armed internally at base with a triangular tooth; length of forceps variable in being short and stout with various intermediate stages. Genitalia with

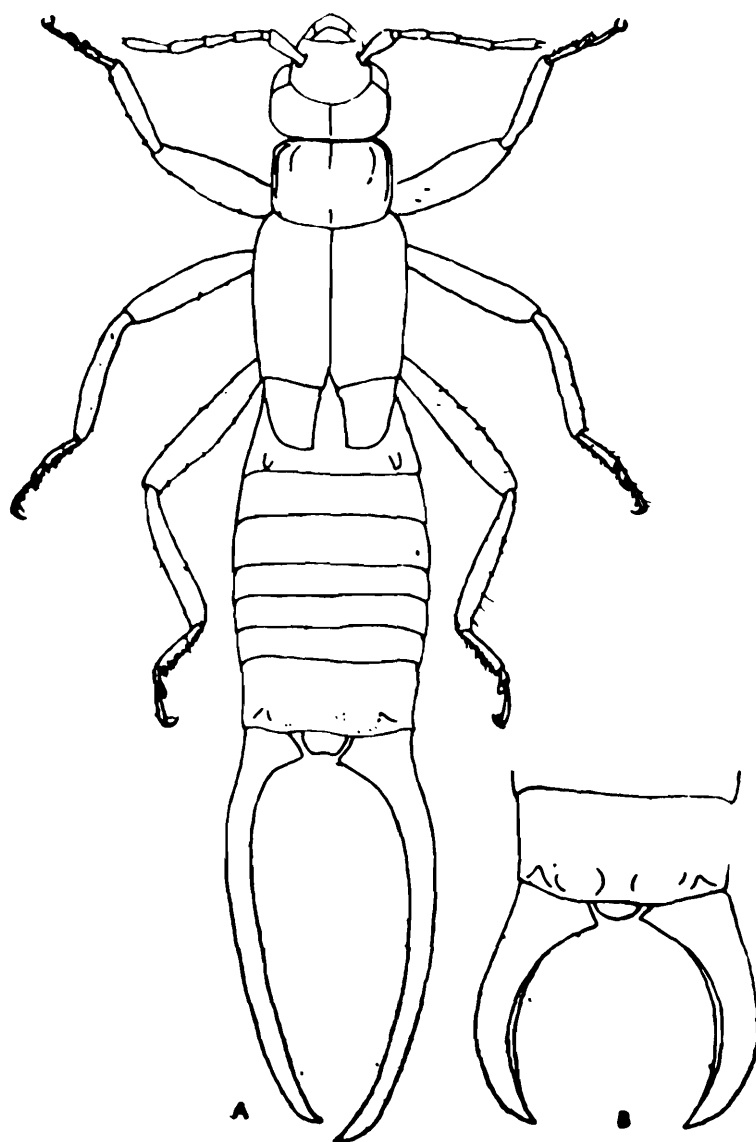


Fig. 7. *Anechura stoliczkae* Burr, ♂ A. Dorsal view with macrolabic form of forceps, B. Ultimate tergite and forceps with microlabic form.

parameres broader at base, narrowed apically; virga distinct. In female forceps simple, straight and pygidium not visible from above.

	Male	Female
Length of body	10-14 mm	10-13 mm
Length of forceps	5-10 mm	3-4.5 mm

*Material examined*—India : H. P. : Rohtan Medhi, 14 km from Kothikulu, 7 males, 11 female, 21 vii. 1973 (*M. Chandra*); Hadozur, 6 males, 9 females, 31 ii 1973 (*K. K. Mahajan*); U.P. : Garhwal Dist, Uttarkashi, 1 male, 11 vi. 77, 2671 m (*A. Singh*).

*Distribution*—INDIA, NEPAL and BHUTAN (all along the Himalaya).

*Remarks*—This species show remarkable variations in the development of forceps. It is essentially a high altitude species and has been found to be active even on snow. Commonly occurs under stones on the edge of streams and rivers.

#### *Anechura zubovskii* Semenov

*Anechura zubovskii* Semenov, 1901, *Horae Soc. Ent. Res.*, 35 : 188.

*Anechura zubovskii* : Steinmann, 1975, *Fol. Ent. Hung.*, 28 : 162.

*Anechura bipunctata pirpanjalae* Santokh Singh, 1955, *Agra Univ. J. Res. (Sci.)*, 4(1) : 132.

*Anechura pirpanjalae* Kapoor, 1966, *Ann. Mag. nat. Hist* 13 (9) : 391. *Syn. nov.*

General colour black to brownish, somewhat shining; sides of pronotum yellow; elytra and wings with a yellow spot. Glabrous and smooth.

*Male* : Head longer than broad. Pronotum weakly transverse, sides straight, hind margin convex. Abdomen enlarged in middle, convex, smooth, lateral tubercles distinct. Ultimate tergite transverse, posteriorly in middle depressed, tumid above bases of forceps, armed at exterior angle with a sharp ridge, sometimes poorly marked. Pygidium sloping backwards, transverse, rectangular. Forceps with branches stout, remote, strongly undulate or less so, armed at base above with a short conical tooth often poorly developed, another very small tooth present at base on inner ventral margin. Parameres broad at base, strongly narrowed near apex; virga distinct.

In female pygidium long and narrow; forceps simple and straight.

	Male	Female
Length of body	9.5-14 mm	10-13 mm
Length of forceps	5-7 mm	3-4.5 mm

*Material examined*—India : Kashmir : Ladakh, Drass, 1 male, 11.vi. 1973, 3900 m. (*V.K Gupta*); Himachal Pradesh : Lahaul Spiti, Lossar, 41 males, 30 females, 6-9. viii. 71, 4100 m, Khoksar, 25 males, 50 females, 24. vii. 71, 3312 m; Sissu, 10 males, 11 females, 28. viii. 71, 3463 m (*K.K. Mahajan*); Lahaul-Chamba, Udaipur, 9 males, 3 females, 9. vii. 74, 2747 m (*R. Tilak*).

*Distribution*—INDIA (KASHMIR, HIMACHAL PRADESH) ; CHINA (S. W TIBET)

*Remarks*—It occurs in large numbers under stones on the edge of streams.

For a long time it was considered a subspecies of *A. asiatica* Semenov, distributed in Southern European part of U. S. S. R., Mongolia and Chinese Dzungaria. Steinmann (1975) has shown on the basis of male paramere that it is specifically distinct.

Holotype ♂ of *Anechura pirpanjalae* Kapoor (1966), now available in Division of Entomology, Indian Agricultural Research Institute, New Delhi has been examined and found to agree well with this species in most characters. Therefore it is treated here as synonym of *A. zuboyskii*.

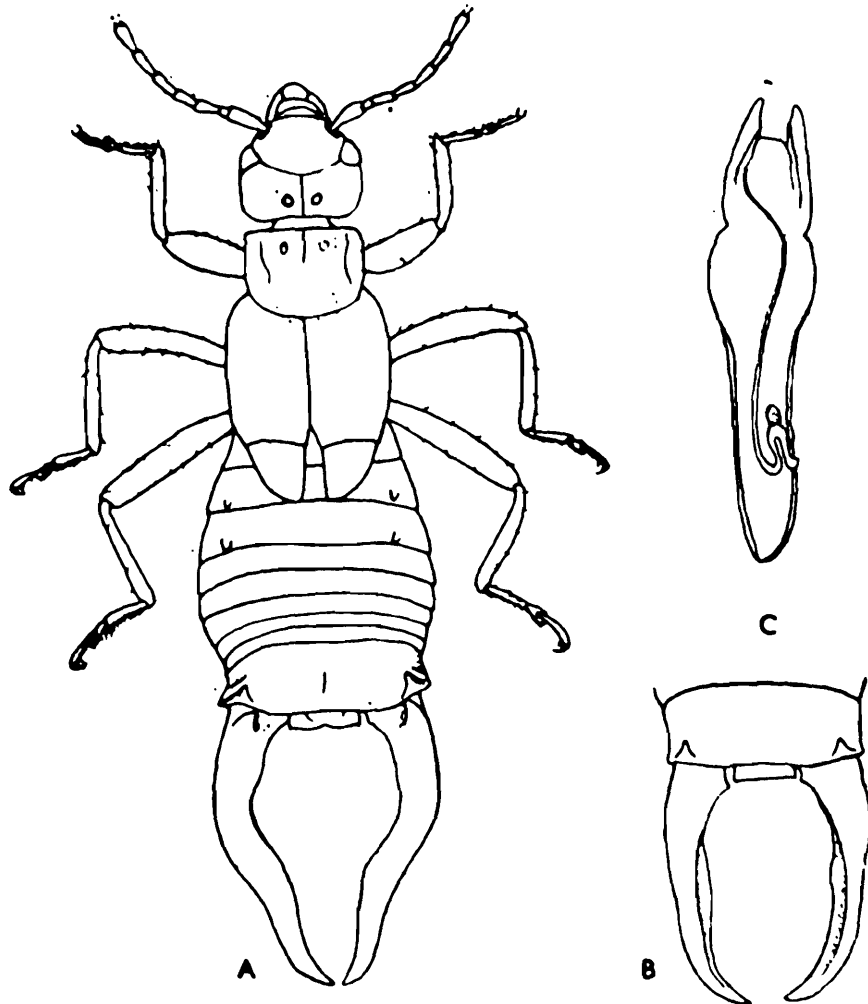


Fig. 8. *Anechura zuboyskii* Semenov ♂ A. Dorsal view, B. Ultimate tergite and forceps and C Genitalia.

***Anechura filchneri* (Burr)**

*Odontopsalis filchneri* Burr, in Filchner, 1908, *Wiss. Ergebn. Exped. China-Tibet Zool. Bot.*, 1 : 58, pl. 3 fig.8 (Male, Lantshow (Kansu Prov., China).

*Anechura filchneri* : Bey—Bienko, 1934, *Ark. Zool.*, 25A (20) : 2 (Male, Female; S. Kansu, China).

General colour shining dark brownish black, sides of pronotum, elytra and wings testaceous brown.

*Male* : Pronotum transverse, sides faintly convex, hind angles and margin rounded. Elytra normal. Wings present or absent. Abdomen faintly enlarged in middle, punctulate. Ultimate tergite transverse, tumid elevation above bases of forceps, strongly or poorly developed. Pygidium transverse, a little reflexed along hind margin, posterolateral angles with minute point. Forceps remote at base, branches short and stout (f. *microlabia*) and long and slender (f. *macrolabia*), armed at base with a small vertical tooth above and below with another somewhat similar tooth. Genitalia with parameres long, narrowed apically with tip obtuse; virga long. In female ultimate tergite more narrowed; forceps simple, contiguous and straight.

	Male	Female
Length of body	7.7-8.5 mm	8.0-8.5 mm
Length of forceps	2.6-4.5 mm	1.9-2.0 mm

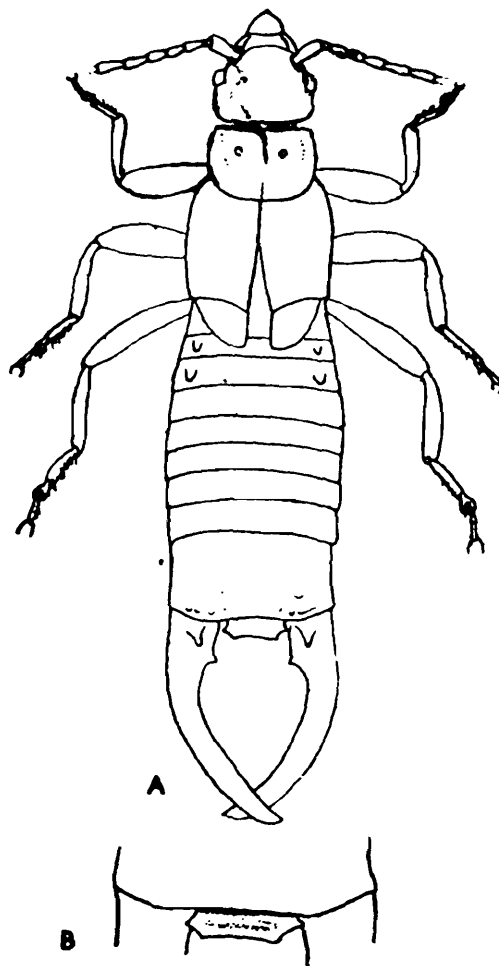


Fig. 9. *Anechura filchneri* Burr, ♂, A. Dorsal view, B. Pygidium enlarged.

*Material examined*—India : Uttar Pradesh : Pithoragarh Dist., Ralam sub. Division, Munsiry, 1 male, 5. x. 1977, 3777 m, under stones, (H.C. Ghosh) ; Garhwal Dist., Uttar Kashi, 9 males, 2 females and 6 nymphs, 11. vi. 1977, 2671 m (Asket Singh).

*Distribution*—Hitherto recorded from China (Szechwan and Kansu Prov.) the present record of the species from Garhwal Himalaya is new to India.

*Remarks*.—The occurrence of this species in the mountains of central China at an altitude ranging between 2833 and 3148 m and present record from India between 2671 and 3777 m clearly reveals monticolous habits. Originally described from a brachypterous male, it is recorded here on macropterous specimens.

### **Oreasiobia calciatii (Borelli)**

*Anechura calciatii* Borelli, 1909, *Boll. Mus. zool Anat. comp. Torino*, 24 (603) : 3.

General colour brownish black, head somewhat lighter with an orange patch on frons in middle and narrowed to form a stripe on occiput; pronotum, elytra and abdomen darker, legs with knee joints darker. Build stout. Body covered with long dense hairs, more pronounced on forceps.

*Male* : Head longer than broad, sutures fine. Pronotum transverse, sides gently reflexed and parallel. Elytra well developed; wings slightly projecting beyond elytra. Abdomen impunctate, enlarging gradually from base to 7th tergite and afterwards again contracted. Ultimate tergite transverse, above the roots of forceps armed with a mammiform tubercle directed backwards. Pygidium laminate, narrowed at base, apically raised upwards, hind margin with two faint tubercles in middle. Forceps stout, gradually curving from base to apex, internally at base with a triangular tooth below and somewhat similar tooth above directed inwards. Genitalia with parameres expanded at base and apex, contracted in middle : virga slightly longer than parameres and undulate.

*Female* : Agrees with male in most characters except that the ultimate tergite without any mammiform tubercle above the bases of forceps and gently narrowed posteriorly; pygidium short, subvertical, hind margin provided with a minute tubercle in middle and at posterolateral angles and forceps simple and straight.

	Male	Female
Length of body	11.1 mm	11.3-13.2 mm
Length of forceps	3.5 mm	3.4-4.1 mm

*Material examined*—Syntypes, 1 male, 3 females labelled as Srinagar Kaschmir (Museo di Zoologia della Universita Torino—Italia).

*Remarks*—Borelli (1909) based the original description of the species on 1♂, 3♀♀ and provided locality data as “lungo la strada che conduce da Sirinagaur a Gilgit, altitudine 2500 circa” The present material is not labelled as such and in the invoice from Museo di Zoologica della Universita Torino, Italia, against its name it has been marked as “4 ? Type” In all probabilities this is the original material referred to by Borelli (l.c.) since it comes from the same area and agrees well with the original description. From the introductory para of the paper it is also clear that the material was deposited in Torino University Museum. Moreover, no other specimens were ever referred to this species by Borelli subsequently as is evident from published literature.

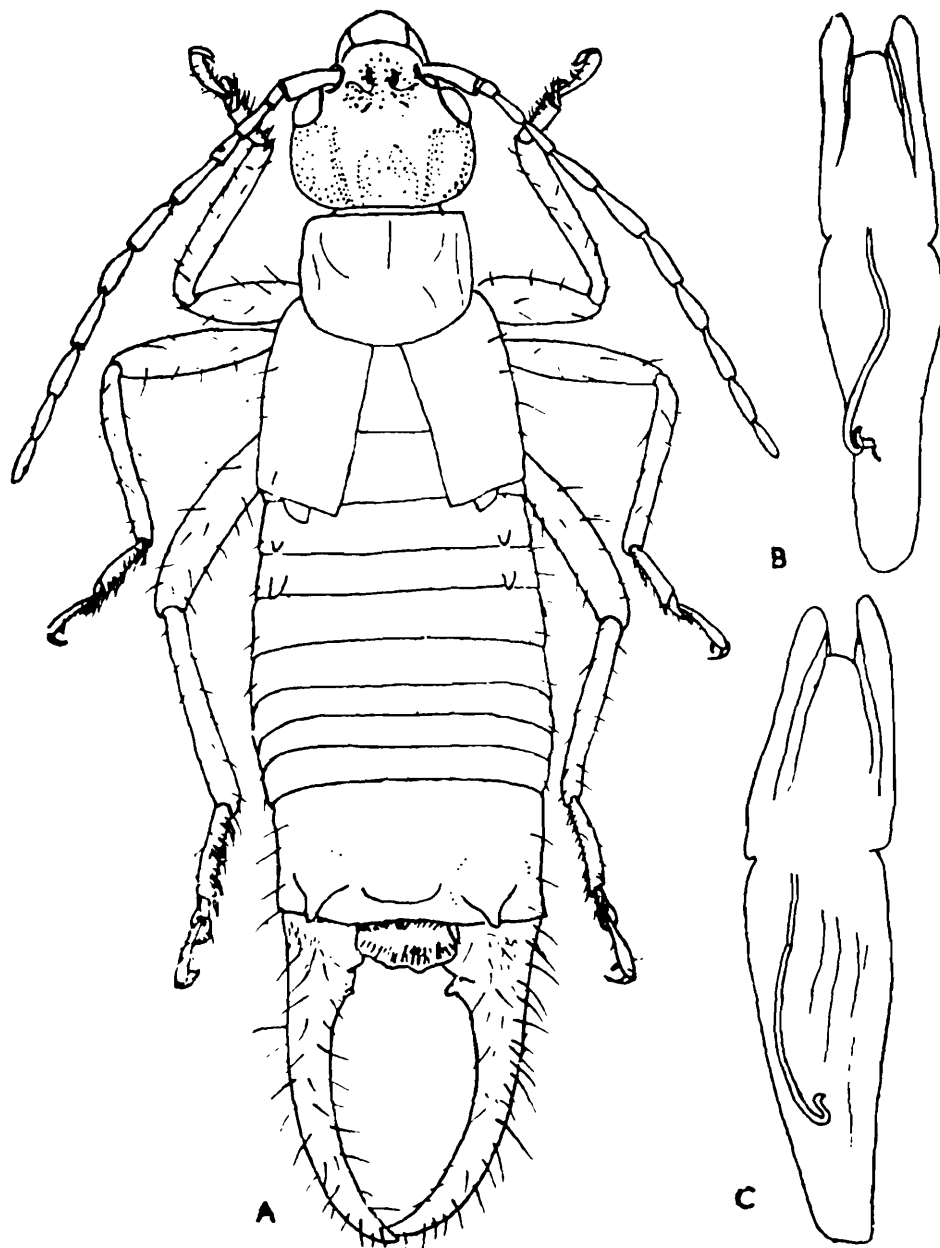


Fig. 10. *Oreasiobia calciatii* Borelli, Syntype ♂, A. Dorsal view, B. Genitalia; *Oreasiobia fedtschenkoi* (Saussure) ♂, C. Genitalia.

Bey-Bienko (1935) considered this as subspecies of *Oreasiobia fedtschenkoi* (Saussure). But in *Anechura caliciatti* Borelli, pronotum is more strongly transverse and male parameres are quite distinctive in being contracted in middle and expanded at base and apex whereas *Oreasiobia fedtschenkoi* possesses pronotum weakly transverse and male parameres are gradually narrowed from base to apex. In the light of these differences former is considered as specifically distinct. Though its present highest altitudinal record is 2900 m it is included here since in all probabilities it may occur at higher elevation when further explorations are taken up owing to its purely monticolous habits. Uptil now it has been recorded only once subsequent to its original description.

### *Guanchia bicarinata* Hincks

*Guanchia bicarinata* Hincks, 1947, *Ark. Zool.*, 39 A (1) : 28, Fig 14.

General colour brownish black, head occasionally orange; pronotum on sides, antennae, distal half of tibiae and tarsi testaceous and forceps reddish black.

Pronotum gently widened posteriorly. Elytra smooth, abbreviated, obliquely truncate posteriorly. Wings absent. Abdomen sparsely punctate. Ultimate tergite transverse, narrowed backwards, posteriorly in middle with inverted V-shaped carina. Forceps with branch remote at base regularly curving from base to apex, at base above with a rectangular tooth, directed upwards and inwards. Parameres broad and flat, apex convex; virga long and thin. In female ultimate tergite without median depression, forceps contiguous, straight, crenulate internally in basal half only.

	Male	Female
Length of body	9.4-10.0 mm	9.6-9.8 mm
Length of forceps	3.0-3.7 mm	3.1-3.3 mm

*Material examined*—India : Arunachal Pradesh : Kameng Dist., Tsela, 2 males, 3 females, 25. iv. 1966, 3657 m (*A. N. T. Joseph*).

*Distribution*—INDIA, BURMA and CHINA (Szechwan).

*Remarks*—Type of this species, collected from N.E. Burma, Kambaiti at 2204 m possesses black head. In the material before me which is from much higher altitude, i. e., 3657 m in Arunachal Pradesh, the head is orange which perhaps represents high altitude melanism in this species.

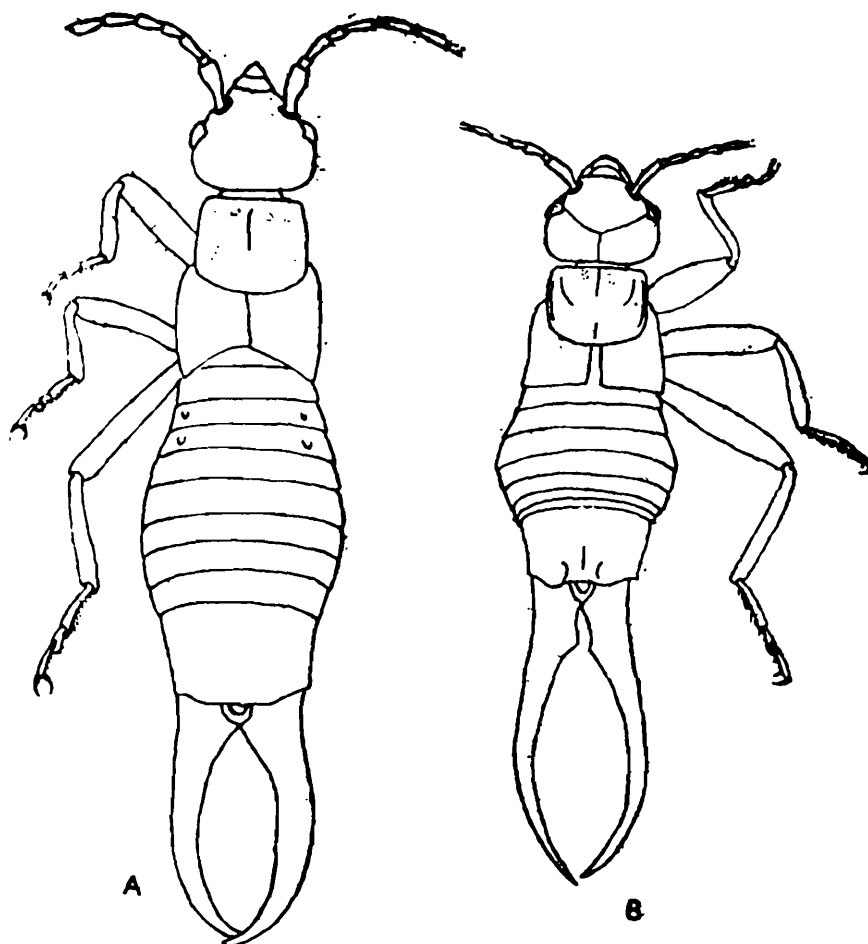


Fig. 11. *Guanchia bicarinata* Hincks ♂, A. Dorsal view; *Guanchia chirurga* Burr ♂, B. Dorsal view.

### *Guanchia chirurga* Burr

*Guanchia chirurga* Burr, 1911, *J Asiatic Soc. Bengal* (N.S.), 7 : 798 (male; W. B., Tonglu, 13-1400 ft.).

General colour testaceous brown; head, antennae and legs yellowish. Pronotum transverse. Elytra abbreviated, hind margin slightly oblique, truncate. Wings wanting. Abdomen greatly enlarged in middle, smooth. Ultimate tergite transverse, smooth, gently narrowed posteriorly. Pygidium short, obtuse, scarcely visible from above. Forceps long and slender, gradually curving from base to apex, armed at base above with a vertical, lamellate tooth, faintly crenulate internally.

*Female* : Unknown.

	Male
Length of body	6.9-9 mm
Length of forceps	4.5-5.5 mm

*Material examined*—India : Sikkim : Lachen, 2 male, 9. iv. 1959, 2706 m; Thombyak, 1 male, 30. iv. 1959, 3879 m (A.G.K. Menon).

*Distribution*—INDIA : W BENGAL (Tonglu) and SIKKIM (Lachen and Thombyak).

### **Forficula beelzebub (Burr)**

*Chelisoches beelzebub* Burr, 1900, *Ann. Soc. ent. Belg.*, 64 : 51.

*Forficula beelzebub* : Burr, 1910, *Fauna Brit. India, Dermaptera* : 167.

*Forficula celer* Burr, 1905, *J. Asiatic Soc. Bengal (N. S.)*, 1 : 31.

General colour orange reddish or testaceous shaded with black in parts, rarely complete black, sides of pronotum, legs and forceps often lighter in colour.

*Male* : Pronotum weakly to strongly transverse. Elytra and wings well developed. Abdomen long or short, greatly dilated posteriorly or often feebly dilated in middle, densely and deeply punctate. Ultimate tergite transverse, tumid above the roots of forceps, sometimes poorly marked. Pygidium long, tongue shaped, hind margin convex. Forceps short (f. brachylabia) or long (f. macrolabia), in former dilated internally in basal half and in the latter in basal one third. In female ultimate tergite narrowed posteriorly; forceps simple and straight.

	Male	Female
Length of body	8.7-12.2 mm	8.2-12.3 mm
Length of forceps	3.1-5.7 mm	2.7-3.4 mm

*Material examined*—India : Arunachal Pradesh : Kameng dist., Sangtichu River, 6 males, (in one ex. abdomen missing), 12. iii. 1961, 1967 m, Siggon Dupla, 1 male, 2 females, 1 nymph, 31 iii. 1961 2011 m, Siggon, 3 males, 9 nymphs, 30. iii. 1961 2011 m, Chug, 3 males, 9 females, 33 nymphs, 16-17. iii. 1961, 2133 m Chug village, 1 male, 1 female, 14. iii. 1961, 2133 m., Rupa, 4 females, 13 nymphs, 1 3. iv. 1961 2133m., Moshing, 4 nymphs, 25. iii. 1961, Moshing village, 1 female, 2 nymphs, 26. iii. 1961, 2133 m, Shergaon, 1 male, 1 female, 2 nymphs, 29 iii. 1961 2012 m, Direng Dzong village, 1 nymph, 1618 m., Dikongko river, 3 females, 2 nymphs (in 1 ex. abdomen missing), 3. iv. 1961, 2133 m, Bomdila, 1 nymph, 7. iv. 1961 2971 m., Bomdila Pass, 4 nymphs, 7 iv. 1961 2971 m, Bomdila Town, 3 females, 29. iv. 1961 2648 m. Milankang, 3 males, 2 females, 12 nymphs, 18. iv. 1961 2133 m., (K.C. Jayaramakrishnan); Meghalaya : Shillong, 2 females, 15 xi. 1930, 1 male, 2 females, 3-9. xii. 1930 (H. S. Rao) Khasi Hills, between Serraring and Mawphlong, 1 male, 1 female, - vi. 1927 (Gopi Ram), Nartiang Jantia Hills, 1 male, 1 female 28,29. x. 1930 (H.S Rao); Himachal Pradesh : Simla, 2 males, 2 females, - viii. 1925, 1828-2133 m, in stream or near water edge; Uttar Pradesh : Dehra Dun dist., round about Mussoorie, 3 males,

1 female, 15-16. viii. 1930, under leaves in damp places in jungle  
(*B. N. Chopra*).

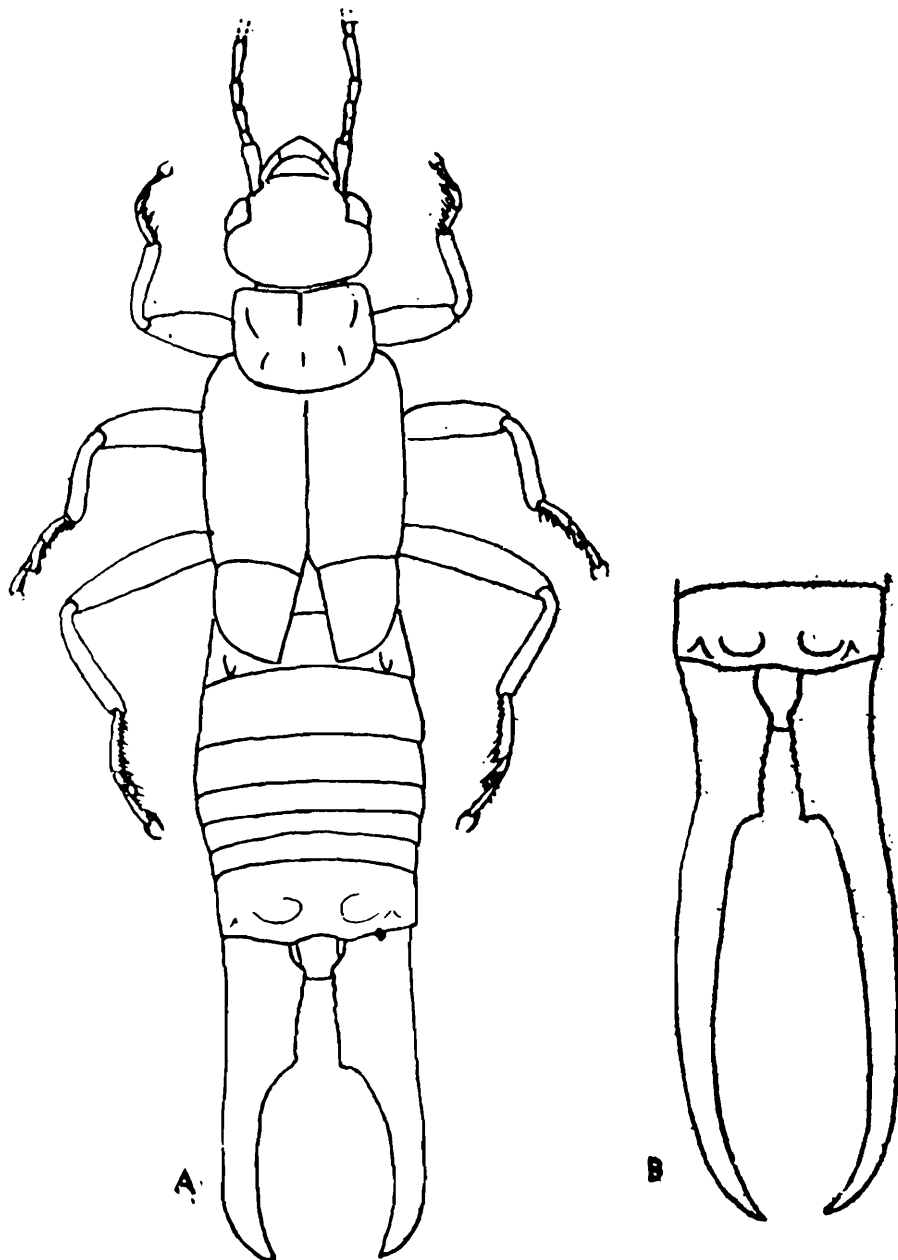


Fig. 12. *F. ficula hezzebub* (Burr) ♂, A. Dorsal view with brachylabic form of forceps, B. Ultimate tergite and forceps showing macrolabic form.

*Distribution*—All along the Himalayas in INDIA, NEPAL and BHUTAN

*Remarks*—This species shows great variation in general body colour size, shape of pronotum and the forceps.

It appears to be one of the most common species in Himalayas equally well distributed at lower and higher altitudes. The highest altitudinal record for the species is from Kotaka-Gogona in Bhutan between 2600 to 3400 m (Brindle, 1975). Its favourite haunts are under stones along the banks of rivers and streams but also occurs under the bark of dead decaying logs and trunks of standing trees. During rainy seasons it can be collected easily from the foliage of shrubs and trees.

**Forficula planicollis Kirby**

*Forficula planicollis* Kirby, 1891, *J. Linn. Soc. Zool. Lond.*, **23** : 256.

*Forficula ambigua* Burr, 1904, *Trans. ent. Soc. Lond* : 321.

*Forficula lehongae* Hebard, 1923, *Mem. Dept. Agric. India, Ent. Ser.*, **7** : 226, pl. 20, fig. 23.

*Forficula bhatnagari* Gangola, 1965, *Entomologist* :229, figs. 3-8.

*Forficula gardneri* Kapoor, Bhardawaj and Banerjee, 1972, *Bull. Ent.*, **12** : 37, figs. 9-11.

General colour shining reddish black or testaceous brown

*Male* : Head smooth. Pronotum weakly transverse, hind margin convex. Elytra and wings well developed. Abdomen strongly dilated in middle, punctate. Ultimate tergite transverse with low tumid tubercles above the roots of forceps. Pygidium rounded or obtusely rounded with two small tubercles laterally towards apex thus making it bisinuate (f. microlabia) or pointed (f. macrolabia). Forceps (f. microlabia) stout, strongly bowed, dilated from base to one fourth or one fifth of total length; (in f. macrolabia) branches slender almost straight, gently curved near apices. Female with forceps simple and straight.

	Male	Female
Length of body	7.1-9.5 mm	6.4-10.8 mm
Length of forceps	2.6-3.0 mm	1.5-2.8 mm

*Material examined*—India : Arunachal Pradesh : Kameng dist., Bomdila, 1 male, 2 females, 22. iv. 1966, 2621 m., (*A.N.T Joseph*); Meghalaya : Mawphlong forest, west of dakbunglow, 1 male, 13. iv. 1927 (*Gopi Ram*); West Bengal : Kurseong, 2 females, 22. vi. 1910, 1447-1542 m (*N Annandale*); Uttar Pradesh : Garhwal dist., Mandoli, 1 female, 1 vi. 1958 Silapuri, 3 males, (in one ex. head missing), 8. v. 1958, 1786 m (*B. S. Lamba*); Sikkim : Sandakphu, Sikkim Nepal border, 2 males (one ex. damaged), 3600 m.

Burma : Take-pum Mtn Chinese frontier, 1 male, 3 females, -. xi. 1910, 1234-1542 m. (*C.W Beebe*).

*Distribution*—INDIA, NEPAL, BHUTAN (all along the Himalayas) BURMA and CHINA (Yunnan).

*Remarks*—This is a fairly common species all along the Himalayas occurring in variety of habitats i. e., in dead decaying logs, flowers and amongst foliage.

Srivastava (1976) synonymised *F. lehongae* Hebard, described from Darjeeling (Lebong) on account of similar morphological details.

Unfortunately *F. planicollis* Kirby, was not adequately described prior to Srivastava and Saha (1975) who on the basis of large series not only recorded in detail various intraspecific variation but synonymised three other species as listed under synonymy.

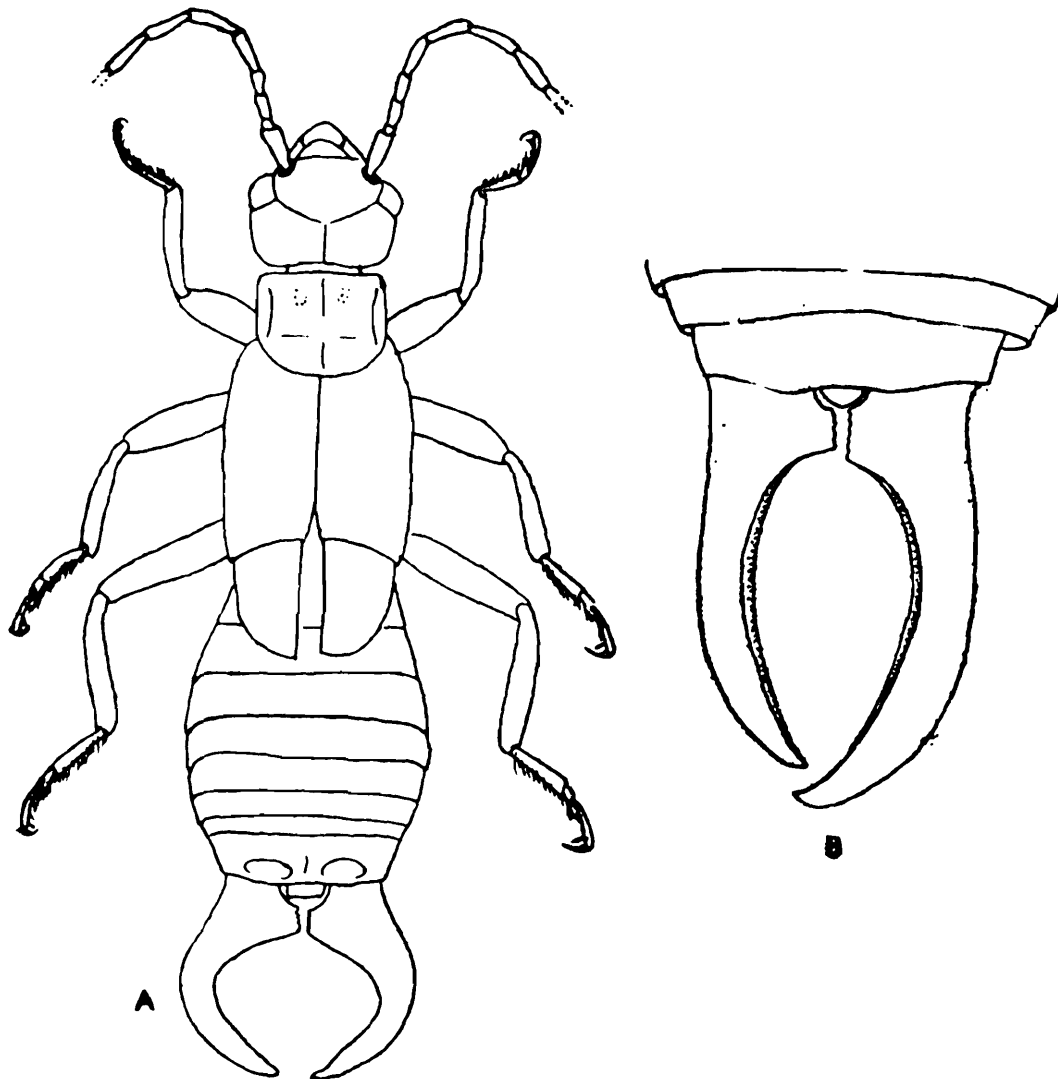


Fig. 13. *Forficula planicollis* Kirby, ♂, A. Dorsal view, B. Ultimate tergite and forceps.

### ***Forficula schlagintweiti* (Burr)**

*Anechura schlagintweiti* Burr, 1904, *Trans. ent. Soc. Lond.* : 314.

*Forficula schlagintweiti* : Burr, 1910 *Fauna Brit. India, Dermaptera* : 165.

*Anechura stoliczkae* : Hebard, 1923, *Mem. Dept. Agric. India Ent. Ser.*, 7 : 224 ("Brachylabic condition").

Generally jet black, shining, sometimes head reddish.

*Male* : Head smooth. Pronotum strongly transverse. Elytra and wings normally well developed but latter sometimes wanting. Abdomen smooth, enlarged in middle and depressed. Ultimate tergite transverse with low tumid elevations above roots of forceps.

Pygidium small, subvertical, obtuse. Forceps (in Forficuloid phase) stout strongly bowed, (in Anechurioid phase) somewhat straight, gently curved near apices, internally armed at base with an obtuse tooth, crenulate internally. In female ultimate tergite narrowed posteriorly; forceps simple and straight.

	Male	Female
Length of body	10.1-12.9 mm	11.7-15.3 mm
Length of forceps	3.3-4.1 mm	4.7-5.7 mm

*Material examined*—India : Arunachal Pradesh : Kameng dist., Salari, 1 male, 22. iv. 1961, 1234 m, Bomdila Town, 2 males, 2

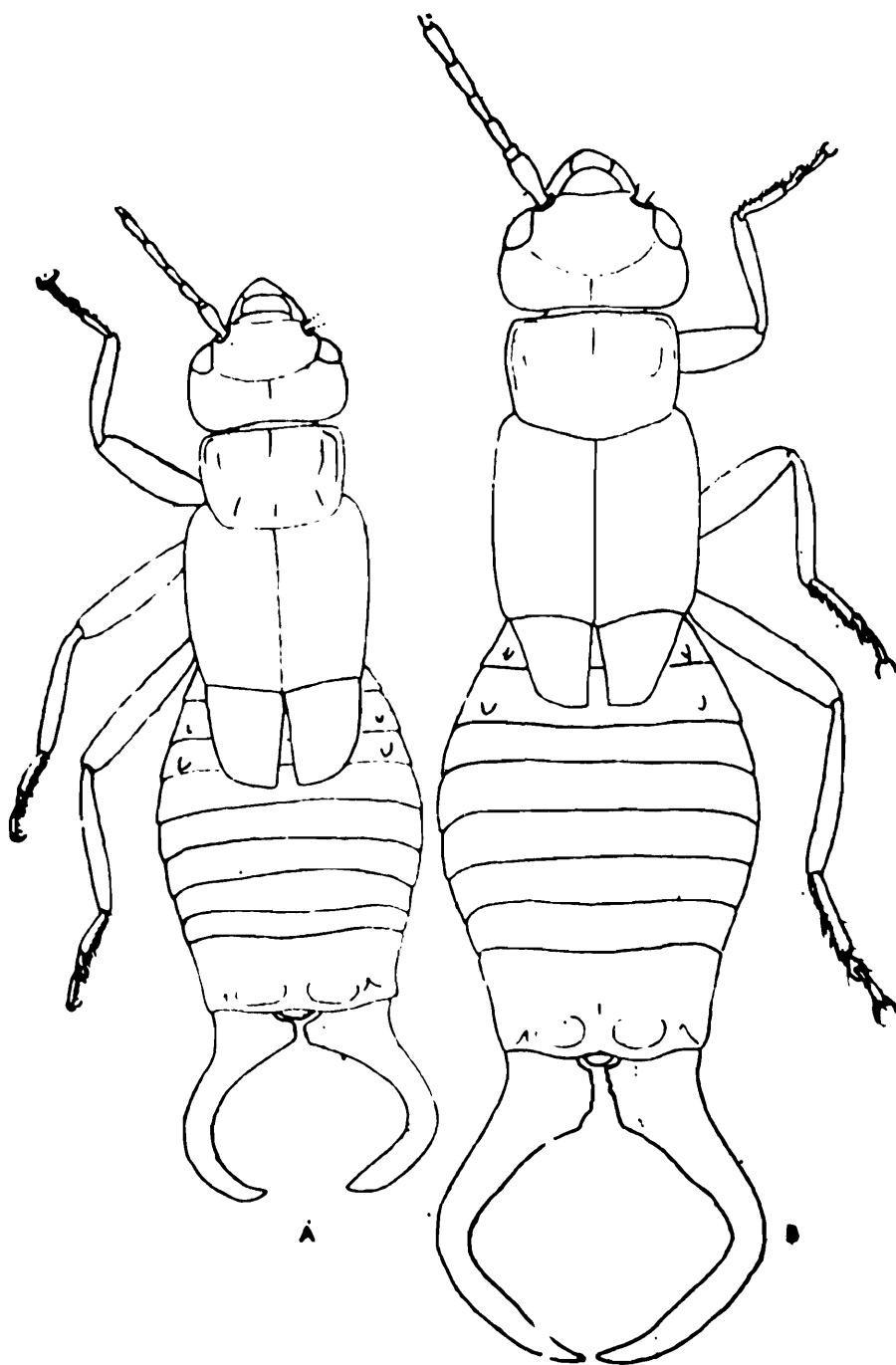


Fig. 14. *Forficula schlagintweiti* (Burr), ♂. A. Dorsal view ; *Forficula bhutanensis* Brindle, ♂, B. Dorsal view.

females, 4 nymphs, 29. iv. 1961 2648 m, Bomdila Pass, 8 nymphs, 7. iv. 1961 (*K. C. Jayaramakrishnan*), Bomdila, 2 males (one specimen yellow), 6 females, 10 nymphs, 22. iv. 1966, 2621 m, Tawang, 2 males (one specimen yellow), 28. iv. 1966, 3200 m (*A.N.T. Joseph*); West Bengal : Sandakphu, 55 males, 66 females, 19. vi. 1974, 3600 m, understones (*R.K. Ghosh*); Tonglu, 10 females, 16. v. 1975, 3069 m, Rangiroon, on way 3 mile, 3 males, 6. vi. 1975, 1941 m. (*J. K. Jonathan*).

*Distribution*—INDIA, NEPAL, BHUTAN (all along the Himalaya), TIBET, BURMA and CHINA (Szechwan).

*Remarks*—This species varies greatly in size, general colouration and the shape of forceps. Generally the specimens are complete black but sometimes at higher elevations (above 3000 m) brachypterous specimens with orange head are reported (*Brindle, 1974*).

#### ***Forficula bhutanensis* Brindle**

*Forficula schlagintweiti* (Burr) : Hebard, 1923. *Mem. Dept. Agric. India, Ent. Ser.*, 7: 225 ("Forficuloid forceps").

*Forficula bhutanensis* Brindle, 1975, *Ent. Basil.*, 1 : 43 figs. 46-51 (Male, female; Bhutan).

Shining black to dull blackish brown, sometimes a few abdominal tergites testaceous brown and forceps lighter in colour.

*Male* : Pronotum decidedly more transverse than *F. schlagintweiti*. Elytra and wings well developed. Abdomen depressed, enlarged in middle, sparsely punctulate, in some impunctate. Ultimate tergite smooth, transverse. Pygidium short obtuse. Forceps stout, strongly bowed, internally lamellate in basal one fourth, rectangular, with its inner margin crenulate and oblique. In female ultimate tergite narrowed posteriorly, pygidium subvertical, narrowed apically and obtuse.

	Male	Female
Length of body	9-13 mm	8-12.5 mm
Length of forceps	3-4 mm	2.5-3.2 mm

*Material examined*—India : West Bengal : Darjeeling Dist., Sandakphu, 3 males, 17 females, 19. iv. 1974, 3600 m, understones (*R.K. Ghosh*); Tonglu, 6 males, 3 females and, nymph, 14-16. v. 1975, 3669 m (*J.K. Jonathan*).

*Distribution*—INDIA (W.B. : Darjeeling dist.) and BHUTAN.

*Remarks*—This species resembles closely *F. schlagintweiti* but can be easily separated in having the pronotum more transverse and the

inner basal lamellation of forceps rectangular and crenulate internally. The specimens with weaker form of forceps recall *F. planicollis* but the latter has weakly transverse pronotum and abdomen is convex, densely punctulate and the crenulations of inner lamellation of forceps are quite distinct.

#### **Forficula beebei Burr**

*Forficula beebei* Burr, 1911, *J. Astatic Soc. Bengal* (N.S), 7 : 795 (male, female; West Bengal, Darjeeling dist., Phallut, 1200').

*Forficula schlagintweiti* : Hebard, 1923, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 225, pl. 20, fig. 21 (Anechuroid forceps).

General colour shining black to brownish black, head often dark brown to clear orange, legs black or clear yellowish brown.

*Male* : Head transverse, smooth. Pronotum transverse, hind margin convex. Elytra normal, wings generally wanting but sometimes present also. Abdomen gently widened in middle, punctation fine and sparse, often obscure. Pygidium declivient, narrowed apically, hind angles projecting and margin faintly convex provided with minute point. Forceps with branches remote at base, gently dilated at base, afterwards gradually tapering and gently curved, at base above with a low tubercle often poorly developed, internal margin in basal half with crenations. Genitalia with parameres broader at base, apex obtusely pointed; virga long and narrow.

In female ultimate tergite narrowed posteriorly; pygidium sloping, convex above and triangular hind margin with small tubercles in middle and on angles as well.

	Male	Female
Length of body	6.5-7.8 mm	6.1-7.5 mm
Length of forceps	2.8-2.9 mm	1.7-2.0 mm

*Material examined*—India : Arunachal Pradesh : Kameng dist., Tsela, 9 males, 12 females and 1 nymph, 25. iv. 1966, 3657 m., Bomdila, 1 male, 22. iv. 1966, 2621 m., Pinjuli, 1 female, 4. v. 1966, 244 m (*A.N.T. Joseph*); West Bengal : Darjeeling Dist., Sandakphu, 1 male (brachypterous), 20. vi. 1974, 3600 m (*R.K. Ghosh*), Tonglu, 1 male (macropterous), 16. v. 1975, 3069 m (*J.K. Jonathan*).

*Distribution*—All along the Himalayas in INDIA, NEPAL and BHUTAN.

*Remarks*—This species is in true sense a high altitude species as it generally occurs above 3000 m in Himalayas. But the record of a single female from Pinjuli at 244 m in Arunachal Pradesh is curious one. Perhaps its occurrence at such a low altitude may not be natural but purely accidental. This can be further explained if we look into the

habitats of these insects. They are generally secretive and conceal themselves in a variety of habitats. One of the most common habitat is under the bark of trees and dead decaying logs. These objects are generally transported from one place to another by human agency and natural means thus resulting in the transportation of these insects as well, often far from their natural abode.

This species shows great variations in general body colouration and the punctuation of abdominal tergites. Therefore, it will not be desirable to place much reliance on the latter while discriminating the various species of the genus *Forficula*.

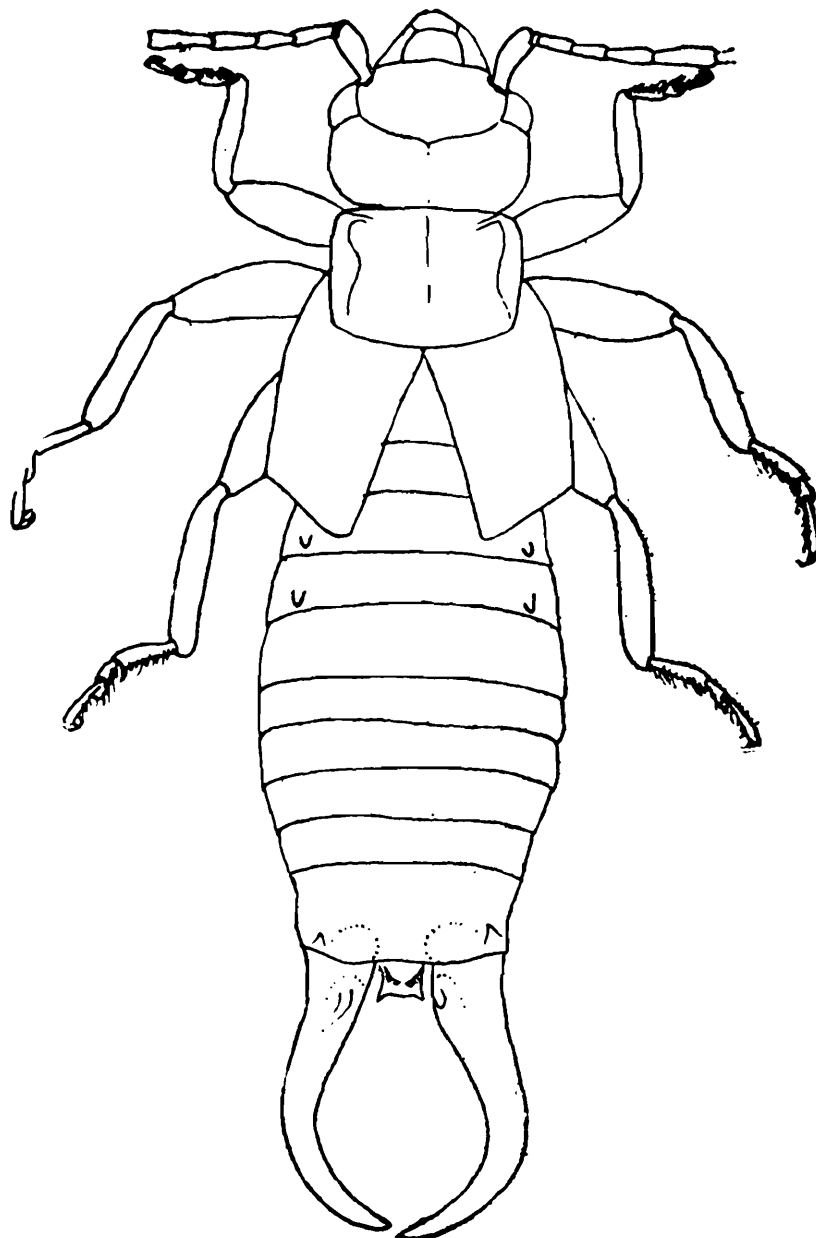


Fig. 15. *Forficula beebei* Burr, ♂ Dorsal view.

#### ***Forficula lucens* Brindle**

*Forficula lucens* Brindle, 1975, *Ent. Basil.*, 1 : 48, figs. 56-57 (male, female; Bhutan).

General colour testaceous to blackish brown, shining; sides of pronotum yellow; antennae dark brown and legs yellow.

*Male*: Pronotum transverse, convex along the hind margin. Elytra abbreviated, wings wanting. Abdomen gently enlarged, a little beyond middle, uniformly punctate, punctures more close on distal tergites. Pygidium short, obtuse. Forceps dilated in a little less than half with internal margin dentate, afterward branches tapering and strongly curved. In female ultimate tergite narrower posteriorly, pygidium sloping backwards, hind margin almost straight with angles a little projecting.

	Male	Female
Length of body	7-8 mm	7-8 mm
Length of forceps	3 mm	1.75 mm

*Distribution*—BHUTAN.

*Remarks*—This species is known by its type series and closely resembles with *F. planicollis* Kirby, but differs in having the elytra abbreviated, wings wanting and the inner lamellation of forceps extending up to a little less than half of its length.

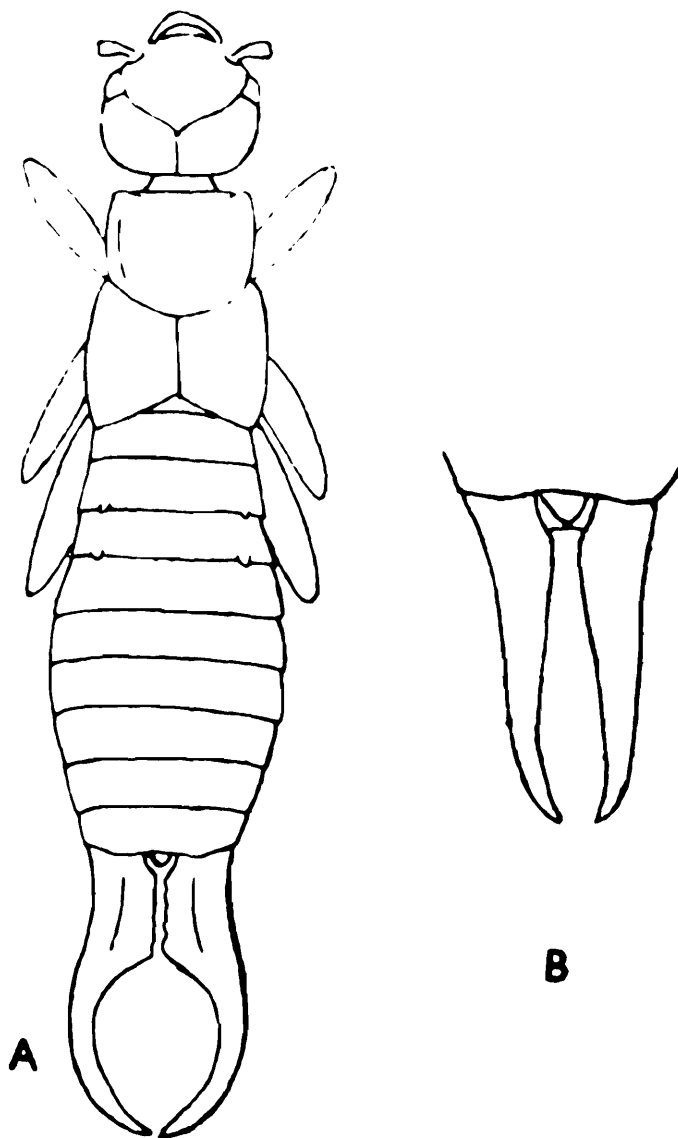


Fig. 16. *Forficula lucens* Brindle, ♂, A. Dorsal view, ♀ B. Ultimate tergite and forceps (redrawn from Brindle, 1975).

***Forficula tawangensis* sp. n.**

*Material examined*—India : N.E.F.A., Kameng dist., Tawang, *Holotype* male, *Allotype* female, *Paratypes* 3 males, 4 females, 10 nymphs, 28. iv. 1966, 3200 m. (*A.N.T. Joseph*); all deposited in the collections of the Zoological Survey of India, Calcutta.

*Description*—*Male* : General colour deep black but in two specimens testaceous black; a few anteapical antennal segments, sides of pronotum, tibiae and tarsi testaceous brown, abdomen and forceps reddish black.

Head longer than broad, convex, sutures faint, hind margin emarginate in middle ; antennae 12-segmented, 3rd longer than 4th but slightly shorter than 5th, remaining long and cylindrical. Pronotum one and half times broader than long, anterior margin straight, sides gently convex, flat, posterior margin broadly rounded, median sulcus faint; prozona weakly raised, little differentiated from flat metazona. Elytra twice as long as pronotum, smooth humeral angles weak, hind margin concave. Wings ample, smooth. Legs long and slender, hind metatarsal segment equal to remaining two; distal part of tibiae and whole of tarsi covered with thick pubescence below. Abdomen convex, punctulate, sides of segments rounded, lateral tubercles on 3rd tergite weakly and on 4th strongly developed. Penultimate sternite broadly rounded posteriorly. Ultimate tergite three times broader than long, declivient, punctation distinct in anterior half only, faintly tumid above the roots of forceps, hind margin trisinate and oblique laterally. Pygidium short, obtuse, with a few thick hairs posteriorly. Forceps stout, concave externally and dilated internally in a little beyond basal half with margin straight, crenulate and terminating into a faint blunt lobe, afterwards branches strongly bowed, cylindrical, tapering with apices pointed. Genitalia as seen in fig. 17, C.

*Female* : Agrees with male in most characters except that the ultimate tergite narrowed posteriorly, strongly sloping and lacking tumid elevations above the bases of forceps ; pygidium subvertical, posteriorly provided with a tubercle in middle and laterally ; forceps simple, straight, tapering with apices pointed and gently incurved, faintly crenulate internally.

*Measurements.*

	Holotype	Allotype	Paratypes	
	Male	Female	Males	Females
Length of body	12.8 mm	13.5 mm	12.4-12.6 mm	12.1-13.3 mm
Length of forceps	4.6 mm	3.2 mm	3.7-4.7 mm	3.6-3.9 mm

*Distribution*—INDIA : ARUNACHAL PRADESH.

*Remarks*—This species comes close to *Forficula kambaitiensis* Hincks, known from Burma but differs in having the pronotum feebly convex on sides and broadly rounded posteriorly; the elytra and wings well developed, former with weak humeral angles and the lamellation of forceps extending upto a little beyond basal half.

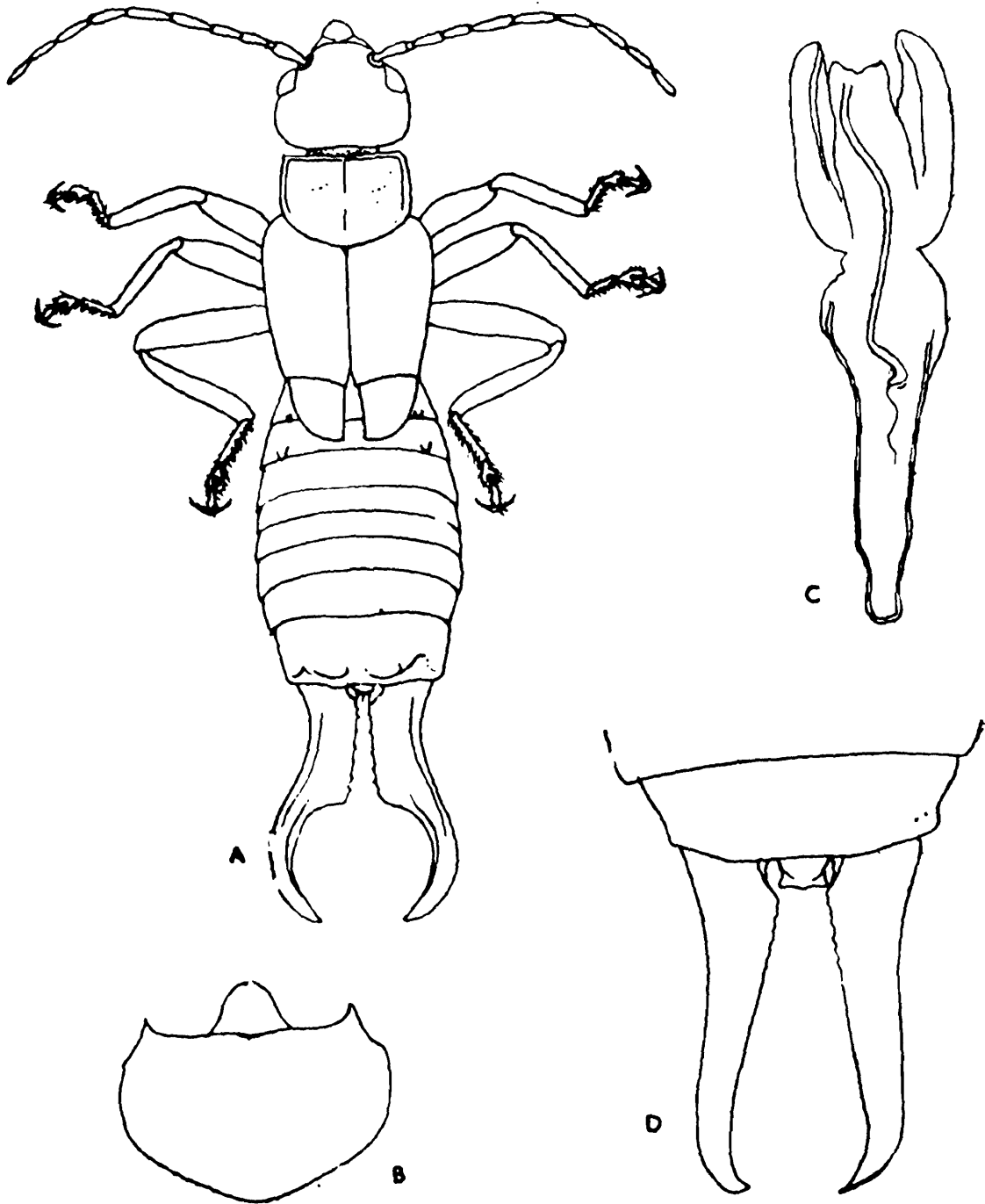


Fig. 17. *Forficula rawangensis* sp. n., Holotype ♂, A. Dorsal view, B. Penultimate sternite, C. Genitalia ; ♀, D. Ultimate tergite and forceps.

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## HIGH ALTITUDE EPHEMEROPTERA OF INDIA

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### INTRODUCTION

Our knowledge of High Altitude Ephemeroptera of India is not very comprehensive. It is comprised of 31 species under 15 genera and 7 families vis-a-vis 87 species under 33 genera and 12 families known from India, which is about  $\frac{1}{3}$  of the known Ephemeroptera fauna of India. Contributions of Eaton (1833-1888), Traver (1939), Kapur and Kriplani (1963), Dubey (1970, 71) and Kaul and Dubey, (1970, 71) have added towards high altitude Ephemeroptera of India.

A family-wise account of High altitude ephemeropterans along-with salient diagnostic features of imago and larvae have been dealt. Effect of high altitude on ephemeropterans has also been discussed.

### OBSERVATIONS

Ephemeroptera fauna of India from high altitude is approximately  $\frac{1}{3}$  of known Indian ephemeropterans being 31 : 87. Most of these species occur in the range of 3000-4000 metres. A few though found in transitory altitude of 2000-3000 metres are also included in present consideration as they do belong to torrential streams of Himalayan Mountain range. There is but a single record of these insects, viz. *Ororotsia hutchinsoni* Traver (Family Heptageniidae) occurring beyond an altitude of 4000 metres.

7 families under which high altitude Ephemeroptera occur are Baetidae (15 species under 3 genera), Heptageniidae (8 species under 6 genera), Leptophlebiidae (2 species under 2 genera), Ephemerellidae (2 species under 1 genus), Ephemeridae (2 species under 1 genus), Caenidae (single species) and Siphonuridae (single species). Baetidae is thus single largest family species-wise though Heptageniidae has got maximum genera. These two taken together constitute bulk of high altitude Ephemeroptera which comes to about three fourths (23 : 8).

### Family BAETIDAE

*Salient diagnostic features* : *Imago* : Mayflies of very diverse size. Hind wing very much reduced or totally eliminated with great reduction of wing venation. Eyes of males often divided into two aspects dorsal turban shaped lobe and ventral relatively smaller lobe. Hind tarsi with 3 or 4 movable joints. Some of those having 5 tarsal joints, the basal one is immovably joined with tibia.

TABLE I

High Aititude Baetidae	Particulars of locality	Altitude	Remarks
<b>Genus Baetiella Ueno</b>			
1. <i>B. ladakae</i> Traver, 1939	Igu Ladak, J.K., N.W. Himalaya.	3522 m	<i>Ann. Mag. nat. Hist.</i> (11), 4 :50. ♂ Imago,
<b>Genus Baetis Leach</b>			
2. <i>B. acuticostalis</i> Dubey, 1971	River Solang, H.P. N.W.H.	2800 m	<i>Oriental Ins.</i> , 5 : 533. ♂ and ♀ Imago.
3. <i>B. bifurcatus</i> Kapur & Kriplani 1963	Ralha, Kulu Valley, H.P., N.W.H.	3048-3358 m	<i>Rec. Indian Mus.</i> , 59 : 196 ♂ Imago
4. <i>B. chandra</i> Kapur & Kriplani 1963	Chhatoru, Lahul Spiti Valley H.P., N.W.H.	2743-3658 m	<i>Rec. Indian Mus.</i> , 59 : 189 ♂, ♀ Subimago Nymph
5. <i>B. festivus</i> K. & K. 1963	South of Ralha, Kulu Valley, H.P., N.W.H.	3048-3258 m	<i>Rec. Indian Mus.</i> , 59 : 197. ♀ Imago
6. <i>B. himalya</i> K.K. 1963	Sissu, Lahul Valley, H.P., N.W.H.	3200 m	<i>Rec. Indian Mus.</i> , 59 : 194 ♂, ♀ Imago
7. <i>B. lahulensis</i> Kaul & Dubey 1970	Gramphu, H.P., N.W.H.	3507 m	<i>Oriental Ins.</i> , 4 : 147 ♂, ♀ nymph
8. <i>B. longistylus</i> Kaul & Dubey 1974	Gramphu, H.P., N.W.H.	3057 m	<i>Oriental Ins.</i> , 4 : 143 ♂, ♀ Imago
9. <i>B. punjabensis</i> K. & K. 1963.	South of Ralha, Kulu Valley, H.P., N.W.H.	3048-3358 m	<i>Rec. Indian Mus.</i> , 59 : 192 ♀ Imago
10. <i>B. septemmenes</i> Dubey, 1970	Slope of Pir Panjal range, H.P., N.W.H.	2800 m	<i>Oriental Ins.</i> , 5 : 537 ♂ Imago
11. <i>B. seragrui</i> Dubey, 1970	Seragru Icefall Kukinew, N.W.H.	3600 m	<i>Oriental Ins.</i> , 4 : 299 ♂ Imago
12. <i>B. simplex</i> K. & K. 1963	Kothi, Kulu Valley, H.P., N.W.H.	2438 m	<i>Rec. Indian Mus.</i> , 59 : 191, 206 ♀ Imago, Nymph
13. <i>B. solangensis</i> Dubey 1971	River Solang, Southern slope of Pir Panjal range, H P. N.W.H.	2800 m	<i>Oriental Ins.</i> , 5 : 537 ♂ Imago
<b>Genus Cloeon Leach</b>			
14. <i>Cloeon inscriptum</i> Bengtsson 1914	Nurba Valley, Srinagar. J. K.. N.W.H.	1893 m	<i>Ent. Tidskr.</i> , 35 : 215. ♂, ♀ nymph
15. <i>C. kashmiri</i> Traner, 1939	Srinagar & Shadipur, J.K. N.W.H.	1893 m	<i>Ann. Mag. nat. Hist.</i> , (11) 4 : ♂, ♀ Imago

*Nymphs* : Nymphs are mostly spindle shaped, stream lined body which enables them to steer through pebbles, rocks etc. near the shore and provided with clawed hook for proper hold. 7 paired abdominal gills and cerci beset with lot of hair to give them shape and function of swimming organ.

*Remarks* : High altitude Baetid Ephemeroptera in India are represented by 15 species under 3 genera, *Baetiella* Ueno, *Baetis* Leach and *Cloeon* Leach and have been reported to occur at an altitude of 2400-3500 metres in North West Himalaya but majority of these species (13 : 2 occur in range of 3000-3500 metres. Species-wise this is single largest predominantly occurring family among high altitude Ephemeroptera and occur in about 50% (15 : 16). Of these the genus *Baetis* is single largest representative with 12 species.

A list of high altitude species representing Baetidae is indicated in Table I along with their particulars.

#### Family HEPTAGENIIDAE

*Salient diagnostic features* : *Imago* : Mayflies of variable size wing ranging between 5-15 mm. Eyes of male simple and may vary in their size in different genera. Both wings present. Venation relatively more. Two parallel pairs of cubital, intercalaries not attached at base. Outer fork of Rs in hind wing present. Forceps in male 4 jointed.

*Nymphs* : Nymphs are sprawling type with protective colouration. Bodies more or less dorsoventrally depressed head more so. Eyes lateral in position. Gills are present on segments 1-7 of the abdomen. Each pair consists of a dorsal lamellate and ventral fibrillar portion.

*Remarks* : High altitude Heptageniidae in India is represented by 8 species under 6 genera. Species-wise this is the second largest family among high altitude Ephemeroptera though genera-wise it overwhelms other and has been reported occurring between 1900 m to 5297 m in North West Himalaya. Incidentally *Ororotsia hutchinsoni* Traver under this family is found at an highest altitude of 5297 m and that too in freshwater lake a lentic water body.

TABLE II

High altitude Heptageniidae	Particulars of locality	Altitude	Ramarks
<b>Genus Afronurus Lestage</b>			
1. <i>A. curtus</i> Dubey, 1971	Right bank of River Solang, Southern slope of Pir Panjal range H. P., N. W. H.	2900 m	<i>Oriental Ins.</i> , 5: 547. ♀ Imago
2. <i>A. solangensis</i> Dubey, 1971	-do-	2800 m	<i>Oriental Ins.</i> 5 : 545, ♀ Imago

High altitude Heptageniidae	Particulars of locality	Altitude	Remarks
3. <i>E. bengalensis</i> Ulmer, 1970	Darjeeling, W. B., Eastern Himalaya	2178 m	<i>Arch. Naturges- ch.,(A) 85 (11) :</i> 75, ♂, ♀ Imago
<b>Genus Epeorus Eaton</b>			
4. <i>Epeorus (E.) lahulensis</i> Kapur and Kriplani, 1963	Sissu, Lahul Valley, N. W. H.	3200 m	<i>Rec. Indian Mus., 59 : 199,</i> ♂ Imago
5. <i>Epeorus (E.) psi</i> Eaton, 1885	"Kooloo" Valley (= Kulu), H. P., N. W. H.	2743 m	<i>Trans. Linn. Soc. Lond. (Ser.2) Zool., 3 : 242</i> ♂, ♀ Imago.
<b>Genus Heptagenia Walsch</b>			
6. <i>H. solungensis</i> Dubey, 1971	River Solang, Pir Panjal Range, N. W. H.	2800 m	<i>Oriental Ins., 5 : 541, ♂, ♀</i> Imago.
<b>Genus Ororotsia Traver</b>			
7. <i>O. hutchinsoni</i> Traver, 1939	Ororotse Tso (Fresh Water lake highest in the area) N. W. H.	5297 m	<i>Ann. Mag. nat Hist., (11) 4 :</i> 33, ♀ nymph.
<b>Genus Ichthybotus Eaton</b>			
8. <i>P. dolcus</i> Dubey, 1971	Southern slope of Pir Panjal range, N. W. H.	1900 m	<i>Oriental Ins., 5 : 521, ♂ ♀</i> Imago.

#### Family LEPTOPHLEBIIDAE

*Salient diagnostic features : Imago :* Small mayflies with long tails and well preserved cross veins in forewings. The costal cross veins of the fore wing are well preserved in the stigmatic area. In both wings a line of cross veins joins the principal forks and in the hind wing there is no other cross vein. The costal angle of hind wing is prominently rounded at the top. Forceps 3 jointed.

*Nymph :* Gills of nymph are lanceolate, widest on segments 1-2. Spinules are present on the apical margin of abdominal tergites 1-10.

*Remarks :* High altitude Leptophlebiidae in India is represented by 2 genera each with one species and both reported occurring in north west Himalaya between 2900-3880 m. A list of Indian high altitude Leptaphlebiidae is given below along with their particulars.

TABLE III

High altitude Leptophlebiide	Particulars of locality	Altitude	Remarks
<b>Genus Atalophlebia Eaton</b>			
1. <i>A. chialhnia</i> Dubey, 1971	R. Alhni, H. P., N. W. H.	3200 m	<i>Oriental Ins.</i> , 5 531 ♀ Imago.
<b>Genus Thraulodes Eaton</b>			
2. <i>I. Marhiens</i> Dubey, 1970	R. Alhni, H. P., N. W. H.	3880 m	<i>Oriental Ins.</i> , 4 : 302, ♀ Imago
<b>Genus Paraleptophlebia Lestage</b>			
* <i>Paraleptophlebia</i> sp. in Kapur & Kriplani 1963	Kothi and Ralha, Kulu Valley, H. P., N. W. H.	2438- 2743 m	<i>Rec. Indian Mus.</i> , 59 : 201-20, Nymph.
*Not included in family or generic count as only upto generic level)			

## Family EPHEMERELLIDAE

*Salient diagnostic features : Imago :* Small to moderate sized mayflies. Eyes of male divided into small basal and large distal portion, two eyes closely approximated dorsally. Eyes of female not divided, small located on lateral side of head. Vein  $Cu_2$  strongly angulate before mid point. Hind wing developed, with a slight rounded costal elevation near the base. Median vein of hind wing forked slightly less than half between base and margin. Forceps 3 jointed. *Nymphs* of genus variable sprawling with broad femora, beset with spines and or tubercles.

*Remarks :* High altitude Ephemerellidae in India is represented by a single genus *Ephemerella* Walsch and following two species This also constitutes one of the fringe Ephemeroptera from high altitude point of view but are also included in present consideration as they do inhabit Himalayan water bodies.

TABLE IV

High altitude Ephemerellidae	Particulars of locality	Altitude	Remarks
<b>Genus Ephemerella Walsch</b> <b>Subgenus Druella Needham</b>			
1. <i>Ephemerella (Druella)</i> <i>traverae</i> Allen & Edmund, 1963	East of Nurla. Kashmir, J.K., N. W. H.	1893 m	<i>Pacific Ins.</i> , 5 : 20, Nymph
2. <i>Ephemerella indica</i> K. & K. 1963,	Ralha Kulu valley, N. W. Himalaya.	2743 m	<i>Rec. Indian Mus.</i> , 59, 186, ♀ Imago

## Family EPHEMERIDAE

*Salient diagnostic features : Imago :* Mayflies of moderate size. Wing 10-15 mm in length with dark spots. Fore wing cross veins at and below bulla tend to be distinctly crowded. In hind wing  $M_2$  is often detached from  $M_1$  and directed downwards towards Cu. Eyes in male small separated apically by a distance which is at least as great as diameter of one eye. Forceps 4 jointed.

*Nymphs :* Nymphs fossorial. Frontal process of nymph bifid. Mandibular, tusk present slender, divergent at tips. Maxillary palp 3 jointed, slender, jointed, quite long. Gills dorsal in position.

*Remarks :* High altitude Ephemeridae in India is also represented by a single genus *Ephemera* Linnaeus, as in previous family, and under it following two species are recorded.

TABLE V

High altitude Ephemeridae	Particulars of locality	Altitude	Remarks
<b>Genus Ephemera Linnaeus</b>			
<b>Subgenus Ephemera Linnaeus</b>			
1. <i>Ephemera (Ephemera) consors</i> Eaton, 1892	Kulu, N.W.H.; Sikkim, E. H.	2743 m	<i>J.R. Asiatic Soc. Beng.</i> , 60 : 412, ♂, ♀ Imago
2. <i>Ephemera (Ephemera) remensa</i> Eaton, 1892	Kulu Valley, H. P., Mussorie, U. P., N. W. H.	2005- 2743 m	<i>J. R. Asiatic Soc. Beng.</i> , 60 : 410, ♂, ♀ Imago

## Family CAENIDAE

*Salient diagnostic features : Imago :* Small mayflies with 2-5 mm wing, male and female of more or less similar colour. Posterior margin of head almost straight. Pronotum deeply excavated posteriorly in median area. Posterior branch of media in fore wing, and the long intercalary between the two branches of this vein as long as anterior branch and extending up to the base of the wing. Cross veins of wings arranged singly. Tails three, relatively long in male. Forceps base entire its apical margin slightly convex.

*Nymph :* Head and pronotum of nymph narrower than mesonotum. A well developed filamentous gill rudiment on segment 1. Gill on abdomen 2 operculate, single, large quadrate with its outer angles, somewhat rounded. Gills of 3-6 single, deeply fimbriate on outer 2/3 of its margin.

*Remarks* : High altitude Caenidae Ephemeroptera in India is represented by a single species *Caenis srinagari* Traver, 1939 at an altitude of 1900 m from Gabirial, Srinagar, J. & K. amongst N.W Himalaya. (*Ann. Mag. nat. Hist.* (11) 4 : 48. ♂, ♀ Imago). This constitutes one of the fringe Ephemeroptera from high altitude point of view but are included here as they inhabit Himalayan torrents. The genus in India as such is represented by other four species besides the one mentioned above.

#### Family SIPHLONURIDAE

*Salient diagnostic features : Imago* : Medium sized mayflies, male and female of more or less similar colour, eyes of males large, not divided into lobes and usually contiguous. Forewing relatively long and narrow about 3 times as long as wide. Hind wing well developed with its costal angulation. Venation typically dark. Stigmatic cross veins usually forked and anastomosed. Median vein of the hind wing is forked near the base.

*Nymphs* : Nymphs having stream lined body. Gills simple, small and oval.

*Remarks* : High altitude Siphonuridae in India is represented by a single species *Ameletus primitivus* Traver, 1939 at an altitude of about 3000 m in Kayam in N. W. Himalaya (*Ann. Mag. nat. Hist.* (11), 4 : 43, ♀, nymph). The genus is represented in India only by above species.

#### EFFECT OF HIGH ALTITUDE ON EPHEMEROPTERANS

Members of order Ephemeroptera, have predominantly larger part of their life cycle spent in water as different instars of larvae (nymph) and very small insignificant portion spent in air as subimago and imago. Adult life is so short that it remains to function only for copulation and egg-laying. Due to fact of total dependence on water for major portion of their life these are considered part of insect community which have colonized aquatic ecosystem. It has to be kept in mind, therefore, that while considering effect of high altitude the effect of their aquatic abode must also be taken into account.

Kapur (1956) has discussed certain aspects of High altitude on Ephemeroptera alongwith other high altitude insect communities. Mani (1962) analysed in detail various factors of high altitude ecology and their effect on Insects including ephemeropterans. Dubey and Kaul (1971) have also made certain observations on the ecology and character of insect communities of the river Alhni a typical torrential stream of glacial origin in the North West Himalaya.

Effect of high altitude on subimago and Imago of Ephemeroptera, which are very short lived, is not very much pronounced specially as compared to their aquatic nymph. Factors include reduced atmospheric pressure, atmospheric cold, atmospheric aridity, high wind velocity, light, snow cover, biotic factors etc.

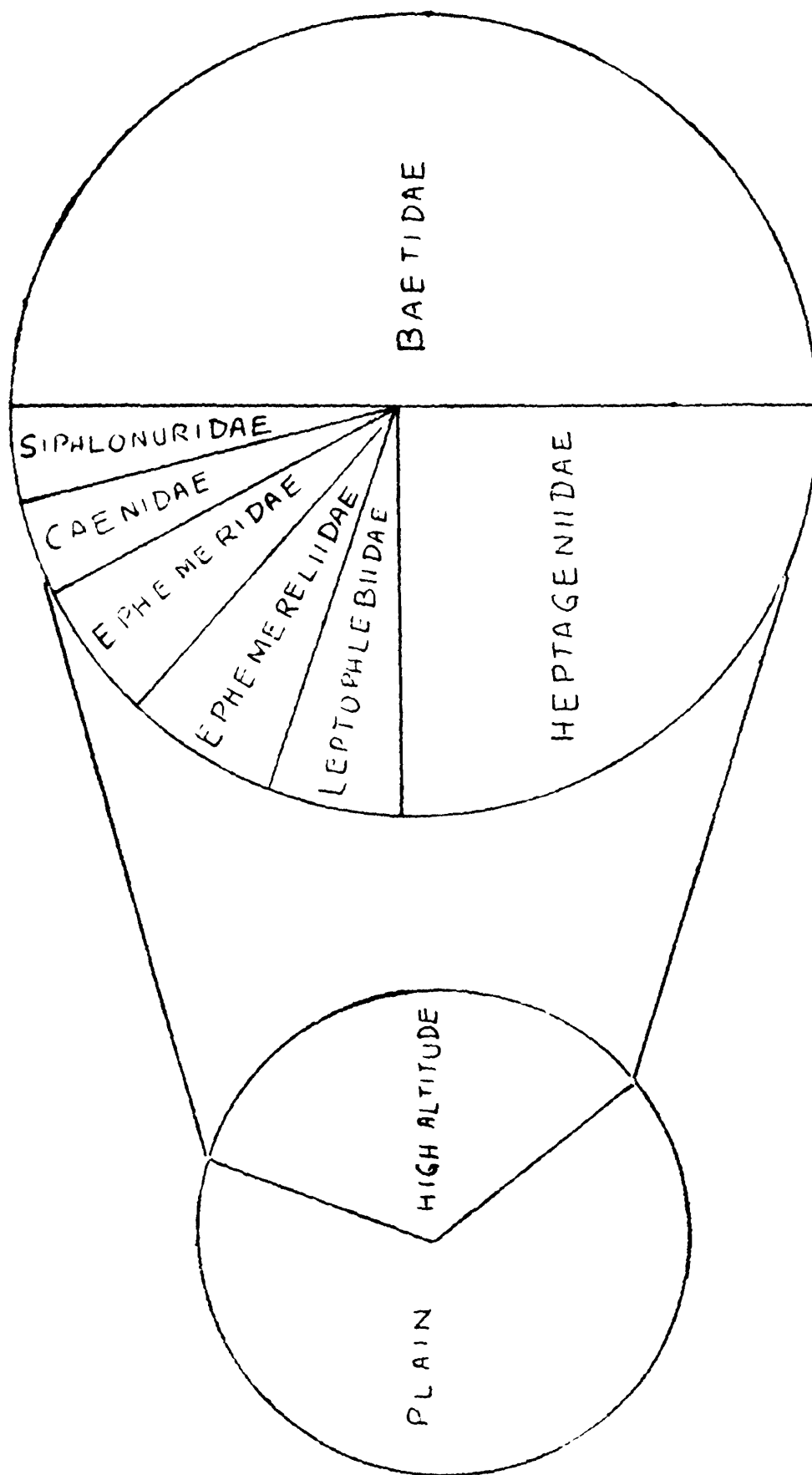
Effect of these factors include certain major trends in specializations. Some of these are high altitude melanism, reduction and loss of wings, reduction in average size of the body, increase in number of variety and aggregation at certain points of favourable conditions. These are not so well pronounced in adult stage, for reasons stated earlier. Adults of ephemeropterans are known to commonly visit surface of rock or on to the snow but these are only casual visitors and or neither true rock or snow communities member. Emergent vegetation and pebbles in littoral zone or nearby shore are very commonly utilized for resting by adults specially subimagos. Of the high altitude ephemeropterans *Baetis* are predominantly represented probably due to their small size and reduction of wing much so as to completely lose hind wing.

Aquatic stages of Ephemeroptera, the various instars of nymph, have more adaptive features in them than adults. Three types of communities are known namely communities of melt water streams (lotic water body), ponds and lake communities (lentic water body) and thermal and chemical springs. Former two are colonized by ephemeropteran nymphs in order of preference of community mentioned but the last one is not known to be colonized by ephemeropterans.

Various adaptations acquired by aquatic stages of ephemeropterans will be discussed below. These are very well adapted to torrential current due to steep gradient effect of altitude.

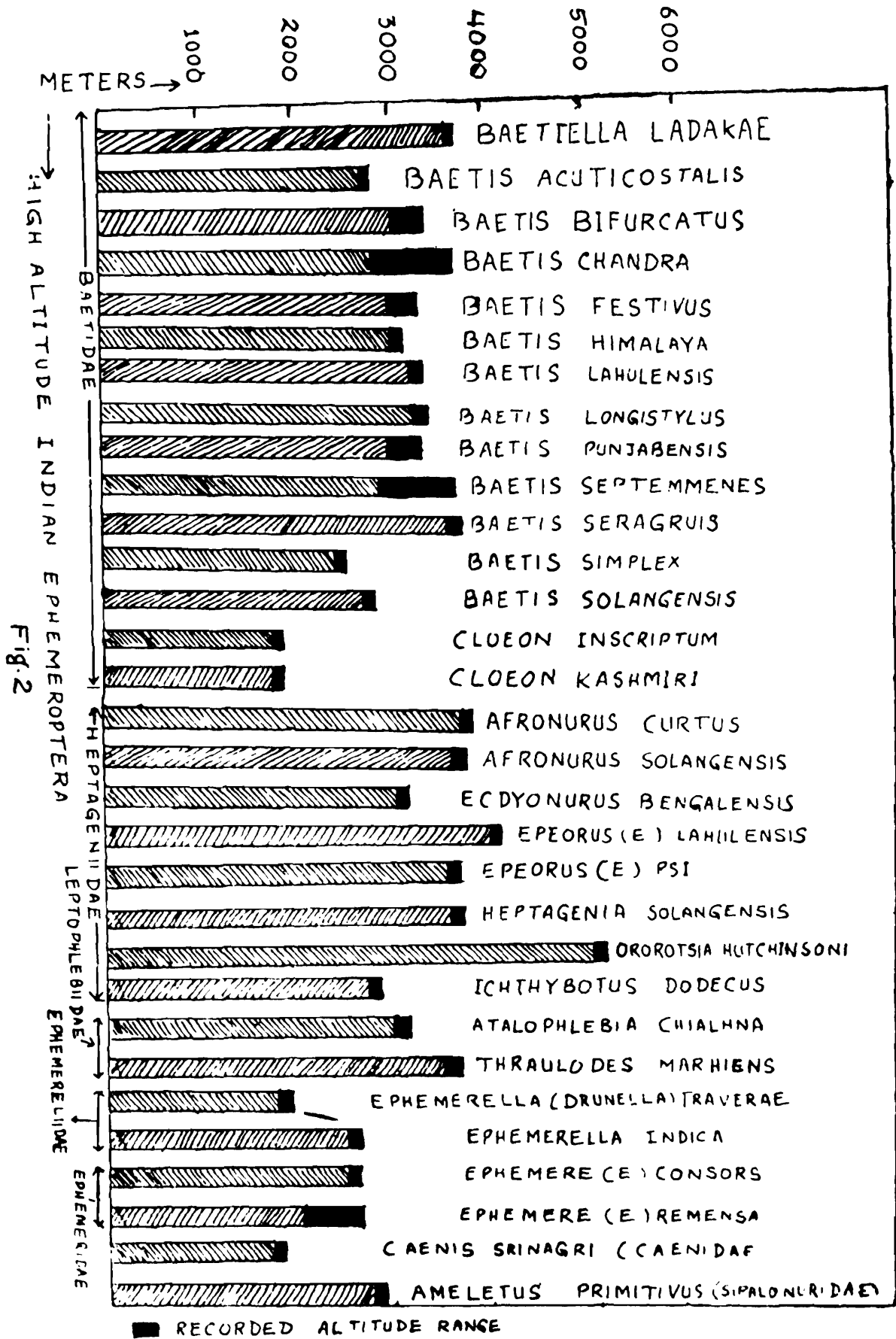
They are well adapted to torrential current of a river or a stream and rather less represented in placid water of a pond or streams. These they do by not only adapting themselves to withstand but also utilizing the current in their favour for food, better and easier supply of dissolved oxygen and removal of carbon dioxide from the vicinity of the individual. The last two have to be achieved in lentic forms by vigorous movements of gills which are relatively better developed. Temperature of a water body is higher and congenial in water media than otherwise at an high altitude. As regards food it is in plenty, firstly they depend on rich algal slime on submerged stones and current brings also abundant food particles of organic matter.

The force of current is countered by adapting to streamlined bodies alongwith elongated legs and claws adapted for clinging. In placid water body, where there is no force of water, such streamlined forms take to active swimming helped by oar like action of



INDIAN EPHEMEROPTERA - PLAIN : HIGH ALTITUDE

FIG. 1



three, ciliated caudal filaments. Against the force of water in lotic water bodies such larvae are helped by the shape of body to face minimum force and coupled with anchoring legs and claws they remain attached to moss or rocks as periphyton. Hora (1930) reported some *Baetis* members to effectively anchor to rock even in vicinity of falls. *Baetis* alongwith *Ameletus* and *Baetiella* are good examples of such nymphs among high altitude forms in India.

Another set of nymphs have adapted themselves to avoid the force of current by not having spindle shaped body as in previous case but dorsoventrally flattened body and clinging posture to rock, like limpets. Members of family Heptageniidae and representing genera *Heptagenia*, *Ecdyonurus*, *Epeorus*, *Ironopsis* are examples of such adaptation amongst high altitude ephmeropterans of India. In such forms the dorsal profile is arched gently in stream lines and ventral surface is flat. This body shape is helped by organs of attachment formed by modified gill lamellae. Legs are robust, flattened and claws are powerful and these together also help in maintaining hold. The anal cerci are well developed and in some species these are utilized for increasing friction.

Next category of torrent inhabiting nymphs are those which take abode on the bottom burrowing in sand sediments etc. are under stones. Amongst high altitude forms in India members of *Ephemerella* and *Ephemera* belong to this category.

*Ephemerella* live under stones in torrents or even amongst trash which gets accumulated at bottom against an obstruction. Body is depressed with flat ventral surface. The femora of fore legs are flattened with tubercles on dorsal aspect, tibia, tarsus slender, claws are strong and sparsely denticulated. Lateral edges of abdomen are pectinated with backwardly directed spines. Since they lie at bottom under stones or amongst trash force of torrent is almost nil. Morphology of these nymphs is well adapted to such ecological niches.

*Ephemera* with slender body, protruded mandibles and forwardly directed fore leg are well adapted to burrow at bottom sand, sediments. This way they also avoid current and competition from inhabitants of former type.

After having seen Ephemeroptera in relation to torrential streams and rivers at a high altitude we may now look them in relation to placid water bodies like lakes and ponds. Water temperature in such body is subjected to fluctuations compared to streams which is not only due to lack of currents but also size and depth of water body. Dissolved oxygen is also relatively much less than former type of water body. Ephemeroptera are thus much less represented in such water

bodies, both quantitatively and qualitatively. Among high altitude Ephemeroptera in India bulk of them are represented in lotic system with but a few exceptions for those from lentic ecosystems.

#### SUMMARY

The salient points discussed are that Indian high altitude Ephemeroptera are represented by 31 species, 15 genera and 7 families which is about 1/3 of known ephemeropterans in India. *Baetidae* is single largest family with 15 species representing about 50% of high altitude Ephemeroptera. Normally they have been recorded occurring in range of 3000-4000 m but for one species ranging upto an altitude of 5297 m. Most of them are represented from North West Himalaya. Nymphs of these are mostly represented in lotic type of water bodies and relatively much less in lentic water body. Salient features of each family and effect of high altitude on these insects are also discussed.

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## RECORD OF MITES AND THEIR RELATIONSHIP WITH THE FOREST HABITATS IN THE KASHMIR VALLEY (J&K STATE)

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### INTRODUCTION

Acari are known to inhabit all kinds of habitats available to animal life and thorough knowledge of the varied habitats of mites and the exact niches which these exploit needs to be understood. Although mite fauna associated with animals, agroecosystem, soil and water have been fully explored. It is believed that aerial parts of vascular higher plants, low lying or tall trees also harbour quite a few groups of mites. Forest ecosystem provides a favourable protective habitat for a number of mite species which associate with the foliage, bark, litter and soil, but hardly any work has been reported in this direction from Asia or India.

Knot (1965) reported *Abrolophus batotensis*, Battacharyya (1969) recorded six species of Mesostigmata mites associated with bark from North East region and Gai (1973) collected predatory mite species *Agistemus* and *Anystus* and *Bryobia eharei* P & K on *Chrysanthemum* from Delhi. Chant (1960) and Lindquist (1968,69) also reported some species from India and Kashmir. But the work is fragmentary and far between. The valley of Kashmir because of geophysical location is between the subtropical or temperate region of Asia at latitude 32. 17°-34. 58° The latitudinal relation and climatic variations therefore provide a unique habitat to a diverse acarine fauna associated with coniferous forest ecosystem and their community function with regard to food requirements, and to locate the niches therein, for evaluation of practical aspect of the problem, were therefore carried out.

### RESULTS AND DISCUSSION

The forest floor has a great variety of habitats occupied by an abundant and diverse arthropod fauna. Among which larger free living insects carabids, scarabaeid and scolytid beetles predominate. These serve as hosts for great variety of mites. Inner bark and phloem of unhealthy trees provide habitats for a variety of bark beetles viz., *Scolytus deodara*, *Ips longifolia*, *Tomicus longifolia*, *Cryphalus boswelliae*, *Dendroctonus cedrus* and *Polygraphus* species with which

*Iponemus asiaticus* Chant, *I. gaebleri himalayensis*, *I. balsameus*, *Digamasellus quadrisetus* (Berl.) and species of *Tarsonemus*, *Lasioseius* were mostly seen to remain as symbionts. These acari species were habit specific and were found to be associated with a variety of unrelated scolytids at egg, larval and pupal stages. These mites act as sanitizer in the galleries by feeding on fungal excrements.

Acari directly associated with conifers and broad leaved forest tree associates recorded are, *Eriophyes wallichiana* on needles of *Pinus wallichiana* and *Pinus excelcea* at 9000 ft. and with *Ulmus wallichiana* at 5500 ft. The infestation noticed as beaded pustules projecting down the under surface of the infested leaves. Species of *Trisetacus*, *Epitrimerus* and *Brevipalpus* were observed in large number under the sheaths and at the base of the foliage of *Abies pindrow*, *Nalephella* nr. *halourga* Keifer on spruce, while *Trisetacus quadrisetus* (Thomas) is widely distributed in forest habitats between 5500-7500 ft. *Aceria* sp. and *Bryobia eharei* were recorded on *Polygonium*, *Artemisia* and *Chrysanthemum* which grow adjacent to edges of hill streams. *Salix* species are grown as common plantation plants for willow works and cricket batwood in the valley, are infested with *Aculops* species, *Eriophys insidiosus* with *Typhlodroma mountanus*, *T. finlandicus* and *Amblyseius borealis* as parasitic mites, while *Schizotetranychus schizopus* is host specific on *Salix alba* and *Phytoseius macropilis* (Banks) on *Populus alba*. *Garmania urticana* Nesbitt is highly associated at all habitats with *Urtica dioica*. Poplars, wild roses, *Celtis australis* and *Ulmus* become infested with *Tetranychus urticae* and *T. tilias*. *Phytocoptes* sp. is host specific to *Rosa webbiana*. These feed either as saprophagous (Macrophytophagous) on dead and decaying tissues of these plants or as microphytophagous on the microflora which subsist on such decaying plant matter

Wood boring or xylem penetrating xylophagous insects or mites provide another set of habitats to which mites are adapted. These are found on insects *Acolesthes sarta*, *Oryctes nasicornis* whose larvae are mostly infested by *Hoploseius* species both in the range and agroecosystem. Animal grazing pastures and grass lands and high altitudes have Tarsonemid mites, *Bakardania arvorum*, *B. kashmirensis*. *Phygmospus indicus*, *Scutacarus himalayensis*, *S. quadrangularis* and *Imparipes minor* (Scutacaridae) are the commonest species which coexist with forest litter, moss and soil substrata. The predatory mites viz., *Phytoseius macropilis* (Bank), *Agistemus* and *Abrolophus batotensis* are widely distributed under the forest habitats. Tetranychidae and Tenuipalpidae are dominating families in the forest habitat because of their structural adaptations, correlated with phytophagy. They show less host specificity in the

forest habitat. Cryptostigmata mostly lie on forest floor and produce faecal pellets consisting of finely shredded woody tissues. Some skeletonize decaying leaves or burrow into conifer needles in forest litter, while some prefer decomposing outer sheaths of roots. They therefore play an important part of the natural biota that disposes biodegradable products. Eriophyids are the most highly adapted in the forest protected niches. They are highly host specific which limit their niche exploitations and promote rapid speciation. Bark beetles provide a unique set of control problems to forests. Their chemical control is too expensive and hazardous to forest ecosystem. Therefore the mite species associated with various forest habitats become better known systematically and ecologically. They will have great potential and environmental impact studies as biological indicators of qualitative and quantitative organic changes in the various habitats of the valley.

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## LEPIDOPTEROUS INSECTS INFESTING APPLE IN HIMACHAL PRADESH

By

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### INTRODUCTION

In recent years, with the intensification of apple cultivation there is a considerable increase in insect pests on apple. Among Lepidoptera alone more than twenty insects were recorded on apple in Himachal Pradesh (Bhalla and Pawar 1977; Anonymous, 1978). Keeping in view the importance of new lepidopterous pests, the larvae that were found feeding on apple (stem, bark, foliage, buds, flowers and fruits) during 1976-78 were reared in the laboratory to get authenticated adults for identification. Larval population of different insect species was recorded every week from ten randomly selected apple trees. This intensity of insect population was rated as severe, moderate, low and scanty (sparse). The active feeding stage of the insect was recorded as the time of incidence.

### OBSERVATIONS

Out of eighty four species of Lepidoptera found feeding on apple at the Regional Fruit Research Station, Mashobra, Simla (2000 m.a.s.l.) the species as given in Table I were determined on the basis of reared adults.

From Table I, it is revealed that most of the insects are, at present, the casual feeders on apple but with the intensification of apple cultivation and deforestation, many of them may permanently shift to apple. The attack of hairy caterpillars, *Porthesia (Euproctis) scintillans* (Walker) and *Varmina indica* Walker has increased during May-June, 1978 as compared to their incidence during the previous years. A brown hairy caterpillar, *Moma champa* Moore which was found to be a casual feeder on apple in 1976, caused considerable defoliation two years later. Among geometrids, green looper, *Bapta myrtilata* Guenee was found to be more common than other loopers feeding on apple foliage. So far one species of butterflies could be seen damaging apple foliage.

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TABLE I. Incidence and intensity of lepidopterous insects on apple.

Name of the insect	Plant part	Incidence	Intensity <sup>a</sup>	Reference
<b>I. LASIOCAMPIDAE</b>				
1. Lappet moth, <i>Paralebeda flagifera</i> Walker	Leaves	April-May	+	Chander (1977 a)
2. Blue spotted grey hairy caterpillar, <i>Trabala visluou</i> (Lefebvre)	Leaves	June-August	+	Bhalla & Pawar (1977)
3. Tent hairy caterpillar, <i>Malacosoma indica</i> Walker	Leaves	April-May	+	Sharma & Bhalla (1964)
4. <i>Cosmotriche pyriformis</i> (Moore)	Leaves	May-June	+	New Record
<b>II. ZYGAENIDAE</b>				
5. <i>Zygaena</i> moth, <i>Aglaope hyalina</i> (Kollar)	Buds, leaves, young fruits	April-May July-September	++ +	Sharma & Bhalla (1964) Chander (1977c)
6. Red slugworm, <i>Soritia pulchella</i> (Kollar)	Leaves	July-August	+	Chander (1977c)
7. Black spotted orange slugworm, <i>Trypanophora semihyalina</i> (Kollar)	Leaves	May-June	+	New record
<b>III. LIMACODIDAE</b>				
8. Green slugworm, <i>Thosea cana</i> (Walker)	Leaves	August-October	+	Chander (1983a)
<b>IV. SATURNIIDAE</b>				
9. Walnut caterpillar, <i>Dictyoploca simla</i> (Westwood)	Leaves	May-June	+	New record
10. Green giant caterpillar, <i>Neoris luttoni</i> Moore	Leaves	April-May	+	Chander (1977b)

TABLE 1 (continued)

Name of the insect	Plant part	Incidence	Intensity	Reference
11. Blue hairy caterpillar, <i>Caligula tibeta</i> (Westwood)	Leaves	April-May	+	New record
12. <i>C. lindia</i> (Moore)	Leaves	May	+	New record
13. Pear caterpillar, <i>Antheraea roylei</i> Moore	Leaves	June-July	+	Pruthi & Batra (1960)
14. Luna moth, <i>Actias selene</i> Hubner	Leaves	July-September	+	Pruthi & Batra (1960)
15. <i>Samia cynthia</i> (Drury)	Leaves	July-August	+	New record
V GEOMETRIDAE				
16. Yellow lined green looper, <i>Bapta mytylata</i> Guénee	Leaves	May-August	++	New record
17. Dull brown looper <i>Opisthograptis (Rumia) luteolata</i>	Leaves	April-May, July-August, October	+	New record
18. Grey looper, <i>Ectropis deodarae</i> Prout	Leaves	July-September	+	New record
19. Horny brown looper, <i>Memomiza cruentaria</i> Moore	Leaves	August-September	+	New record
20. Twig like brown looper, <i>Medasina albidaria</i> Walker	Leaves	July-September	+	New record
21. Dirty green looper, <i>Photoscotosia miniosata</i> Walker	Leaves	August-September	+	New record
22. Looper, <i>Rhodostrophia</i> sp.	Leaves	July-August	+	New record
23. Greyish green looper, <i>Cleora</i> sp.	Leaves	June-August	+	New record
24. <i>Gonodontis bilinearia</i> Swinhoe	Leaves	June-July	+	New record
25. Praying looper, <i>Psyra spurcataria</i> (Walker)	Leaves	May-July	+	New record

TABLE I (continued)

Name of the insect	Plant part	Incidence	Intensity	Reference
26. <i>Urapteryx abuleatea</i> Guénee	Leaves	August-September	:	New record
27. Brown looper, <i>Hyposidra successaria</i> (Walker)	Leaves	May-July	+	New record
28. <i>Crocalis obliquaria</i> Moore	Leaves	June-July	+	New record
VI. NOTODONTIDAE				
29. Brown notched larva, <i>Neopheosia fasciata</i> Moore	Leaves	July-September	+	Chander (1983b)
VII. LYMANTRIDAE				
30. Black hairy caterpillar, <i>Varmina indica</i> (Walker)	Leaves	May-August	++	New record
31. Grey black hairy caterpillar, <i>Lymantria concolor</i> Walker	Leaves	June-July	+	New record
32. Yellow hairy caterpillar, <i>Dasychira horsfieldi</i> Saund	Leaves	May-July	+	New record
33. <i>D. grotei</i> Moore	Leaves	May-July	+	Bhalla & Pawar (1977)
34. <i>D. dalbergiae</i> Moore	Leaves	June-July	+	New record
35. Golden moth, <i>Euproctis vitellina</i> (Kollar)	Leaves, buds	April-June, August-November	++ +	New record
36. Yellow lined humped caterpillar, <i>Porthesia scintillans</i> (Walker) (= <i>Euproctis scintillans</i> )	Leaves, buds, young fruits	May-September	+++	Bhalla & Pawar (1977)
VIII. DREPANIDAE				
37. <i>Albara lilacina</i> (Moore)	Leaves	May-August	+	New record

TABLE I (continued)

Name of the insect	Plant part	Incidence	Intensity	Reference
<b>IX. TORTRICIDAE</b>				
38. Black headed green leaf folder, <i>Archips pomivora</i> Walker	Leaves, buds, fruits	April-September, August-October	+++ ++	Chander <i>et al.</i> (1979)
39. Brown headed green leaf folder, <i>Acleris orphnoocykla</i> Meyrick	Leaves, fruits	May-August	+	New record
40. Green striped leaf folder, <i>Capua</i> sp.	Leaves	July-September	+	New record
41. Bud worm, <i>Eucosma</i> sp.	Leaves, buds	April-July	++	New record
<b>X. NOCTUIDAE</b>				
42. Cutworm, <i>Autographa nigrisigna</i> (Walker)	Leaves, buds	May-June	+	New record
43. Army worm, <i>Helicoverpa armigera</i> (Walker)	(Nursery) Leaves	April-May	+	New record
44. Brown hairy caterpillar, <i>Moma champa</i> Moore	Leaves	June-August	++	Chander (1978)
<b>XI. NYMPHALIDAE</b>				
45. <i>Neptis hylas</i> Linn.	Leaves	July-August	+	New record

\* ++++ severe, +++ moderate, ++ low and + very low.

During the course of laboratory rearing of different insect pests of apple, different kinds of hymenopteran and dipteran parasites were also obtained which appear to be responsible for keeping the pest population under natural control. Constant surveillance is necessary on these insect pests so that in the event of their attaining the status of a major pest, steps may be taken to control them by spraying suitable insecticides.

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## INSECTICIDE RESIDUES IN CAULIFLOWER SEED CROP

By

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Late varieties of cauliflower seed crop especially snowball types is the main and exclusive enterprise of Solan district of Himachal Pradesh. It is highly remunerative and an average farmer earns Rs. 15,000-20,000 per acre from a good crop. One of the limitations in growing a good crop is its susceptibility to a number of insect pests viz., *Bevecoryne brassicae*, *Pieris brassicae* and *Chrotogonus* sp. in this area. Since all these insect pests can easily be controlled by commonly recommended insecticides like malathion, endosulfan, fenitrothion, methyl demeton, etc. farmers resort to indiscriminate application of these insecticides. Normally a farmer gives 15-20 applications of different pesticides during its entire cropping period. The off type of heads are rogued in the month of March and April and normally the farmers sell these heads in the local market. These heads are expected to contain very high insecticide residues. In view of this the present project on the estimation of insecticide residues in such heads was undertaken.

Samples of rogued cauliflower heads were purchased from different shops of local market, chopped and 50 gm sample was taken for the estimation of insecticide residues. The sample was blended with 150 ml of acetone at high speed for 5 minutes and was filtered through whatman No. I under pressure. The volume of the filtrate was made up to 250 ml with distilled water out of which 50 ml was taken in a separating funnel along with 20 ml of petroleum ether (b.p. 60-80°C.) and 110 ml of 2% sodium sulfate solution. It was shaken for one minute and the different layers were allowed to separate. The upper petroleum ether layer was utilized for making residue films, half ml of which was taken in both top and bottom of 7.5 cm petri dish in 3 replications. The dishes were allowed to dry and 10 *Drosophila* adult males, 24 hrs. old, were released in each of them. Mortality counts were noted after 24 hrs. Since the spray history of market samples was not known, the mortality in different samples was compared with that in control extracts fortified with carbaryl at the tolerance level of 2 ppm (untreated cauliflower heads). Carbaryl was chosen for comparison because *Drosophila* is least sensitive to it, out of all the

contact insecticides. On the basis of mortality counts samples were categorised as follows :

Much above tolerance level	=	100% Mortality
Above tolerance level	=	47-99% Mortality
Detectable level	=	0-47% Mortality
Non-detectable levels	=	0% Mortality

The data on residue analysis revealed that 7.23 per cent samples had very high insecticide residues much above tolerance levels, 21.53 per cent had high residues above tolerance levels or 28.76 per cent samples had residues above tolerance levels, 28.53 per cent samples had detectable residues but were below tolerance levels and rest of 35.71 per cent samples were apparently free from all toxic residues. It is significant to note that the residues analysed do not include that of systemic insecticides like methyl demeton which cannot be tested by the ordinary bio-assay technique using *Drosophila*.

These studies clearly reveal that the rogued cauliflower heads are dangerous to consumers and therefore should not be permitted to be marketed for human consumption.

## PESTS OF POTATO CROP IN HIGH ALTITUDE AND THEIR CONTROL

By

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Potatoes are rich source of important food elements essentially needed for the maintenance of normal health and, therefore, can substantially supplement the food requirements of the country. Several species of insects and mites cause damage to potato crop resulting in heavy economic losses in crop yield. The main pests infesting the crop in the high altitudes include aphids, leaf hoppers, cutworms, white grubs, *Epilachna* beetle, flea beetles, leaf eating caterpillars and *Mylloceris* weevil. The aphids and leaf hoppers are, however, not so important as direct pests but play a notorious role indirectly by transmitting viral and mycoplasmal entities, respectively, in the crop. Other minor pests of casual occurrence in the crop in the hilly regions are: blister beetle, green bugs, lunate fly, weevil [*Alcidodes westermanni* (Boh)] and bulb mite (*Rhizoglyphus echinopus* F. and R.). The present article deals with the pest complex of potato crop in high altitudes of the country and their control measures.

### APHIDS

The aphids are popularly known as plant lice or green fly. Both adults and nymphs of the aphids damage the crop by sucking sap from its foliage. In severe infestations the infested leaves curl downwards, turn yellow, get wrinkled and ultimately die. Such severe aphid infestation, however, seldom occurs on potato crop but they become a great limiting factor in healthy potato seed production as vectors of viruses. The common species infesting the crop are *Myzus persicae* Sulz., *Aphis gossypii* Glover, *A. fabae* Scop. and *Macrosiphum euphorbiae* Thos. The other aphids recorded on potato crop at Simla and Shillong are *Myzus ornatus* Laing, *Macrosiphum rosae*, *Aphis medicaginis* Koch, *Rhopalosiphoninus latysiphon* Davis, *Hydraphis* (*Lipaphis*) *erysimi pseudobrassicae* Davis and *Brevicorne brassicae* (Anonymous, 1971).

*M. persicae* is the principal vector of potato leaf roll and potato virus Y in the crop, although it is known for transmitting more than 100 plant viruses. Besides some clones of *A. gossypii* also transmit

these two viruses in this crop. The losses in potato yield due to leaf roll virus and potato virus Y are estimated to be 20-50 and 40-85 per cent, respectively (Nagaich and Agarwal, 1969). If the tubers from infested crop are used as seed, the yield losses of subsequent crops further increase.

The distinguishing characters of the adults of *M. persicae* and *A. gossypii* are given below for identifying them in the crop.

The apterous adults of *M. persicae* (Fig. 1) are green in colour, with a pair of well developed frontal tubercles. The colour may turn slightly reddish or pinkish in some periods of the year. They have long cylindrical cornicles swollen in the middle. The alate forms (Fig. 2) have black head and green abdomen with a dark patch on the dorsal surface. The adults of *A. gossypii* are variable in colour ranging from pale yellow to brown or black or light to dark green. The tips of the



Fig. 1. *Myzus persicae* Sulz. (Apterous form)



Fig. 2. *Myzus persicae* Sulz. (Alate form)

leg joints, eyes and cornicles are black. The cornicles are cylindrical (Verma, 1977).

Production of healthy seed is a factor of prime importance in potato cultivation. Surveys were conducted in different agro-climatic regions of the country to locate suitable areas for healthy seed production during low aphid periods. These surveys revealed that *M. persicae* generally crosses the critical level (20 aphids/100 compound leaves) by mid July/August in the Northwestern higher hills of India, i. e. from Kashmir to Kumaon. In the Nilgiri hills there are three crop seasons. The population of *M. persicae* generally remains below the critical level throughout the crop season in the rainfed summer crop and irrigated winter crop. In the rainfed autumn crop, however, its infestation remains quite high. In Meghalaya hills its population reaches the critical level during second and third weeks of May in the summer crop and from fourth week of October to first week of November in the autumn crop. In Darjeeling hills the aphid crosses the critical level between 1st and 2nd weeks of May.

Reproduction of *M. persicae* is generally parthenogenetical (viviparous) although both sexual and viviparous cycles have been reported (Batra, 1953). This aphid has marvellous quality of withstanding extreme cold and survives even when the foliage is covered with snow.

### LEAF HOPPERS

The nymphs and adults of leaf hoppers suck sap from the mesophyll and cause direct damage to the potato foliage. Besides some of them are vectors of mycoplasmal diseases viz., witch's broom, purple top roll and marginal flavescence in the crop in the hills and plateau region. The loss in crop yield due to purple top roll and marginal flavescence was estimated at 40-70 and 70-80 per cent, respectively (Nagaich, 1974).

Several species of leaf hoppers have been recorded on potato crop in Simla and Shillong. These include, *Alebroides nigroscutulatus* Dist., *Amrasca devastans* Dist., *Balclutha* spp., *Cycadula monatus*, *Empoasca devastans* Dist., *Exitianus coronatus* Dist., *E. indicus* Dist., *E. nanus* Dist., *Ophiola bicolor* Pruthi, *Parabolocratus parrcotus*, *Phyronomorphus* sp., *Psammotettix provincialis* Rib., *P. striatus* (L.), *Seriana equata* Singh, *Subhimalus melanus* Ghauri and *Thamnotettix prabha*.

The leaf hopper, *A. nigroscutulatus* has been reported to be a vector of witch's broom and purple top roll and *S. equata* for marginal flavescence in the potato crop (Singh and Nagaich, 1977;

Nagaich, 1979). The adults of *A. nigroscutulatus* are white in colour with black compound eyes. In another form head is yellowish white. It has two red longitudinal stripes on the upper side of the forewings. The males and females measure 2.86 to 3.16 mm and 2.91 to 3.50 mm in length, respectively. Besides potato it feeds on the leaves of wild mulberry, *Calendula* spp., *Dahlia* sp. and several weeds occurring in and around potato fields (Saxena *et al.*, 1977). Its life history is as follows: The female deposits white elongate eggs singly inside the leaf lamina below the epidermis. The compound eyes of the developing embryo inside the eggs are visible as black specks through the bulgings. The eggs measure 0.8 to 0.9 mm in length and hatch in 7-8 days. On hatching the nymphs pass through five nymphal instars and become adults. The first, second, third, fourth and fifth nymphal instars occupy 3-4, 2-4, 2-5, 3-6 and 3-6 days, respectively. Total nymphal period varies from 13 to 25 days. Total life cycle from egg to adult occupies 20 to 33 days during August to October. The adults live for 15 to 28 days in captivity on potted potato plants. The adults of *S. equata* are dark brown in colour, having black eyes, brown wings and with black transverse marks on thorax and abdomen.

**Control:** The aphids and leaf hoppers infesting potato crop can be effectively controlled by spraying oxydemeton-methyl (Metasystox 25 E. C.) or dimethoate (Rogor 30 E. C.) @ 1.25 and 1.0 l/ha spray respectively, after diluting in 1125 litres of water. First spray should be given soon after the completion of germination in the seed crop. Subsequent sprays may be given at intervals of 10-15 days depending on the persistence of aphid population in the seed crop. Soil application of 10% phorate granules @ 15 kg/ha in the furrows at planting is also effective for their control provided there is ample moisture in the soil for the translocation of the toxicant to the foliage. However, in the higher hills granular application of systemic insecticides is not of much significance for two main reasons (i) lack of ample moisture before rains and (ii) heavy rains during rainy season leading to leaching of the insecticide. If aphids are noticed on the plants inspite of the application of phorate granules in the later stages of the crop then this treatment may be supplemented with the foliar sprays of any one of the above insecticides. Besides, several other foliar and soil insecticides viz., disulfoton (Disyston 5 G), phosphamidon (Dimecron 100), monocrotophos (Ekaton 25 E. C.) have also been reported effective against aphids (Nirula, 1962; Nirula and Kumar, 1969; Anon. 1971; Misra and Verma, 1974; Rizvi *et al.*, 1976; Verma *et al.*, 1976).

### LEAF EATING CATERPILLARS

Several species of lepidopterous caterpillars cause considerable

damage to the crop by feeding on its foliage in the Meghalaya and Himachal Pradesh hills (Fig. 3). The important leaf eating caterpillars are, *Heliothis armigera* Hb., *Manestra brassicae* L., *Plusia orichalcea* F., *P. ni* Hb., *Spodoptera exigua* Hb. and *S. litura* F.



Fig. 3. Lepidopterous caterpillars feeding on potato foliage.

*Plusia orichalcea* is the main defoliating pest in the summer and autumn crops at Shillong. Its moths can be easily recognised by a golden yellow angulated band on their forewings. A single female may lay 350-450 eggs in its life time. Its average population was 30.5 and 55.5 caterpillars per 100 plants in the summer and autumn crops, respectively. Its larvae caused 60 to 70% damage to potato foliage during May and June in 1976 at Shillong. The moths lay light yellow eggs singly on the lower surface of potato leaves. The larva is a semi looper of light to dark green in colour. When full grown it measures about 4 cm in length. It feeds by nibbling on potato leaves. The incubation, larval and pupal periods occupied 4-5, 10-14 and 8-10 days, respectively. The adults lived for about 4 days (Saxena *et al.*, 1976).

The moths of *H. armigera* emerge in the second week of April and can be seen in huge numbers on street lights during that month at Simla. Profuse egg laying by the moths takes place on the leaves of young potato and other plants at that time. Its damage to potato foliage goes very high during May especially in dry weather. The moths of *H. armigera* are stout, yellowish brown measuring about 3 cm with expanded forewings. Female moths lay greenish

yellow, shiny and sculptured eggs singly on tender foliage of host plants. A single female can lay about 750 eggs in her life time. The incubation, larval and pupal periods occupy 2-7, 12-20 and 8-15 days respectively.

*Control*: Verma *et al.* (1975) reported that chlorfenvinphos, endosulfan and DDT are effective for the control of *H. armigera* on potato crop. Verma *et al.* (1976) have also reported the effectiveness of acephate, formothion and methyl-parathion against *Spodoptera* spp. infesting potato crop in India.

In general, foliar application of endosulfan (Thiodan 35 E. C.) or chlorfenvinphos (Birlane 24 E. C.) @ 1.5 and 1.1 litres, respectively, diluted in 1150 litres of water for one hectare are effective for the control of leaf-eating caterpillars on potato crop. First spraying should be given soon after the appearance of pests and subsequent sprayings, if needed, at 15-day intervals.

### CUTWORMS

Cutworms are cosmopolitan and polyphagous insects. Five species of cutworms viz., *Agrotis ypsilon* (Hfn.), *A. interacta* Wlk., *A. flammatrix* Schiff, *A. spinnifera* Hb. and *A. segetum* (Schiff) damage the potato crop in India (Saxena, 1977). *A. segetum* is more prevalent in hilly regions of the country. *A. spinnifera* is the prevalent species of cutworm in the Meghalaya hills. Damage by this species has been recorded to the extent of 40.5 per cent in summer and 30.3 per cent during autumn season to potato crop (Saxena *et al.*, 1976).

Studies conducted on the life-cycle of *A. segetum* and *A. spinnifera* reveal that moths copulate during night and early in the morning. The incubation period varies from 5-7 days. The average larval periods are 33 and 59 days and pupal periods 18 and 46 days respectively, for *A. segetum* and *A. spinnifera* at Shillong. Longevity of the adults varies from 6-7 days (Saxena *et al.*, 1976).

The cutworms are nocturnal in habit. During nights they come out of their hiding places, which are about 5-8 cm below the ground level and cut off tender stalks of young potato plants at their bases or a few centimetres above the ground level and feed on them, resulting in reduction of crop yield. In fact they spoil much more than what they actually consume. In grown-up crops the damage is usually confined to cutting of tender shoots and branches before tuberization. After tuberization they feed by boring and nibbling into the underground tubers (Fig. 4) affecting their marketing value. Female moths lay about 300 eggs in clusters of 15-35 each on the under-side of the potato leaves or on the moist soil in the fields. The

eggs are dome-shaped and creamy white and hatch in 2-13 days. Larval period takes about 12-35 days. The pupae are dark brown in colour and pupal period occupies 10-30 days. Total life-cycle is completed in 45-78 days.

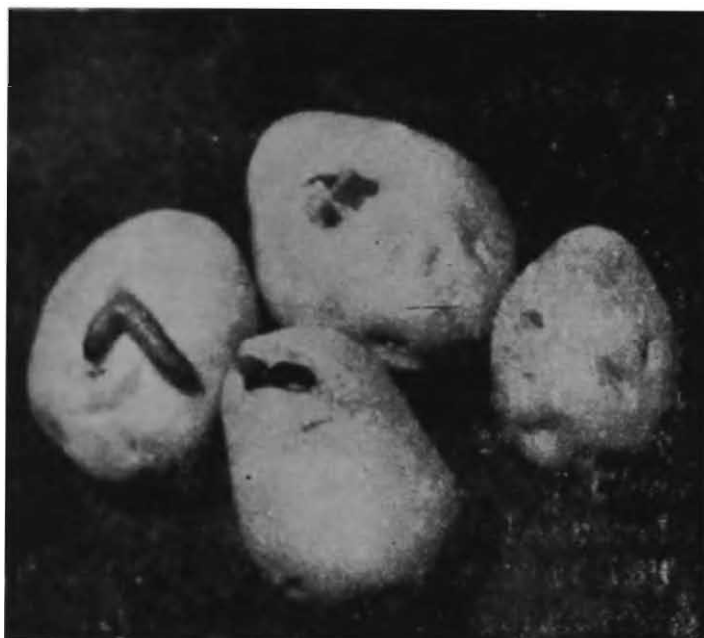


Fig. 4. Cutworms damaging potato tubers.

*Control*: Several contact insecticides viz., aldrin, heptachlor, toxaphene, DDT+pyrethrum dusts and carbaryl bait and phosphamidon, chlorpyrifos, dicotophos, endosulfan, carbaryl and acephate as sprays have been reported to be effective for the control of cutworms on potato crop (Chaudhuri, 1953; Nirula, 1961; Abraham *et al.*, 1972; Purohit *et al.*, 1973; Chandla *et al.*, 1976). Soil application of 5 per cent aldrin or heptachlor dust @ 45 kg/ha at planting gives effective control for longer period.

Besides insecticidal control deep ploughing of potato fields will expose the immature stages of this pest to predators, etc., thus their population is reduced. These control measures are also equally effective for other insect-pests damaging potato tubers underneath the soil such as white grubs, termites, etc.

While applying the soil contact insecticides against soil pests especially in table potato crops, special care should be taken not to use aldrin and heptachlor dusts which are known to leave their toxic residues above the tolerance level at harvest in potatoes grown in such treated soils (Singh and Kalra, 1972; Attri *et al.*, 1976; Misra *et al.*, 1977). According to Rizvi and Chandla (1977) application of chlorpyrifos (Dursban 20% E. C.) @ 2.5 l/ha/spray treatment, twice at 15-day intervals has been found quite effective against cutworms. This insecticide may be substituted for aldrin and heptachlor for

the control of cutworms on potato crop provided it is found safe from the residue angle.

### WHITE GRUBS

The white grubs have attained national importance in the country during the last two decades. Now they have been reported from all the states and union territories of the country, causing damage to a wide variety of cultivated crops including potatoes.

The larvae of Cockchafer beetles are known as white grubs. They are fleshy, dingy white in colour with brown head. Their body is curved in an arch and the apical segment is large and smooth (Fig. 5). They are usually present in the potato crop grown in all types of soils in the hilly areas. The grubs feed on the underground potato tubers by making large circular holes into them thus rendering them unfit for marketing. The information on the species of white grubs associated with potato crop and on their bionomics and control measures is, however, lacking. Two species viz., *Lachnosterna coriacea* Hope (Nair, 1975) and *Melolontha* sp. are known to damage the potato crop. The latter is a metallic green coloured beetle. It lays eggs in the soil at a depth of 4-6 cm. The eggs are round in shape and light yellow in colour and are slightly smaller than mustard seed. The eggs hatch in 15-20 days. The larval and pupal periods occupy 90-100 and 18-21 days, respectively.



Fig. 5. White grub.

### EPILACHNA BEETLE

Epilachna beetle is a polyphagous defoliating insect which often

becomes one of the limiting factors in successful potato cultivation. *Henosepilachna ocellata* Redt. is the species prevalent at high altitudes above 1500 metres in hilly regions of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and Bengal. The adult beetle is dark brown in colour having 12 black spots encircled by a lighter colour on its elytra (Fig. 6). The grubs are about 6 cm long, yellowish in colour and have six rows of long branched spines.

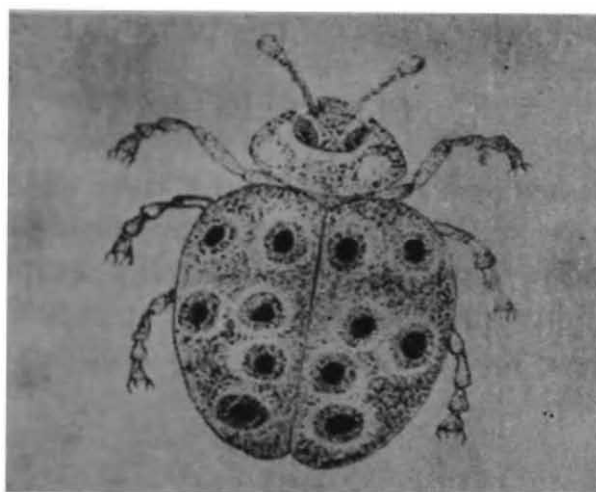


Fig. 6. *Henosepilachna ocellata* Redt. (Adult).

Both the adults and grubs feed voraciously by scraping the chlorophyll of the leaves resulting in characteristic lace like skeletonized appearance (Fig. 7). Severe infestation results in premature destruction of foliage and consequently in reduction of potato yield. In the years of severe infestation the crop may be completely destroyed (Jolly, 1962).



Fig. 7. Potato foliage damaged by *Henosepilachna ocellata* Redt.

Female beetles lay cigar-shaped, yellowish eggs in clusters on the underside of potato leaves. The number of eggs in each cluster may vary from 15-65. A single female may lay upto 450 eggs in her life-time. The eggs hatch in 3-7 days. The grubs attain their full growth within 2-3 weeks time. Pupation takes place exposed on the leaves of the host plants. The duration of pupal stage is 2-4 days during summer and about 8-15 days in winter. The survival of adults may vary from 4-6 months depending upon the season. There are about 3-4 generations of this pest in a year.

### FLEA BEETLES

Flea beetles (*Sthenaridea pusilla* Reut.) have been found feeding on potato foliage at Simla. They start appearing on the crop soon after its germination. The damage is done by scraping green matter from its foliage and by making holes in the leaves. These beetles are of minor importance for the present as the crop yield is not much effected by their attack.

### BLISTER BEETLE

Blister beetle (*Epicauta hirticornis*) has been observed attacking the summer potato crop in the Khasi hill district of Meghalaya. This is very active from May-July. The damage to potato crop is caused by adults only which defoliate the potato leaves. The adults are black in colour with red head. These beetles are also present in Himachal Pradesh and damage the potato crop as a minor pest. In Simla, they start appearing in June-July.

The female beetles lay eggs in clusters. The eggs are cylindrical in shape, tapering towards the posterior end. They are yellowish in colour and are arranged longitudinally on the leaves of host plants. The incubation period is 15-20 days. The larvae pass through 4 markedly different instars. The average time required for the development of the larvae is 4-5, 2-3, 2-3 and 5-8 days for the 1st, 2nd, 3rd and 4th instars respectively. After the 4th instar, they form pupa like structure and go for hibernation. In the next season they moult and come out as adults.

**Control:** For protecting the potato crops from the attack of epilachna and other beetles spraying with any of the insecticides namely, ethyl parathion, DDT dimethoate, carbaryl, diazinon, formothion, chlorpyrifos and endosulfan has been reported to be effective (Chowdhuri, 1965; Hameed and Adlakha, 1973; Misra, 1975; Verma and Misra, 1975). Spraying with chlorpyrifos (Dursban 20 E. C.) or endosulfan (Thiodan 35 E. C.) or carbaryl (Sevin 50 WP) @ 2.5, 1.5

and 1.25 kg respectively diluted in 1150 litres of water has been recommended for the control of epilachna beetle. First spraying should be given soon after noticing the infestation on the crop and 1 or 2 subsequent sprayings may be given at 15-day intervals, if required (Misra and Raj , 1977).

### PENTATOMID BUGS

Several species of pentatomid bugs have been reported infesting potato crop at Simla and Shillong (Saxena *et al.*, 1976). The green bug (*Nezara viridula*) has been found damaging the summer crop both at Simla and Shillong. The extent of damage generally remains low at Simla but at Shillong it caused serious damage to the crop during 1976. Its infestation was very heavy ranging from 50-60 per cent at Laitlyngkot and Upper Shillong (Saxena *et al.*, 1976).

The nymphs and adults of *N. viridula* are green in colour. Both nymphs and adults damage the crop by sucking the sap from its top shoots which become brown and ultimately dry up and die. Besides potatoes, it also causes damage to cabbage, cauliflower and radish etc., in the Khasi Hill district of Meghalaya.

The female bugs lay whitish to yellow eggs, which turn reddish or blackish grey later on. The eggs laid by a single bug range from 60-72. Incubation period is 5-13 days. First instar nymphs are black in colour. After hatching they migrate to the top shoots of the potato plants. There are 6 nymphal instars which can be easily identified by seeing the colour and markings on their body. The fifth instar nymphs are greenish in colour with conspicuous black markings on the head region. These black markings gradually disappear as the nymphs grow older and turn into green adult bugs. The duration of each instar varies from 5-12 days depending upon the prevailing agroclimatic conditions.

**Control :** The systemic insecticides generally used for the control of aphids, leaf-hoppers and other sucking insect-pests are also effective against green-bugs.

### BULB MITE

Wadhi *et al.* (1971) recorded the bulb mite, *Rhizoglyphus echinopus* F. & R. on potato tubers from Simla. This mite has also been reported from other countries infesting a large variety of plant materials. Infestation due to *R. echinopus* resulted in 50% loss to the crop of *Allium bakeri* in Japan (Kishida and Morino, 1936) while in Britain, out of the total narcissus bulbs examined, Hodson (1928)

found 95% to be infested with this mite. Both the nymphs and adult mites suck the sap from potatoes. During 1978, this mite was again found on potatoes kept in jars for rearing the tuber worm cultures in the laboratory at Simla.

### LUNATE FLY

Misra and Verma (1975) reported lunate fly (*Eumerus* sp.) damaging the potato tubers at harvest time at Simla. The maggots of this fly bore into the tubers and feed on the pulp. The infestation results in the rotting of potatoes.

### WEEVIL

A weevil, *Alcidodes westermanni* (Boh.) was found infesting potato plants during the crop season of 1977 at Simla (Kishore *et al.*, 1979). Its infestation was as high as 33% in some of the badly infested fields during July. Eggs are laid singly in the excavations. Incubation, larval and pupal periods were 6-8, 40-42 and 8-10 days, respectively under laboratory conditions.

### ASH GREY WEEVIL

The ash grey weevil (*Myllocerus subfasciatus* G.) causes damage to the potato crop both in summer and autumn seasons in Nilgiris. During the last few years it has assumed the status of a serious pest of potato crop in that region.

Both the weevils and their grubs damage the crop. The weevils feed on the foliage while their grubs feed on the underground tubers in the fields. Highest tuber damage at 31.5% was observed in Kufri Chandramukhi during January and the lowest damage was observed during February at Ootacamund.

The weevils congregate inside the whorls of the leaves or under the old leaves and nibble the leaf lamina. In severe infestations they feed all the green matter leaving the veins. They lay eggs in clusters in the soil and on hatching the grubs move to the root zone and feed on tender rootlets. After tuberization, they feed on the tubers by cutting small holes and thus reduce their marketing value. The pest goes to the stores with the infested tubers.

**Control:** This pest can be controlled by foliar application of DDT at 0.05 per cent active ingredients or ethyl-parathion at 0.07% active ingredients twice, one month after germination and again at earthing up in the crop. Several new contact insecticides are being evaluated against this pest with a view to selecting safer and more promising ones for its effective control.

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RELATIVE TOXICITY OF SOME INSECTICIDES  
TO THE ADULTS OF DEFOLIATING BEETLE,  
*BRAHMINA CORIACEA* HOPE (MELOLONTHINAE :  
COLEOPTERA)

By

MAHABIR SINGH\* AND G.S. DOGRA\*\*

INTRODUCTION

Out of twenty beetles collected attacking apple cultivars, at the Regional Fruit Research Station, Mashobra, Simla, seventeen were scarab beetles. Singh (1964) reported 35 species of beetles which damage fruits and forest trees in temperate regions. Amongst the scarab beetles only one species, *Brahmina coriacea* Hope, the population of which exceeded 90%, was 99 per cent responsible for defoliating apple cultivars in the months of May and June during 1977 and 1978 in the vicinity of Regional Fruit Research Station, Mashobra, Simla. In view of the serious damage caused by *B. coriacea* seven insecticides were screened in the laboratory for its control. The findings are presented in this paper.

*Time of attack* : *B. coriacea* attacked apple plants in swarms at dusk or just after it, and after defoliating plants disappeared into the forest before dawn. After the last week of May the population of the pest started increasing and maximum attack was observed in the month of June. Thereafter, the population started declining. One interesting point observed was that the beetles came in large numbers when it had rained during the day and cleared in the evening. If the rain continued at dusk time, the pest did not attack.

MATERIALS AND METHODS

Seven insecticides viz., carbaryl, endosulfan, isofenphos, malathion, methyl-parathion, phosalone and phoxim, obtained in formulated form as emulsions except carbaryl as wettable powder were tested. Six to seven concentrations of each insecticide were replicated thrice. The concentrations which gave less than 5% and more than 99% mortality were

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not considered. Fresh insecticidal dilutions, prepared in the laboratory in tap water, were used for every experiment. For experimental purposes, leaf strips (4 cm × 2.5 cm) of Golden Delicious cultivar were treated for six seconds in the insecticidal solution and were later dried for 6 hours so as to avoid fumigating effect of the insecticides. In control the leaves were likewise treated in tap water. The adults of *B. coriacea* were collected and preconditioned in cages at room temperature for 24 hours. Five insects, collected randomly from cages, were liberated on the treated leaves, kept in the petridishes (100 × 17 mm) covered with muslin cloth. For the assessment of the toxic effect the insects were kept for 12 hours in the petridishes and the mortality recorded. Moribund insects were taken as dead. No mortality was found in control. Percent mortality at different concentrations was calculated and corrected by Abbott's formula (Abbot, 1925). The LC 50 values were calculated by the method of Probits (Finney, 1952). Tests of parallelism of the regression lines were made and common slopes of regression lines were determined so as to effectively compare the relative potency of different insecticides. The relative toxicity of insecticides has been calculated by taking LC 50 of endosulfan as unit.

## RESULTS AND DISCUSSION

Toxicity of the seven insecticides tested against the beetle, *B. coriacea* was found in the order of methylparathion > insofenphos > phoxim > carbaryl > malathion > phosalone > endosulfan which were 151.2, 60.5, 35.6, 32.8, 13.4 and 1.7 times respectively, more toxic than endosulfan (Table I). Singh (1964) has suggested 0.25 per cent DDT spray, but a comparison is not feasible as in the present findings the insecticides tested are of different groups. Endosulfan was proved least effective. The carbamate, carbaryl, has proved better than the organophosphates viz., malathion and phosalone, among organophosphates. Beetles were more susceptible to methyl-parathion followed by isofenphos.

TABLE I. Relative toxicity of some important insecticides against the adults of defoliating beetle, *Brahmina coriacea* Hope.

Insecticides	Heterogeneity	Regression equation	LC 50	Fiducial limits	Relative toxicity
Carbaryl	$X_{(3)}^2 = 2.248$	$Y = 2.27x - 4.866$	0.0221	0.0301 0.0160	32.8
Endosulfan	$X_{(2)}^2 = 5.918$	$Y = 2.27x - 8.304$	0.7256	1.0920 0.4594	1.0
Isofenphos	$X_{(1)}^2 = 2.551$	$Y = 2.27x - 4.264$	0.0120	0.0195 0.0032	60.5
Malathion	$X_{(2)}^2 = 1.409$	$Y = 2.27x - 5.745$	0.0542	0.0092 0.0331	13.4
Parathion (methyl)	$X_{(1)}^2 = 0.683$	$Y = 2.27x - 3.362$	0.0048	0.0073 0.0009	151.2
Phosalone	$X_{(2)}^2 = 4.286$	$Y = 2.27x - 7.86$	0.4299	0.7610 0.2543	1.7
Phoxim	$X_{(1)}^2 = 0.020$	$Y = 2.27x - 4.786$	0.0204	0.0453 0.0134	35.6

In none of these cases data were found significantly heterogenous at  $P = 0.05$ ,  $Y =$  Probit Kill;  $X =$  Log (concentration  $\times 10^6$ ), LC 50 = Concentration calculated to give 50 per cent mortality.

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## STUDIES ON THE POPULATION BUILD UP, VARIETAL SUSCEPTIBILITY AND CONTROL OF GARLIC THRIPS IN HIMACHAL PRADESH

By

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### INTRODUCTION

Garlic is grown as a commercial crop in Himachal Pradesh. It is attacked by the adults and nymphs of thrips, which lacerate the foliage at a time when bulb formation is in progress, as a result of which the bulb size is severely affected. Elsewhere *Thrips tabaci* has been reported to damage garlic (Lal and Singh, 1968; Ananthakrishnan, 1969), but here *Thrips flavus* Schr. and *T. varius* Bhatti are responsible for the damage. There is a large collection of garlic germplasm in the State and these exhibit varying degree of resistance to thrips. Keeping these points in view, studies were undertaken on the population build up, varietal susceptibility and control of the thrips causing damage to garlic and the results are reported in this paper.

### MATERIALS AND METHODS

*Population build up* : A local cultivar, L. S. 2, was planted in September in 120 m<sup>2</sup> area at a distance of 15 cm × 8 cm, at the university farm, Solan (1500 m. a. s. l.). Weekly thrip population (adults and nymphs) was recorded on 10 randomly selected plants. Temperature records were maintained to find out its relationship with the population fluctuations if any.

*Varietal susceptibility* : Eight local selections were planted each in plot size of 4 × 3 m<sup>2</sup>. Adult and nymphal population was recorded on 10 randomly selected plants at 10 days interval after 20th March. However, the susceptibility of local selections was determined on the basis of number of nymphs/plant. An attempt was also made to correlate the varietal susceptibility on the basis of phenology of the plant.

*Control* : Nine insecticides were evaluated for the control of thrips on garlic in a randomized block trial with three replications.

The plot size was  $4 \times 3 \text{ m}^2$ . Insecticides were sprayed with a foot sprayer on 20th March. The control was sprayed with water only. Adult and nymphal population was recorded on 10 randomly selected plants from each plot. The efficacy of insecticides was judged from average number of thrips per 5 plants counted 1, 2, 4 and 10 days after treatment.

## RESULTS AND DISCUSSION

*Population Build up* : As evident from Fig. 1, crop remained free from the attack of thrips upto February and the adults appeared in the 2nd week of March. Significant population was noticed upto first week of April with a maximum population of 11.0 adults/plant on 21st March, thereafter it gradually declined to its minimum on 25th April, when 1.0 adult plant was recorded. Nymphal population appeared in the third week of March and was maximum on 28th March with an average of 81.0 nymphs/plant. After this it declined and reached to its minimum on 18th April when 1.0 nymph/plant was recorded.

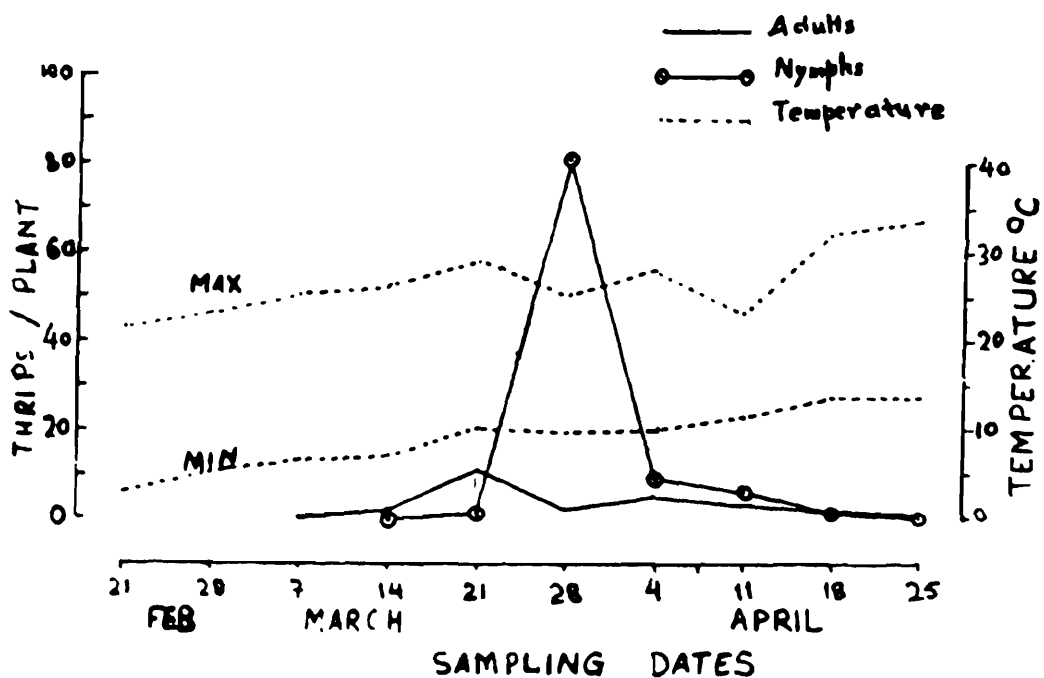


Fig.1 Seasonal population of *Thrips* spp on garlic at Selan during 1973-74

Absence of thrips during winter may perhaps be due to unfavourable winter temperature. With the onset of spring, in the beginning of March, when the temperature fluctuated between  $7^{\circ}\text{C}$  and  $26^{\circ}\text{C}$  (Fig. 1) and plants had maximum foliage, population was high; however, during April and May when the temperature was as high as  $33.5^{\circ}\text{C}$  and

the crop was heading towards maturity, the population rapidly declined. It could be that maturing nymphs have migrated to other suitable hosts, as these species have also been reported from the flowers of apple (*Pyrus malus*), coriander (*Coriandrum sativum*), pomegranate (*Punica granatum*), jangali palak (*Rumex hastatus*), grapes (*Vitis vinifera*), peach (*Prunus persica*) and leaves of bitter gourd (*Mimordica charantia*) (Thakur *et al.*, 1974; Bhalla and Thakur, 1974). The data suggest that there is only one generation of thrips on garlic.

*Varietal susceptibility* : Though all the 8 local selections had an equal number of adults, yet there were perceptible differences in the number of nymphs (Fig. 2). Highest average nymphal population of 98.8/plant was observed on L. S. 2 and least of 1.50 nymphs/plant on L. S. 5, a large segmented local selection. In between these two extremes the rest of the selections harboured varied nymphal populations. The results suggest that L. S. 5 exhibited a greater degree of resistance to garlic thrips and this could be ascribed to the leaf structure, since this selection has broad, flat leaves as compared to somewhat narrow and folded leaves of remaining varieties, which provided better feeding and hiding places for the nymphs.

FIG 2 POPULATION OF THRIPS (nymph, adults) ON DIFFERENT LOCAL SELECTIONS

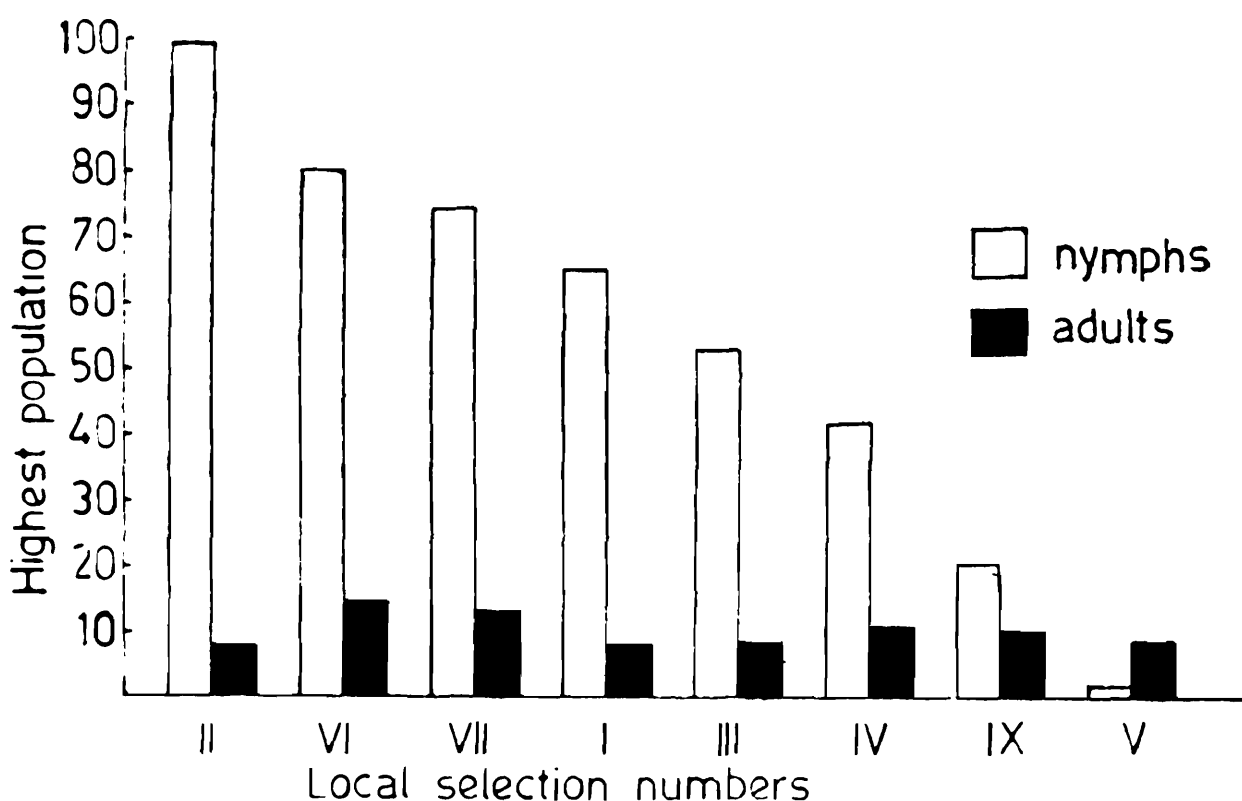


TABLE 1. Comparative efficacy of different insecticides against garlic thrips.

Treatment & Concentration (%)	Mean number of thrips /5 plants at indicated days after treatment											
	1			2			4			10		
	A	N	T	A	N	T	A	N	T	A	N	T
Fenitrothion 0.05 (Folithion 50 EC)	1.0	0.0	1.0 a(1.38)	3.3	3.7	7.0 ab(2.57)	0.3	9.0	9.3 a(2.99)	37.0	18.3	55.3 ab(7.15)
Fenthion 0.025 (Lebeycid 82.5EC)	1.0	0.0	1.0 a(1.38)	2.0	0.7	2.7 ab(1.90)	1.3	10.3	11.6 ab(3.33)	18.0	27.0	45.0 ab(6.78)
Dichlorvos 0.05 (Nuvan 100)	1.3	0.0	1.3 a(1.52)	3.0	13.0	16.0 bcde(4.03)	0.3	47.0	47.3 cd(6.79)	13.0	246.0	259.0 de(16.06)
Malathion + fenitrothion (Ambithion 50 EC)	1.0	1.0	2.0 a(1.67)	0.7	1.0	1.7 a(1.48)	0.7	8.3	9.3 a(2.95)	22.0	14.3	36.3 a(6.67)
Malathion 0.05 (Cythion 50 EC)	1.7	1.3	3.0 ab(1.89)	0.7	9.6	10.3 abcd(3.05)	0.7	32.5	33.2 abc(5.82)	18.8	80.5	99.3 bc(9.97)
Monocrotophos 0.04 (Nuvacron 40)	3.3	0.0	3.3 ab(1.86)	3.3	5.6	8.3 abc(2.93)	0.0	31.0	31.0 abc(5.50)	15.0	4.3	19.3 a(4.40)
Methyl demeton 0.025 (Metasystox 25 EC)	3.3	0.0	3.3 ab(1.86)	2.0	17.3	19.3 bcde(3.97)	1.3	36.0	37.3 bc(6.12)	37.3	18.3	55.3 ab(7.15)
Endosulfan 0.035 and 0.05 (Thiodan 35 EC)	8.7	1.3	10.0 cd(3.27)	8.0	20.0	28.0 def(5.32)	1.7	42.3	44.0 ce(6.56)	12.0	326.0	338.0 e(17.71)
	6.7	2.0	8.7 bc(3.03)	2.0	34.0	36.0 ef(5.94)	3.3	52.7	56.0 cd(7.29)	15.0	86.7	101.7 bc(9.88)
DDT 0.05 (50 W.P.)	5.7	5.6	11.3 cd(3.36)	4.7	21.3	26.0 cdef(5.11)	1.7	41.3	43.0 c(6.43)	9.3	150.0	159.3 cd(12.49)
Control	18.3	1.3	19.3 e(4.41)	7.0	36.0	43.0 f(6.61)	3.3	92.3	95.3 d(9.62)	11.0	361.9	372.0 e(18.97)
CD			1.35			2.34			2.94			4.74
S.E. ( $\pm$ )			0.65			1.129			1.418			2.287

Figures in the parenthesis are  $n+1$  transformations. A = Adults; N = Nymphs; T = Adults + Nymphs.

*Control*: Table I shows that nymphal population was significantly controlled by the treatments, adults being highly mobile jumped away at the slightest disturbance and therefore, were not considered for judging the efficacy of the insecticides, except in the initial stages. At one day fenitrothion, fenthion, dichlorvos, malathion+fenitrothion were found significantly superior over the control in reducing thrips population (1.0 to 2.0/5 plants) ; followed by malathion, monocrotophos, methyl demeton with 3.0 to 3.3 thrips/5 plants. Both the concentrations of endosulfan and DDT with 8.7-11.3 thrips/5 plants were less effective. Similar response was recorded on 2nd and 4th day, except in case of dichlorvos where the nymphal population reached 246.5 plants by 10th day. After 10 days of treatment, nymphal population with 3.4—14.3/5 plants was lowest, on plants treated with monocrotophos, malathion+fenitrothion followed by methyl demeton, fenitrothion and fenthion with population 18.3-27.0 nymphs/5 plants. Malathion, DDT and both the doses of endosulfan were least effective as thrip population in these treatments was as high as 80.5—326.0/5 plants. Lal and Singh (1968) also found malathion and DDT least effective against onion/garlic thrips.

Results show that nymphs are the real destructive stage because of their high population and static habit. Their high population between 21st March and 4th April was undoubtedly due to mass emergence from the eggs laid by spring adults. Therefore, the treatment given on 20th March when adults appear was effective in preventing population build up. Monocrotophos with persistent and systemic action proved highly effective, followed by methyl demeton. Fenitrothion also proved effective, however, fenthion was less effective perhaps due to lower dose. As compared to malathion and fenitrothion, fenitrothion+malathion (Ambithion) proved effective. It may be pointed here that the reduced nymphal population within a week from the control experiment was due to the pupation of the nymphs (Fig. 1). The newly emerged adults flew away to other hosts and did not start new generation on garlic. It is inferred here that a single spray given around 20th March when spring adult appears is effective in controlling the thrips on garlic.

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POPULATION STUDIES OF SMALL BROWN PLANT HOPPER,  
*LAODELPHAX STRIATELLUS* (FALLEN), A NEW INSECT OF  
RICE IN INDIA

By

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A new insect, small brown plant hopper, not previously known to occur in India was collected from the rice nursery around Ludhiana in 1978. The identification of this insect as *Laodelphax striatellus* has been confirmed by the CIE, England (Shukla, 1979). The small brown plant hopper (3.5 mm) is slightly smaller than the white backed plant hopper, *Sogatella furcifera* (4 mm) commonly seen on rice crop in Punjab. The two insects are easily distinguished by the colouration of their scutellum (Nasu, 1967). In *S. furcifera* there is an oblong white spot in the middle of the scutellum, thus the name white backed plant hopper. In small brown plant hopper, *L. striatellus*, scutellum is dark brown/black except at the apex. They can also be distinguished by the shape of parameres in their genitalia.

The small brown plant hopper is known to be distributed in Taiwan, Japan, Korea, China and Palearctic regions only (Khush, 1977). It causes considerable direct damage to rice crop in these countries and is known to be a vector of rice stripe virus and black streaked dwarf virus. This insect also serves as a vector for some other viral diseases such as barley yellow striate mosaic, northern cereal mosaic, cereal tillering, wheat chlorotic streak, maize rough dwarf and oat pseudo rosette, which are known to have a wide host range (Table I).

During 1979 this insect was seen as early as April 15. Collections have been made from late maturing plants of wheat, young plants of bajra, maize grown as off-season crops at PAU and sugarcane. The occurrence of this insect in 1978 and its presence in the fields even before the rice nursery is planted this year indicates that the insect may be prevalent in this zone at a high frequency. As this insect is inhabited to temperate countries, it was considered worthwhile to monitor the population build up of this insect during the summer months. Therefore, the population counts of adult plant hoppers are being made with a hand net at 10-day interval on bajra crop at PAU Farm.

TABLE I. Viral diseases transmitted by *L. striatellus* (Fallen).

Disease	Transovarial passage	Occurs in	Host range	Reference
1. Rice stripe	Yes	Japan, Korea	Rice, barley, sorghum, wheat, maize, bajra, oats, rye and 25 species of grasses	Iida, 1969
2. Black streaked dwarf	No	Japan	Rice, wheat, maize, barley, oats, rye and 20 species of grasses	Shinkai, 1962
3. Barley yellow striate mosaic	—	Italy	Wheat, oat, barley and grasses	Conti & Appiano, 1973
4. Northern cereal mosaic	—	Northern Japan	Wheat, barley, oat, rice, rye and 15 species of grasses	Wiese, 1977
5. Cereal tillering	No	Italy, Sweden	Wheat, barley, rye, oats, corn and grasses	Conti & Appiano, 1973; Lindsten, 1974
6. Wheat chlorotic streak	Yes	France	Wheat and <i>Agropyron repens</i>	Signoret, 1974
7. Maize rough dwarf	—	—	Wheat, barley, oat, corn and grasses	Harpaz, 1972; Lovisolo, 1971
8. Oat pseudo rosette	—	—	Wheat, oats, barley, corn and millets	Sukhov <i>et al.</i> , 1941

An average of 3.4 adults (males and females) per net sweep were collected on 20.4.1979. This number decreased in subsequent collections and an average of 0.40 adults were collected on 9.6.1979 (Table II). These observations, though only preliminary do indicate a declining trend in the population of this insect. This decline may be due to change in temperature which increased from a mean temperature of 26.4°C to 31.0°C in this period. Non-availability of preferred host plants seems to be an important factor. It is expected that the population of this insect will rise when the rice crop is planted over large areas because of the collection made on 9.6.1979 from the rice nursery higher number of adults were collected. It is possible that this insect is more prevalent at higher altitudes where temperatures are low and the gap between the wheat harvesting and rice plantation is narrower.

TABLE II. Population counts of *Laodelphax striatellus* (Fallen) on Bajra at PAU from April to June 1979.

Date of hand-net sweeping	No. of net sweeps	No. of adults collected			No. of adults per sweep	Mean temp. (°C)
		Male	Female	Total		
20/4	10	18	16	34	3.40	26.36
30,4*	—	—	—	—	—	28.82
10,5	100	58	159	217	2.17	29.74
20,5	100	39	89	128	1.28	29.13
30/5	100	50	52	102	1.02	27.83
9/6	100	22	18	40	0.40	30.98
9/6	100	80	44	124	1.24	

(rice nursery)

\*Observations not taken.

During 1978, hopper burns on rice were seen in Punjab at Kapurthala and some other places. Though exact epidemiological studies were not made, the damage was attributed to white back plant hopper. It is possible that alongwith white back plant hopper, small brown plant hopper was also present in these areas. All these points need to be carefully observed and a systematic and intensive population monitoring of this insect is needed in the coming months. A survey for this insect in different states has been initiated recently by the All-India Coordinated Rice Improvement Project.

Rice cultivars/stocks resistant to small brown plant hopper (Table III) have been indentified (Khush, 1977) and could be utilized if needed.

TABLE III. Rice varieties/stocks possessing resistance to *L. striatellus*.

S. No.	Variety/stock	Tests done in
1.	ASD 7	Korea
2.	Vellailangaayan	-do-
3.	Murunga 137	Taiwan
4.	Pannetti	-do-
*5.	Konanso	Japan
*6.	Tadukan	-do-
*7.	Hu-nan-tsao	-do-

\*Tested under field condition only (Khush, 1977).

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## POPULATION STUDIES ON THE INSECT-POLLINATORS VISITING CAULIFLOWER BLOOM AROUND SOLAN

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### INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) being selfincompatible requires the services of insects for its cross-pollination. Wind pollination of cauliflower is not possible due to the wetness of the pollen. As many as 34 insect species have been found visiting cauliflower bloom under mid-hill conditions (Sharma *et al.*, 1974). Honey bee *Apis cerena indica* increased the seed yield of cauliflower to 3-fold (Kakar and Sharma, 1978). Since the seed yield of the cauliflower depends upon insect pollination, therefore, studies were conducted to assess the number of insects visiting cauliflower bloom in two locations around Solan i. e. Bairty and Chambaghat.

### MATERIALS AND METHODS

Insect pollinators visiting cauliflower bloom were regularly counted at both the localities from 7 A.M. to 6 P.M., every fifth day, after the crops had come into bloom sufficient-enough to attract noticeable number of insects with the help of a cone-type muslin 'Sweepnet' with a diameter of 37 cm ring. Each count consisted of 30 sweeps and the data were converted into insects/100 sweeps for the purpose of comparison.

### RESULTS AND DISCUSSION

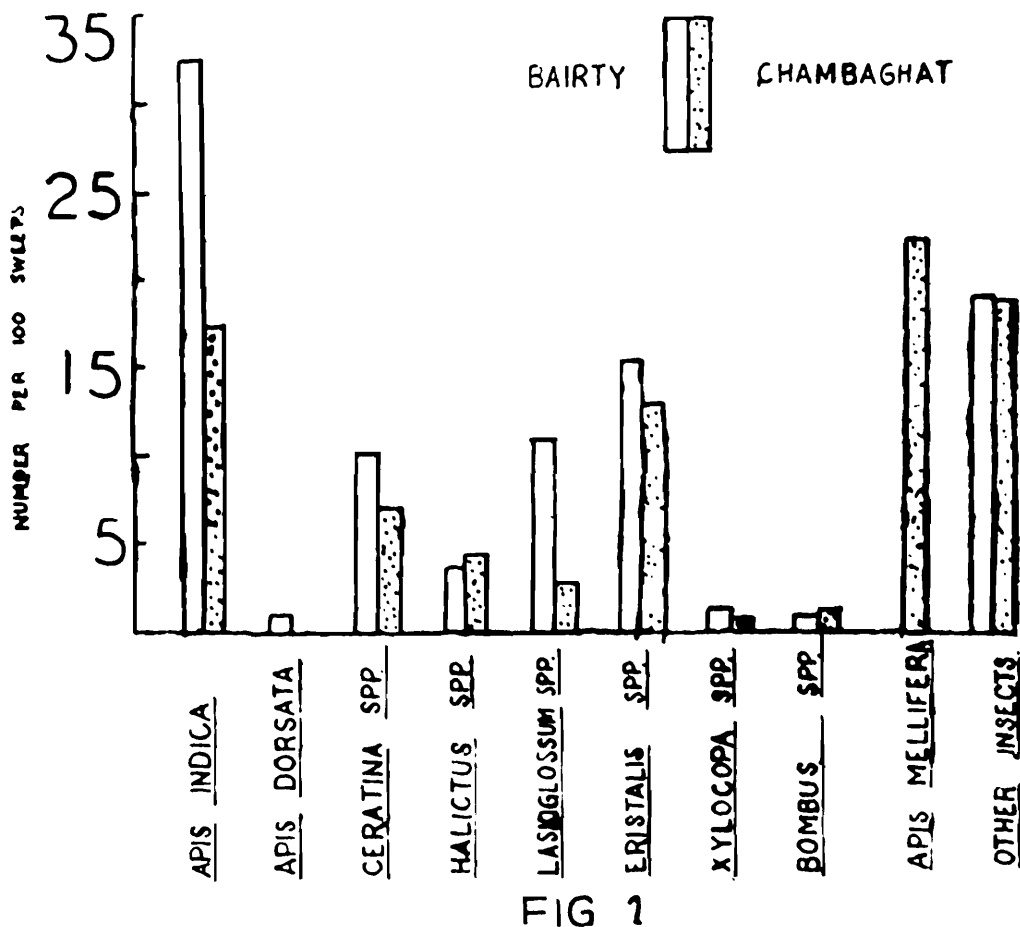
These studies revealed that insect population tended to follow the curve of flower development. Peak population was observed 15-20 days of flowering.

At Bairty, average population/100 sweeps was 87.14 insects including *Apis indica* 37.62%, *A. dorsata* 0.11%, *Ceratina* sp. 11.60%, *Halictus* sp. 4.18%, *Xylocopa* sp. 1.31%, *Bombus* sp. 0.92%, *Lasioglossum* sp. 3.95% and *Eristalis* sp. 17.69%. Other insects which included known harmful insect pests of cauliflower, although of little

pollination value constituted a large group amounting to 21.71%. Most abundant insect was the honey bee *A. indica* followed by a syrphid fly, *Eristalis* sp. which accounted for 32.78 and 15.42/100 respectively. Population of *Ceratina* sp., *Halictus* sp., *Lasioglossum* sp., *Xylocopa* sp., *A. dorsata* and *Bombus* sp. was 10.11, 3.64, 3.44, 1.14, 0.89, 0.80 per 100 sweeps respectively. Other insects accounted for 18.92/100 sweeps (Fig 1).

At Chambaghat, average insects population/100 sweeps was 65.01 comprising of *A. indica* 17.31, *Eristalis* sp. 13.03, *Ceratina* sp. 6.92, *Halictus* sp. 4.29, *Lasioglossum* sp. 2.64, *Bombus* sp. 1.22 and *Xylocopa* sp. 0.77. Other insects constituted 18.83/100 sweeps. Other insect comprising of harmful pests of cauliflower accounted for 28.96 per cent of total population which cannot be relied upon for pollination. Honey bee *A. indica* comprised 26.64% of the total population followed by *Ceratina* sp. 10.64%, *Halictus* sp. 6.60%, *Xylocopa* sp. 1.18%, *Bombus* sp. 1.88% *Lasioglossum* sp. 4.06% and *Eristalis* sp. 20.04% (Fig 1).

POPULATION OF INSECT POLLINATORS OF  
CAULIFLOWER



No doubt number of insects/100 sweeps were less in this locality, but *A. indica* was most abundant followed by *Eristalis* sp. Earlier, Kapil *et al.* (1971) reported *A. indica* as the principal pollinator comprising 85% of the total population.

From the above observations it may be observed that insect pollinator population was high at Bairty as compared to that of Chambaghat. *A. indica* was always in high number, at Bairty as compared to Chambaghat. But when *A. mellifera* colonies were located at Chambaghat to supplement the population of honey bees, it contributed 22.49/100 sweeps. In this way, in deficient localities having low insect population, services of domesticated species, *mellifera* and *indica* can be utilized. Population of wild bees including *Bombus* sp., *Ceratina* sp., *Halictus* sp., was also less (15.84) at Chambaghat as compared to that at Bairty (19.13). The difference in population may be attributed to the fact that :

1. Bairty fields were located in a valley area situated on the northern aspect of the hill range fully covered with forest trees, shrubs and bushes. On the other hand, Chambaghat fields were situated in the open flank by almost bald hills-because of more natural flora in Bairty the population of wild bees was higher as compared to Chambaghat.

2. Availability of more cultivated flora may be another reason. The Bairty belt was specialised in cauliflower seed production which afforded continuous flowering fields owing to which more and more wild bees were attracted. At Chambaghat, only an isolated field was located under the cover of cauliflower.

3. Availability of nesting sites. The high insect population at Bairty may also be attributed to the availability of bush and shrub studded waste land which provided ideal grounds for nesting of wild bees.

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MORPHOLOGICAL CHARACTERISTICS OF INDIAN  
HONEYBEE, *APIS CERANA INDICA* F.  
IN HIMACHAL PRADESH

BY

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INTRODUCTION

Honeybees are highly social and cosmopolitan insects that are of great economic importance to mankind. Besides their value as honey and beeswax producer, they also play an important role in the pollination of several agricultural crops.

Indian honeybee, *Apis cerana indica* F. is native to southern and eastern Asia. This bee is found practically throughout Himachal Pradesh. This is a bee with gentle temperament, industriousness quality and easy to handle. However, this species suffers from certain defects like frequent swarming, absconding and robbing habits, production of large number of laying workers and helplessness against the attack of predators.

European bee, *Apis mellifera* L. is superior to *Apis cerana indica* F. in respect to better honey yield, less swarming, maintenance of prolific queen and guard against the enemies except wasps. However, both these species are close relatives because of similar nesting behaviour and building of parallel combs, etc. (Singh, 1962). This bee has been introduced only recently in various parts of the State on the experimental basis. But importation of *Apis mellifera* L. to our country as well as to the other countries like Japan, Pakistan, Indonesia, North Korea and Sri Lanka has met with little success.

In order to improve our native bee species, *Apis cerana indica* F. by selection and breeding, it is essential to collect the basic information on phylogenetic, cytogenetic, morphological and behavioural aspects of this bee. Out of all these aspects, detailed knowledge of quantitative parameters for certain morphological characters that directly or indirectly affect pollination and honey production, is quite important. It is, therefore, essential to identify the pure ecotypes of *Apis cerana indica* F. through morphometric studies. Lot of work has been done on races and strains of *Apis mellifera* L. in Europe, North America, Australia and Africa (Alpatov, 1929; Carlisle 1955; Wafa *et al.*, 1965;

Ruttner 1975, 1976) but little is known about our native bee species (Narayanan *et al.*, 1960, 1961a, b; Kapil, 1956; Kshirsagar, 1976).

The present investigation is a preliminary approach in the direction of identifying pure ecotypes of *Apis cerana indica* F. in Himachal Pradesh. Besides taxonomic implications, such studies may have a bearing on bee selection and breeding programmes. European bee, *Apis mellifera* L. was studied to have the morphometric comparison of the introduced European bee and native bee species.

### MATERIAL AND METHODS

Himachal Pradesh is mainly a hilly State lying between 30°-22'-14" to 33°-12'-44" N and 75°-45'-55" to 79°-04'-20" E in north-west Himalayas. This region is bestowed with rich bee flora and presents a variety of climatic and topographical conditions.

Keeping in view the above geographical conditions, honeybee samples were collected from different parts of the State having different altitudes, latitudes and climatic conditions. Samples of *Apis cerana indica* F. worker bees were collected from locally available colonies of this bee at Simla, Mandi and Bilaspur whereas *Apis mellifera* L. samples were collected from Himachal Agricultural University farm at Solan. About 150 bees were collected from each locality randomly either from the entrance of the hive or from central frames. Some of them were kept as preserved specimens and others were used for investigations. Bees were collected with the help of an aspirator, killed in chloroform and preserved in a medium of alcohol, acetic acid, formaline and distilled water.

Different morphological parts were dissected out and mounted in a medium composed of Arabic gum, glycerine, acetic acid and distilled water. All the morphological parts were mounted in between the two glass slides except for tergites and sternites. The latter parts were mounted on glass rods so as to retain their natural shape and to simplify the procedure of measurement. All measurements were taken with the help of a microscope equipped with an ocular scale of 0.01mm. Various measurements on wings were made by projecting the slides on the wall of a dark room.

Various morphological characters studied in the present investigations were based on the previous work of Alpatov (1929) and Ruttner (1975) on *Apis mellifera* L. The following characters were determined: Tongue length, length and breadth of forewings, length and breadth of hindwings, number and extent of hamuli, cubital index, length and breadth of wax glands, length of third and fourth tergites, length and

breadth of third and sixth sternites, wing venation angles, length and breadth of different parts of hind leg and colour patterns.

## RESULTS AND DISCUSSION

Morphometric studies on Indian honeybee, *Apis cerana indica* F. showed colour differences in the bee samples collected from different parts of Himachal Pradesh (Table III). Honeybee samples from Simla hills were darker in colour than bees collected from Mandi and Bilaspur area. Kshirsagar (1976) had also found bees of darker and lighter colours at higher and lower altitudes respectively. Such changes may be due to altitudinal and geographical variations (Narayanan *et al.*, 1961a).

Present morphometric results on the tongue length of *Apis cerana indica* F. support the conclusions of Kshirsagar (1976) that this character is not related to the altitude as reported earlier by Narayanan *et al.* (1961a). For example in the present investigations it was observed that tongue length of bees collected from Simla hills (5.3039mm) and Bilaspur regions (5.3112mm) were almost same whereas tongue length of bees from Mandi (5.2866mm) were shorter than bees collected from Bilaspur area (Table II). Bilaspur and Mandi regions of Himachal Pradesh are almost at the same altitude whereas Simla is located at a much higher elevation. So the present results support the view of Geotze (1951) that tongue length may be related more to the flower morphology than to the altitude.

Forewings and hindwings of *Apis cerana indica* F. collected from Simla hills were more longer and broader than the bee samples collected from Mandi and Bilaspur area (Table I). Similar results were also reported by Kapil (1956) and Kshirsagar (1976) for this species present at higher altitudes. As the size of wings is directly related to flight ability of bees (Lindaeur, 1957) it is suggested that hilly area bees may be more efficient foragers than plain area.

Cubital index of *Apis cerana indica* F. collected from Simla hills (3.828) was lower than bees from Mandi (3.981) and Bilaspur area (3.936) (Table I). However, Kapil (1956) found higher cubital index for bees of Srinagar (Hills) (4.248) than bees from Allahabad (plains) (3.582). Kshirsagar (1976) also could not find any relationship between cubital index and altitude. Cubital index is an important character in the racial differentiation of bees. As revealed by data, it may be suggested that lower value of cubital index indicates bigger size of wings.

Number of hooks were smaller in *Apis cerana indica* F. collected from Simla hills (18.50) than bees from Mandi (19.15) area (Table I). These results support the statement of Narayanan *et al.* (1961a) that smaller number of hooks are found in bees at higher altitudes. These

TABLE I. Comparative biometrical data on introduced *Apis mellifera* L. and *Apis cerana indica* F. collected from different parts of Himachal Pradesh.

Name of species	Place of collection of sample	Forewings (mm)		Cubital index			Hindwings (mm)				Hind Legs (mm)			
		Length 1	Breadth 2	a 3	b 4	a : b 5	Length 6	Breadth 7	Number of h k 8	Extent of hamuli 9	Length of femur 10	Length of tibia 11	Length of basitarsus 12	Breadth of basitarsus 13
<i>Apis cerana indica</i> F.	Simla Hills	8.561 ±.017*	2.853 ±.015	.521 ±.003	.139 ±.002	3.828 ±.080	5.953 ±.023	1.677 ±.009	18.5 ±.195	1.242 ±.007	2.520 ±.006	3.112 ±.009	1.969 ±.006	1.088 ±.005
	Mat. di	8.483 ±.021	2.832 ±.007	.536 ±.003	.138 ±.002	3.936 ±.079	5.758 ±.010	1.643 ±.005	19.15 ±.143	1.247 ±.004	2.419 ±.004	3.071 ±.008	1.922 ±.006	1.081 ±.002
	Bilas-pur	8.330 ±.014	2.834 ±.007	.544 ±.004	.140 ±.002	3.981 ±.100	5.741 ±.015	1.629 ±.006	18.38 ±.196	1.196 ±.008	2.459 ±.005	3.116 ±.006	1.925 ±.006	1.078 ±.003
<i>Apis mellifera</i> L.	Solan	9.119 ±.016	3.110 ±.006	.566 ±.003	.226 ±.003	2.536 ±.043	6.308 ±.019	1.932 ±.005	20.78 ±.129	1.390 ±.004	2.676 ±.006	3.220 ±.009	2.017 ±.007	1.109 ±.004

\*Standard error about mean.

TABLE II. Comparative biometrical data on introduced European bee, *Apis mellifera* L. and *Apis cerana indica* F. collected from different parts of Himachal Pradesh.

(All measurements are in mm.)

Name of species	Place of collection of sample	Tongue length	Third tergite			Fourth tergite			Third sternite				Sixth sternite	
			Length of light band	Length of dark band	Total length	Length of light band	Length of dark band	Total length	Length of wax gland	Breadth of wax gland	Area between wax gland surfaces	Total length	Length	Breadth
		14	15	16	17	18	19	20	21	22	23	24	25	26
<i>Apis cerana indica</i> F.	Simla Hills	5.303 ±.069*	1.019 ±.012	.839 ±.018	1.992 ±.007	.643 ±.009	1.121 ±.010	1.905 ±.006	1.518 ±.006	1.989 ±.012	.199 ±.005	2.448 ±.007	2.350 ±.007	2.607 ±.011
	Mandi	5.286 ±.067	1.021 ±.019	.766 ±.020	1.953 ±.017	.655 ±.009	1.089 ±.010	1.895 ±.007	1.506 ±.005	2.019 ±.009	.211 ±.006	2.432 ±.005	2.329 ±.009	2.571 ±.011
	Bilas-pur	5.311 ±.066	1.046 ±.020	.724 ±.022	1.906 ±.025	.673 ±.007	1.073 ±.008	1.887 ±.006	1.524 ±.006	1.976 ±.009	.216 ±.007	2.388 ±.009	2.277 ±.007	2.505 ±.030
<i>Apis mellifera</i> L.	Solan	6.108 ±.073	1.658 ±.006	.529 ±.006	2.339 ±.006	.384 ±.019	1.649 ±.021	2.163 ±.007	1.703 ±.006	2.413 ±.008	.247 ±.003	2.887 ±.008	2.662 ±.006	3.066 ±.008

\*Standard error about mean.

TABLE III. Comparative biometrical data on introduced European bee, *Apis mellifera* L. and *Apis cerana indica* F. collected from different parts of Himachal Pradesh.

(All angle measurements are in degrees)

Name of species	Place of collection of sample	Wing Venation angles**											Colour patterns**	
		Angle 31	Angle 32	Angle 33	Angle 34	Angle 35	Angle 36	Angle 37	Angle 38	Angle 39	Angle 40	Angle 41	3rd tergite	4th tergite
		27	28	29	30	31	32	33	34	35	36	37	38	39
<i>Apis cerana indica</i> F.	Simla Hills	32.33 ±.231*	107.26 ±.635	93.26 ±.005	19.33 ±.217	88.73 ±.499	43.73 ±.448	99.33 ±.855	83.80 ±.474	14.17 ±.272	74.13 ±.576	30.73 ±.358	3.628 ±.079	1.985 ±.024
	Mandi	31.93 ±.186	107.73 ±.588	94.00 ±.641	19.86 ±.154	88.40 ±.329	43.20 ±.707	97.06 ±.650	81.58 ±.279	15.37 ±.335	73.40 ±.678	31.06 ±.327	3.842 ±.063	2.014 ±.014
	Bilaspur	31.80 ±.302	108.06 ±1.090	94.26 ±.596	18.33 ±.278	87.53 ±.485	44.20 ±.519	98.40 ±.829	80.53 ±.883	14.06 ±.139	75.20 ±.920	31.66 ±.469	3.742 ±.007	2.014 ±.014
<i>Apis mellifera</i> F.	Solan	30.93 ±.308	109.66 ±.597	95.46 ±.295	22.60 ±.310	92.73 ±.367	52.04 ±.367	94.80 ±.492	82.06 ±.537	14.26 ±.209	86.33 ±.478	34.40 ±.563	3.99 ±.010	1.99 ±.017

\*Standard error about mean.

\*\*Different wing venation angles shown in Fig. 1.

\*\*\*For the colour of tergites a scale of 1-5 is used from 1 (completely dark) to 5 (completely or almost completely yellow).

differences in number of hooks of hill and plain area bees may be due to the differences in environmental conditions of these regions (Narayanan *et al.*, 1961a,b).

Size of tergites and sternites is the index of abdominal size (Morimoto, 1965). According to this parameter, size of *Apis cerana indica* F. collected from Simla hills was found bigger than bees from Mandi and Bilaspur area (Table II). Narayanan *et al.* (1960, 61a,b) and Kshirsagar (1976) also reported bees of bigger size at higher altitudes.

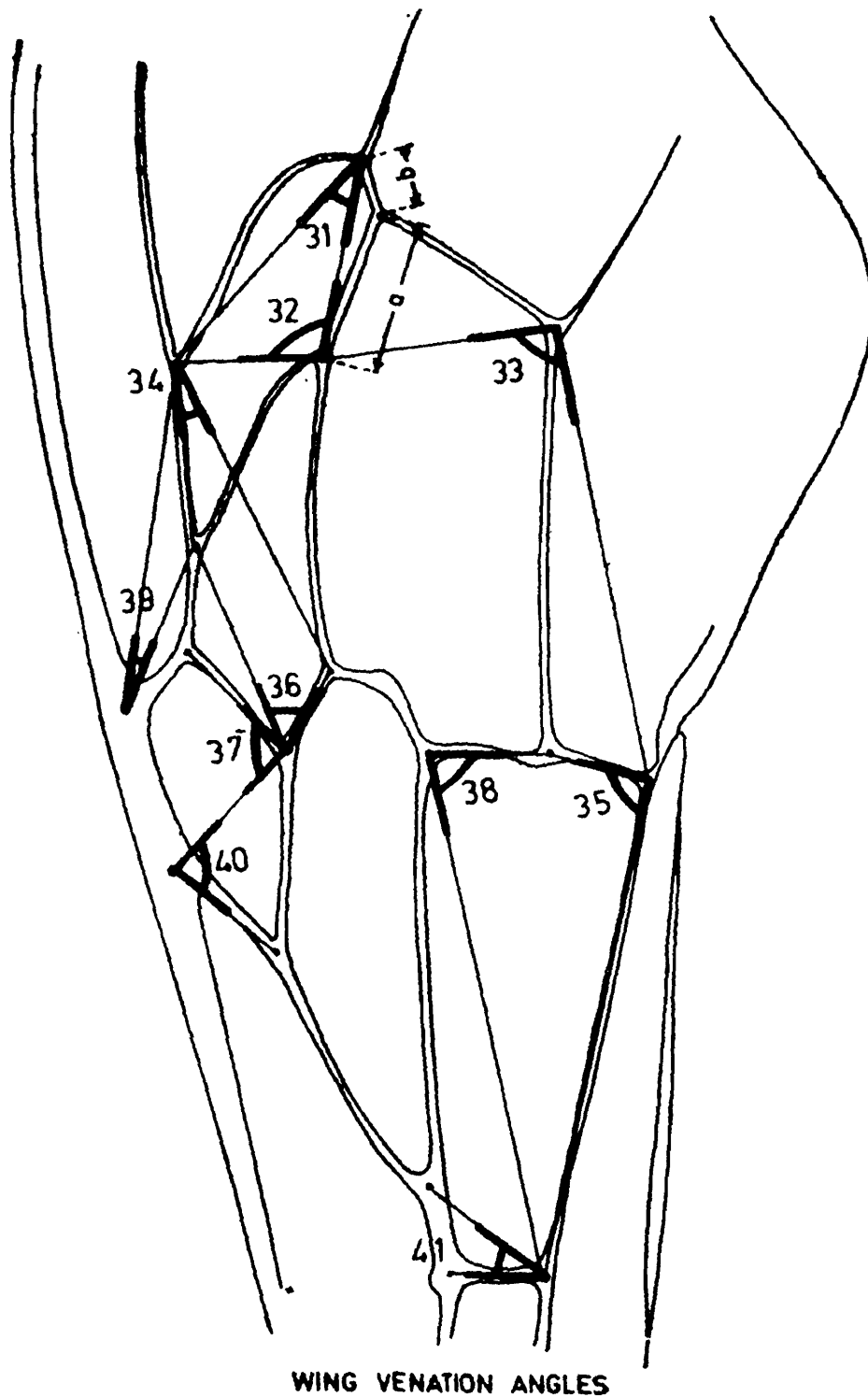


Fig. 1. Different wing venation angles used in Table III. Ratio  $a : b$  = cubital index; 31 to 41 are different angles.

Morphometric studies on different morphological characters such as size of wings, tongue length, size of tergites and sternites, number and extent of hamuli, different wing venation angles, etc. revealed higher values for introduced European bee *Apis mellifera* L. than *Apis cerana indica* F. except cubital index and some wing venation angles (Figs. 1&2). So *Apis mellifera* L. is definitely bigger in size than *Apis cerana indica* F. Since some of the morphological characters

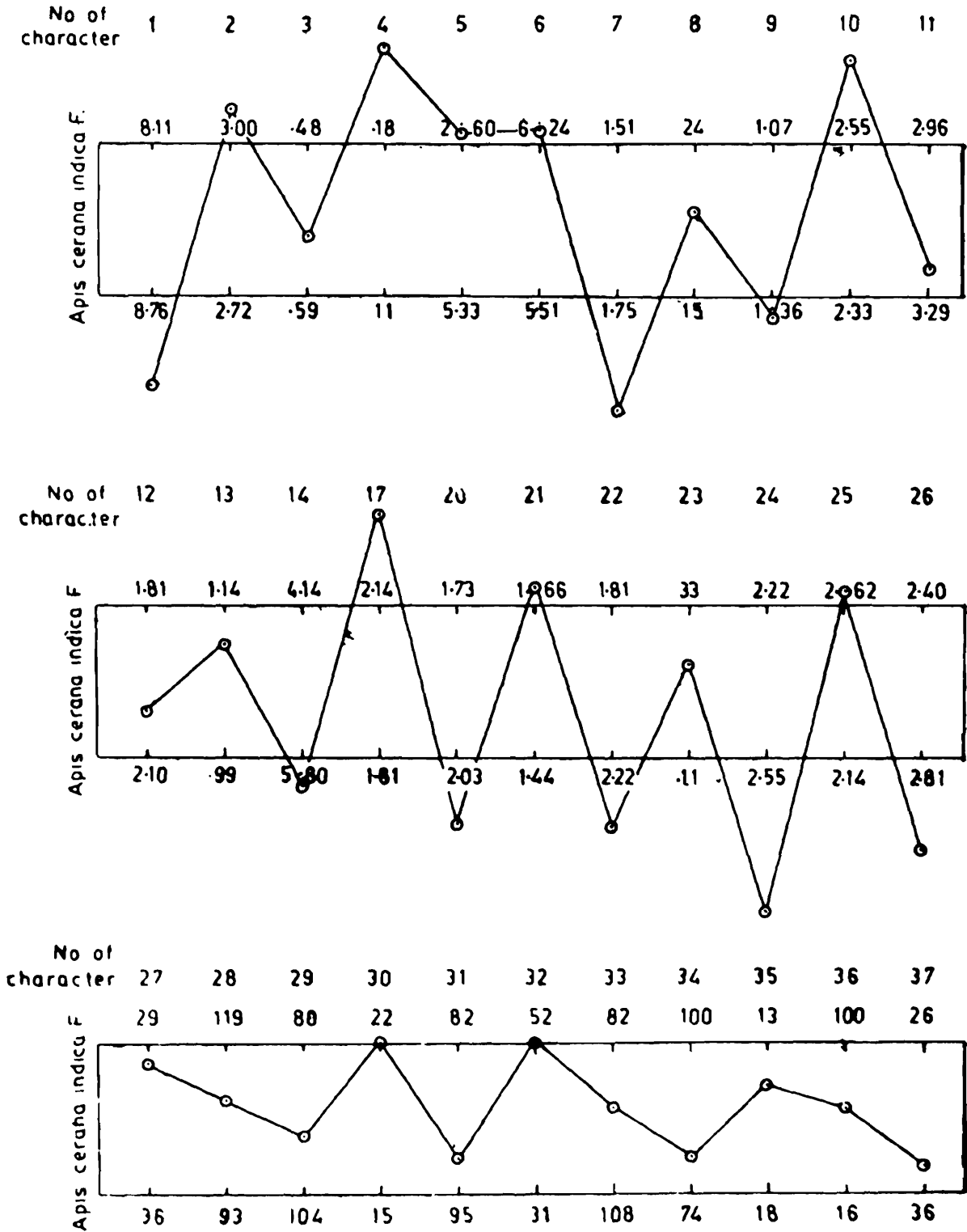


Fig. 2. Mean values of different morphological characters of introduced *Apis mellifera* L. plotted in the range of variation of *Apis cerana indica* F. collected from different parts of Himachal Pradesh, shown above and below the rectangle. (See Tables I, II, III for explanation of different characters).

possibly affect the flight ability, foraging activity and nectar and pollen collection capacity of the bees so the present morphometric studies suggest the better honey production and pollination ability of European bee, *Apis mellifera* L.

However, there are little chances of successful introduction of *Apis mellifera* L. on large scale in India because of different environmental conditions, flora, hazards of many diseases, pests and predators and unsuccessful mating flights. Moreover, in many parts of Asia particularly in Japan, the introduction of European bee has led to the suppression of native bee species. So it is better to concentrate on our native bee, *Apis cerana indica* F. that has many valuable characters of economic importance, which have not been explored so far. By identifying the various ecotypes of *Apis cerana indica* F. through morphometric studies, we can then develop the better strains of this species by selective breeding and improved beekeeping techniques.

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## SOME OBSERVATIONS ON THE ECOLOGY OF THE HIGH ALTITUDE FAUNA IN NORTH SIKKIM

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### INTRODUCTION

An ecological study in the high altitude areas of North Sikkim was undertaken by the author in collaboration with the Geological Survey of India, Calcutta, Physical Research Laboratory, Ahmedabad and Indian Meteorological Department, New Delhi, during August-September, 1978.

Sikkim (Lat. 27°5' and 28°9' N; long. 87°59' and 88°56' E; alt. varying from 300m to 8598m), lies almost in the middle of the eastern Himalayas, a stretch of extremely rugged mountainous area along the northern boarder of India, with an area of *c.* 7317 sq. km. Owing to its position in the lap of the Great Himalayan Ranges it receives a heavy annual rainfall, about 125 cm even in the comparatively dry upper valleys of Lachen and Lachung, increasing to about 350 cm in other parts, which feeds innumerable tributaries of the Tista.

The mountain ecosystem is classified into three natural zones : the forest zone occupying the lower, middle and upper parts of the mountain flanks up to *c.* 3900m, the next high-level zone with its alpine vegetation up to *c.* 5000m and the highest zone beyond *c.* 5000m elevation is the niveal zone, with its glaciers. The forests of Sikkim cover approximately an area of 2,65,216 hectares. This constitutes about 36.2 per cent of the total land area. In addition, the alpine pastures and permanent snow covered areas occupy about 30 per cent more.

### CLIMATE

The climate varies between humid tropical and alpine cold. During the period of our study the day temperature ranged from 12° to 19°C and 4° to 5°C in the night, and the relative humidity 56 to 75%. at the base camp at Chungthang which is at *c.* 1525m altitude. The clouds like stratus, cumulus and stratocumulus were commonly observed, and visibility was quite good during clear days. At the higher altitudes the fall in the night temperature was more apparent than the day temperature. The diurnal temperature ranged from

10° to 14°C and 2° to 5°C in the night, and the relative humidity 56 to 80%, up to Yumthang at an altitude of c. 3684m. The formation and dissipation of all the above three clouds were frequent with intermittent rains. Visibility became poorer successively on higher altitudes. The wind speed was approximately 8 to 12 km/hr. Even in the alpine zone at Somdong at an altitude of c. 5093m the maximum day temperature recorded was 13°C but the minimum night temperature was -2°C, and the relative humidity 60 to 90%. The fluctuation of temperature was frequent depending upon the rains and snowfalls. The wind speed in the morning up to 10.00 hrs. used to be 5 km/hr. but gradually increased from 8 to 12 km/hr. beyond 10.00 hrs. Visibility was generally very poor particularly after 7.00 hrs. Above c. 5093m elevation there was no significant change in the meteorological readings except slight increase in the wind speed up to 15 km/hr. even in the Chungme Khamphu glacier at c. 5200m elevation.

### OBSERVATIONS

The present study was confined to the upper parts of the forest zone (i.e. in the moist temperate forest belt) and alpine zone in the North Sikkim. The base camp at Chungthang was bordering the moist temperate belt with the tropical-subtropical forest types having the dominant plant species like *Litsea* sp., *Machillus* sp., *Lyonia* sp., *L. ovalifolia*, *Viburnum foetus*, *Ilex* spp., *Rhus wallichia*, *R. elegans*, etc. A herb, *Lycopodium* sp. and orchids like *Ceohgya* sp., and *Dendrobium* sp. are common. Among the avian fauna Hoopoe (*Upupa epops* Linnaeus), Tibetan Grey backed shrike [*Lanius tephonotus* (Vigors)], Whistling Thrush [*Myiophoneus caeruleus* (Scopoli)], Black headed Sibia [*Heterophasia capistrata* (Vigors)] and Whitecapped Redstart [*Chaimarrornis leucocephalus* (Vigors)] were common.

The regions between c. 1525m and c. 3050m which include both Lachen (alt. c. 2745m in the north-west) and Lachung (alt. c. 3050m in the north-east) valleys, are with a bracing climate, comparatively broad and flat, with a moderate rainfall, fairly well populated and cultivated. Ecologically both these valleys fall under the moist temperate belt.

*Flora* : This belt consists of predominantly dense tall evergreen forest with moss and lichen-covered trees. Some of the dominant plant species are *Betula* sp., *Cinnamomum* sp., *C. tamala*, *Ulmus nepalensis*, *Onerins* spp., *Pinus excelsa*, *Cedrus* spp., *Cupressus forulesa*, etc., besides the herbs and orchids as mentioned earlier were plentiful up to c. 2438m elevation. The upper limits, from c. 2745 to c. 3965m, cover the areas up to Yabuk (alt. c. 3965 m in the north-west) and Yumthang (alt. c. 3684 m in the north-east), bordering the alpine zones. The conifers like Silver fir (*Abies webbiana* and

*A. pindrow*), junipers (*Juniperus communis*, *J. squamata*, *J. wallichiana*) and herbaceous plants of medicinal importance, viz., *Nardostachys jatamansi*, *Rheum nobile*, *Aconitum palmatum*, *Allium wallichiana*, *Bergenia ligulata*, etc. occur in this area, with which are mixed deciduous trees such as magnolias and poplars. The undergrowth is made up largely of dwarf rhododendrons, occasionally with bamboo (*Arundaria* sp.) and other evergreen shrubs. There is a luxurious growth of moss, ferns and epiphytes, *Rhododendron campanilatum*, *R. anthopogan*, *R. arboreum*, *R. hookeri* and *R. lepidotum* around c. 3200m becoming abundant at c. 3355m while from c. 3684m to c. 4267m altitudes they form the mass of shrubby vegetation. Several species of rhododendrons and junipers of the upper moist temperate forest belt extend to the alpine zone which stretches from c. 4000 to c. 5000m elevations. The vegetation in this zone is composed chiefly of small stunted trees and large shrubs interspersed with patches of fir (*Abies* spp.), pine (*Pinus* spp.) and deodar (*Cedrus* spp.). The plants in this zone meet their water requirements largely from the snowfall and melting snow. They become progressively dwarfed and scanty towards the upper limits. Patches clear of snow up to Marcopolis (alt. c. 4800m in the north-west) and Somdong (alt. c. 5093m in north-east) become carpeted with a profusion of many species of herbaceous plants including those of medicinal importance as mentioned earlier, besides *Picrorhiza hurrea*. Beyond c. 5000m altitude is the nival zone, Zemu in the north-west and Chumge Khampu in the north-east, where plant growth virtually ceases, the heights above c. 5000m being covered by rocks and perpetual snow. But the receding of the glacier during the last few years (approximately 400 metres in Zemu glacier, personal communication U, Bhattacharya), a phenomenon that has been studied by Glaciology division of the Geological Survey of India, Calcutta has exposed cirques in both the above zones, which have developed into new meadows at c. 5185m altitude. The high valleys from c. 3657 to c. 5170m are now used for grazing of domesticated livestock like yak, sheep and ponies in summer.

*Fauna* : Sikkim is still rich in flora and fauna which are unique in the world. Some of the birds collected are : Whistling Thrush [*Myiophonus caeruleus* (Scopoli)], Speckled wood pigeon (*Columba hodgsonii* Vigors), Snow Pigeon (*Columba leuconota* Vigors), Redbilled Chough [*Pyrhocorax pyrrhocorax* (Linnaeus)], Red headed Rosefinch (*Propyrrhula sublimachala* Hodgson), Beavan's Bullfinch (*Pyrrhula erythaca* Blyth), White capped Redstart [*Chaimarrornis leucocephalus* (Vigors)], Rufousbellied crested Tit (*Parus rubidiventris* Blyth), Green backed Tit (*Parus monticolus* Vigors), etc., and the other species observed were the Monal (*Lophophorus impelanus* Latham), the Satyr Tragopan [*Tragopan satyra* (Linnaeus)], Blood Pheasant [*Ithaginis cruentus* (Hardwicke)] in the conifers, junipers and rhododendron

forests from c. 2745 to c. 5000m elevation. The Tibetan Snowcock (*Tetragallus tibetanus* Gould) was confined only in the alpine and nivéal zones of both Zemu and Chumge Khamphu glaciers in the north-west and north-east Sikkim, respectively. Among the mammals : Tibetan Ass [*Asinus kiang* (Moorcroft)] in a group of ten in the north of Donkya La near Bomchho La; the Woolly Hare (*Lepus oiostolus* Hodgson), and the Bharal [*Pseudois nayaur* (Hodgson)] in Kirang-Dongkung areas were observed in the north-east Sikkim and again the Woolly Hare and the Snow Leopard [*Panthera uncia* (Schreber)] in Mugothang area in the north-west Sikkim at altitudes ranging from c. 5185 to c. 5490m (personal communication U. Bhattacharya, G.S.I.). The Bharal in herds over 20 was often seen on the hills adjacent to our camp at Somdong in north-east Sikkim. The Goral (*Nemorhaedus goral hodgsoni* Pocock) in a small group of five individuals were encountered near about Somdong. Other animals like the Brown Bear (*Ursus arctos* Linnaeus), the Himalayan Black Bear [*Selenarctos tibetanus* (Cuvier)], the Tibetan Wolf (*Canis lupus chanco* Gray), the Musk Deer (*Moschus sifanicus* Buchner), etc. were occasionally met with on the eastern border of the Kanchanjunga National Park, around Jakthang, Yabuk, etc. at altitudes ranging from c. 3300 to c. 3965m in the north-west Sikkim. In addition, a troop of seven langurs (probably *Presbytis* sp.) was observed in Jedang (approximately 12 km north-west of the Forest Rest House, Lachen, at an altitude of c. 3050m across the Jedang river. The head and under parts of this langur were snowy white, whereas the upper coat was light gray. This animal has further been sighted in Talung valley, Rangit valley, Kahtchu valley, etc., during December-March (personal communication U. Bhattacharya, G.S.I.)

Specimens of some other species were also collected as under but have not yet been identified Vole (1 ex, Yumthang, alt. c. 3684m); Mouse Hare (2 ex, Somdong, alt. 5093m and Lachen, alt. 2745m); Bat (2 ex, Chungthang, alt. c. 1525m and Yumthang); Snake (2 ex, Chumthang and Lachen); Rat (2 ex, Lachen); besides several insects at different altitudes.

## DISCUSSION

It is known that the Goral is a mountain dweller and prefers rugged grassy hills and rocky ground near forests at moderate elevations from c. 900m to c. 2750m and was rare up to c. 4250m, whereas the Bharal occupied a habitat with rich and abundant grasses from c. 4250 to 4800m altitudes according to Blanford (1888-91) and Prater (1965). The Woolly Hare was observed at Kongra La Pass (c. 4270m) by Blanford (1888-91) in north-west Sikkim. Similarly, the Snow Leopard operated from c. 3660 to c. 3965m according to Pocock

(1939), Prater (1965) and Walker (1968). But on the basis of the present study it may appear that the animals like the Goral, Bharal, Woolly Hare, etc., are extending their ranges in areas where they were not known to occur previously. The probable reason for this upward extension of range may be the melting of glaciers (either by catabetic wind or glacier cycle) on account of rapid changes in the environmental conditions in the nival zone that has brought into existence the new pastures in c. 5170 to c. 5490m altitudinal zone.

Such migrations of the primary consumers like Goral, Bharal, Woolly Hare, etc. have led the secondary consumers such as the Snow Leopard to follow its prey. This suggests that the existing fauna of the eastern Himalayas in the north Sikkim are set for extension to the new pastures for their existence due to the remarkable changes in the environment. So long the wildlife of this region have survived due to the undisturbed and inaccessibility of their habitats. But now these protections are gradually being curtailed through the introduction of modernisation in the area, such as the settlement, agriculture, construction of high mountain roads and improved fire arms. Now they have been left with only course to seek refuge from man and the tropical heat of the valley by extending their range further in the inaccessible snow covered regions of the Himalayas. This phenomenon needs adequate and critical observations since these animals belong to the palaeartic realm. It is needless to emphasize that the severe climatic conditions impose limitations on their breeding potentials and growth rates. Seasonally they are forced to shift their feeding and shelter grounds and often compelled to survive within a narrow margin of subsistence level. The status of none of these animals has yet been ascertained, but there is reason to believe that their population has declined due to human interference.

The change in the land use during the last decade, particularly opening up of forests for settlement and agriculture in both Lachen and Lachung valleys, exploitation of remaining forests for timber and fuel, indiscriminate killing of animals for food and other economic purposes, etc., are probable reasons for such remarkable change in the area, though a National Park of about 800 sq. km in extent covering Lachen, Jedang, Jakthang, Yabuk, etc., has already been notified on 26th August, 1977. The unlimited destruction of the forests may further affect the stability and fertility of soil, water course and protection against avalanches and land slides. It is well known that the masses of cold air (i.e. anabatic wind) with harsh properties are formed in both the alpine and nival zones, but are made to loose their harshness and modified into pleasantness in the forest zone during their downward flow. The avalanches which may occur both in winter and summer in the nival zone, are blocked by the shrubs of rhododendron or shattered in the forest zone, before they reach to valleys

without any ill effect. Further, the stability and fertility of soil are being affected by land slides, which are becoming common in the eastern Himalayas.

The natural resources of the Himalayas are still abundant and diverse, but not boundless. These riches may continue to serve the mankind if exploited rationally. Thus, it would appear that the mere creation of the National Park may not be enough to protect the fauna of the area, unless the entire ecosystem is managed scientifically. It would be worthwhile if the area of the existing Kanchanjunga National Park which is already covered by the Biosphere Reserve of the Government of India, is extended to cover the eastern extremity of Lachung, Yamthang and Yume-Somdong valleys for the protection of the existing wildlife.

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## WILDLIFE ECOLOGY AND CONSERVATION IN UTTARKHAND HIMALAYAS

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### INTRODUCTION

Wildlife, *sensu stricto*, should be taken to comprise ownerless wildlife animals difficult to lay hold of and to manipulate. It should include many wild animals which are today outside the scope of wildlife studies, e.g. many arthropods (constituting about 70% of animals), giant snails and molluscs, fishes (among which the mighty Mahser of Kumaon is rapidly declining) and Amphibia (Batrachians), some of which are found nowhere else in the world except the Himalayas.

Ecological study of wildlife, and its utilisation and management as an aspect of land use, remains practically ignored in national research programmes in India. This is all the more unfortunate since they are no longer present in sufficient numbers to be utilised economically as a forest product. It is therefore necessary to separate management of forests from that of wildlife, which represents many vanishing species in Uttarkhand Himalayas.

The Himalayan ecological biosphere of the Oriental (Indian) region has palaeartic affinities. Almost one third of the fauna of Kashmir is palaeartic in origin (Das, 1966), and about one fourth of that of Nepal (Sreshta, 1981). However, palaeartic incursions have also taken place in Uttarkhand Himalayas, where animal life is more or less distinct from the rest of India.

### ALTITUDINAL ZONATION OF BIOTOPES

Due to the large range of altitude in the Himalayas, there is a characteristic altitudinal zonation of wildlife as also of the forest plants on which the animals are ecologically dependent. Four main altitudinal biotopes may be recognized : (1) Forest zone; (2) Moist temperate zone; (3) the Arid plateau; and (4) the Alpine forest.

(1) *The forest zone* : Biotope can again be divided into four sub-zones :—

(a) *The Tropical deciduous forests (100-1000 metres)* : This comprises the Doons of foot-hills, and lower valleys. The

dense forests of this zone are made up mainly of Sal, Shisham, Silk-cotton and giant Bamboo. The tropical forests of Uttarkhand Himalayas rise higher than in the Western Himalayas including Kashmir. The annual rainfall is from 50 to 100 inches. The typical large wildlife of this zone are the tiger, leopard, elephant, and Muntjac (Kakar), clouded leopard, wild boar, flying squirrels, sloth bear, gaur, wild dog, grey fox, large civet, jackal, leopard cat, jungle cat, yellow throated marten and the otter.

- (b) *The Tarai-Bhabar zone (200-1500 metres)*: This zone consists of a sloping low-lying country adjoining the foot-hills. The land is mostly covered with dense forests, with large cultivated areas. The main trees are Tun, Shisham, Kayar, Semal, Sal, Bamboo and now the introduced Eucalyptus. The annual rainfall is from 50 to 100 inches.

It is the home of water buffalo, cheetal deer, amcheeta, palm civet, yellow bellied weasel, hog deer, swamp deer, the goral, blackbuck, barasingha, chausinga, neelgai, the jackal, pigmy hog and the porcupine.

- (c) *The low hills (1500-2500 metres)*: This high rainfall (150-200 inches) zone is covered with dark gloomy rain forests characterised by stands of Oaks, Cypresses, Pines, Laurels, Firs, Magnolias, Rhododendrons, Birches and many epiphytes. Most of the Uttarkhand (Kumaon-Garhwal) Himalaya lies in this zone.

The principal wildlife here consists of the black-faced langoor sloth bear honey badger Himalayan otter, stone marten, pine marten, mountain tiger leopard, caracal, spotted civet, red hill fox, spotted flying squirrel, black bear the hill porcupine, goral, bharal and kakar.

- (d) *The medium wet mountains (3000-4000 metres)*: Here we have pure stands of Rhododendron, beech, juniper, yew, dwarf bamboo, dwarf oaks, dwarf cypresses and firs upto the tree line at 4000 metres. The rainfall is 50 to 100 inches annually, with occasional snowfall.

The typical animals are hog badgers, ferret badgers, honey badgers, crestless porcupine, goral, serow, occasional snow leopard, occasional tigers, the lynx, Himalayan black bear Himalayan brown bear red panda, red hill fox, orange and hoary bellied Himalayan squirrels, beech marten, the Ibex, tahr, markhor, golden Takin and bharal.

(2) *The moist temperate zone biotope (2000-4000 metres)*

This temperate biotope (not present in Uttarkhand) is confined to the western Himalayas (Kashmir, Hazara, Chitral, Gilgit and Hunza). The typical forests here are mainly of the conifers *Abies*, *Cedrus*, *Pinus*, *Tonga* and *Picea*; while other plants are *Quercus*, laurels, *Acer*, *Prunus*, *Vimus* and *Betula*. The annual rainfall is 30 to 50 inches and snowfall is very common.

Many rare animals inhabit this biotope; the musk deer, the giant flying squirrel, Ibex, Tibetan sheep, Tibetan lynx, Tibetan antelope, brown bear, black bear and Panda cat-bear.

(3) *The arid plateau biotope (3000-5000 metres)*

This temperate arid biotope is typified by Ladakh in J. & K. State and Tibet (now in China), as also some high altitude regions of Uttarkhand. Although many parts are cold deserts (as in Ladakh) other plateaus are covered with 'oases' of grass, stunted birches, junipers and berries. In some favourable spots are formed beautiful meadows, where Gujjars and Bakkarwals graze their sheep, goats and cattle in summer and migrate to lower heights in winter. The average rainfall is 3-10 inches a year with occasional meagre snowfall.

The wildlife here consists of pockets of Goral, Bharal, Ibex, Markhor, Tahr, Chus and Serow, which are sought after by hunters successfully, as there is little cover for the animals.

(4) *The alpine forest biotope (4000-6000 metres)*

The trees in this biotope consist of crooked dwarfed trees, alpine shrubs with some conifer overwood, as also dwarf Rhododendron, valleys of flowers and alpine meadows, where gentians Primulas, Iris, *Saxifraga*, geraniums, *Thymus* and astors bloom, representing palae-arctic flora in Uttarkhand. The few plants are *Larix*, *Abies*, *Betula*, Rhododendron thickets, Primulas, and epiphytic mosses and lichens. The average annual rainfall is only 10-30 inches.

This alpine forest stretches only upto the snowline, the altitude of which varies from 4000 to 6000 metres from mountain to mountain. The alpine biotope ends in alpine scrub and grassland extending a little above the snowline. Above 5000 metres are rugged empty regions of rock, ice and glaciers. Only berries, guggal and mamla grass grow here during the short summer.

Surprisingly, this biotope is also inhabited (albeit sparsely) by some wild life such as Marmot, Ibex, Urial, Tibetan antelope, Tibetan

gazelle, great Tibetan sheep, Musk deer, Mouse deer, Bharal and the Yak.

Although these four altitudinal biotopes are not sharply demarcated faunally in Uttarkhand (there being summer and winter migrations of wildlife from one biotope to another), one may define each of the four zones by its characteristic plant and wildlife indicators ecologically.

### WILDLIFE ECOLOGY

Ecologically the indigenous fauna of a particular region, such as Uttarkhand, should be understood as a special form of animal life evolved through centuries of specialised mountain forms. With the advent of man in the mountains and the rapid utilisation of wildlife on a land use pattern, by harvesting wild animals for subsistence, protein food, fishing, hunting, trapping, shooting, they become rarer and rarer. This has been further accelerated by trading in hides, skin, furs, ivory, horns, muskpods, rhinohorns, fangs, claws, feathers, wool, antlers, stuffed animals and even trapped live rare animals, specially for foreign countries. Rhinohorn and spinytailed lizard oil are extensively used even today as aphrodisiacs and talismans.

Besides killing for food and trade, wildlife was decimated in the Uttarkhand Himalayas by the ecologically destructive practice of "Jhoom" which is a shifting slash and burn agriculture. But even with sedentarisation of land-use, the domesticated meat source was dwarf goats, chickens and pigs; and each hill village or habitation demarcated its own territory for hunting wild animals' meat which formed about 50% of the meat-food source even 50 years back. This intensive utilisation of local wildlife played an essential role in the subsistence of rural population in the hills, wild animal meat today forming hardly 1% of the meat food.

The present day wildlife management on an ecological basis, practised in many advanced countries of the world, according to the principle of sustained yield, is found in a very few places in India today, and practically none in the Himalayas. This management involves the employment of experts, methodical measures for breeding and preservation of wildlife stocks, for optimal natural balance and optimal satisfaction of human needs both material and non-material.

Controlled sport for food and trophy-hunting (Hunting tourism) and animal byproducts for trade, are the main material natural exploitation of wildlife. This requires a strict licence system, division of an area into hunting zones or blocks, temporal census of wildlife in these blocks, and total ban on shooting, trapping and killing

of rare wildlife. Besides the extensive destruction of the biotope taking place today must be stopped by law to preserve ecological niches for the wildlife.

The nonmaterial utilisation of wildlife may be represented by bird-watching, tourism, photography, establishment of wildlife sanctuaries for tourists, and national game reserves or parks, involving scientific tourism. The actual proportion of land area for such purposes in Africa are : Tanzania 12%, Botswana 15%, Zambia 8%, Rhodesia 7%, Uganda 6%, Kenya 5%, Ivory Coast 3% and Zaire 2.5%. Figures for India are not available, but on a rough estimate it would be 0.1% in the Himalayas. The only wildlife sanctuary proposed for the Uttarkhand Himalayas, is the Nanda Devi sanctuary (5000 metres), where most regional wildlife is still naturally preserved, and which has not been set up.

The most urgent problem in the Himalayas generally, and Uttarkhand Himalayas in particular, is the development of wildlife by intensive management and breeding of game animals and fish, and a thorough rationalisation of land-use in relation to indigenous fauna. Game-ranching and game-farming in fenced areas, with their breeding, represents the most intensive form of game management to secure sustained production, yield and marketing of wild animals and their byproducts. This should apply specially to the musk-deer in Uttarkhand Himalayas, which is now a rare species, and which yields musk pods estimated to cost Rs. 4000/- per pod per animal.

### WILDLIFE DOMESTICATION AND CONSERVATION

Wildlife farming would of course require a thorough study of food of these animals, since much natural food consumed in the wild would be unavailable in these breeding reserves. A local experimental farming of musk deer has shown that they do not remain healthy and refuse to breed when fed with leaves of local plants or substitute food. Many wild animals, which refuse to breed in captivity, do so when proper food and living area (territory) is allotted to them. This aspect requires further research, specially for high altitude wildlife of the Himalayas.

Domestication and intensive breeding of some wildlife of economic importance is a virgin area for future research and development. If the high altitude Llama, Vicuna, Alpaca and Guanaco of S. America could be extensively domesticated for centuries for their superior wool; and the high altitude Yak completely domesticated in Tibet and Ladakh; there is no reason why the musk deer, goral, bharal, shapu, serow, ibex, markhor and Nayan (all economically

important high altitude-herbivores) could not be domesticated, intensively farmed and harvested in enclosed reserves. Similarly the fast vanishing rare wild birds, such as monal, kalij, cheer and koklas pheasants, snow partridge and wild rock pigeon, could be successfully reared as poultry farms.

Recent research findings (Talbot *et al.*, 1965) in different wildlife species have also shown that most of them compare more favourably than domestic livestock. In most cases, in terms of sexual maturity and rate of reproduction, wild animals in the tropics are significantly more productive than an equal weight of domestic stock under comparable conditions. They show very rapid growth rates compared with cattle of similar weight in similar areas, which also holds true for tropical highlands (Das, 1968).

Attempts at successful domestication and intensive breeding of wild-living indigenous animals have been made in East Africa. Treus and Kravchenko (1968) reported domestication of a herd of eight African Eland (*Tragelephus oryx oryx*) which has multiplied to 225, which are being managed under similar conditions to cattle and are also being milked. Roth (1965) reported positive domestication of a herd of Eland in Rhodesia, as also the Oryx (*Oryx beisa callotis*) in Kenya.

Among birds the Ostrich (*Struthio camelus australis*) has been kept under domestication since 1900 in South Africa; the Guinea fowl (*Numidia meleagris galeata*) domesticated for centuries; while efforts to domesticate the bushfowl (*Francolinus bicalcaratus*) is being made today in Nigeria. Ajayi (1975) has also reported the domestication and breeding of the giant pouched rat (*Cricetomys gambianus*) in west Africa, which is used as a delicacy. Similarly the world's largest rodent the Capibara (*Hydrochoerus hydrochaeris*), the African tapir and the Amazon manatee are being domesticated today. Breeding endangered species in captivity (Martin, 1975) also elucidates this aspect of wildlife conservation.

It is hightime that such attempts at domestication be made in India, specially for the rare wildlife of the Himalayas. A list of such wildlife for possible domestication is given below :—

*Mammals :—*

<i>Common name</i>	<i>Zoological name</i>	<i>Use for man</i>
Red bill fox	<i>Vulpes vulpes</i> (Linn.)	Fox fur and fox tail fur.
Himalayan mouse Hare	<i>Ochotona roylei</i> (Ogilby)	Meat and fur.
Hispid hare	<i>Caprolagus hispidus</i> (Pearson)	Meat and fur.
Pigmy hog	<i>Sus salvanius</i> (Hodgs.)	Meat.

<i>Common name</i>	<i>Zoological name</i>	<i>Use for man</i>
Barking deer (Kakar)	<i>Muntiacus muntjack</i> (Zim.)	Meat, hide.
Hog deer (Para)	<i>Axis porcinus</i> Zim.	Horn.
Chausingha antelope	<i>Antelope cervicapra cervicapra</i> (Linn.)	Meat, hide, horn.
Tibetan gazelle	<i>Procarpa picticaudata picticaudata</i> (Hodgson)	Meat, hide, horn.
Musk deer (Kasturi)	<i>Moschus moschiferus moschiferus</i> Linn.	Musk pod of commerce.
Brown goral (goral)	<i>Nemorhoedus goral goral</i> (Hardwicke)	Meat, hide, horn, milk.
Tahr (Him. wild goat or Jharal)	<i>Hemitragus jemlahicus jemlahicus</i> (Smith)	Meat, hide, horn, milk.
Himalayan ibex (Pashmina goat)	<i>Capraibex sibirica</i> (Pallas)	Pashmina wool for finest shawls.
Blue sheep (Bharal)	<i>Pseudois nayaur nayaur</i> (Hodgs.)	Wool, fur, meat, horn.
Great Tibetan sheep (Nayan)	<i>Ovis ammon hodgsoni</i> Blyth	Wool, horn.
Thar or Serow	<i>Capricornis sumatraensis</i> (Bech) thar (Hodgs.)	Meat.
<i>Birds :—</i>		
Monal pheasant	<i>Lophophorus impejanus</i> (Linn.)	Meat, eggs, feathers.
Cheer pheasant	<i>Catreus wallichii</i> (Linn.)	Meat, eggs, feathers.
Kaleej pheasant	<i>Gennaesus hamiltoni</i> (Griff.)	Meat, eggs, feathers.
Koklas pheasant	<i>Ceriornis macrolophus</i> Vigors	Meat, eggs, feathers.
Him. snowcock (Partridge)	<i>Tetraogallus himalayensis</i> Vigors	Meat, eggs, feathers.
Himalayan chakor	<i>Alectoris graeca chukor</i> Vigors	Meat, eggs, feathers.
Snow pigeon	<i>Columba leuconota</i> Vigors	Rare, to be protected.
Turk. Rock pigeon	<i>Columba rupestris</i> Linn.	Rare, to be protected.
Mountain quail	<i>Osphrasia superciliosa</i> (extinct)	Rare, to be protected.
Red head duck	<i>Rhodonessa caryophyllacea</i> (Latham)	Rare to be protected.
Him. woodcock	<i>Scolopax rusticola</i> Linn.	Meat, eggs, feathers.
Red jungle fowl	<i>Gallus gallus (bankiva)</i> Linn.	Meat, eggs, feathers.

## WILDLIFE VERSUS CATTLE ECONOMY

It is not generally known that coefficient of efficiency in meat production and carrying capacity (a primary index for productivity of land) is much higher for wild animals than for domestic stock (such as cattle, sheep, goats, etc.). Deer, antelope and gazelle are also so highly physiologically adapted to their ecosystems, that they are 50% more efficient in meat production than cattle kept on similar grasslands. Sheep and goats destroy saplings of forest trees and cause general destruction of the environment. So do hill cattle; but not so wildlife. Thus wildlife farms would be cheaper than cattle farms, if kept in large natural enclosures.

The secret lies in the better physiology of high altitude animals over that of cattle. Firstly, these animals have evolved to conserve energy in the mountain environment, whereas cattle must expend an enormous amount of energy merely to survive in an environment alien to them. Secondly, cattle must drink more water to perspire to keep cool during the day; and expend more energy to keep warm at night, for which an abundance of fat tissue is essential. This fat tissue formation requires two to three times as much food as does the formation of lean meat in the body. Wild deer and gazelle drink far less water, conserve energy by varying body temperatures, perspire less to cool their bodies and heat is stored during warm days and released during cold nights. Thus they do not require an abundance of fatty tissue and therefore need less grass to gain weight which is mainly protein and not fat.

### WILDLIFE BIOMASS POTENTIAL

The productive potential animal biomass i.e. the above-ground live weight of the larger wildlife in tropical highlands (such as Uttarakhand), exceeds that of other biotopes. In general wildlife biomass is also higher than that of domestic animals in the same biotope (although the balance may now be tilted by man). Wild animals are more resistant to diseases affecting cattle, can make optimal use of different layers of vegetation, and are less dependent on water (King and Heath, 1975).

Trees, shrubs and ground vegetation of these areas appear rather more suitable for mansided and equilibrated utilisation by indigenous game species, than for a one-sided pasturing of herds of cattle, sheep or goats. Sommerlatte (1969, quoted by Smith, 1976) gave a rough estimate of biomass of herbivorous wild mammals in different biotopes, which are as follows :—

<i>Biotope</i>	<i>Species</i>	<i>Biomass in Kg/Km<sup>2</sup></i>
Temperate mountain forest (Upper Bavaria)	(Red deer, <i>Cervus elaphus</i> )	566-870
Highland moor (Scotland)	( <i>Cervus elaphus</i> )	1.000
Mixed Woodland (Michigan USA)	(white tailed deer)	350
Tropical montane forest (Uttarakhand, India)	50 (large & small)	12,250 (1969)
Tundra (North Carolina)	(Carnivore)	800
Thorn bush savannah (Serengeri)	22	5000

But these values are only comparative rough estimates, as seasonal migration, calving periods, length of rainy season and other ecological factors affect their distribution. Real values would emerge only when statistical investigations of wildlife in different biotopes are undertaken. There is hardly any systematic policy in India in wildlife census and monitoring; and techniques of population analysis are still in their infancy (e.g. counting of tigers by their repeated pugmarks).

Meanwhile according to *red data book* (1973) 40 species of wild animals have become extinct in the last 50 years. The data would swell if all the small and large game of Uttarkhand, not seen today, were to be taken into account. Many more are now nearing extinction and may be called vanishing species. Besides widespread commercial private hunting and poaching and over-exploitation of wildlife resources in tropical highlands, they are also being sapped by demands of zoology laboratories in colleges and universities, research institutions, zoological gardens and museums in India and abroad, fur and feather traders, and horn-ivory cottage industries.

### VANISHING WILDLIFE

Today over 600 species of animals are threatened with extinction all over the world (Red data book); while in the Kumaon Himalayas (Das, 1978) these vanishing species number over 40 today. Trade in wildlife products and by-products for export and also for Indian market (besides hunting for sport and food) are main causes of our vanishing wildlife. Only recently snake-skins worth eight lakhs were intercepted in Bombay from export goods. Unfortunately no successful means have been found to prevent poaching. Other recent Indian data for export of wildlife in rupees are : untanned snake skin, 7 crores; tanned snake skin, 3 crores; leopard and tiger skin, 20 lakhs; musk, 20 lakhs; bird export, 34 lakhs; high altitude and forest animal collections, 26 lakhs; Himalayan animals, 2 lakhs; elephants, 2 lakhs and tigers, 83 thousand.

### CONCLUSION

The ultimate objective of wildlife management in the poverty-stricken Uttarkhand Himalayas should be improvement of living conditions (human ecology) of the rural population. Do not cut trees (and starve for fuel), do not kill wildlife (starve for protein food), do not trade in hides, skin, furs, musk-pods and other animal products (and starve for money), are being ordered by the administration. But the expanding population in the hills must get these necessities of life to survive; only 'do not's' will not help.

This is where the projects proposed by the author for wildlife farms and their domestication and production comes in as a solution. Since the hill population will not eat beef, cattle are automatically ruled out as a protein food source; and wildlife utilisation by higher production becomes a necessity. Wildlife management on an ecological basis can thus become a decisive factor in the development of rural regions in the hills. Future hill projects must cover this aspect in the Himalayas.

We have certainly got to preserve the rare wildlife in the Uttarkhand Himalayas some of which are found nowhere else in the world (Das, 1978); and the decline of wildlife in the Himalayas must be ecologically prevented by tackling the main causes of decline, which are : (a) demands of exploding population; (b) over-exploitation of forests; (c) extensive cultivation in Tarai and mountain slopes which reduce the lebensraum for wildlife; (d) reduction of breeding and rearing grounds (breeding ecology) and reduction of both plant and animal food (feeding ecology); (e) heavy poaching and killing for hides, skins, furs, etc. (which can be regulated lawfully to a minimum); and (f) senseless killing for sport (as one Raja of Madhya Pradesh described his shikari days as "killed 1,170 tigers only"; and Col. Pollock, a military engineer of the old days reported; "shot at least one wildlife everyday before breakfast"). It may be reiterated that the 1972 Wildlife Protection Act has hardly been successfully enforced in the mountain regions of Uttarkhand.

Martin (1975) in his compilation "Breeding endangered wildlife in captivity", has reviewed succinctly (from different authors) the problem of planned breeding of endangered species in captivity. Zoos, according to him, should become "*wildlife banks*" rather than "stationary circuses", where endangered species should be bred and returned to their natural habitats. This should cover some rare species of Uttarkhand Himalayas, such as the four pheasants, the wild fowl, the musk deer, tigers, langurs, and sloth bears. This method of restocking wildlife in nature, should one day become common practice if we are to preserve the vanishing wildlife of today.

It is therefore urgently recommended that a string of wildlife resources and captive breeding centres and research projects for high altitude animals be established in Uttarkhand Himalayas. One low altitude Corbett National Park in the foot-hills cannot preserve much high altitude wildlife. Surprisingly out of the 21 sites for biosphere reserves decided at the UNESCO sponsored International South Asia Conference at Varanasi in 1975, the only hill reserve for India mentioned was : "Sal-chir forest northwest of Dehradun" We must

seriously propose here and now several wildlife biosphere reserves in the Himalayas, two for each of the four biotopes and at least one for each in Uttarkhand Himalayas.

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## ADAPTIVE FEEDING MECHANISM IN KINGFISHERS OF WESTERN HIMALAYAS

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As the name itself suggests kingfishers fish for their food. But fish is not the only item of their food. Besides fish they rely on aquatic insects, crabs, frogs, tadpoles, crustaceans, etc., as well as some terrestrial feeding kingfishers feed on grasshoppers, crickets, beetles, etc., and occasionally they even prey upon lizards, small birds and rodents.

Based on their proportion of food items Indian kingfishers can be divided into two categories.

I. *Predominantly aquatic feeders* : These kingfishers feed more frequently near water though their food may be supplemented with terrestrial diet in some cases. The proportion of food, however, varies in different genera. Himalayan Pied Kingfishers (*Ceryx* sp.) feed exclusively on fishes; *Alcedo* and *Ceryx* feed on aquatic insects, tadpoles and crustaceans besides fishes; and *Pelegoropsis* and *Halcyon* (except *Halcyon smyrensis* L.) may rely on terrestrial diet besides aquatic food.

II. *Predominantly terrestrial feeders* : These include White-breasted kingfishers. They feed more on ground though aquatic diet is also included in their menu.

Feeding mechanism of two extreme exceptional feeding forms of kingfishers which are distributed in Western Himalayas has been discussed in the present paper. These are Western Himalayas Pied Kingfisher, *Ceryx lugubris continentalis* Hartert (exclusively piscivorous) and Whitebreasted Kingfisher, *Halcyon smyrensis smyrensis* (Linnaeus) (predominantly terrestrial feeder), which provides an example that the proportion of aquatic and terrestrial diet is not merely co-incident but appears to be correlated with adaptive beak structure.

### NATURAL HISTORY

The Western Himalayan Pied Kingfisher is distributed in the Western Himalayas (upto c. 2000 metres). Usually it keeps in pairs perched together or separately on rock near a hill stream. It dives

obliquely to get fishes near the surface. It feeds on fishes upto c. 15-18 cm (Ali & Ripley, 1970).

The Whitebreasted Kingfisher is a resident of plains and low hills of N. W India. Usually it keeps singly or in separated pairs perched upright on a fence post, telegraphic wire or a tree, often well away from water (Ali & Ripley, 1970). It is predominantly a terrestrial feeder relying largely on insects like grasshoppers, crickets, mantises and beetles. Fish constitutes only a secondary item. Capturing of prey on ground as well as on water nevertheless is similar, a sudden swoop from its perch to seize the quarry in the bill. If the prey is too large it is battered into pieces before devouring.

### BEAK STRUCTURE

Both upper and lower beaks of Western Himalayan Pied Kingfisher are long, stout and daggershaped. Both the bills are concave inside and the tomium is sharply edged (fig. 1a, T.S. of beak). It can exert pressure at its tip and when the beak is closed some gap remains between them (fig. 1b). This indicates that the beak is working something like a forceps or a prong.

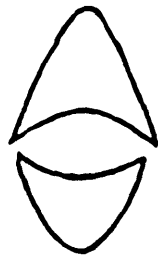


fig. 1 .a

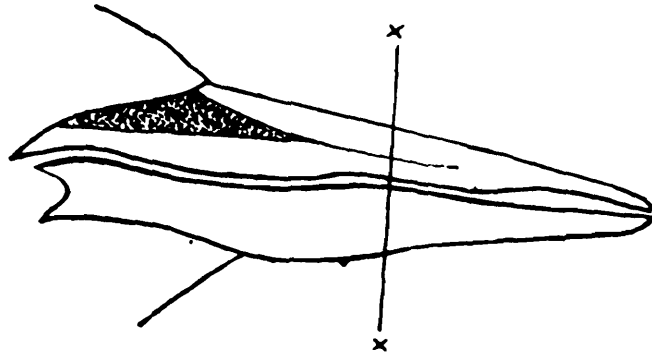


fig.1. b



fig.2. a

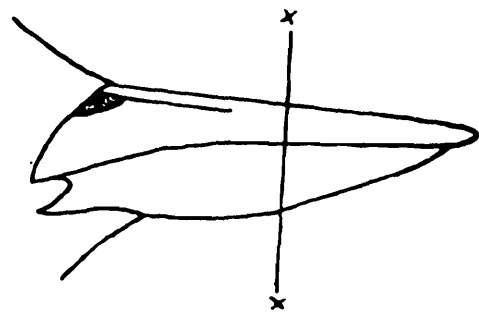


fig.2. b

- Fig. 1a. T.S. of Beak of Western Himalayan Pied Kingfisher.  
 Fig. 1b. Beak structure of Western Himalayan Pied Kingfisher.  
 Fig. 2a. T.S. Beak of Whitebreasted Kingfisher.  
 Fig. 2b. Beak structure of Whitebreasted Kingfisher in lateral view.

In Whitebreasted Kingfisher, *rhamphotheca* is thin and the bill is less stout in comparison to Western Himalayan Pied Kingfisher. The beak forms an angular cavity inside. The lower beak is a bit smaller and when it is closed it fits little inside the upper beak thus forming a rectangular cavity inside (figs. 2a & 2b).

This kind of beak structure suggests that when the beak is opened for feeding some vacuum is likely to be created.

### DISCUSSION

The Western Himalayan Pied Kingfisher and Whitebreasted Kingfisher present examples where they have picked up different feeding habits contrary to what is easily available in nature.

Thus the Western Himalayan Pied Kingfisher fishes in torrential waters where fishes are very difficult to approach and locate. It does not feed on other animals which are available in plenty. What possible reasons have tended this creature to pick up a rather difficult kind of feeding habit? The possible explanation can be gained from its beak structure and feeding mechanism.

As already mentioned it dives obliquely to get fishes near the surface. The beak structure suggests that it is well adapted for picking up fishes in the manner of a forceps or a prong. The stout bills, the dagger-shaped tips and the sharp-edged tomium are well-suited for this kind of feeding habit.

The Western Himalayan Pied Kingfisher on one hand has ended competition in its feeding zone, because there are no other fishing animals in the area and it is all in all feeding on fishes. But at the same time it has developed its own specialised features which are suited for a specific food and not for other. The gap that remains between the two beaks does not permit to hold smaller animals. It is something like an irreversible type of adaptation. Thus if by some reasons fishes are not available in its area either it will have to migrate to some other locality or it will altogether become extinct.

On the other hand Whitebreasted Kingfisher occupies an area where there is no dearth of fishes but even then it relies more on terrestrial diet than fishes. Again possible explanation is furnished by beak structure and feeding mechanism. While feeding on ground it sweeps obliquely at its prey, upper beak being slightly longer touches the ground first, the lower beak being lowered simultaneously. Thus the prey falls between the two beaks. It can also sweep with both the beaks open to hold the prey. When the lower beak is closed presumably it sucks air upwards with the help of its lungs and thus pushing

the prey upwards. If the insect is smaller it can be retained in the cavity when the beak is closed and larger insects are fragmented to pulp before devouring.

While coming to aquatic diet the same phenomenon of suction appears to be involved. The beak is opened and by suction a current of water is created which leads the fishes into the beak.

It may be seen that with this kind of feeding mechanism it can feed more conveniently on ground than under water. Terrestrial insects are available in plenty and are easy to locate and pick up than aquatic animals and probably for the same reason it is found at considerable distance from water venturing for food.

### ADAPTIVE SIGNIFICANCE

Significance of adaptation can be judged in terms of energy utilisation. A structure is more adapted because it can successfully discharge its biological role by using minimum amount of energy. Bock and Von Wahlert (1965) have suggested a satisfactory formula to judge the efficiency of adaptation. In brief it means the maximum force that can act during the life of individual animal with minimum amount of energy. It will be seen that Western Himalayan Pied Kingfisher and Whitebreasted Kingfisher save energy by different means.

When a bird (Western Himalayan Pied Kingfisher in this case) holds any object (i.e. fish) and intends to bite it harder the object being bitten exerts a pressure normal to the curvature of tomium (Bock, 1974). The curvature of tomium is very little in Western Himalayan Pied Kingfisher and hence the fish exerts proportionately lesser force and lesser energy is required to balance it. The sharp-edged tomium is also a factor in reducing energy consumption. A flat tomium would have required more energy to hold the fish in its beak.

The Whitebreasted Kingfisher has a larger curvature of tomium and beak material is also thinner. It will have to exert more energy if it will feed like Western Himalayan Pied Kingfisher. However, this disadvantage is compensated by utilising suctional force during feeding and thus reducing pressure on the tomium to hold the prey.

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## ECOLOGY AND ADAPTATIONS OF HILL STREAM FISHES

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### INTRODUCTION

Fishes inhabiting montane torrential streams and at higher elevations exhibit exclusive features as compared to those living in the plains. The ecological parameters associated with fish life in such torrential streams clearly reflect the impact of the environment. An assessment of the different categories of torrential streams and their main features would be a pre-requisite for a discussion of their adaptations.

### TYPES OF TORRENTIAL STREAMS

Five categories of torrential streams mainly based on their water sources are known. These are as below :

1. Rain-fed streams 2. Glacial streams 3. Spring fed streams  
4. Subterraneous or Cavernicolous streams 5. Valley streams.  
The last three rarely harbour any hill-stream fishes with peculiar adaptations and are as such not detailed further. The main ecological features of the first two streams are as below :—

1. *Rain-fed streams.*—These are largely seasonal and dry up during the non-rainy months. As such the total discharge and volume of water carried is highly fluctuating with no diurnal variation. The temperature of the water is generally high and mostly “warm” Turbidity is also usually high, depending on the amount of silt carried which in turn is related to the frequency and abundance of rainfall. The current velocity varies abruptly. More dissolved gases like  $\text{CO}_2$ ,  $\text{NO}_2$ ,  $\text{SO}_2$  are present. The depth of the stream is variable with abundant marginal vegetation and shade. The stream bed is uneven, often times comprising of loamy soil, or sand, with patches of pebbly and rocky substratum. When not in floods, the stream tends to meander. Many of the rain-fed streams proliferate with effluent rivers and rivulets and ultimately reach the sea. They are as such long in their stretch.

2. *Snow-fed or glacial streams.*—As compared to rain-fed streams, the snow-fed or glacial streams are entirely different in their features.

These are more or less perennial, swelling in summer months because of the melting of snow and glacier ice and as such the waters are described as "cold". These continue to flow even in winter because of melting of the bottom layer of glacier and ice, under the weight of the mass of ice above, without high total discharge fluctuation, but with a marked diurnal fluctuation in summer. The water is rich in O<sub>2</sub>, with low temperature, without decaying organic matter, and without high turbidity which however tends to increase in summer afternoons. No sudden floods changing the current velocity occur and as such it is uniform. Dissolved gases present in the water are mostly little ozone. The shallow streams are without marginal macrophytes or rooted vegetation. The stream bed is generally of rocks, pebbles and glacier beds and the flow is more or less uniform. Very few reach the sea directly without tributaries. Most of the glacial streams commence in the form of small lakes or pools and often end as such.

Compared to rain-fed torrents glacial streams are limited in distribution and are restricted to high mountains above the timber line. They are common in semi-arid continental areas where precipitation is exclusively as winter snow-fall. Some of the best known and largest glacial torrential streams are found in the Himalaya and the Alps.

#### FISHES OF GLACIAL STREAMS

In conformity with the environmental features available in a glacial-fed stream the fishes lack specific modification as these occur in a rain-fed hill stream torrent. Since the velocity of the current is moderate without fluctuation, and the substratum is more or less uniform, fishes of the highly specialised family Homalopteridae are not seen. Mostly loaches of the family Cobitidae, a few Sisoridae and some cyprinids occur. The Cobitidae is represented by the genus *Noemacheilus* van Hasselt, the Sisoridae by *Glyptothorax* and *Glyptosternum* and the Cyprinidae by *Oreinus*, *Schizothorax*, *Diptychus*, *Cymnocypris* which are all genera of the subfamily Schizothoracinae. Schizothoracinae is dominant, probably because of their great adaptability to different situations in the habitat they live. Mukerji (1936) reporting upon the fishes collected by the Yale North India expedition from the lakes, rivers, and channels in the Kashmir Valley and from several rapid running torrential streams of the upper Indus system in Tibet at altitudes varying from 230 to 400 metres, listed only 16 species of fishes. Amongst these eight are found in Tibet and excepting *Glyptosternum reticulatum* McClelland the rest are all Schizothoracine fishes of the genera *Schizothorax*, *Oreinus*, *Schizopygopsis*, *Diptychus* and *Ptychobarbus*. A hybrid between *Schizothorax labiatus* and *Oreinus sinuatus* was also recorded. Hora (1936) likewise described nine

species of cobitid loaches from the same area, involving them in three "associations". Species such as *Noemacheilus vittatus* living at the bottom layer of the glacial lakes in one or two metres of water, have the air-bladder simple with the two lateral chambers enlarged so that they come in close contact with the skin. In areas of contact the bony capsules are incomplete so that the bladder can react to surrounding

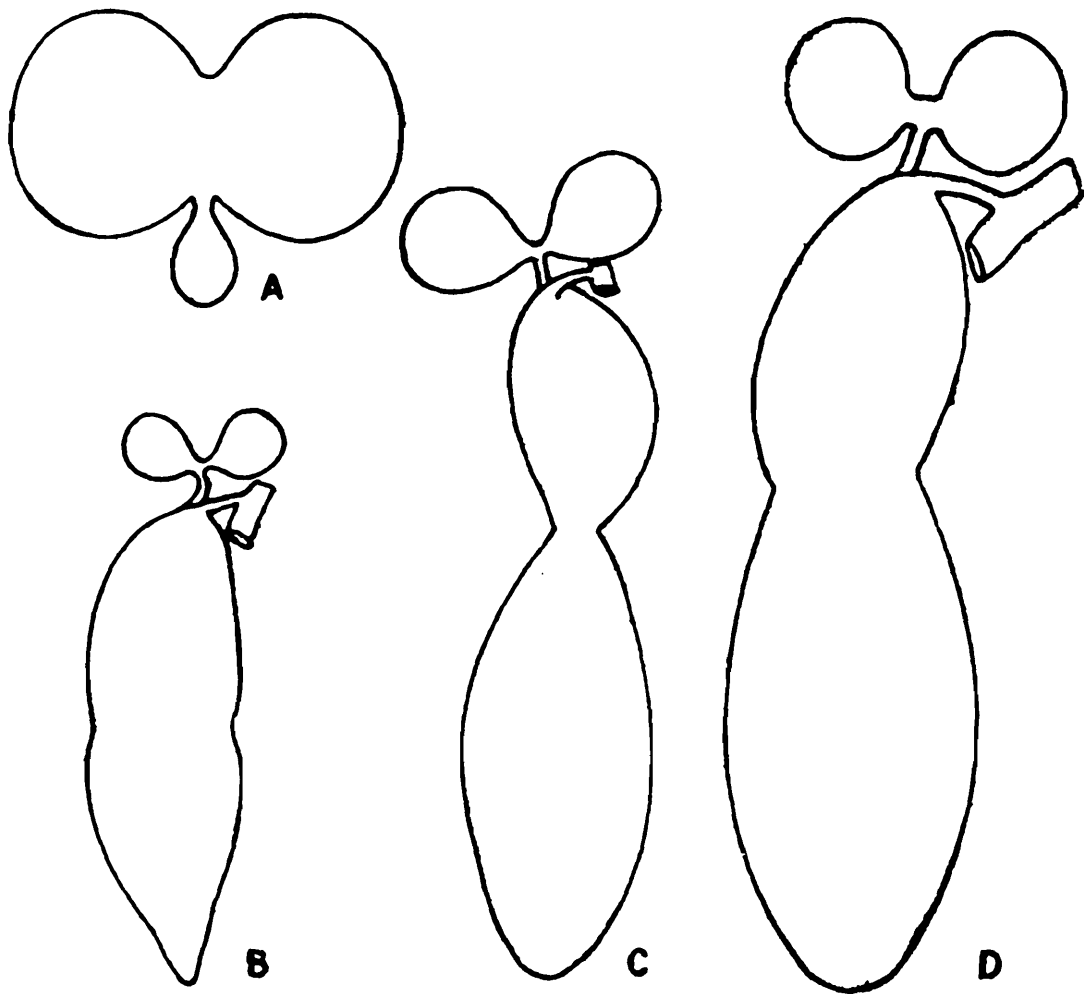


Fig. 1. Air bladder of (A) *Noemacheilus vittatus* (B) *N. deterrae* (C) *N. hutchinsoni* (D) *N. panguri*.

changes in pressure. The second group comprises species such as *N. stoliczkae*, *N. gracilis*, *N. microps* and *N. tenuicauda*, habitually living adhered to rocks and stones in swift currents, though at times especially during the breeding season they may enter springs, pools, and lakes. These have the anterior portion of the air-bladder reduced as two small lateral chambers. The buoyant function of the bladder is thus diminished. The third group such as *N. deterrae*, *N. hutchinsoni*, *N. panguri* swim about freely in the lake but cling to rocks and objects at the bottom only for feeding purposes. These have the posterior chamber of air-bladder long and elongated as in the typical cyprinid fishes.

In a similar manner, in species living in somewhat stagnant waters such as the glacial lakes, the upper lobe of the caudal fin is longer and better developed than the lower whereas in the case of torrential species, the lobes are either equal or the lower lobe is longer than the upper.

Barring these, there are no other modifications in the fishes of glacial streams and as has been shown the fauna is also poor.

### FISHES OF RAIN-FED STREAMS

An entirely different set of ecological parameters are faced by the inhabitants of rain-fed streams. The most important criteria for the fishes and other animals of the torrential streams is the fact that they have to constantly face water in motion and that too in different velocities. The current and velocity generated by this constantly moving water forces the animals inhabiting that ecosystem to adapt differently for various purposes. Depending upon the velocity or the force of the water there are many association of species and even within the same group different adaptations are exhibited. We shall now analyse this body of water in constant motion which is met with in a waterfall. Though this column of water appears to be a single habitat, it can be divided into different areas (Hora, 1932). Each one of these habitats can be seen to harbour animal life of diverse form and structure. These habitats are as below :

- (i) *Water spout*.—The rushing current falls over some rocky precipice or boulder as such the column of water thus descending has no solid substratum. Because of the high velocity and lack of a base there are no permanent inhabitants. Occasionally fishes such as Salmon, Mahseer leap through the column of water for migration of the spout if the waterfall is of short or of negotiable length. Large waterfalls or cataracts however form effective barriers for the ascent of even these muscular fishes.
- (ii) *Lip of the waterfall*.—The water mass generally falls over rocks or a substratum which may be either covered with vegetation or may be bare. In either case, excepting some torpedo-shaped dipteran and ephemeropteran larvae no fish life is met with in this zone.
- (iii) *Vertical rock behind the spout and not directly influenced by the current*.—This area receives a constant spray of water and is always wet. The mosses that grow on the vertical walls offer protection and substratum for anchorage of many small insects such as water mites and other animals. No fish however, is present although certain species of birds are known to build nests in this habitat.

- (iv) *Rocks at the base of the waterfall over which the water crashes.*—The full blast of the descending torrent strikes this area; it is natural to expect that no animal can be found here. No fishes are certainly seen, but chiton-like larvae of Blepharoceridae are seen in small falls. Nymphs of *Butis bicaudatus* are reported to live on rocks where water falls upon them with considerable force.
- (v) *Slanting or vertical rocks over which the water flows.*—Contrary to the lip of the waterfall, this area receives the force of the current and allows to flow onwards. The nature of area naturally depends upon the velocity of the current. Where there are some crevices, or small rock pools, fishes such as *Garra* and *Glyptothorax* are found. Tadpoles of *Rana afghana* are also found climbing upstream in this habitat.
- (vi) *Rocks in the neighbourhood of waterfalls which receive spray of water.*—This area is a shelter for a number of copepod and insect larvae. No fish life is known.
- (vii) *Pools at the base of the waterfall.*—This is the ideal area for fishes, tadpoles, frogs, insects, leeches, molluscs, which are able to adapt themselves to the swift current by developing modifications.

## ADAPTATIONS

It is thus seen that hill-stream fishes fall primarily into two groups. The first group comprises of those forms that migrate upstream at certain periods of their life for breeding purposes. These are all temporary inhabitants of these streams and show no special adaptations. They travel against the current by sheer muscular effort. The second group are the permanent residents of the stream and these exhibit extreme adaptations.

Basically the adaptations that hill stream fishes exhibit may be correlated into four primary factors or causes in their habitat. These are (a) velocity of the current (b) food and shelter (c) shallowness of water and clarity of the stream resulting in the infiltration of intense sunlight during day time and (d) high oxygen content of the water.

There are several modifications adopted by these fishes and they can be classified under nine important categories.

(1) *The external body form.*—The shape of the body depends upon the strength of the current. In general the form of the fish is directly proportional to the rate of flow of water. Where the current is not very fast, being intermediate between that of a hill-stream and of a

sluggish stream, the body form is cylindrical with not many adaptations, as seen in fishes like *Crossocheilus latia*, *Noemacheilus* species etc. On the other hand where the velocity is high as in a fast hill-stream, the body tends to become short and small. Such a size has a distinct advantage because small forms can find more shelter under rocks and stones during floods. Moreover a large body size needs larger space in the environment, which is hard to obtain in the places they live. Large size with increased weight renders anchorage more difficult and stream-lining of the body contour is also beset with complications.

(2) *The scale covering.*—As a rule, keeping in conformity with the reduced body size the scales in such groups which possess them as cyprinids and cobitids are small and are absent from the ventral surface. This is mainly to offer less resistance to the flow of water and also to adhere firmly to rocks and crevices.

(3) *Paired fins.*—The pectoral and pelvic fins in most hill-stream fishes are horizontally inserted and are modified for aiding in adherence to the substratum. This shifting of the fins outward also fits in with the ventral contour of the body which is flat. The number of rays is also increased for securing a wider area of support. The outer rays are greatly thickened, flattened and often times become pinnate. In genera like *Myersglanis*, *Oreoglanis*, *Euchiloglanis*, the pectoral spines

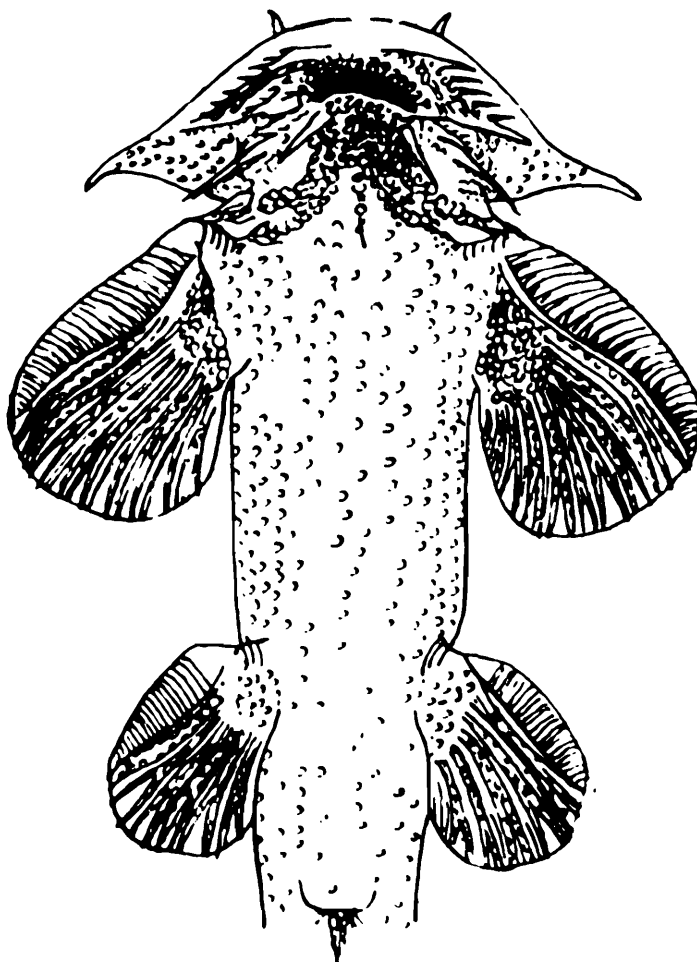


Fig. 2. Ventral view of *Euchiloglanis hodgarti* to show pinnature, paired fins with outer ray thickened-

are absent and are replaced by such thick pinnate rays which firmly secure the fish to the substratum. *Balitora* has 21 rays in the pectoral and 11 in the pelvic fins. Moreover some of the inner rays are directed upwards against the sides of the body so that when the outer rays are used for purposes of adhesion, the inner rays can be kept constantly in motion for respiration.

The distance between the pectoral and pelvic fins ventrally is also much reduced. In the case of *Gastromyzon borneensis* which can be stated as the hill-stream fish showing the best adaptation, the pectoral fins possess long curved bases which are united posteriorly. Between the bases of the pelvic and pectoral fins there is a lateral ridge-like extension of the abdominal skin. By such an exquisite arrangement the whole ventral surface presents to the substratum a vertical wall and with the flattened head, pinnate large fins forms an enormous strong suction disc. No water can seep into this surface to displace the fish and it remains firmly anchored despite the fast current gushing over it. *Gastromyzon borneensis* is found in Borneo.

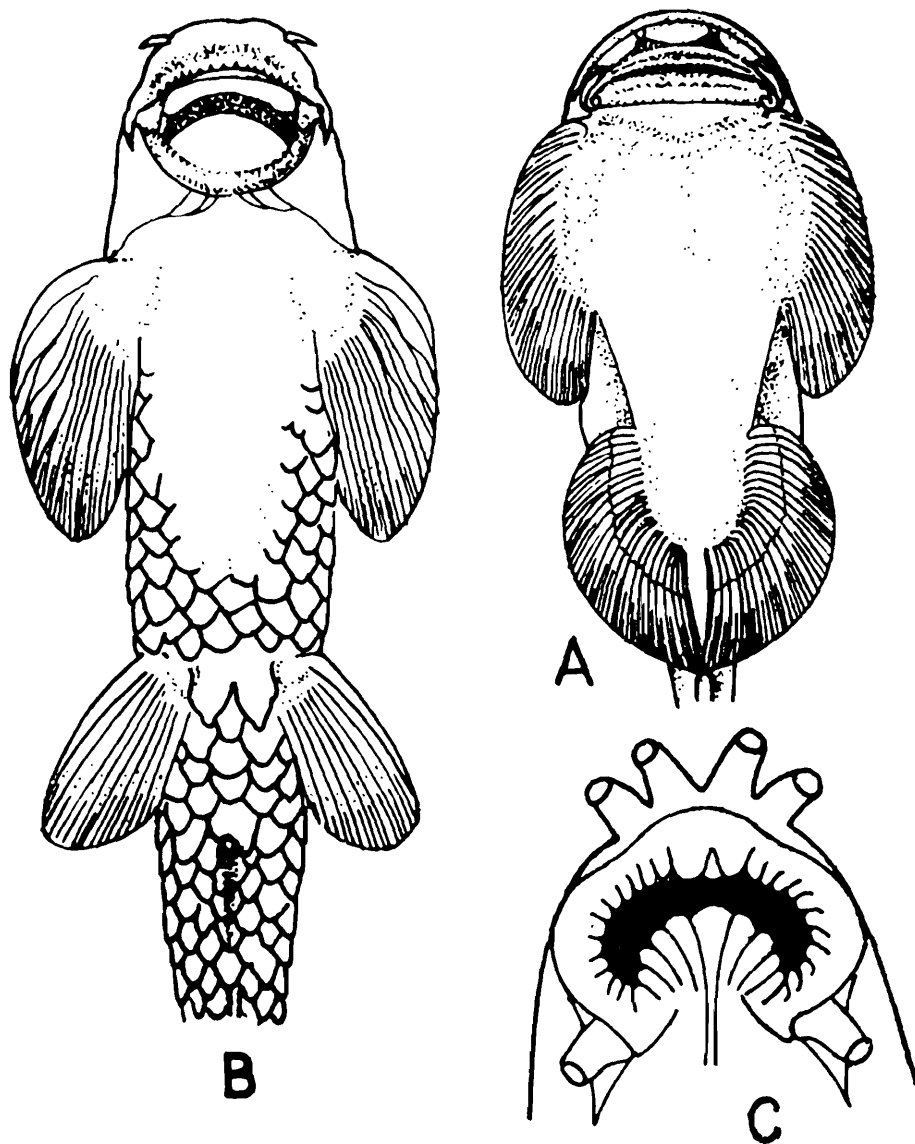


Fig. 3. (A) Ventral view of *Gastromyzon borneensis* to show the position of the paired fins and the flat ventral contour (B) Ventral view of *Garra lamta* to show the sucker (C) Lip structure in *Noemacheilus*.

(4) *Caudal fin and peduncle*.—The caudal fin acts as a propeller in fishes and the caudal peduncle as the structural basal support for such movements. In hill stream fishes where locomotion is limited, a broad, thick caudal peduncle would be a disadvantage. Hence the peduncle is long, and narrow as is seen in *Noemacheilus tenuis* and *N. lhasae*, *Glyptothorax striatus*, *G. saisii* etc. The lower lobe of the caudal fin is longer in *Balitora brucei*, *Bhavana australis*, *Garra nasuta* etc. The long lower lobe helps in quicker movement when it is necessary since the current is faster than in a stagnant body of water and any movement must be made fast before the current pushes the fish away.

(5) *Mouth parts*.—Normally the mouth is a transverse cleft at the anterior end of the fish. In hill stream fishes, the mouth is pushed considerably on the ventral surface behind the tip of the snout and is short and narrow. It is usually crescentic or semicircular in outline. The jaws are greatly strengthened and their edges sharp and modified for cutting and rasping. Teeth being not of much use, the palate is edentulous. Likewise barbels in running waters would become a source of hindrance and hence are reduced or even absent. Moreover the function of the barbels becomes redundant in view of the fish not going in search of food as the current brings the same. However the rostral, maxillary barbels and other tentacular processes test the purity of the water.

In genera like *Garra* and *Oreinus* a sucker is developed on the lips. In *Noemacheilus* the lips are divided in the middle and are greatly swollen so that when they are pulled outwards away from the mouth these divided parts form a continuous ring like sucker. Further the groove in the divided lips act as a channel for the water to enter the mouth opening and preventing them from spreading under the whole ventral surface.

(6) *Eyes*.—To combat the intensity of the sunlight seeping through the shallow streams in which the torrential fishes live, the eyes are reduced in size and are pushed more and more towards the upper surface. In *Balitora brucei*, *B. maculata*, *Glyptothorax saisii*, *Pseudeche-neis sulcatus* the eyes are situated on the dorsal surface and are placed close together.

(7) *Gill openings*.—The gill openings do not extend beyond the base of the pectoral fin and the under surface. The gill slits are narrow as large gill membranes to stir up oxygen are not needed in an already oxygen rich habitat.

With the reduction of the gill openings and the small size of the mouth, the volume of the respiratory current is reduced. To meet

with this situation, shallow pouches along the roof of the mouth are found in *Balitora* and *Travancoria*. In *Bhavana* and *Gastromyzon* these are very well developed (Hora & Law, 1942).

(8) *Adhesive apparatuses*.—In the habitat where hill-stream fishes live, the single paramount factor which they have to face as has been already stated is water in constant motion and that too in high velocities. The current and force generated by this constantly moving body of water forces the animals to hold on to fixed supports such as the substratum, rocks, boulders, crevices, etc., to save itself from being washed away. Thus anchorage and safety become prime factors.

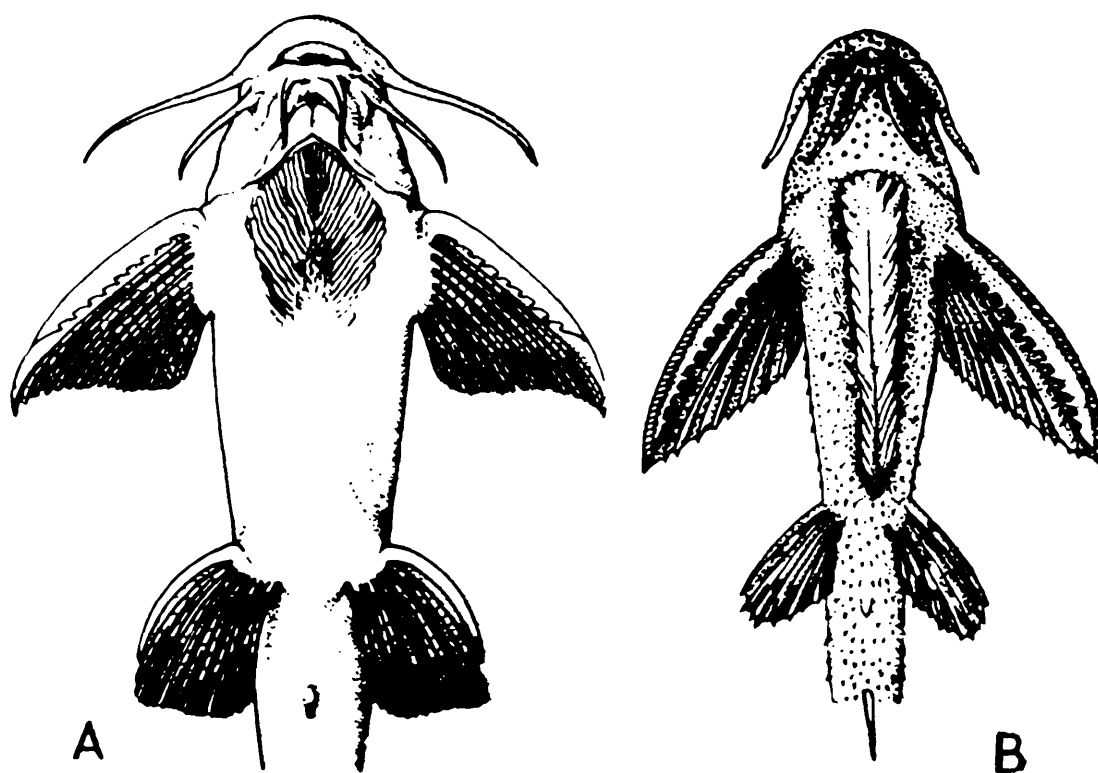


Fig. 4. Ventral view of (A) *Glyptothorax madraspatanum* and (B) *Conta conta* to show extent of adhesive apparatus.

Towards securing efficient anchorage, various adhesive devices have been developed in the thoracic or the abdominal region. It is generally construed that when a normally cylindrical fish enters such a habitat it develops longitudinal folds of skin on the ventral surface as adhesive apparatus, such as the ones seen in most *Glyptothorax* and *Conta* species. If on the other hand an already flattened fish enters such a medium, horizontal folds are formed as adhesive apparatus as seen in *Pseudecheneis*, *Parapseudecheneis*, etc. These pads of skin prevent the fish from slipping off and also aid in procuring it a firm hold on the rock surface by creating a vacuum in between the corrugations of the adhesive pads. The suckers on the lips of *Garra* and *Oreinus*, the pinnate nature of the paired fins, the presence of a central pit in the adhesive apparatus also contribute to such a function.

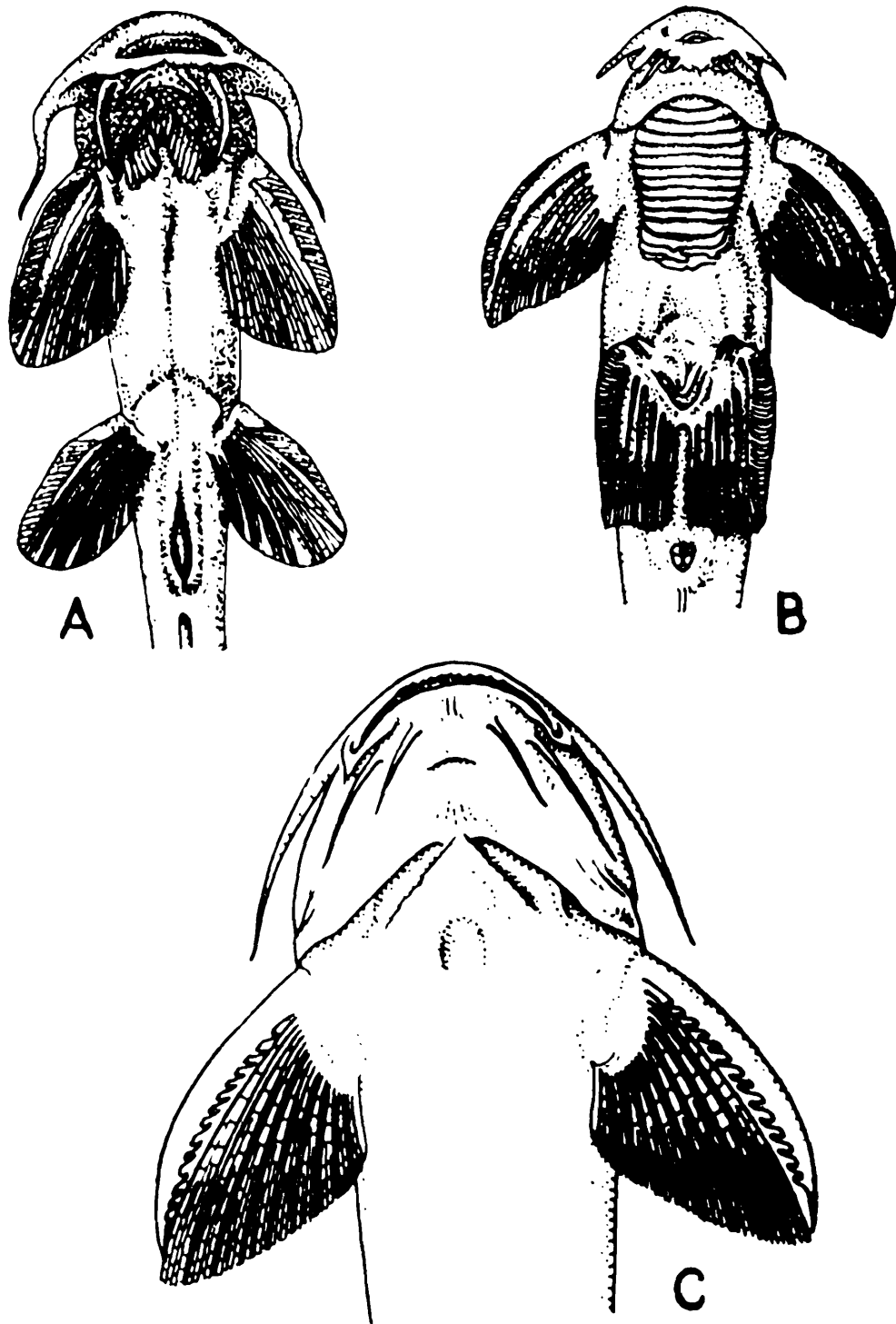


Fig. 5. Ventral view of (A) *Glyptothorax pectinopterus* (B) *Pseudecheneis sulcatus* (C) *Glyptothorax cavia* to show different types of adhesive apparatus.

(9) *Air-bladder*.—Since buoyancy will be a definite disadvantage, the air-bladder is reduced, often times enclosed in a bony capsule. The lateral chambers are variously modified, whilst the anterior and posterior sacs are sometimes elongated or absent. Species of *Noemacheilus* exhibit remarkable modifications in the air-bladder depending upon the habitat they live. This has been discussed earlier.

Besides the above major adaptations, mention may also be made of the absence of vivid colours, or body markings, mucuous secretions, and a low fecundity rate in hill-stream fishes which are also of adaptive significance.

## CONCLUSIONS

It would thus appear that the fishes and other animals inhabiting the torrential streams are entirely in different set of ecological situations. The adaptive modifications they have taken can be clearly correlated to the stress they have to bear in the media they live. Not much work has been done on this fascinating subject subsequent to Hora. This requires greater attention and should yield valuable data for insight into the mechanics of torrential streams and their governing ecological parameters.

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STUDIES ON THE ECOLOGY AND ZOOGEOGRAPHY  
OF NORTHWEST HIMALAYAN PARTRIDGES WITH  
SOME EXPERIMENTS ON THE ARTIFICIAL PROPAGA-  
TION OF *ALECTORIS CHUKAR* AND *COTURNIX*  
*COTURNIX*

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INTRODUCTION

Northwest Himalaya lies among the outermost and the sub-Himalayan zones. The outermost zone borders the Indogangetic Plains and consists of the Siwalik hills. These hills rise upto the elevation of 1200 to 2000 m. The sub-Himalayan rising to the elevation of 2000-5000 m above mean sea level. This zone represents the border of the former land mass of Indian Peninsula and marine basin of Tethys sea. The Siwalik hills form the foot-hills of the Himalaya and stretch from the west to east along the Indogangetic Plain. Inner to this, the Dhauladhar and the Pir Panjal ranges also extend in the Northwest Himalaya which lie west to the defile of river Sutlej, approximately 560 km. long extending to Mt. Nanga Parbat, west of which the R. Indus curves round south-westwards. Whole of the Northwest Himalaya stretches from 30°-36° NL. and forms a separate zoogeographical unit (Mani, 1968). The characteristic formation, the high rainfall due to monsoons and the northwest formation of snow on the peaks of these mountains provide climates ranging from tropical through sub-tropical, temperate and arctic (above the-timber line). These factors primarily determine the floral and faunal constituents of this area. Much of the fauna of this region is Oriental, some Palaeartic while some others are endemic. An appreciable work has been done on the Indian avifauna by many scientists, but the zoogeographical aspects of some species of Indian subcontinent have been dealt with by Ripley (1961). Many genera of tropical lowland penetrate up the valleys and some of the Palaeartic elements also descend to the cold slopes. The transition zone above the tree-line is inhabited by the animal life which is characteristic of Europe and central Asia.

Our work in the field reveals that the different altitudinal abodes of these animals are best represented in the northwest Himalaya. The low hills, the valleys, the higher mountains and a net-work of the river systems are best inhabited by many character faunal and floral

communities (Kalia and Kaul, 1976). The seasonal fluctuation in the abundance of different species of animals can easily be observed by a naturalist in this area. Many of the species of birds and mammals descend down the high mountains and inhabit the low hills and valleys during winter, while some of the species go upto the elevation of 400m during summer. Avifauna which descends down the hills during winter includes some beautiful pheasants and partridges.

### PARTRIDGE FAUNA OF NORTHWEST HIMALAYA

This paper summarises our observations on the partridges of this area, which belong to the following eight genera out of the eleven genera so far recorded in the Indian subcontinent.

1 Genus *Lerwa* : This genus is represented by the only species *Lerwa lerwa* (Hodgson) in this area. This bird commonly known as snow partridge is a resident of high elevations. Gregarious in habit and small parties of 6-8 adults are met with in subalpine and alpine pastures, where it mainly feeds upon lichen, moss, grass seeds and vegetable shoots (Ali and Ripley, 1969). It also feeds upon insects and their larvae found in the dead decaying matter. In Dhauladhar ranges and in Pir Panjal it has always been observed at the snow-line. The closely barred white and black above, deep chestnut streaked with whitish on the abdomen and bright red legs and bill, are the colour patterns which easily distinguish this bird from the other partridges. The nest-building activity which starts in early April is probably equally shared by both the sexes. During the breeding season the pairs are seen closely associated with each other, roosting always together, among the bushes of *Rhododendron*. The nest is made in a shallow cavity on the ground, under some rock or bush. The nest is not impressive and is lined with moss or leaves. During the months of May to July, 3-5 eggs are laid. The long grass during the rainy season (July-August) on the subalpine and alpine pastures give a protective ground cover. Hatching of the eggs starts during late May and continues upto August. During winter with the onset of winter showers in the lower hills and the valleys alpine pastures are covered with snow. This bird starts descending down the hills and inhabits the areas along the snow line. When the lower hills are also covered with snow, this bird inhabits the *Rhododendron*, *Quercus* and *Cedrus* zone taking the benefits of intense ground cover of *Rubus*, *Princepia* and *Berberis* bushes. In no case this bird has been observed in the valleys. At the approach of summer months they again migrate to the high elevation.

2. Genus *Tetraogallus* : This genus with its two species *T himalayensis* and *T tibetanus* is distributed in the Himalaya. *T himalayensis himalayensis* Gray, commonly known as Himalayan snow cock is found in the Northwest Himalaya. This bird also inhabits the higher ranges

(4000-5500 m) on the Dhauladhar and Pir Panjal ranges. It is known to the natives of Kulu Valley as 'Leep' and to Chamba and Kangra Valleys as 'Galaond'. Small parties of 3-5 birds are met with above the timber-line in the vicinity of permanent snow. During winter it descends down to about 2000 m elevation. The distinguishing colour markings are the white throat with a broken chestnut collar and largely grey partridge with white chestnut over the body and black streaked (Baker, 1923). It feeds mainly on root bulbs, green vegetable matter, wild fruits and *Artemisia* leaves. The subalpine and alpine pastures with high altitude Rhododendron bushes provide a good habitat during summer and the rainy seasons. Breeding occurs during April to June and the young chicks can be seen during late June-July and August months. *T. tibetanus* has three subspecies, viz. *T. tibetanus tibetanus*, *T. tibetanus centralis* and *T. tibetanus aquilconifer*. Only *T. tibetanus tibetanus* has so far been reported from Kashmir (Das, 1966).

3. Genus *Arborophila*: The four species *A. mandelli*, *A. atrogularis*, *A. rufogularis* and *A. torqueola* are the residents of the Himalaya. *A. rufogularis* has two subspecies, *A. rufogularis intermedia* and *A. rufogularis rufogularis*, while *A. torqueola* has four subspecies *A. torqueola batemani*, *A. torqueola interstincta* and *A. torqueola millardi*. The distributional pattern reveals that this genus is widely distributed in the eastern Himalaya. *A. mandelli* Hume can be found even at a lower altitude of 350 m spreading upwards to about 2500 m elevation in the eastern Himalaya. From north of R. Brahmaputra it is distributed in Assam, Sikkim and Bhutan. Similarly, *A. atrogularis* (Blyth) is found commonly below 750 m at the foot-hills ranging upwards to not more than 1500 m elevations in the eastern Himalaya. The two subspecies of *A. rufogularis* are also found in the eastern Himalaya at higher elevations. *A. rufogularis intermedia* is distributed between 600-1800 m while *A. rufogularis rufogularis* between 1000-2400 m. *A. torqueola* with the exception of only subspecies *A. torqueola millardi* (Baker) is also found in the eastern Himalaya but has succeeded in spreading its territory on the wet temperate hills to the elevation of even 4000 m. Subspecies *A. torqueola millardi* (Baker) (Simla hill partridge) is distributed in the Northwest Himalaya between 1500-4000 m. It is found at higher elevations of Siwalik hills, and is also common in the Dhauladhar ranges. This bird is commonly known to the natives by the name *Roli* or *Ram Chukro*, inhabiting the forests with heavy undergrowth of evergreen vegetation. Two subspecies *A. torqueola torqueola* (Ban teetar) and *A. torqueola millardi* come close to each other. *A. torqueola torqueola* can be differentiated by the pure white abdomen of male in contrast to the rufescent abdomen in *A. torqueola millardi*. The former species is more abundant in the eastern Himalaya while the latter is found in the Northwest Himalaya. In the transition zone both the species merge with each

other *A. torqueola millardi* is gregarious in habit and breeds from April to June. The nest is made in a scrape on the ground, well hidden in the grass. This bird also descends to the lower elevations during the winter months.

4. Genus *Francolinus*: The different species of this genus have spread throughout the Indian subcontinent. *Francolinus pictus* (Sharma, 1965) with its different geographical races is essentially a Peninsular partridge spreading even upto Sri Lanka. *Francolinus pintadeanus* is common in Arakan, Burma, Yunnan, eastern Indo-chinese countries from Tonkin to Combodia. *Francolinus gularis* is found in the plains of Nepal, Bihar, Assam and Bangladesh. The other two species *Francolinus francolinus* only *Francolinus francolinus asiae* Bonaparte is met with in Kashmir; foot-hills of Dhauladhar range, Siwalik hills extending eastwards to Nepal. In the transition zone, it merges with *Francolinus francolinus melanonotus* which is abundant in the eastern Himalaya. *Francolinus francolinus henriei* has been reported from Pakistan and is commonly known as Persian Black Partridge. *F. f. asiae* meets this species in the transition zone towards the west. The Indian black partridge *F. f. asiae* inhabits the foot-hills and can be found upto the maximum elevation of 2000 m on the Siwalik and Dhauladhar ranges, normally below 1200 m. The tea gardens, high grass cover, forest tracts near the streams and such type of environments are the best ecological niches for its habitation. It is jet-black with white spots on the upper surface. The male has white check patches and chestnut collar. Thick grass cover provides the best roosting place for this bird. It moves about either singly or in scattered pairs and prefers to run among the bushes and grass. At the onset of spring during March and April the nest making activity starts. The nest is a shallow depression scraped in the ground and lined with grass. The nest is well hidden in the tall grass, or among the tea plantations. *Francolinus pondicerianus mecranensis* Zarudny and H' arms is found west of Sind, N. W. F. Province and Baluchistan while *F. pondicerianus interpositus* Hartert (Safed teetar) extends its territory from eastern Sind to the foot-hills of Northwest Himalaya, spreading on the foot-hills of whole of Northern India and even in the northern parts of Indogangetic plains.

It is largely greybrown vermiculated with buff and black above. Underparts are paler and narrowly cross barred. In Kangra valley, the tea gardens provide a good protective cover for its nest building and breeding. It is known to the natives by the name 'Kandle' or 'Safed teetar' During April to June its presence becomes obvious by the loud voice something like "Thekree" "Thekree" "Thekree" a breeding call which can be heard from a considerable distance. It roosts at night in pairs on small thorny trees. It feeds upon insects,

weed seeds, shoots of plants, crop plants etc. In Northwest Himalaya its breeding season is restricted to the summer months only. The chicks and the mother can be seen during July and August in the tall grass cover and in the tea gardens.

5. Genus *Perdix* : The two subspecies of the only species *Perdix hodgsoniae* of this genus are the partridges of the high elevations. *Perdix hodgsoniae caraganae* Meinertzhagen, commonly known as Ladakh Partridge, is distributed in Ladakh and Kumaon (near Gangotri). It is a little known bird which breeds at higher elevations during June and July. *Perdix hodgsoniae hodgsoniae* (Hodgson) is found in considerable number in Tibet where it is known to the natives as 'Sakpha' 'Rhakpa'. It has extended its territory across the Tibet border in Nepal and Sikkim at 3600-5600 m. During winter it may descend down to 3000m elevations. Dwarf *Rhododendron* bushes, *Juniper* and *Betula* zone in the Northwest Himalaya on the Pir Panjal range also forms its home during winter. The commonly known 'Sirloo' partridge at the high altitudes in the Dhauladhar range is probably this bird. It seems that this partridge has spread on these mountains also. The prominent white eyebrows running across chestnut forehead and grey colouration above with barred buffy-grey underparts are some of the distinguishing characters of this partridge. It breeds during March-April and May. A small nest as a scrape in the ground under bushes or rocks is made during the breeding season. It is generally found in small parties but during breeding season the parties break up into pairs. The vegetable shoots, seeds and wind-blown insects constitute its food.

6. Genus *Alectoris* : This genus has one species *Alectoris chukar*, which is further composed of three subspecies. *A. chukar koroviakovi* (Zarudny) affects the barren rocky hill sides of Baluchistan, and Sind between 1000-3500 m; while *A. chukar pallescens* (Hume) is found in bare, stony hill side, ravines and the neighbourhood of terraced cultivated fields in Afghanistan south through Chitral, Gilgit to north Kashmir and Ladakh at an elevation ranging between 1500 m to 4000 m. In north Kashmir and Ladakh this subspecies merges with *A. chukar chukar* (Fig. 1) which has spread widely along the R. Chenab gorge upto the Lahaul valley and across through Dhauladhar range into the Siwalik hills in the Northwest Himalaya. It inhabits the boulder strewn ravines, neighbourhood of fields and river valleys between 1200 m to 5000 m. This subspecies is known as 'Chukor' in Hindi, 'Chakru' in Chamba valley, and 'Kakor' in Kashmir valley. This bird can easily be distinguished from the other partridges by its pinkish grey brown colouration and conspicuous rib-like black bars on the sides. A black band runs across the forehead, back through the eyes and meets at the lower side of

the neck. The beak and the legs are crimson. Bulbous roots, grains, vegetable matter including shoots of grass, wheat, barley, insects form its food. Breeding occurs from April to July which depends on the onset of summer months at different altitudes. The female is believed to be smaller and without the prominent spur on the tarsus, but it seems, that the development of spur depends upon the age of the bird. We have seen a male without any spur (Fig. 2) and a female having well developed spur (Fig. 3). The natives of Kangra, Kulu and Chamba valleys keep a single bird (only male) in their homes as it is considered to be auspicious for health and prosperity of the family. We procured these birds from the field to study their breeding behaviour under artificial conditions. The pairs, we have maintained, feed well on wheat, rice, pulses and vegetable shoots and leaves. It preferred the *Brassica* leaves and shoots while reluctantly accepted the leaves and shoots of *Pisum*.

In our experiments with this bird there was no response of the female for the first two years even during breeding season but during December 1978 and January 1979 the female laid 5 eggs (Fig. 4) one at a time at irregular intervals (Table I). It is observed that before egg laying the female becomes restless, scratching the floor with its beak and claws for about 3-4 hours. The eggs were laid at the darker side of the cage, always in the afternoon. These eggs (Fig. 4, 5) are of light almond colour with rust colour small and larger freckles all over the surface. The average weight of the egg was found to be 22.05 gm, and the average size 45.4 mm X 33.2 mm.

TABLE I

Sr. No.	Date of Egg laying	Weight of Egg in gm	Size of Egg in mm
1.	14.12.78	21.65	44.0 × 31.0
2.	20.12.78	22.00	45.0 × 34.0
3.	30.12.78	22.30	46.0 × 33.0
4.	5.1.79	22.00	46.0 × 34.0
5.	28.1.79	22.03	46.0 × 34.0
Average		22.05	45.4 × 33.2

Further Investigations regarding the incubation and percentage hatchability are in progress.

7. Genus *Coturnix*: This genus includes small partridge like birds with short tail, small and slender bill and strong tarsus. There are three species of this genus in Northwest Himalaya, out of which one species *Coturnix coturnix* is essentially a migratory bird while the others *Coturnix coromandelica* and *C. chinensis* are more or less resident. *Coturnix coromandelica* the black-breasted or rain quail is a local migrant during monsoons. Chiefly found in the

plains it also spreads upto 2000 m elevation on the Himalaya. Similarly, *C. chinensis*, the blue breasted quail is largely found in the Indian Peninsula, rarely ascending to the outer Himalayan ranges, is primarily a resident bird.

*Coturnix coturnix* has two subspecies, *C. coturnix coturnix* and *C. c. japonica*, which are more or less similar. The lengthened and bristly feathers of the chin in *C. c. japonica* is the only distinguishing mark. The *C. c. japonica* is widely distributed in the eastern Himalayas while *C. c. coturnix* breeds in Kashmir (2500 m), east through Bihar, W Bengal, south to Madhya Pradesh and Maharashtra, reaching even up to Kanya Kumari in winter. This subspecies gets mixed up with *C. c. japonica* in the eastern part of the country. *C. c. coturnix* visits the Siwalik hills and valleys during March to July affecting the standing crops of wheat, gram, etc. This bird is plump, pale brown with irregular mottling of reddish brown and black in both sexes. Male has black chin with a black line down centre of throat. Two dark bands curve up from the base of throat to ear coverts. Flanks brown with black streaks, rest of the underparts creamy white. Female has creamy buff throat and chin, and black spots on the breast. Breeding in India occurs from March to July.

With a view to exploit these quails for the table purposes, seventeen pairs of *Coturnix coturnix* (Fig. 6) were obtained and kept in the cages. Necessary conditions for their breeding, by providing them with suitable photoperiod and food were created in the cages. The eggs (Fig. 7) were found to be of an average size of 29.7×22.8mm. The optimum temperature and relative humidity in the incubator were found to be 37.5°C and 80-85% respectively. The average incubation period (Table II) is found to be 18.3 days.

TABLE II-Incubation period for the eggs of Quails

Sr. No.	Date of setting	Date of hatching	Inbubation period	Average incubation period (days)
1.	16.6.78	4.7.78, 5.7.78 7.7.78	17, 18 20	
2.	21.6.78	11.7.78 12.7.78	19, 20	
3.	26.6.78	14.7.78	17	18.3±2.0
4.	2.7.78	20.7.78	17	

The incubation period was found to be 18 days+2 days on an average. The eggs required 380-385 hours from setting to piping and 8.8.5 hours from piping to hatching. The chicks required 4-5 hours for drying.

8. Genus *Perdicula* : This genus is peculiar to Indian subcontinent only, while *Perdicula asiatica punjaubi* (Jungle bush quail) is a resident bird distributed in the valleys and outermost ranges of the Northwest Himalaya. It is abundantly found in the plains of Punjab. Siwalik hills bordering the Punjab plains are also inhabited by this bird up to the maximum elevation of 1200 m. Brown with black streaks above and paler underparts are the colour pattern on its body. It keeps in parties of 6-20 members and roosts at night under some bush. A large gathering is formed at the feeding places and if scattered, they reunite within half an hour. Each individual gives a soft whistling call and moves towards each other's sound. Breeding season is from August to October but in April also the eggs have been seen.

### DISCUSSION

From the above account it becomes clear that these genera can easily be considered as snow loving and rain loving. The snow loving genera include *Lerwa*, *Tetraogallus*, *Perdix* and *Arborophila*, and the rain loving are the *Francolinus*, *Perdicula*, *Coturnix* and *Alectoris*. It may be mentioned here that the genus *Alectoris* is distributed on almost all the habitats in this part of the Himalaya.

The seasonal fluctuations in the ecosystem directly affect the distribution and abundance of these birds. The availability of the food is the principal decisive factor which controls the seasonal, rhythmic fluctuations of the distribution of these birds. The winter snow cover obliterates the availability of the food like lichen, moss, grass seeds, vegetable shoots and the insects at the higher elevations and the snow loving genera are obligatorily obliged to descend to the lower elevations, but they always prefer to remain in the vicinity of the snow line. The peculiar winter habitat for these birds is in the forests of *Cedrus* and *Quercus* (Fig. 8).

During summer as the snow melts, the underground rhizomes sprout, the emergence of the high altitude insects begins, the food becomes abundant and these partridges start inhabiting these areas along with the other birds like pheasants with which they, in fact, form a character community.

The marked climatic fluctuations in the winter and summer directly affects the floral and faunal communities on the Himalaya. The effects of the climates set in a series of events in the floral constituents of the area which directly affect the faunal elements. The animals have to adjust themselves so as to achieve the optimum conditions for their survival. The snow loving partridges achieve

it by invading the lower altitudes. Since the breeding months are limited to the short summer only on the higher altitudes, the spread and the distribution is restricted. In fact this itself is acting as a limiting factor.

The rain dominating or rain loving genera are essentially the residents of the low lands. They too show local movements during the changing seasons. Genera like *Coturnix*, *Perdicula* and *Franco-linus* invade the adjoining hills during summer, not only to avoid the excessive heat of the plains but also to take the advantage of the crop harvesting timings which begin during April in the plains and continue up to the mid June on the hills. These movements can be said to be in their home territory and should, therefore, not be confused with the bird migration as such.

The onset of the monsoon rains is another important event in the lives of these birds. The monsoon season in the north west Himalaya coincides with the hatching time of these partridges. The intensive growth of vegetation which mainly includes the wild grass and the bushes provides excellent and undisturbed coverage and ensures easily available food supply of grass and insects to the developing young ones. The chicks grow sufficiently to look after themselves by the time the winter approaches.

The high elevations above the timber-line on the Himalaya represent the Turkmenian subregion of the Palaearctic realm, while the Indo-Chinese extends along the foot-hills from the east. The Peninsular region spreads upwards to the southern most slopes of the Himalaya bordering the Indogangetic Plains (Mani, 1974). The fauna of Northwest Himalaya (Mani, 1974) in general presents an intermingling of the Palaearctic, Oriental and Ethiopian elements and the partridge fauna in particular also shows a similar distributional pattern. Genus *Lerwa* (Hodgson) is distributed in the fringe area of the Palaearctic region but is endemic to the Himalaya only.

Its centre of origin and further adaptations and dispersal seem to coincide with the uplift of the Himalaya. Genus *Tetraogallus* Grey is a Palaearctic element which is distributed in the mountains of central Asia and at the permanent snow-line on the Himalaya. Similarly, genus *Perdix* Brisson is abundant in the Palaearctic region and only one species i. e., *P. hodgsoniae hodgsoniae* is found on the high Himalaya. The distribution of genus *Alectoris* Kaup reveals that centre of its dispersal should primarily have been in the Palaearctic realm extending to north Africa, western and central Asia and on the cold climates of the Himalaya. The species *A. chukar chukar* has

also adapted to the humid sub-tropical forests of the lower hills. Genus *Francolinus* Stephens is probably Ethiopian in origin and its dispersal has been through Tropical Africa, Asia and in the Indian subcontinent spreading throughout the Indian Peninsula and on the outer Himalayan forests and valleys. Genus *Coturnix* Bonnatere is equally distributed in the Palaearctic, Ethiopian, Oriental and Australasian realms. This genus is primarily migratory. *Perdicula* Hodgson is an interesting genus endemic to the Indian subcontinent only and is found on the lower hills of Northwest Himalaya. Genus *Arborophila* Hodgson is well represented in the Indo-Chinese and the Indo-Malaya regions extending from the east to the western Himalaya. Another genus *Ophrysia* Bonaparte known by only species *Ophrysia superciliosa* from Kumaon hills believed to have become extinct was endemic to the Himalaya only.

### CONCLUSION

The zoogeographical distribution of the avifauna in the Himalaya presents intricate problems regarding the centre of origin of different species and their dispersal. Though some of the species could have invaded the Himalaya from the other regions yet there are many species of birds and other animals which were in fact the constituents of the low lands to begin with but successfully adapted to new environments which were created by the gradual uplift of the Himalaya. Some of the endemic genera like *Lerwa* and *Ophrysia* must have originated on the Himalaya only.

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688.



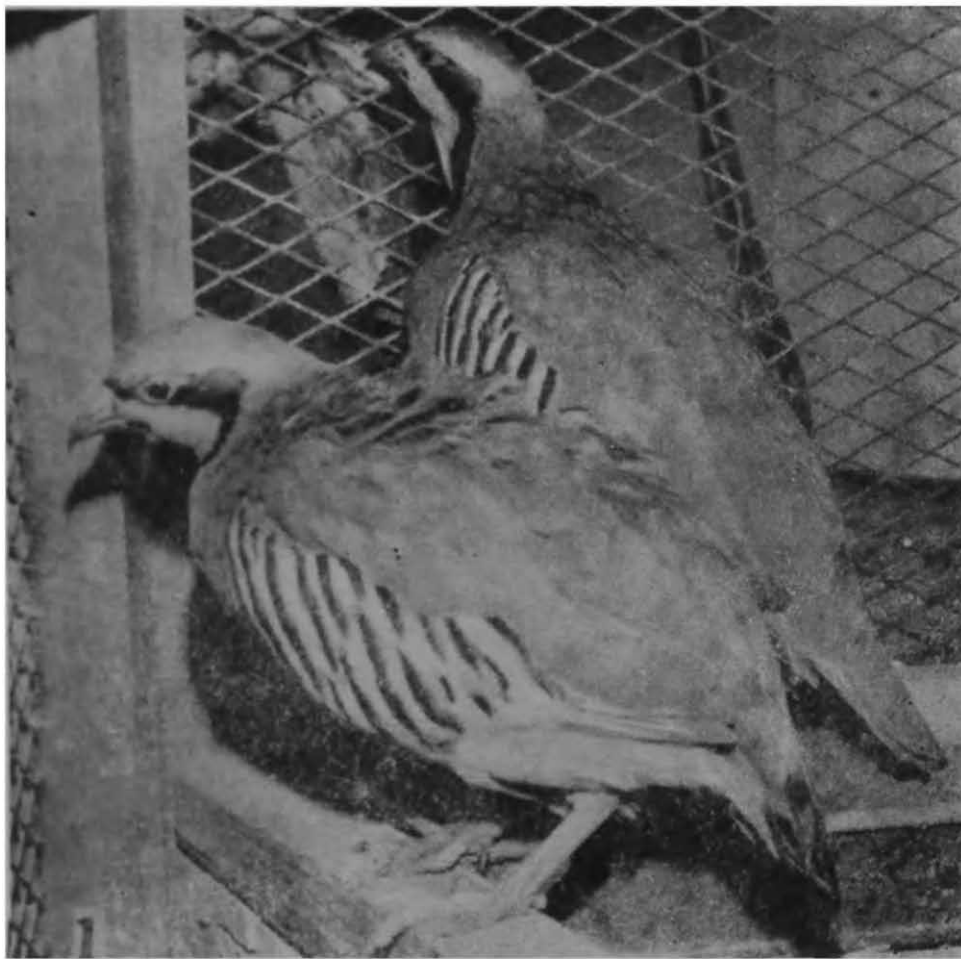


Fig. 1. *Alectoris chukar*: a pair kept in the cage; one of them can be seen accepting the *Brassica* leaves.



Fig. 2. Legs of a male *Alectoris chukar* showing the absence of spur.



Fig. 3. Legs of a female *Alectoris chukar* showing a well developed spur.



Fig. 4. The female *Alectoris chukar* with the eggs.

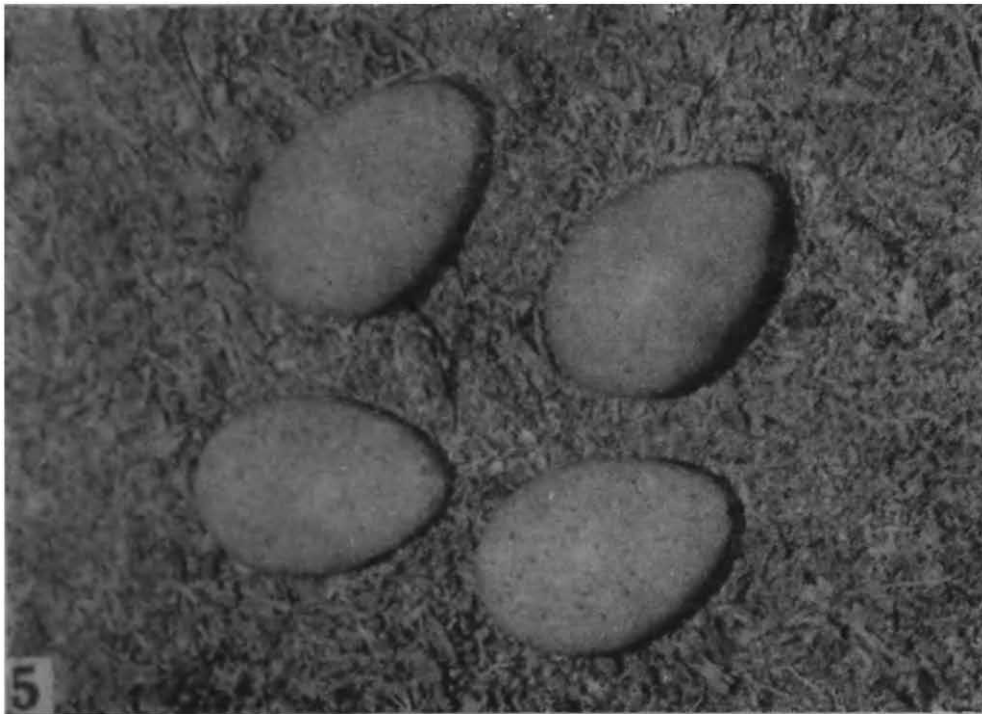


Fig. 5. The eggs of *Alectoris chukar*.

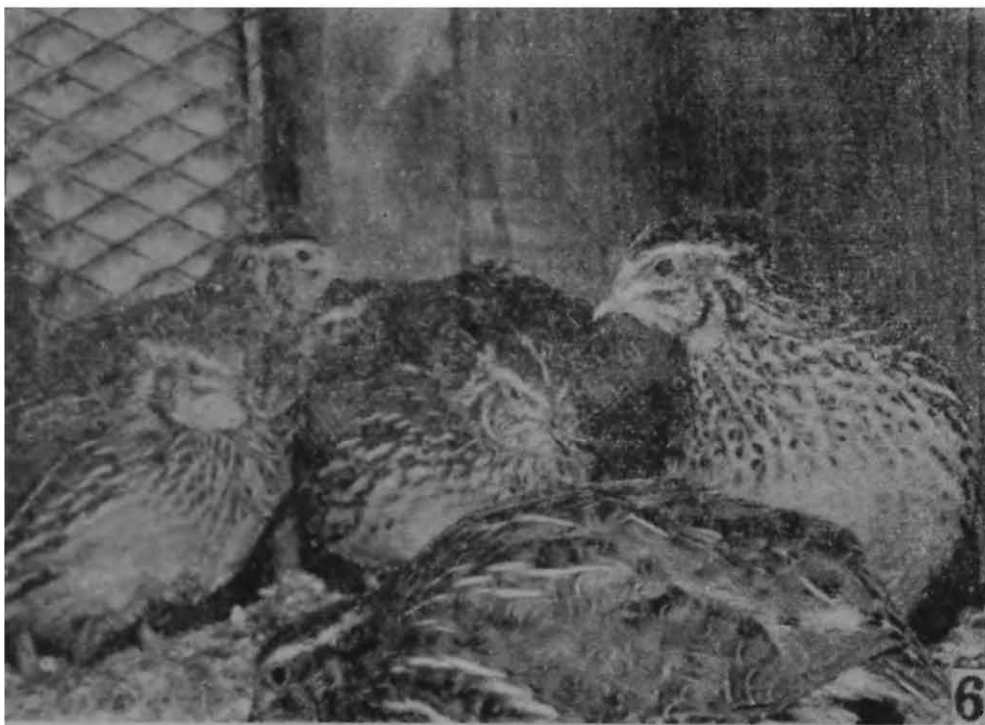


Fig. 6. *Coturnix coturnix* reared under cage conditions.

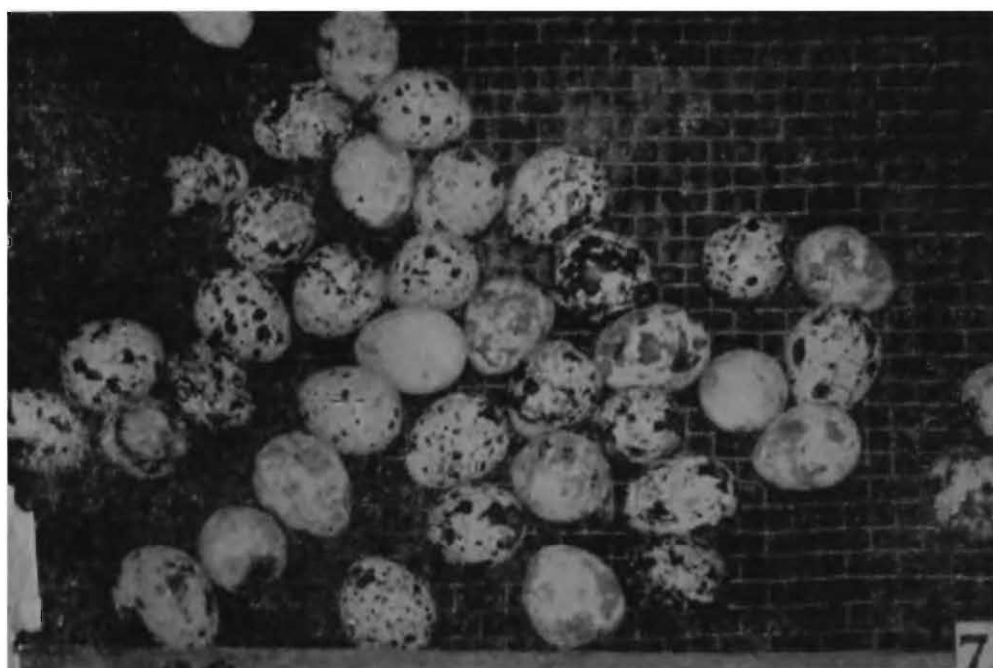


Fig. 7. Eggs of *Coturnix coturnix*.



Fig. 8. Typical winter habitat of some snow loving partridges.

## ECOLOGICAL OBSERVATIONS ON HIGH ALTITUDE RODENTS OF THE INDIAN HIMALAYAS

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### INTRODUCTION

Despite their great importance in agriculture and human health, Rodentia is among the least known groups of high altitude mammals of Indian Himalayas. That several new taxa still await discovery is evident from the fact that even small areas, if thoroughly surveyed, have consistently been yielding a number of new taxa, e. g., collection of Indian mammal survey conducted by Bombay Natural History Society. The author made and/or studied three small collections from the eastern, central and western Himalayas resulting in discovery of five new taxa. The main reason is apparently the high rate of speciation resulting from isolation on high mountain peaks separated by streams and low altitude valleys and unaccessibility of the area for human investigation. An attempt has been made to study the altitudinal distribution and range affinities of the species alongwith other available ecological information with special reference to the author's own work and other published information. An inventory of species/subspecies with distribution has been provided. The species which have received special attention are: *Petaurista elegans gorkhali* (Lindsay), *Callosciurus m. maccllellandi* Horsfield, *Dremomys l. lokriah* Hodgson, *Rattus f. fulvescens* (Gray), *Rattus eha* (Wroughton), *Rattus n. nitidus* (Hodgson), *Rattus r. rattoides*, *Mus p. pahari* Thomas, *Mus musculus homourus* Hodgson, *Mus cervicolor* Hodgson, *Apodemus flavicollis gurkha* Thomas and *Pitymys s. sikimensis* Hodgson. Mammalian adaptation to high altitudes of Kashmir was discussed by Khajuria (1957) and is applicable to this report also as far as rodents are concerned.

Ecological notes could only be provided for twelve taxa and are based on the works of Khajuria, 1957 (West Himalayas), Biswas and Khajuria, 1957 (Eastern Nepal), Khajuria and Ghosh, 1970 (Darjeeling District. West Bengal), and Abe, 1979 (Central Nepal). Other references consulted are Ellerman (1961), Ellerman and Morrison-Scott (1951), Khajuria (1962).

### ZOOGEOGRAPHICAL NOTES

Indian high altitude rodents of the Himalayas show more or less distinct zonation : (i) eastern Himalayan species extending from

western border of Nepal eastward; and (ii) the Western Himalayan species occupying ranges on the west of this line. A few taxa, however, do extend into both of these zones, e.g., *Petaurista petaurista albiventer*, *Pitymys leucurus*, *Rattus n. niviventer*, *Mus musculus homourus*. Both the zones are roughly occupied by equal number of subspecies and many of these about 63% are confined to the Himalayas. About 33 % of taxa show Indo-Malayan affinities. Only very small proportion of subspecies, c. 2%, enter into Indian peninsula. Genera *Sicista*, *Cricetulus*, *Eupetaurus* and *Hyperacrius* are not found elsewhere in India except the Western Himalayas. From available data, it is difficult to ascertain whether any genus is confined to high altitudes of the eastern Himalayas.

A perusal of Table I shows that except the genus *Marmota*, other rodents do not appear to be confined to high altitudes. This table is, however based on a few selected taxa where accurate altitudinal record is available.

## ECOLOGICAL NOTES

### 1 *Petaurista elegans gorkhali* (Lindsay) Lesser gaint flying squirrel

*Distribution* :—Nepal, c. 4,000m.

*Habitat* :—Rests in holes in trees, if available.

*Food* :—Apparently fruit, bark, gum, insects.

*Reproduction* :—Newly born young apparently belonging to this squirrel found in May in a hollow of silver fir tree. Kept in captivity on diluted skimmed milk for few days.

*Miscellaneous* :—Nocturnal

### 2. *Callosciurus m. maclellandi* Horsfield The Himalayan striped squirrel

Text Fig. 1

*Distribution* :—Nepal, Sikkim, Bhutan, N.E. India, Burma. Altitudinal distribution (Table I).

*Food* :—Vegetable matter with insects. In captivity a juvenile accepted groundnut, coconut and bread.

*Reproduction* :—June, July, possibly spread over a few months. A juvenile and a foetus were collected on the same day.

*Economics* :—May damage ripening corn (Walker).

*Miscellaneous*:—Well adapted to high forest and very rarely ascending to ground; hides itself in mossy coat of trees, mainly oak,

and conifers in Darjeeling District; agile movements and sound closely resemble small birds with which it is found in the district at high altitudes and colouring resembles the bark of the trees.; found in parties upto about  $\frac{1}{2}$  dozen individuals; diurnal.

### 3. **Dremomys l. lokriah** Hodgson

*Distribution* :—From Nepal to Northern Burma.

*Habitat* :—Usually found in oak forests from 1,525m to 3,000m and found by the author on a number of occasions in sparsely forested areas; inhabits holes in trees.

*Food* :—Four individuals found with insect and berries in ratio of about 50 : 50 in their stomachs (Abe). It is reported to feed on fallen fruit.

*Reproduction* :—Most parturition apparently in early summer The mating season is apparently in spring but chases of females by males also observed in June in Darjeeling Distt.

*Miscellaneous* :—Call repeated loud chatter, helminth parasites recorded.

### 4. **Marmota bobak** (Muller)

The Himalayan Marmot or Bobak

### 5. **Marmota caudata** (Jacquemont)

The long-tailed Marmot

*High altitude distribution and habitat* :—*M bobak* : Himalayas from c. 4000m to c. 6000m from Kashmir to Sikkim.

*M. caudata* : Gilgit and Kashmir, Ladak from c. 2500m to c. 4500m.

*Food* :—Various types of vegetable matter.

*Reproduction* :—Litters consisting of 2-4 young are born in spring.

*Economics* :—Skins and fat are articles of commerce; farming of the animals in India possible.

*Miscellaneous* :—Probably hibernate for some time during long winter in their burrows for which enough food is stored; may sit on their hind quarters to look around; an alarm cry in the form of a whistle.

## 6. *Hystrix indica* Kerr

### The Indian Porcupine

*High altitude distribution and habitat* :—Upto about 2500m in the Himalayas in natural caves although widely distributed in the plains.

*Food* :—Vegetable matter of various kind including bark of trees.

*Reproduction* :—Not recorded on high altitudes; in captivity both parents look after the young; the female in heat exposes its vagina by spreading its quills against the back.

*Economics* :—Flesh is good eating; quills used in fishing; considered as pest of agriculture if found in large number.

*Miscellaneous* :—It can hop about on its hind legs in groups and with its quills erected and look like dancing troupe of girls. It wards off its enemies by a backward rush thrusting its quills in the enemy's body. Tigers and panthers have been killed by its quills.

## 7. *Pitymys (Neodon) sikimensis* (Hodgson)

### The Sikkim Vole

*Distribution* :—Sikkim to Nepal (upto Pangboche, 500m) from 2100 to 3700m. Western slope of Imaza Khola. Altitudinal distribution Table-1

*Habitat* :—Meadows, rhododendron and coniferous forests: found near human habitation. Abe (1972) examined fourteen stomachs and gave this composition : 95% green herbs, 2.1% moss, 2.9% seeds.

*Reproduction* :—June, July-2-4 foetuses found. Abe (1972) gave the mean number of foetuses found in females as 2-6 in a sample of 6 females. According to Hodgson it also breeds in hollow decayed trees and roots of trees making a nest of soft material.

*Miscellaneous* :—Adapted to regions of high altitudes with help of its burrows dug into fallen dry leaves and further protected above from snow by vegetation. No burrow castings; used to proximity of human presence.

## 8. *Apodemus flavicollis gurkha* Thomas

*High altitude distribution and habitat* :—Gorka, c. 3450m Nepal (Thomas); Central Nepal, c. 2290m to 2730m (Abe). According to Abe it inhabits rhododendron and pine forests.

*Food* :—Insect and vegetable matter in ratio of about 70 : 30.

*Reproduction* :—Mating possibly takes place in May.

#### 9. *Rattus rattus brunneusculus* (Hodgson)

*High altitude distribution and habitat* :—Nepal, Sikkim, c. 300m to 1300m, Darjeeling District; W. Bengal, c. 325m to c. 2258m. Forest, maize fields, deserted houses; also arboreal.

*Food* :—Vegetable matter and insects in ratio of about 70 : 30 (Central Nepal).

*Reproduction* :—Breeding season in summer. About 5-11 young may be born in a litter.

*Miscellaneous* :—Common in Darjeeling District. Apparently a pest.

#### 10. *Rattus rattoides rattoides* (Hodgson)

##### The Turkestan rat

*High altitude distribution and habitat* :—Kumaon, c. 1240m to 3600m, Sikkim. Near human habitation or near cultivated fields in cooler pockets.

*Food* :—Mainly vegetarian; c. 75% of its food may consist of vegetable matter and the rest of insects.

*Reproduction* :—It breeds in May and litter may contain 1-5 young.

*Miscellaneous* :—Pest of agricultural crops. No specimen could be collected in February and March.

#### 11 *Rattus n. nitidus* (Hodgson)

##### The Himalayan rat

*High altitude distribution and habitat* :—Kumaon, Central Nepal 1890m Darjeeling District c. 1650m to 2250m, Sikkim, N.E. India, China. Generally near villages and towns and their environs. Maize fields (Darjeeling Distt.) near stream in forest (Eastern Nepal).

*Food* :—Remains of insects found in stomach of one specimen.

*Reproduction* :—Litter may contain upto about a dozen young. The breeding season is in summer (July, Abe).

#### 12. *Rattus f. fulvescense* Gray

##### Chestnut rat

*High altitude distribution and habitat* :—Kumaon to Nepal (1150m to 2500m) Darjeeling (Palmajua, c. 2250m, Takdah, 1650m) Sikkim,

Assam, Burma, Tenasserim, Indo-China. Evergreen broad leaved forest with shrubs (Central Nepal); forest and maize fields (Darjeeling District).

*Food* : --About 1/3 of its food consists of insects or their larvae and the rest of the vegetable matter including berries and seeds. Khajuria and Ghosh (1970) found vegetable matter only in stomach of one adult.

*Reproduction* :—Peak, in April to June. Litter may consist of 3-8 young with mean value of 4-5.

*Economics* :—Apparently an agricultural pest.

### 13. *Rattus e. eha* (Wroughton)

The smoke bellied rat

*High altitude distribution and habitat* :—Nepal (c. 1150m to 3200m), Darjeeling Distt. (c. 2,250m to c. 3600m). Mainly Pine, bamboo and rhododendron forests (Nepal and Darjeeling District).

*Food* : —Stomach contents showed vegetable matters and Arthropods in ratio of about 70 : 30.

*Reproduction* :—In summer, about 2-3 young may be born in a litter.

### 14. *Mus cervicolor cervicolor* Hodgson

*High altitude distribution and habitat* :—Nepal c. 300m to 3200m. Various types near cultivated fields among stone heaps and grass, occasionally in forest.

*Food* :—Stomach contents of 20 individuals collected in Nepal from April to July, showed Arthropods and vegetable matter in the ratio of c. 69 : 29.

*Reproduction* :—The breeding season is during hot season and 4 to 8 young may be born in a litter

*Economics* :—Apparently a pest of agricultural crops.

## INVENTORY OF TAXA

### Family SCIURIDAE

#### 1. *Belomys pearsoni* (Gray)

1842. *Sciuropterus pearsoni* Gray, *Ann. Mag. nat. Hist.*, 10, 263.

*Range* : Sikkim, N. Bengal, Darjeeling, Assam, Naga Hills.

**2. *Petaurista elegans caniceps* (Gray)**1842. *Sciuropterus caniceps* Gray, *Ann. Mag. nat. Hist.* **10**, 262.*Range* : Sikkim, Nepal (1200-1800m).**3. *Petaurista elegans gorkhali* (Lindsay)**1929. *Sciuropterus gorkhali* Lindsay, *J. Bombay nat. Hist. Soc.*, **33** (3) : 565.*Range* : Nepal, Gorkha (4000m).**4. *Petaurista elegans clarkei* (Thomas)**1922. *Petaurista clarkei* Thomas, *Ann. Mag. nat. Hist.*, **10**, 396.*Range* : Yunnan (2700-3000m), Mekong Valley.**5. *Petaurista alborufus candidulus* Wroughton**1911. *Petaurista candidulus* Wroughton, *J. Bombay nat. Hist. Soc.*, **20** (4), 1014, 1922.*Range* : Manipur, Assam, Naga Hills (1500m).**6. *Petaurista petaurista albiventer* (Gray)**1834. *Pteromys albiventer* Gray, *Illustr. Indian Zool.*, pl. xviii. Type in British Museum, Labelled Nepal.*Range* : Murree, Lahul, Simla, Garwal, Kumaon, Nainital, Assam.**7. *Hylopetes alboniger alboniger* (Hodgson)**1836. *Sciuropterus alboniger* Hodgson, *J. Asiat. Soc. Beng.*, **5**, 231.*Range* : Sikkim (2580m), Darjeeling, Manipur, Assam, Naga Hills 1500m).**8. *Hylopetes fimbriatus fimbriatus* (Gray)**1837. *Sciuropterus fimbriatus* Gray, *Ann. Mag. nat. Hist.*, **1**, 584.*Range* : Murree, Lahul, Chamba, Simla, Kashmir, Gilgit.**9. *Eupetaurus cinereus* (Thomas)**1888. *Eupetaurus cinereus* Thomas, *J. Asiat. Soc. Beng.*, **57**, 2 (3), 258.*Range* : Chitral and Gilgit, Kashmir (c. 1500m).**10. *Callosciurus macclellandi macclellandi* (Horsfield)**1839. *Sciurus macclellandi* Horsfield, *Proc. zool. Soc. Lond.*, 152.*Range* : Nepal to Burma (2250m).**11. *Callosciurus caniceps crumpi* (Wroughton)**1916. *Callosciurus crumpi* Wroughton, *J. Bombay nat. Hist. Soc.*, **24**, 425.*Range* : Sikkim (1950m), Sedonchen.

12. **Dremomys lokriah pagus** Moore1956. *Dremomys lokriah pagus* Moore, *Amer. Mus. Novit.*, No. 1816, P.1.*Range* : Mt. Victoria, Pakokku Chin Hills, Western Burma, Assam, Lushai Hills13. **Dremomys lokriah lokriah** (Hodgson)1836. *Sciurus lokriah* Hodgson, *J. Asiat. Soc. Beng.*, 5, 232.*Range* : Nepal, Sikkim, Mishmi, North Burma.14. **Dremomys pernyi pernyi** (Milne-Edwards)1867. *Sciurus pernyi* Milne-Edwards, *Rev. Nag. Zool.*, 230, p. 1-19.*Range* : Kohima, Naga Hills (1500m), Manipur15. **Marmota bobak himalayana** (Hodgson)1841. *Arctomys himalayanus* Hodgson, *J. Asiat. Soc. Beng.*, 10, 777. Nepal,*Range* : Ladak, Lahul, Garhwal, Sikkim (c. 4000m to 5000m).16. **Marmota caudata caudata** (Jacquemont)1844. *Arctomys caudatus* Jacquemont, *Voy. dans L' Inde*, 4, Zool., 65.*Range* : Kashmir Ladak, (c. 2500m to 4500m).17. **Marmota caudata aurea** (Blanford)1875. *Arctomys aureus* Blanford, *J. Asiat. Soc. Beng* 44, 106, 123.*Range* : Chitral, Chinese Turkestan, Samarkand, Pamir.

## Family HYSTRICIDAE

18. **Hystrix indica** Kerr1792. *Hystrix cristatata* var. *indica* Kerr, *Anim. Kingd.* 213, India.*Range* : High altitude Indian Himalayan range (2500m) Kashmir to Nepal.

## Family DIPODIDAE

19. **Sicista concolor flavus** (True)1894. *Sminthus flavus* True, *Proc. U. S. natn. Must.* 17, 341.*Type-locality* : Central Kashmir (3300m).

## Family RHIZOMYIDAE

20. **Cannomys badius badius** (Hodgson)1841. *Rhizomys badius* Hodgson, *Calcutta J. nat. Hist.* 2, 60, 410.*Range* : Nepal, Sikkim, Darjeeling, Assam, Naga Hills (1500 m).

## Family MURIDAE

21. **Cricetulus migratorius fulvus** (Blanford)1875. *Cricetus (Cricetulus) fulvus* Blanford, *J. Asiat. Soc. Beng.*, 44, 2, 108.*Range* : Kashmir, Gilgit.

**22. *Cricetulus alticola* Thomas**1917. *Cricetulus alticola* Thomas, *Ann. Mag. nat. Hist.*, **19**, 455.*Range* : Ladak.**23. *Alticola roylei roylei* (Gray)**1842. *Arvicola roylei* Gray, *Ann. Mag. nat. Hist.*, **10**, 265.*Range* : Kumaon.**24. *Alticola roylei cautus* Hinton**1926. *Alticola roylei cautus* Hinton, *Monogr. Voles and Lemmings*, **1**, 313.*Range* : Lahul, Rahla.**25. *Alticola roylei blanfordi* (Scully)****The Gilgit Vole**1880. *Arvicola blanfordi* Scully, *Ann. Mag. nat. Hist.*, **6**, 399.*Range* : Kashmir, Lahul (2000 to 3000 m), Kangra Valley.**26. *Alticola roylei montosa* (True)**1894. *Arvicola montosa* True, *Proc. U. S. natn. Mus.*, **17**, 11.*Range* : Kashmir.**27. *Hyperacrius wynnei* (Blanford)**1881. *Arvicola wynnei* Blanford, *J. Asiat. Soc. Beng.*, 1880, **49**, 2, 244.*Range* : Murree, Kashmir.**28. *Hyperacrius fertilis* (True)**1894. *Arvicola fertilis* True, *Proc. U. S. natn. Mus.*, **17**, 10.*Range* : Kashmir.**29. *Hyperacrius fertilis brachelix* (Miller)**1899. *Microtus (Hyperacrius) brachelix* Miller, *Proc. Acad. nat. Sci. Phila.*,  
290.*Range* : Kashmir (2700 m).**30. *Hyperacrius fertilis fertilis* (True)**1894. *Arvicola fertilis* True, *Proc. U. S. natn. Mus.*, **17**, 10.*Range* : Kashmir.**31. *Pitymys leucurus* Blyth**1863. *Phaiomys leucurus* Blyth, *J. Asiat. Soc. Beng.*, **32**, 89.*Range* : Kashmir, Mount Everest.**32. *Pitymys leucurus leucurus* (Blyth)**1863. *Phaiomys leucurus* Blyth, *J. Asiat. Soc. Beng.*, **32**, 89.*Range* : Ladak.

33. **Pitymys sikimensis** Hodgson1849. *Neodon sikimensis* Hodgson, *Ann. Mag. nat. Hist.*, **3**, 203.

Range : Nepal, Sikkim and Bhutan, 2100 to 3700 m.

34. **Apodemus f. flavicollis** (Melchior)1834. *Mus. flavicollis* Melchior, *Danske Staats og Norges Pattr.*, 99.

Range : Kashmir, Punjab, Kumaon.

35. **Apodemus flavicollis rusiges** (Miller)1913. *Apodemus flavicollis rusiges* Miller, *Proc. biol. Soc. Wash.*, **26**, 81.

Range : Kashmir, Punjab, Kumaon.

36. **Apodemus flavicollis gorkha** Thomas1924. *Apodemus gorkha* Thomas, *J. Bombay nat. Hist. Soc.*, **29**, 4, 888.

Range : Laprak, Gorkha, Nepal (3450 m).

37. **Apodemus flavicollis wardi** (Wroughton)1908. *Micromys sylvaticus wardi* Wroughton, *J. Bombay nat. Hist. Soc.* **18**, 282.

Range : Ladak, Kashmir.

38. **Micromys minutus erythrotis** (Blyth)1855. *Mus erythrotis* Blyth, *J. Asiat. Soc. Beng.*, **24**, 721.

Range : Assam, Naga Hills (1500 m).

39. **Rattus rattus brunneusculus** Hodgson1845. *Mus brunneusculus* Hodgson, *Ann. Mag. nat. Hist.*, **15**, 267.

Range : Nepal to N. E. India (c 325 m to 2250 m).

40. **Rattus rattus gangutrianus** Hinton1919. *Rattus rattus gangutrianus* Hinton, *J. Bombay nat. Hist. Soc.*, **26**, 389.

Range : Chamba, Keylong, Dharmasala.

41. **Rattus rattus rattoides** (Hodgson)1845. *Mus rattoides* Hodgson, *Ann. Mag. nat. Hist.*, **15**, 167.

Range : Kumaon (c. 1240 m to 3600 m) to Sikkim.

42. **Rattus rattoides turkestanicus** (Satunin)1903. *Mus turkestanicus* Satunin, *Ann. Mus. St. Petersb.*, **7**, 588. (April, 1903)  
Assam-bob, Russian Turkestan.

Range : Kashmir, Gilgit, Ladak, Poonch, Kishtwar, Chamba.

43. **Rattus n. nitidus** Hodgson1845. *Rattus n. nitidus* Hodgson, *Ann. Mag. nat. Hist.*, **15**, 267.

Range : From Kumaon to Assam-China, 1650-2250 m.

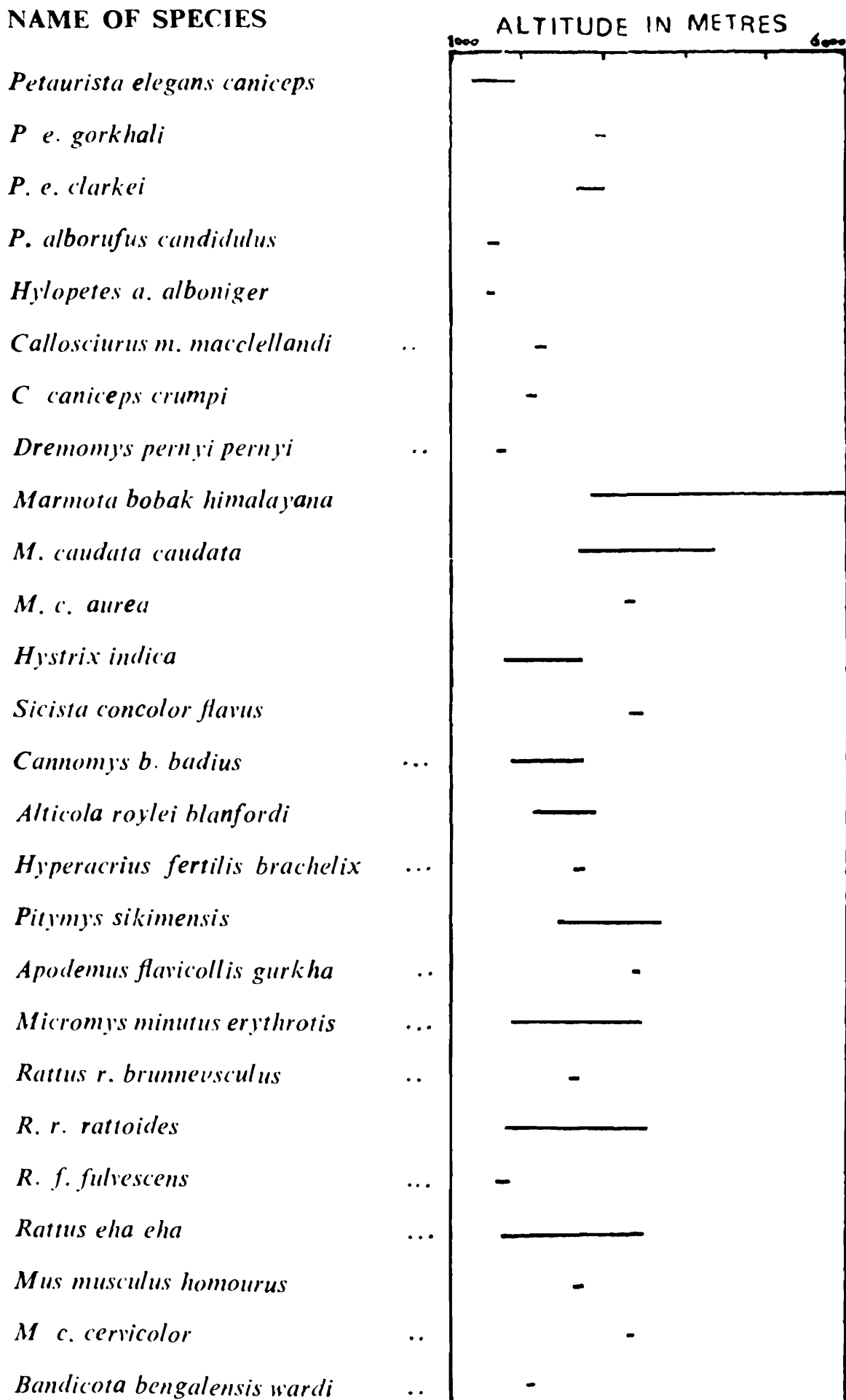
**44. *Rattus manipulus kekrimus* Roonwal**1948. *Rattus manipulus kekrimus* Roonwal, *Proc. natn. Inst. Sci. India*, **14**, 386.*Range* : Manipur.**45. *Rattus niviventer niviventer* Hodgson**1836. *Mus (Rattus) niviventer* Hodgson, *J. Asiat. Soc. Beng.*, **5**, 234.*Range* : Simla, Nepal.**46. *Rattus fulvescens fulvescens* (Gray)**1847. *Mus fulvescens* Gray, *Cat. Hodgson Coll.*, 18.*Range* : Assam, Burma, Sikkim, Nepal (1150 m to 2500 m),  
Mishmi, Kumaon.**47. *Rattus eha eha* (Wroughton)**1916. *Epimys eha* Wroughton, *J. Bombay nat. Hist. Soc.*, **24**, 428.*Range* : Lechen, Sikkim (2500 m), Nepal (c. 1150 m to 3200 m),  
Darjeeling Dist., c. 2250 m to 3600 m.**48. *Mus musculus bactrianus* Blyth**1846. *Mus bactrianus* Blyth, *J. Asiat. Soc. Beng.*, **15**, 140.*Range* Kashmir, Dras, Ladak.**49. *Mus musculus homourus* Hodgson**1845. *Mus homourus* Hodgson, *Ann. Mag. nat. Hist.*, **15**, 268.*Range* : Chamba, Sikkim, Darjeeling (2580 m).**50. *Mus cervicolor cervicolor* Hodgson**1845. *Mus cervicolor* Hodgson, *Ann. Mag. nat. Hist.*, **15**, 268.*Range* : Nepal (c. 300 m to 3200 m) to Burma.**51. *Mus pahari pahari* Thomas**1916. *Mus pahari* Thomas, *J. Bombay nat. Hist. Soc.*, **24**, 3, 415.*Range* : Darjeeling, Assam, Naga Hills.**52. *Bandicota bengalensis wardi* (Wroughton)**1908. *Gunomys wardi* Wroughton, *J. Bombay nat. Hist. Soc.*, **18**, 745.*Range* : Kashmir (1650 m), Chamba, Srinagar, Garhwal.

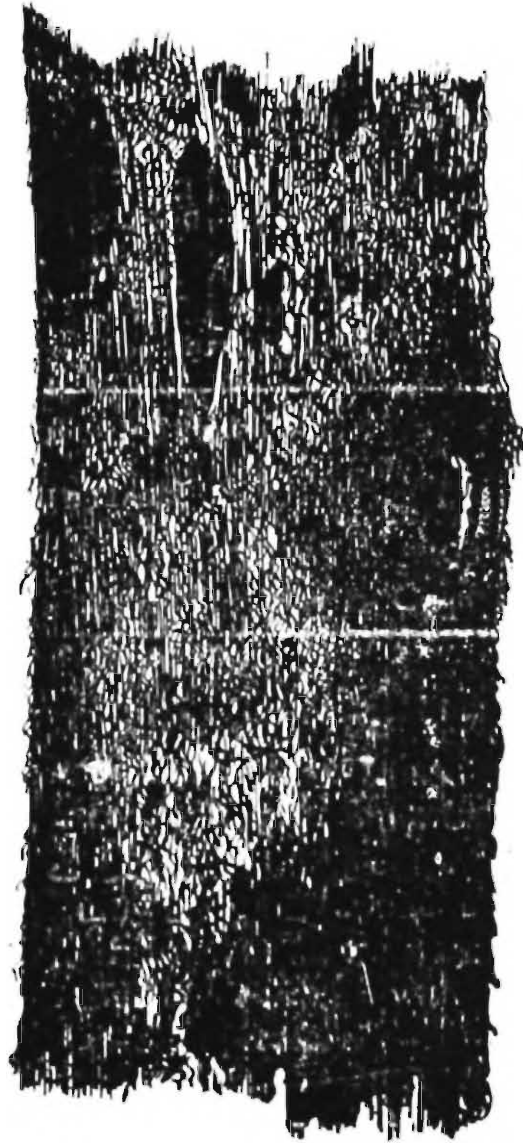
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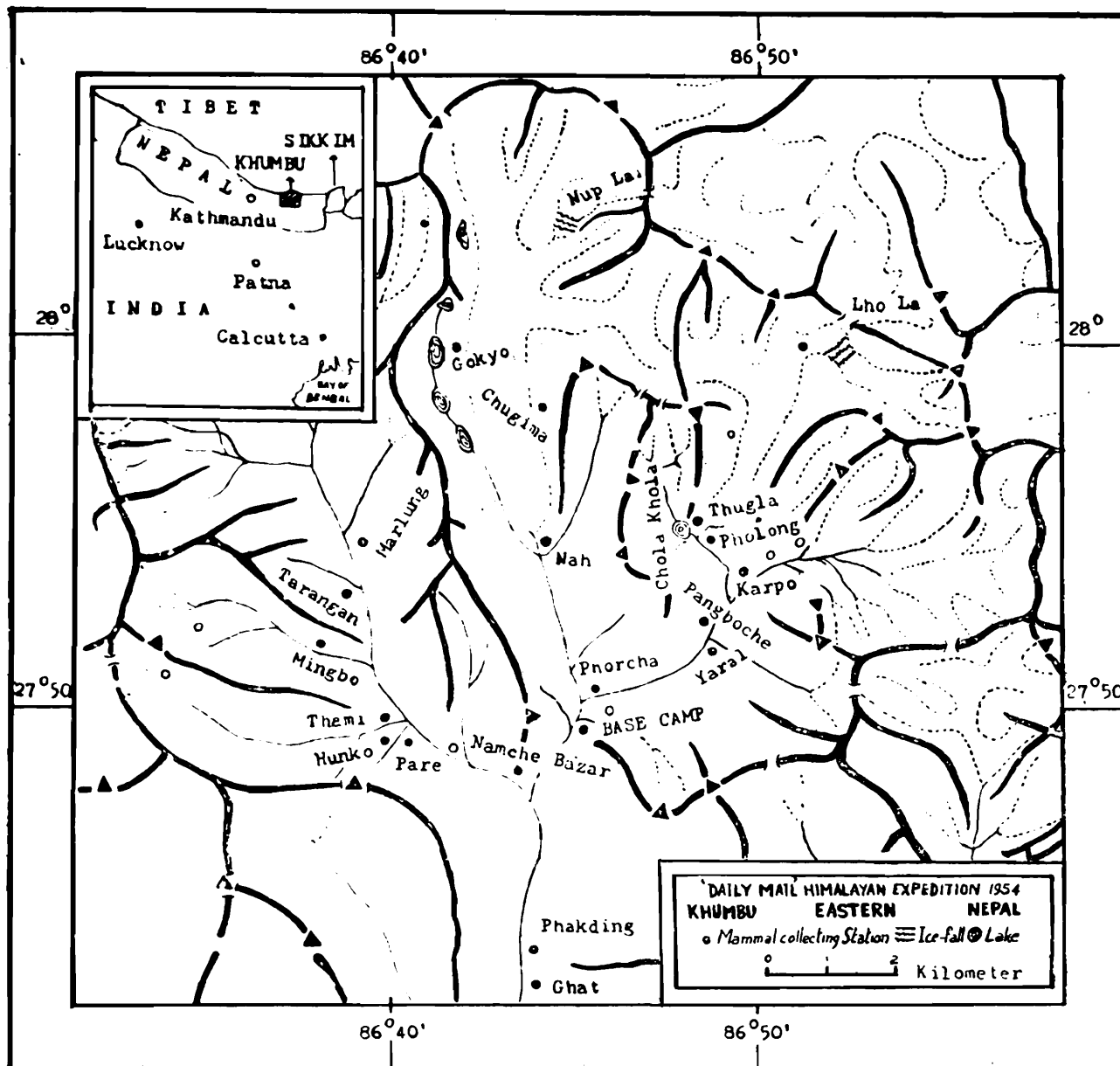
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TABLE I. Altitudinal distribution of high altitude Himalayan rodents where accurate record of altitude is available.





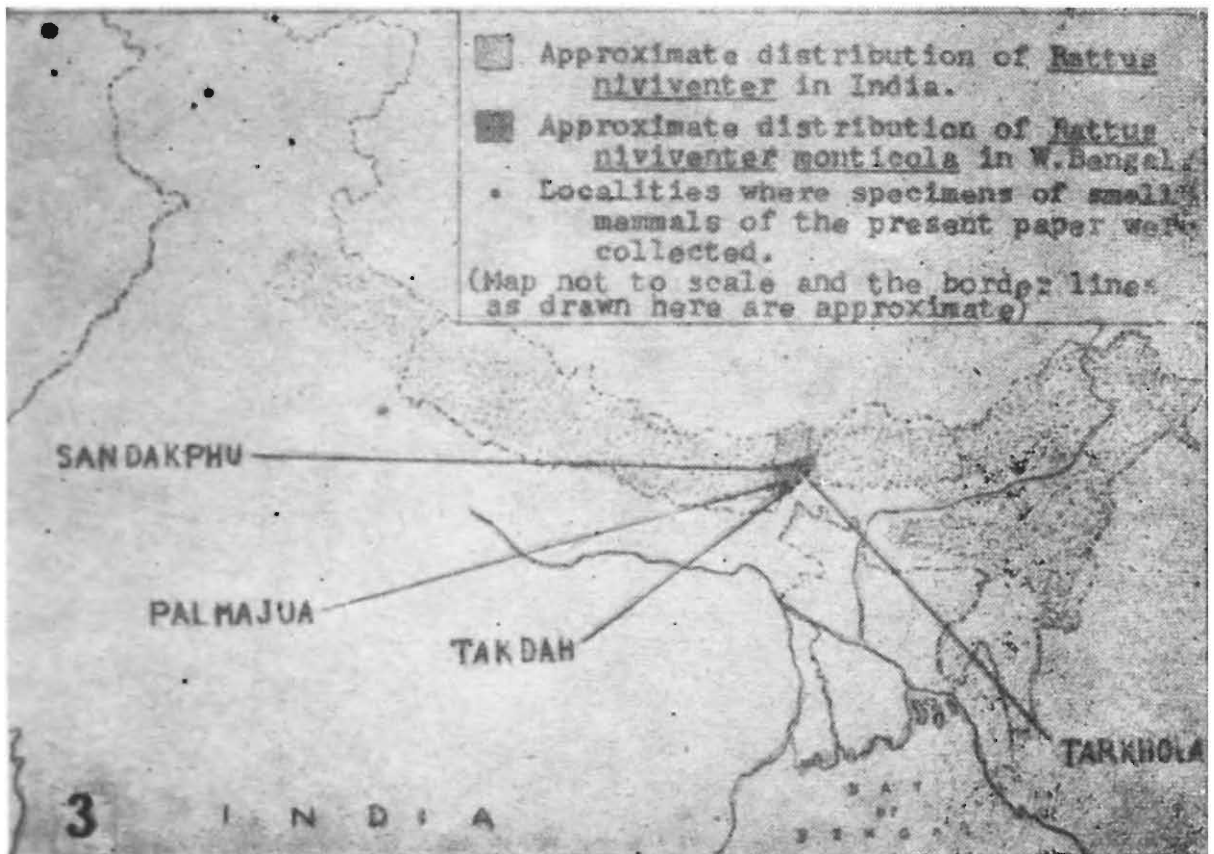
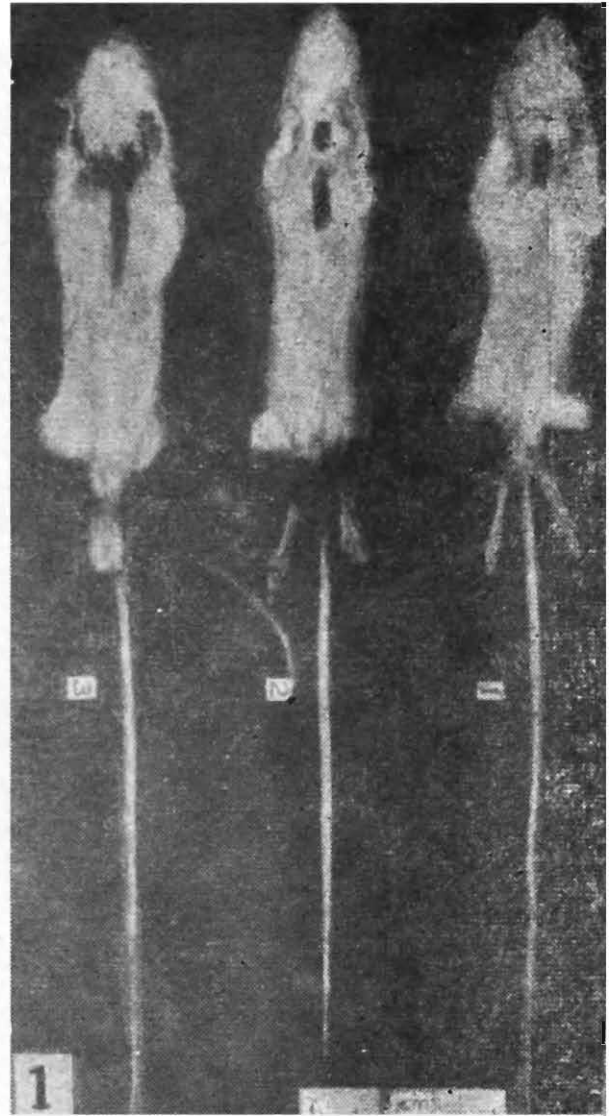
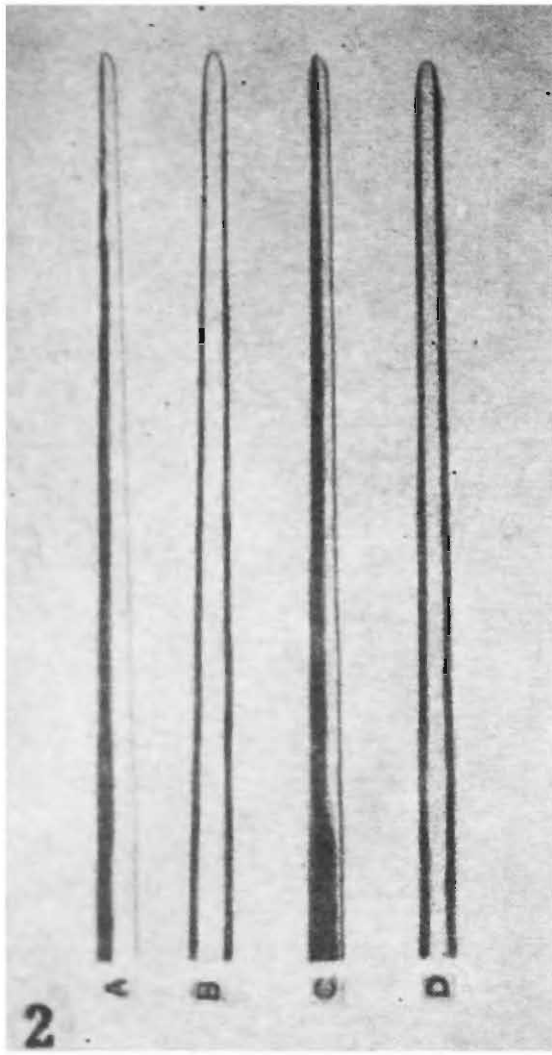
**Text Fig. 1.** A specimen of *Callosciurus m. macellanli* hiding in the mossy coat of old tree at Palmajua, 2250 m.



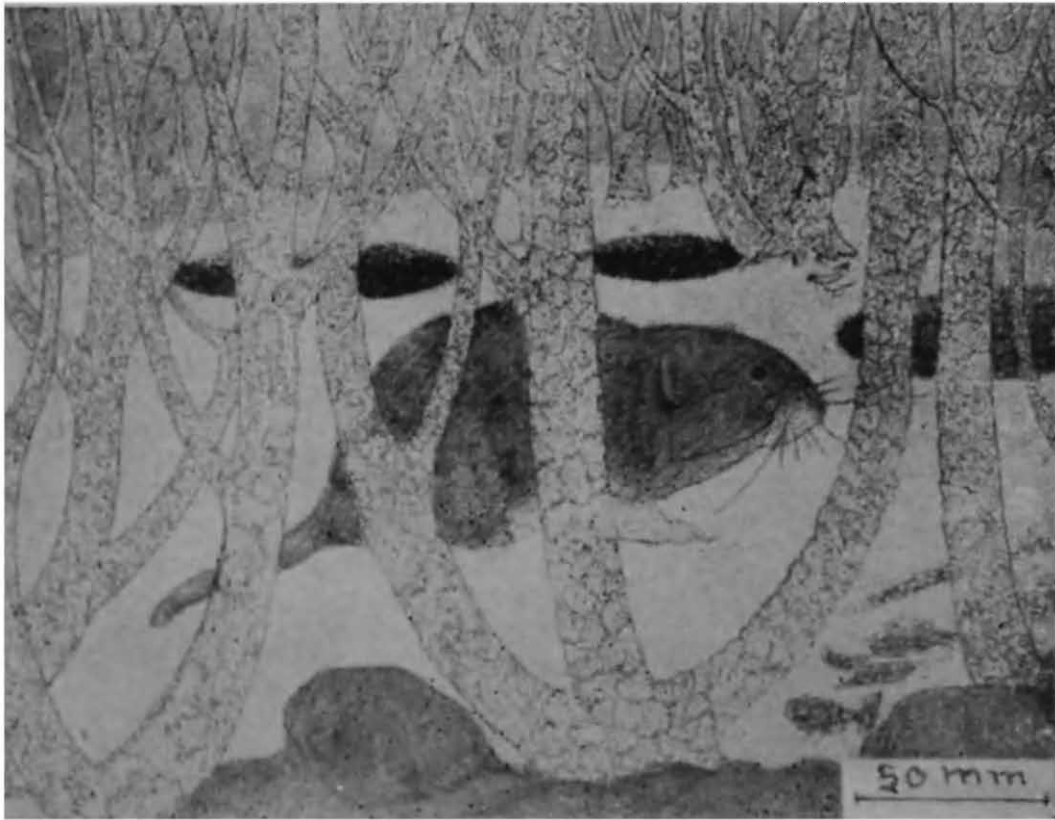
Text Fig. 2. Map of Khumbu District Eastern Nepal from where a collection of rodents was studied (after Biswas & Khajuria, modified).

## PLATE I

**Fig. 1.** 1, 2, 3 showing the variation in characteristic colour pattern on the ventral side of three specimens of *R. niviventer monticola*, alt. 2250 m (after R. K. Ghosh); 2. A and B lateral and ventral views respectively of the distal portion of the tail in *R. niviventer monticola*; C and D the same of *R. f. fulvescens* showing the difference in colour pattern, natural size (approx.) from made-up skins (after R. K. Ghosh); 3. Sketch map of Darjeeling district, West Bengal where collection of rodents was made.



## PLATE II



The Sikkim Vole (*Pitymys s. sikimensis* Hodgson) in its natural habitat.

## ON HABITS OF SOME HIGH ALTITUDE BIRDS OF INDIAN WESTERN HIMALAYAS

By

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### INTRODUCTION

The western Himalayas because of their zoogeographical location and great expansion in latitudes and altitudes present a very interesting area for the study of high altitude avifauna, particularly above about 3000 m altitude. The present paper deals with some ecological observations made from September, 1978 to March, 1979 on the house swift, *Apus a. affinis* Gray and the common swallow, *Hirundo r. rustica* Linn. which are found in large colonies in human habitations at Solan. The observations will be helpful in manipulation of their populations. Besides, data on breeding in captivity of some high altitude pheasants found in the area have also been collected with the courtesy of wildlife department of Himachal Pradesh and is important in development of farming of these game birds. Available information on altitudinal distribution of the species has been tabulated with discussion of their zoogeographical affinities.

### MATERIAL AND METHODS

The observations on house swift were made by one of authors (H.K.) at two sites; a residential and an office building at Solan, and on common swallow in a hospital building at the same place. The colony in residential building was subjected to day and night observations. The birds were also caught by mist net. Some were ringed and released and a few were kept in captivity in the wire netting cage. A very interesting new method was developed for the study of food of the young of the common swallow which was found to breed in large number in a hospital building. A mist net was spread across the main gate of the building where the birds were breeding and fetching food for the young. As the bird struck the net, they dropped the food from their bills which was immediately and thoroughly collected. The advantages of this method for study of food of the young over the stomach contents method are obvious: (i) it ensures more detailed identification of the food as it is practically uninjured; (ii) there is no need for sacrificing young; (iii) the food variation can be studied over a long period of time even if a few young

are available. The method can be used in similar situations in other species of birds.

The data on captive pheasants was collected from the Aviary and Zoological Gardens, Simla with the courtesy of Wildlife Warden, Himachal Pradesh. Zoogeographical and altitudinal distributional data has been abstracted from recent literature mainly Ali (1949) and Ali and Ripley (1968-1974).

## OBSERVATIONS

*Zoogeographical and altitudinal data* :—The list of important birds is given in Table I with altitudinal distribution of 69 birds based on information given by Ali (1949). About 29% of birds are confined to this zone. About 8% have palaeartic, c. 38% Indo-Malayan, c. 1% Indian peninsular and c. 17% have both Indo-Malayan and Indian peninsular affinities. About 7% birds are probably seasonal migrants.

### 1 The House Swift

*Apus a. affinis* Gray & *A. a. galilejensis* Antinori

*Distribution* : The area of observation lies in the intergradation zone of *A. a. affinis* and *A. a. galilejensis*. The population resembles the latter in presence of supercilium.

*Habitat selection* : The observations are restricted to two nesting sites both on ceiling of verandahs. There were six nests at one site, a private residence and ten at the other, an office building. A flying bird was seen to take out its own loosened feathers and use them in nest building. An immediate attempt is made to rebuild the nest if it is destroyed. It is built at the rate of 3 sq. cm per day (about 60 sq. cm was built in 20 days) in a space between two rafters. However, the nest building activity varies considerably in four roosts examined, where nests were destroyed. In one case where there was a crack to hide, no attempt was made to build the nest. In two cases, where the nest was originally built in space between two rafters converging to a slight depression in walls, the extent of nest building was reduced to about half. There is a great attachment to the roost and birds do not stop roosting even if their nests are repeatedly destroyed and birds disturbed during night frequently. This is possibly because the nest is built with great diligence and also by using bird's own feathers and with saliva. A nest was abandoned immediately after one of the pair was netted (3-10-69). Incomplete nests were also abandoned on approach of winter in the beginning of November (1-11-79). Early in March, 1980, two pairs started rebuilding their incompletely abandoned nests and one of the pair completed it by the end of March, 1980. On 2.4.80 one egg was found in the nest. One pair was netted but it

did not show rings indicating that birds were new to the site. A very young nestling (measurements in Table II) was collected from a hole in a wall after the nests were destroyed.

*Feeding habits* : For hunting area, nearby valleys, comparatively free from human habitations containing lot of green vegetation, are apparently preferred. Parties of upto about 50 birds have been seen in these valleys. Sometimes, they give out loud screams while flying. The significance of this behaviour is not understood but, possibly, i) it may be a method of echolocation for catching flying insects as has been observed in the case of bats; ii) or to warn other close flying birds to keep away; iii) or simply to keep social contact or iv) more than one of these possibilities.

Two adults and four grown-up young kept in captivity have to be forced-fed on house flies. They did not take any insect or water on their own accord. The record of the daily food given to them in captivity is given in Table IV. They continued to live on this meagre diet for four days.

*Breeding habits* : The data collected on breeding habits is summarized in Table II. As chirps of young are also heard on 21.10.79, it appears that broods are continuously being brought up except in winter at an interval of about four months. The grown up young which leave the nests can only fly for short distances as in the case of other birds but when thrown in the air over deep valleys they fly away long distances beyond human sight apparently because the substratum is far below. They are on the whole paler than adults with specklings on the body.

*Miscellaneous* : The time of emergence from and return to roost are dawn to dusk with a few hours of rest during day. On 4.8.79, a bright day, the first bird left at 5.25 A.M. followed by others at an interval of 1-2 minutes. On 21.10.79, the first bird returned to roost at 5.45 P.M. followed by others after an interval of about two minutes. At about 9 A.M. to 10 A.M. during summer months, large parties of about ten birds each were seen entering verandah, where some nests were built but left after giving out a few shrieks. The verandah was possibly used before human occupation for diurnal rest by birds other than those which roosted. The significance of sounds produced has already been indicated above. The sounds of chicks are low in pitch. The screams in chorus are also given out during night even in winter and invariably given when birds are about to leave the roost early in the morning. This shows that they are apparently used in keeping social contacts. This is supported by the fact that when all but one nest were destroyed, no screams were heard during the

whole winter although the nest was occupied. Two birds were seen sitting outside the ruined, nests and two were found where there were no nests before though it was quite cold. They were probably birds whose nests have been destroyed elsewhere. An interesting point under investigation is whether the young build their nests near the parental roost or elsewhere. No single ringed young out of five ringed could be netted on 28.10.79 showing they have started roosting elsewhere and not near the parental roosts. The first chirp of hibernating birds were heard on 12.2.80 after winter sleep (temp. *c.* 15°C) as the spring was rather late to begin.

The population in two different roosts varied from 14 to 19 birds consisting of 7 and 9½ pairs. They lived peacefully with house sparrow, a number of which occupied nearby holes. In one case a small nest where one bird was found entering was found near a larger nest. A cat was found to attempt to reach the nest from nearby projection but without success.

The attachment to the roost of the birds and their exceptional speed and sustained flight can possibly be used to send messages quickly over difficult terrain as in case of pigeons. The birds are swifter but are rather difficult to rear in captivity because of their food habits, i.e., eating flying insects.

## 2. The Common Swallow

### *Hirundo r. rustica* Linnaeus

*Habitat* : In Solan, the place inhabited by the bird during breeding season was the civil hospital, one of the largest building and situated at the outskirts of the main habitations of the town near a drainage from where wet mud can be obtained for nest building. There is considerable disturbance during office hours and even after office hours because of presence of indoor patients so that it is more or less like a residential building as far as human disturbance is concerned. The ceiling is rather low, *c.* 4 m high from the ground and nests are built at the height of *c.* 2½ m above where some projections are available. The only superiority of this building over others is apparently its larger covered area, its situation where insects are apparently abundant and proximity to a drainage. The bird could not be seen except during breeding season.

*Feeding habits* : The observations were made during captivity when the two adults were kept in a small wire netting cage. On the basis of stomach contents, the bird is known to feed chiefly on flies and midges.

After forced feeding on a few occasions, the birds started taking house flies, small yellow butterflies, and grasshoppers thrown in the

cage without forced feeding. This behaviour was quite different from that of the swift which, even after prolonged forced feedings, did not take its natural food from the cage. This shows that, while the swallow may take food from the ground at least occasionally, the swift is not at all a ground feeder. The food given to the young was collected by a new method as given elsewhere, detailed report on which will be published later. Contrary to previous information, it includes variety of insects belonging to the Orders Diptera, Hymenoptera, Odonata, Coleoptera and Lepidoptera. Diptera forms the chief food of the young and roughly at least eight taxa of this order can be distinguished.

The food is generally offered by the parents to the most noisy young which is apparently more hungry than others. On the average, the parents feed the young at an interval of about 15 to 30 minutes but the interval apparently depends on the availability of food. The hunting ground is close to the nesting site.

*Breeding season* : The nesting site is described under the habitat. The first observation was made on 2.4.79 when 45 nests were counted. Although all nests could not be examined, yet about half of them showed birds sitting on an average of 4.5 eggs. Five eggs were found very rarely. Some were still being built/repared. No mating was observed. The measurements of young collected on different dates are given in Table II. On 16-5-79, only two nests were occupied by grown up young, one nest contained just hatched nestlings, while in another a bird was sitting on eggs indicating that some birds continue to breed after the peak from April to middle of May. These may be yearlings. Fully grown young, generally four in number, were found sitting on the edges of the nest begging for food. Some unoccupied nests were found broken on their outer edge possibly because of weight of the young. In one case one adult was seen pushing out fully grown up young from the nest. This may be the usual method employed by parents to make the young leave the nest. In 1980, the birds were seen around the breeding site on 12.2.80 but no nesting or breeding activity was observed on 11.3.80. They have abandoned the site possibly because of cold wave. On 27.3.80, a large number of birds were seen sitting on nests. On 31.3.80 about fifty birds were observed in nests. There were four eggs in each nest.

*Miscellaneous* : The daily activity continued from dawn to dusk with some rest at intervals, particularly during the hotter hour of the day. The population in this roost included about 100 birds before hatching as there were about 45 nests each occupied by two birds (♂ and ♀). As the birds were not shy, there were apparently no enemies inside the roosting building. No other birds including house sparrow were found nesting in the buildings.

*Economics* : The limiting factor in the population dynamics of the bird is apparently its nesting site by manipulation of which its population can easily be controlled. The bird also feeds on the honey bee but the extent of predation could not be ascertained. As bee keeping is important profession in the area, these predatory aspects need urgent investigation.

### 3. Pheasants

The available breeding data is summarized in Table III and is based on information supplied by Forest Department of Himachal Pradesh. Kalia *et al.* (1979) have, however, described in detail the farming of some partridges.

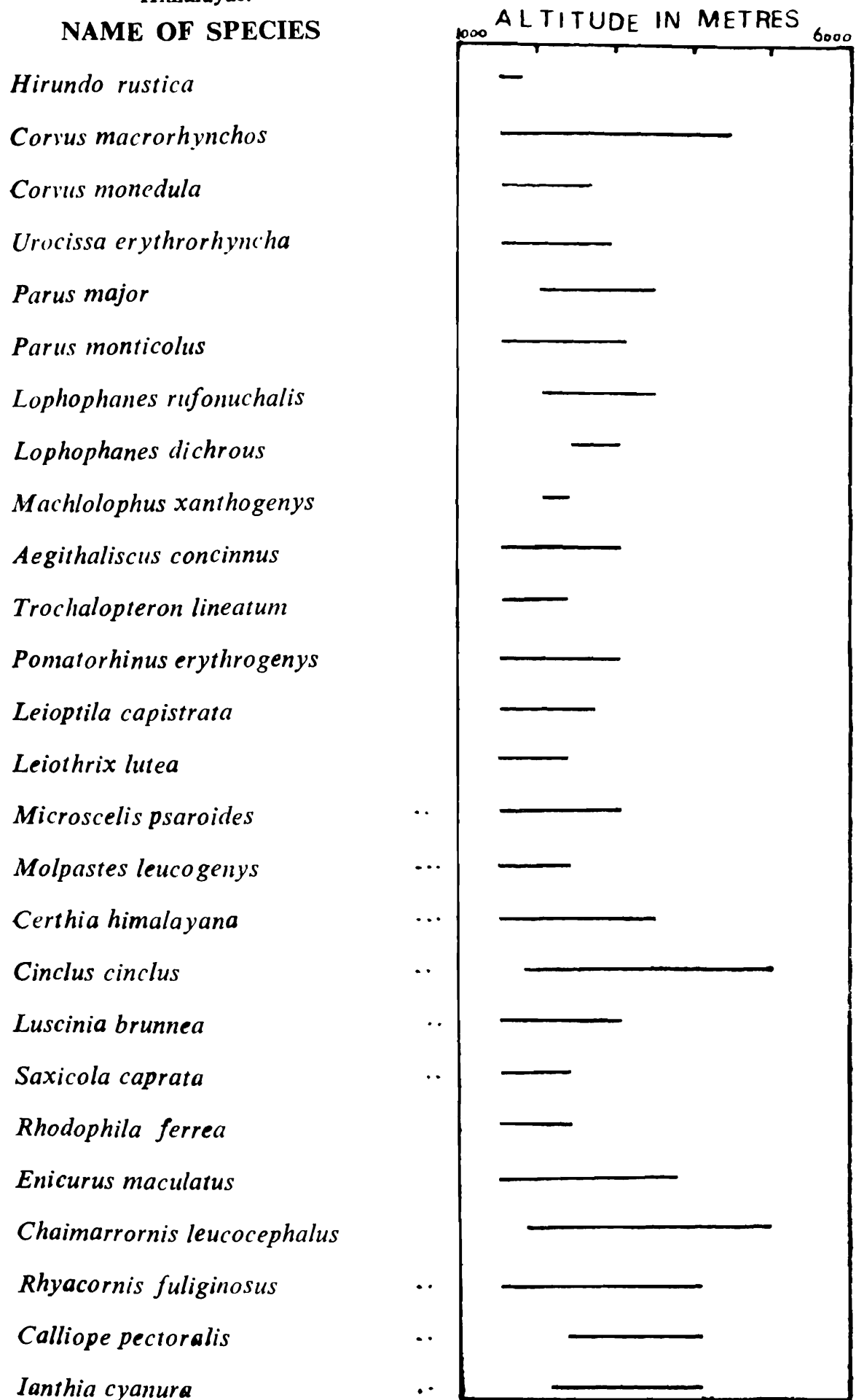
### ACKNOWLEDGEMENT

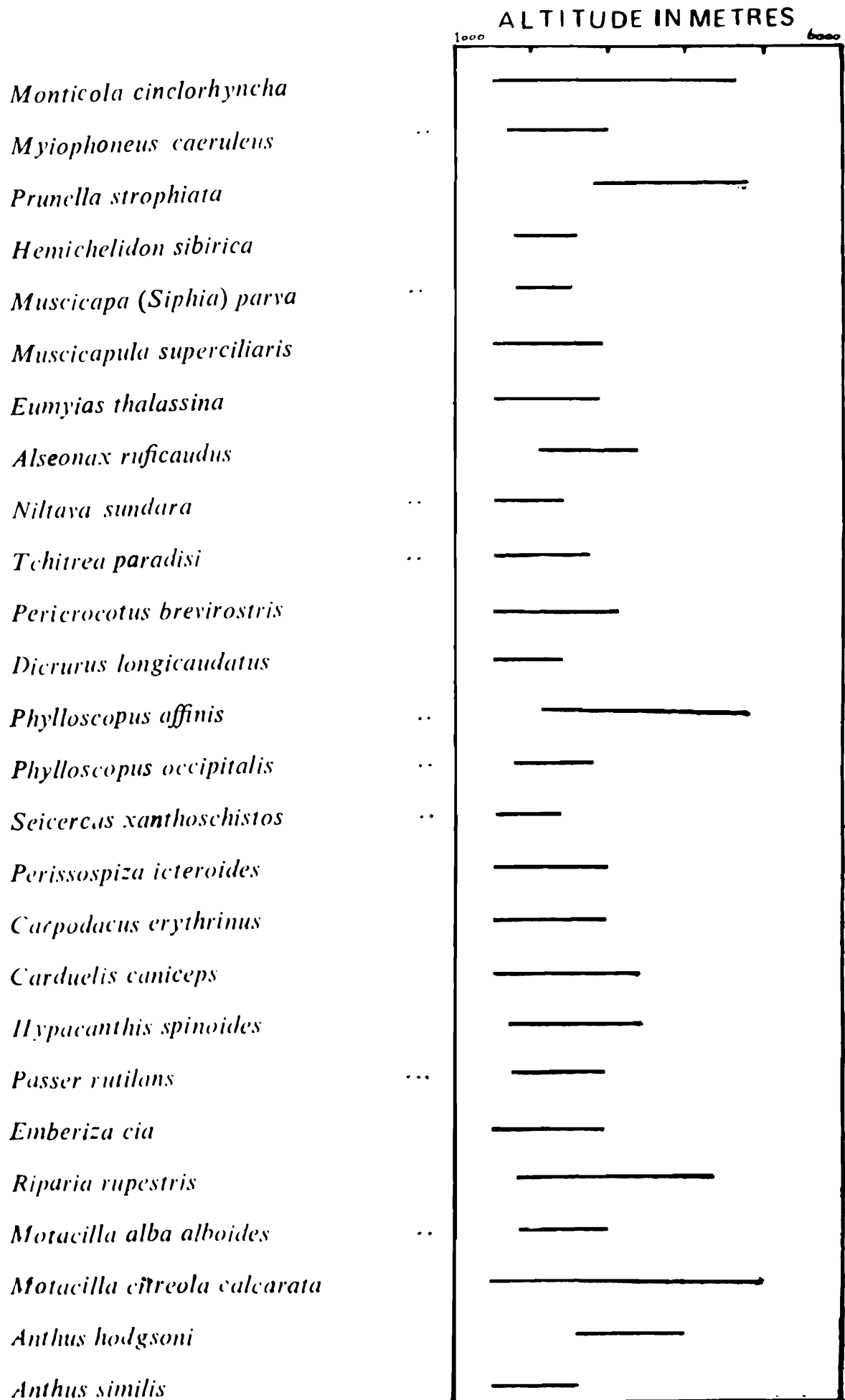
We are grateful to the Director, Zoological Survey of India, for providing facilities and to the Wild Life Warden, Himachal Pradesh, for information on some captive high altitude pheasants.

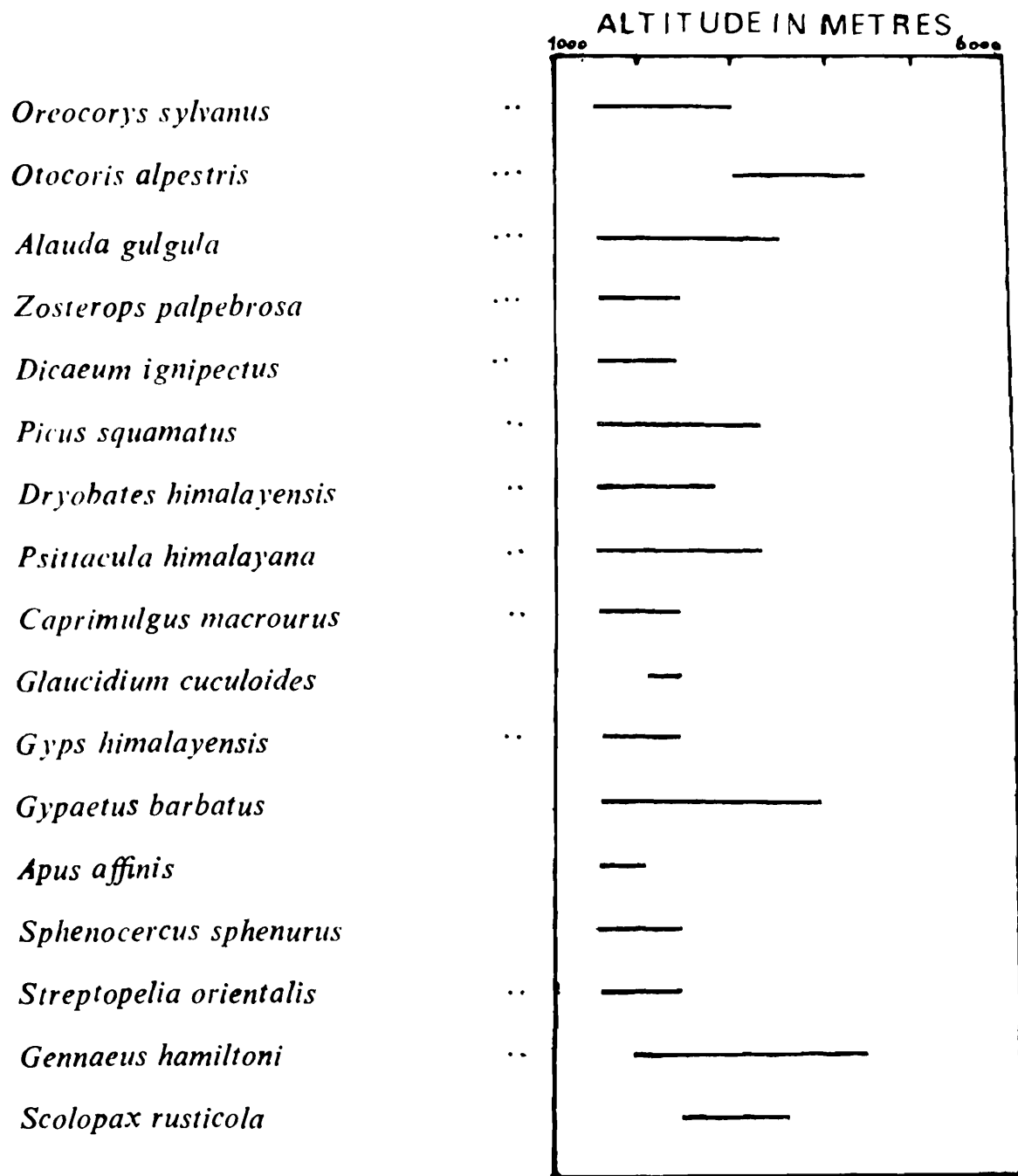
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TABLE I. Altitudinal distribution of high altitude birds of the Western Himalayas.\*







\* Scientific names and data n ostly from Ali (1949).

TABLE II. Showing the measurements in mm. of young of the house swift at different dates.

Date	Wing	Tail	Bill	Tarsus
19-4-79	131	50	7	—
	125	50	7	—
5-5-79	119	45	—	7
10-5-79	105	38	5	11
13-5-79	107	48	6	—
(very young)	27	2	9	12

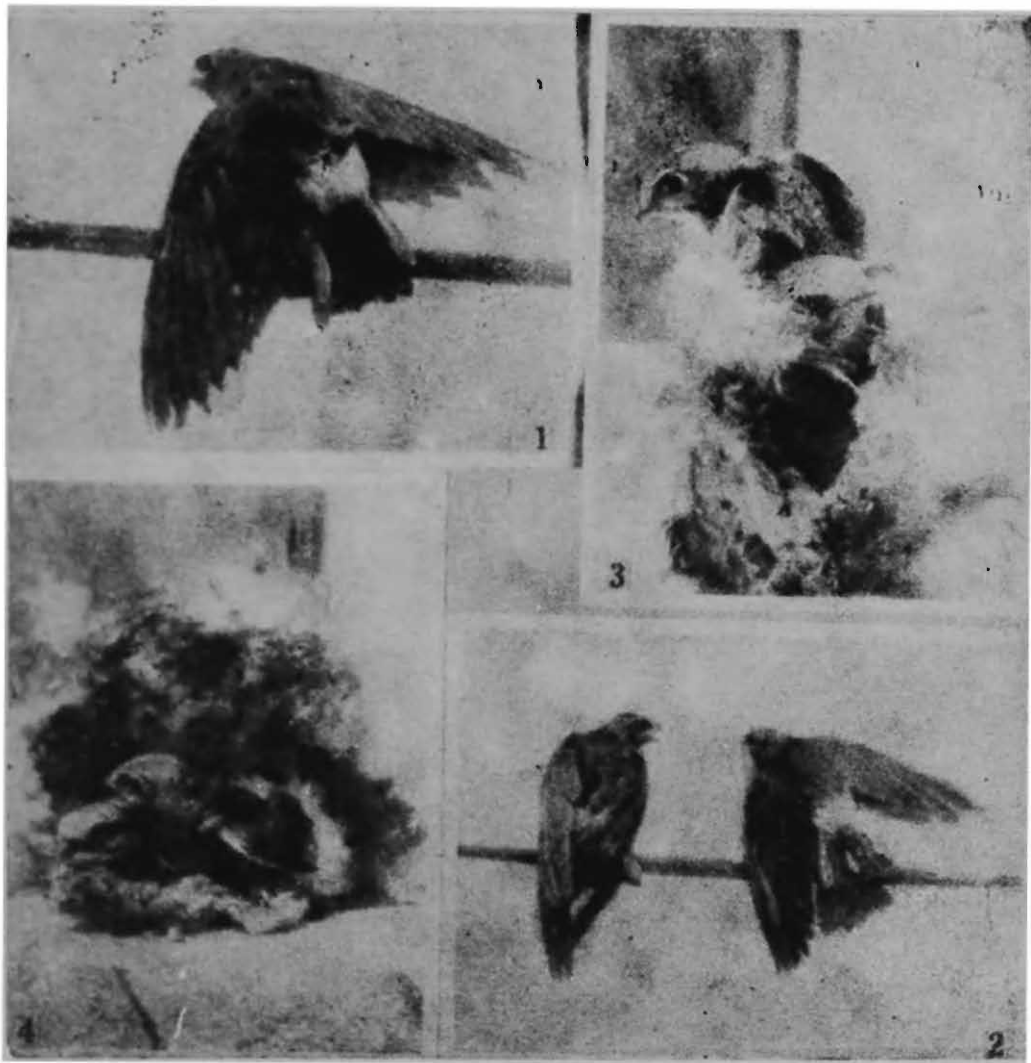
TABLE III. Data on breeding of some high altitude pheasants in captivity.

Sr. No.	Name of Bird	Specimens in captivity	Egg laying period	Hatching period	Survival of young-ones
1.	Kalij pheasant	4 ♂, 3 ♀	May to June	22-23 days	80%
2.	Tragopan	2 ♂ 1 ♀	April to May	23-24 days	50%
3.	Monal	4 ♂, 1 ♀	Starts in May	22-23 days	60%
4.	Chukor	5 ♂ 4 ♀	May to July	24-26 days	50%

TABLE IV Showing food taken in captivity by the house swift.

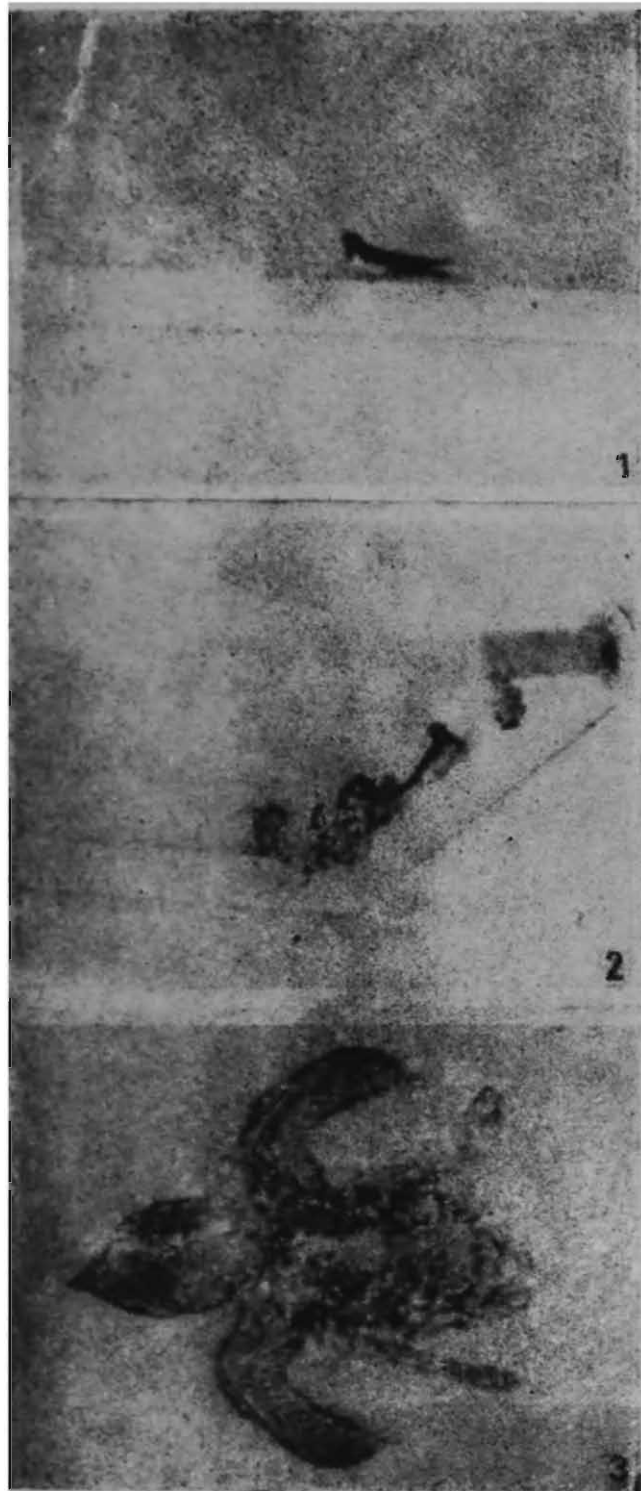
Date	No. of insects taken	Morning	No. of insects taken	Evening
5-5-79	8	Small yellow butterflies		
6-5-79	8	-do-	2	Houseflies
7-5-79	4	-do-	3	-do-
8-5-79	4	-do-	2	Grasshoppers
9-5-79	2	Houseflies	2	Small yellow butterflies
10-5-79	4	-do-	5	Houseflies
11-5-79	8	-do-	4	-do-
12-5-79	4	-do-	4	-do-
13-5-79	4	-do-	4	Small yellow butterflies
14-5-79	6	-do-	3	Houseflies
15-5-79	4	-do-	4	Small yellow butterflies
16-5-79	7	-do-	2	Grasshoppers
17-5-79	11	-do-	2	Small yellow butterflies

PLATE I



Figs. 1 & 2. The house swift outside its nest in captivity; Fig. 3. The same partially inside the nest; Fig. 4. The same, fledglings in the nest.

PLATE II



**Fig. 1.** The common swallow near its nest (hidden); **Fig. 2.** The same near the fledglings; **Fig. 3.** The same, a newly hatched chick.

SOME OBSERVATIONS ON THE DEVELOPMENTAL STAGES  
OF *RANA (PAA) MINICA* DUBOIS (AMPHIBIA) AT  
HIGH ALTITUDES

By

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INTRODUCTION

Although some work has been carried out on the morphology and taxonomy of tadpoles of Indian amphibians (Boulenger, 1890, 1920; Rao, 1918; Smith, 1924; Annandale and Rao, 1918; Kripalani, 1952), but very little is known about their metamorphosis, especially at high altitudes. Recently, Licht (1975) studied the life history of *Rana pretiosa pretiosa* both at low and high altitudes in southwestern British Columbia and in Yellowstone Park, Wyoming, respectively.

The present paper deals with the description of developmental stages of tadpoles of *Rana (Paa) minica*, collected from torrential streams in the western Himalayas. An effort has also been made to trace the duration of each stage under laboratory conditions.

MATERIAL AND METHODS

The material for the present study was collected from hill streams in districts of Solan, Simla and Sirmour (Himachal Pradesh) at altitudes of 600 to 2200m. Under the laboratory conditions, the tadpoles were reared in glass troughs of five litre capacity. Trough was half filled with water and provided with a few submerged stones. The tadpoles were fed with egg albumen and minced meat at regular intervals. Different stages of tadpoles were also collected from the field for comparing them with those reared under the laboratory conditions. Temperature data were collected from Plant Breeding Section, College of Agriculture, Krishi Vishva Vidyalya, Solan (H.P).

OBSERVATIONS

DESCRIPTION OF DEVELOPMENTAL STAGES

*Spawn* : Spawns were composed of 3-5 globular masses, 3-5 mm in diameter each, in the form of white jelly enclosing 100-150 eggs approximately.

*First tadpole stage* (Figs. 1 and 8) (7 days stage): The tail is twice the snout-vent length. Mouth is slightly aterminal with fringed lips at the margins. The upper jaw is with six rows of labial teeth; the outer one is uninterrupted while inner five rows are interrupted in the middle. The lower jaw is with three uninterrupted rows of teeth, thus dental formula is  $\frac{1+5}{3}$ . The lower and upper jaws enclose a horny beak composed of two halves with inner surfaces serrated. The upper half of the beak is semilunar in shape while the lower half is 'V'-shaped structure. There is a left spiracle on the posterior half of the body with opening of the tube directed upwards. Dorsal profile of the tail is maximum wide in the middle which gradually narrows down posteriorly. The intestine is three times longer than snout-vent length. The tadpole is usually found at the bottom of the stream. At this stage, the movements of the tadpoles are brought about by the tail fins. It clings to the substrate with the fringed lips and pointed papillae. The movements of the upper and lower jaws help in browsing the material with the dentitional rows while the inward flow of water is brought about by the movements of the upper lip. The inner surfaces of the beak serve to cut the food particles.

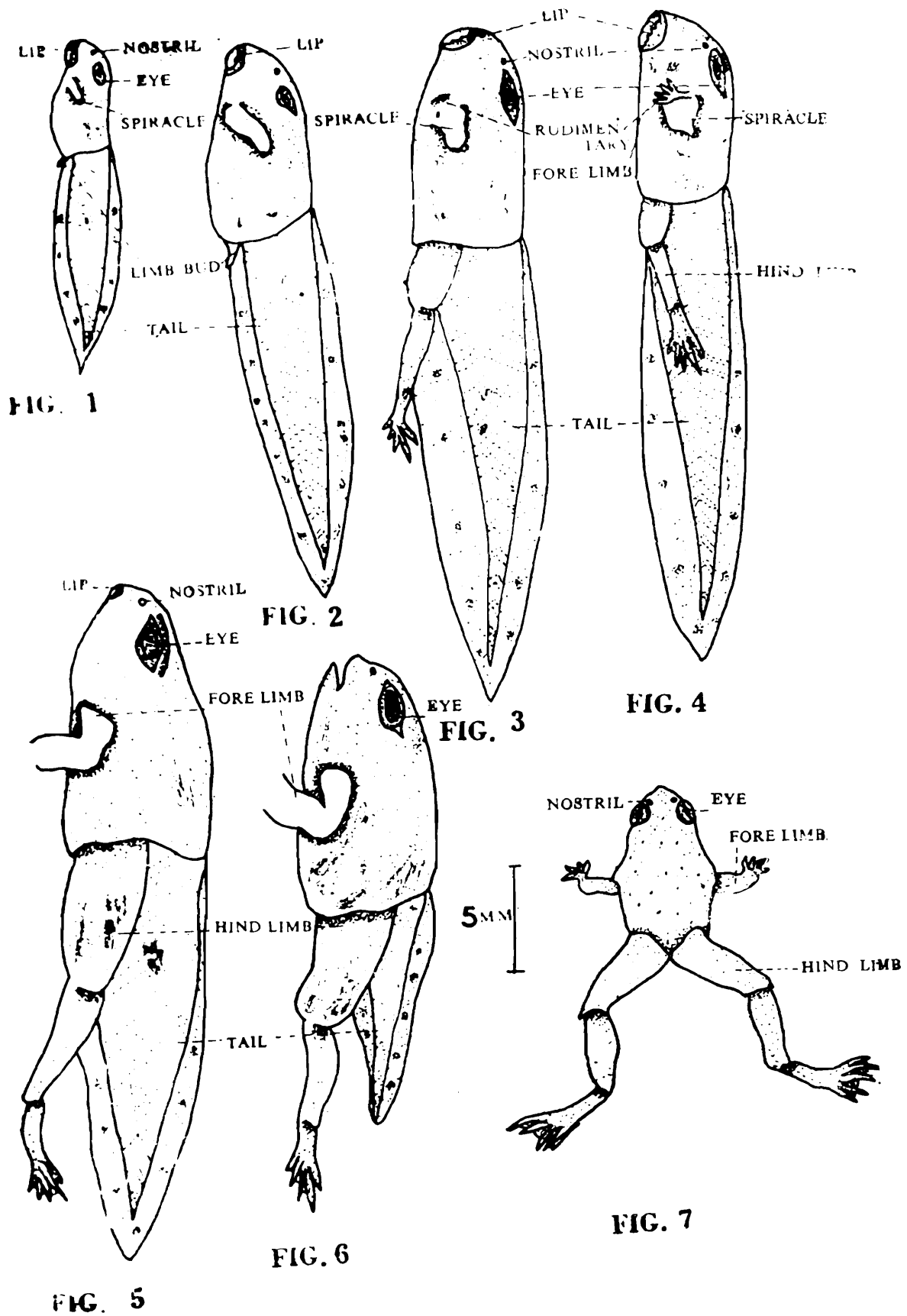
*Second tadpole stage* (Figs. 2 and 9) (10-12 days): At this stage, tadpole is longer than first stage and the growth is comparatively more in snout-vent length. Diameter of the eye is double than that in the first stage. The lips are also increased in size with their outer margins highly fringed. A rudiment of hind limb is also seen in this stage.

*Third tadpole stage* (Figs. 3 and 10) (12-15 days): At this stage, there is a further increase in length of the tadpole. A few characteristic changes, viz. deep sinking of beak, prominent eyes, enlargement of the hind limbs and the appearance of rudiments of fore limbs are seen. This stage of the tadpole is an active stage when the tadpole can swim more efficiently with the pedalling of hind limbs which also serve in adhesion during feeding.

*Fourth tadpole stage* (Figs. 4 and 11) (15-17 days): At this stage, the tadpole is showing some retrogressive metamorphic changes, viz. phagocytosis of the tail and reduction in the length of intestine i.e., 2.5 times the length of the tadpole. Snout becomes prominent with reduction of lips and simultaneously dentitional rows also disappear. The cornification of the two halves of the beak also starts shedding. Rudiments of the fore limbs are seen through the transparent skin. There is a closure of the spiracle.

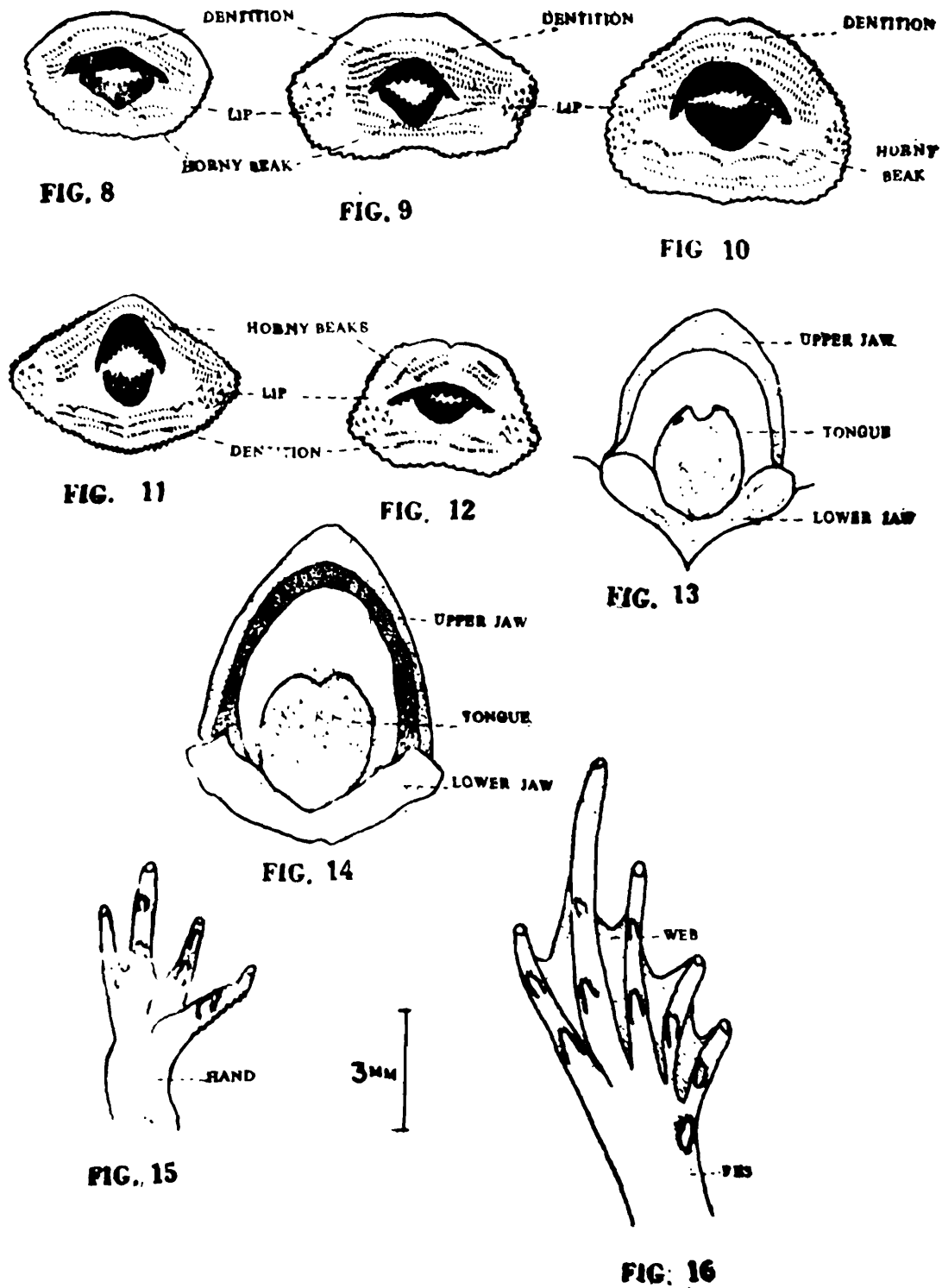
*Fifth tadpole stage* (Figs. 5 and 12) (17-20 days): This is an advanced stage of development when there is considerable change in

the structure of the mouth. The upper and the lower halves of the beak sink deep with the disappearance of dentitional rows. Right and



Figs. 1-6 Lateral views of various developing stages of tadpoles of *Rana (Paa) minica*.  
 Fig. 7 Dorsal view of juvenile of *Rana (Paa) minica*.

left fore limbs are fully formed. The intestine at this stage is twice the length of the tadpole. Tail is also reduced in length. This is a transitional stage when the horny beak gets replaced by cleft of the mouth.



Figs. 8-12 Ventral views of mouth showing dentitional metamorphosis of tadpoles of *Rana (Paa) minica*.

Figs. 13-14. Arched mouth with tongue in stages of development of *Rana (Paa) minica*.

Fig. 15. Ventral view of hand of *Rana (Paa) minica*.

Fig. 16. Ventral view of pes of *Rana (Paa) minica*.

*Sixth tadpole stage* (Figs. 6 and 13) (20-25 days): This is a transitory stage between tadpole and juvenile characterised by the presence of tail remains. Mouth is terminal but cleft of the mouth is not deep and tongue cannot be propelled out. Fore-and hind-limbs are fully developed.

*Seventh tadpole stage* (Figs. 7 and 14, 15 and 16) (25-30 days): This is a juvenile stage when the tadpole has just completed its metamorphosis. Snout, eyes tympanum, fore-and hind-limbs are fully formed. The tail is no more seen. The intestine is twice the snout-vent length.

Various morphometric measurements of different stages of tadpoles are shown in Table I.

TABLE I. Morphometric measurements of different developing stages of *Rana (Paa) minica*.

Sl. No.	Characters	Stage	Stage	Stage	Stage	Stage	Stage	Stage
		1	2	3	4	5	6	7
(All measurements in mm)								
1.	Length from snout to vent	10.5	18.0	19.0	19.0	24.0	24.0	32.0
2.	Total length with tail	30.0	49.0	59.0	56.0	59.0	39.5	No T1
3.	Length of snout	3.5	5.0	5.5	5.5	5.0	4.5	5.0
4.	Diameter of eye	1.0	2.0	3.0	3.0	4.0	4.0	5.0
5.	Interorbital width	1.5	3.5	3.0	3.0	3.0	3.0	2.5
6.	Distance of eye-nostrils	1.0	1.0	2.0	2.0	2.0	2.0	2.0
7.	Length of femur	—	—	6.5	6.0	12.5	14.0	13.0
8.	Length of tibia	—	—	6.0	5.5	12.0	12.0	15.0
9.	Length of hindlimb	—	—	20.0	19.5	39.0	43.0	50.0
10.	Length of 1st toe	—	—	1.0	1.5	4.5	4.0	4.5
11.	Length of 2nd toe	—	—	2.5	2.5	5.0	5.0	5.5
12.	Length of 3rd toe	—	—	3.75	4.0	8.5	6.0	10.5
13.	Length of 4th toe	—	—	5.8	5.5	10.0	12.0	13.5
14.	Length of 5th toe	—	—	3.5	4.0	6.5	9.0	8.5
15.	Length of web/length of 4th toe	—	—	$\frac{2.5}{5.0}$	$\frac{2.5}{5.5}$	$\frac{5.0}{10.0}$	$\frac{5.0}{12.0}$	$\frac{8.0}{13.5}$
16.	Length of forelimb	—	—	—	—	15.0	14.5	16.0
17.	Length of 1st finger	—	—	—	—	4.5	4.5	5.5
18.	Length of 2nd finger	—	—	—	—	4.5	4.5	5.5
19.	Length of 3rd finger	—	—	—	—	5.5	6.5	7.0
20.	Length of 4th finger	—	—	—	—	5.0	5.0	5.0

### METAMORPHOSIS

Various environmental factors influence the rate of metamorphosis in amphibians and important amongst these are temperature and light hours. The breeding in *Rana (Paa) minica* was initiated in April at an altitude of 600 m whereas it was in May (with a gap of 25 days) at 2200 m. The tadpoles from the spawn of late August at

1500 to 2200 m passed the following winter in that stage. The metamorphosis was observed to be suspended or slowed down during this period. The minimum and maximum temperature from September to February varied from  $-1^{\circ}\text{C}$  to  $12^{\circ}\text{C}$  and  $23^{\circ}\text{C}$  to  $30^{\circ}\text{C}$  respectively. The photoperiod was also reduced from 750 to 600 minutes from September to December. Under the field conditions, newly hatched tadpoles took 180 days (September to March) to metamorphose into adults, whereas the period was 195 days in laboratory conditions at a similar altitude of 1500 m. In May, rate of metamorphosis was rapid and the tadpoles took 26 days to become adults (Fig. 17).

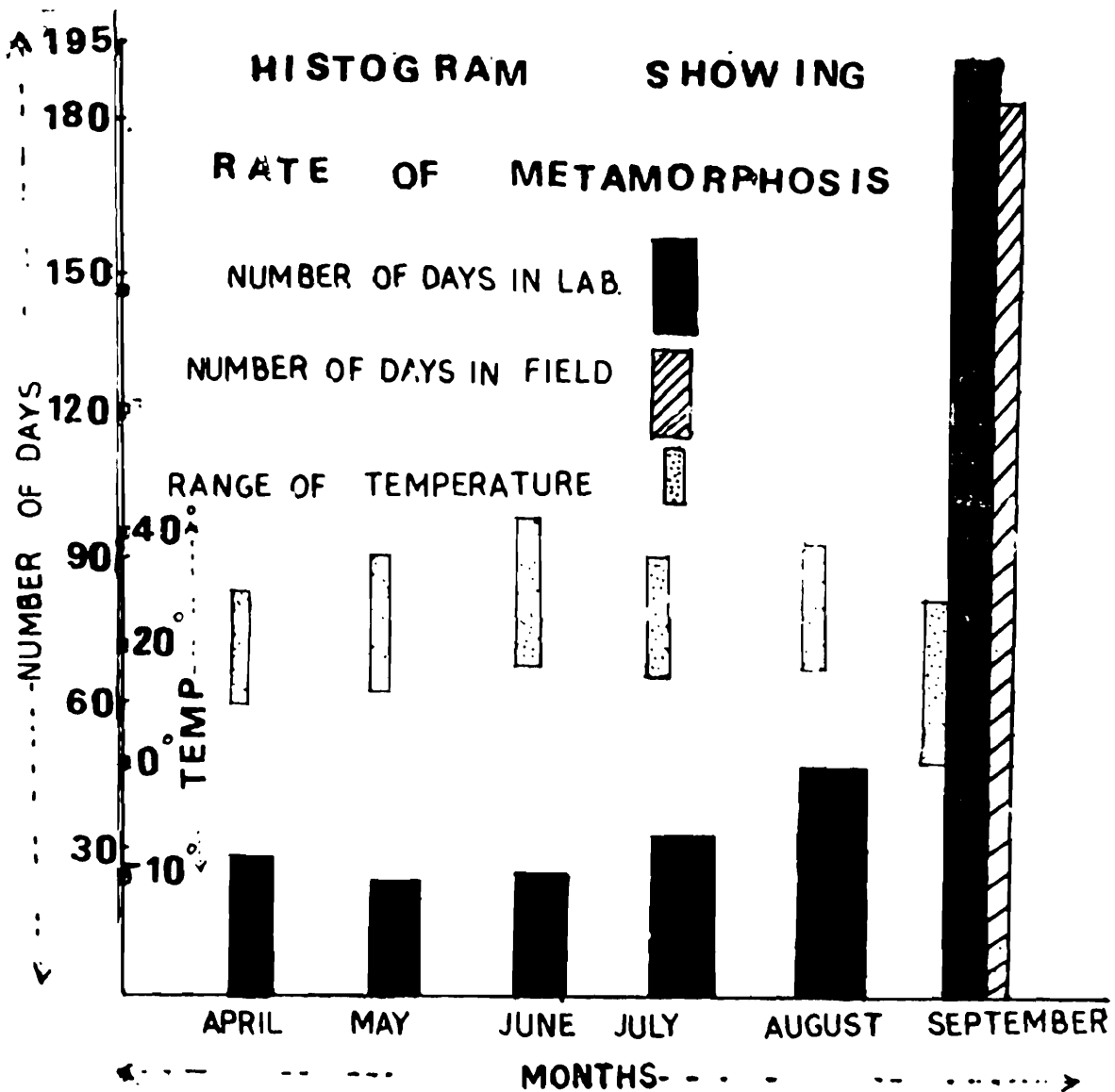


Fig. 17. Histogram showing rate of metamorphosis at 1500 m.

**DISCUSSION**

From the above study, it has been observed that the rate of metamorphosis slowed or remained suspended at high altitudes during the

winter season which was accompanied by reduction of temperature and photoperiod. Sprules (1975) also showed that rate of metamorphosis in *Ambystoma gracile* (Baird) was slower at low temperature. Moore (1964) observed that the rate of metamorphosis accelerated with increased temperature thus favouring TSH over growth factor in the pituitary. Licht (1975) in his studies on the development of *Rana pretiosa pretiosa* at low and high altitudes concluded that the rate of growth was much higher at low elevations than at high altitudes.

In the light of above discussions it can thus safely be interpreted that temperature is one of the major factors influencing the rate of metamorphosis. In high altitudes the slowed or suspended metamorphosis due to lowering of temperature is a unique feature not reported earlier.

#### ACKNOWLEDGEMENTS

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## MANAGEMENT AND ADAPTATION OF WILDLIFE AT DARJEELING ZOOLOGICAL PARK

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### INTRODUCTION

The Padmaja Naidu Himalayan Zoological Park, Darjeeling is located on the Himalayas towards eastern part of the country and possesses the height of about 6,700 feet from the sea level. Thus it has certain characteristic of its own. It can collect, maintain and exhibit various types of animals and birds which are found mainly at high altitudes. At the same time it can also study the various types of ecological, physiological, biochemical, ethological or nutritional aspects, etc. of their physical state. Thus there is a wide scope for continuing research works here. On the other hand it has got the scope for studying the nature and rate of adaptability of those species of animals and birds which are normally found at lower altitude than Darjeeling itself. The question of migratory species of animals and birds of course does not require separate attention, as they are very common ones which are accustomed to adaptation. Since August 14, 1958, that is since the birth of this Zoological Park, it has been playing the same role as has been discussed before.

The Himalayas are not only the sources for natural resources and flora, they are also rich in fauna. But many of the fauna have now become threatened species. They are on the verge of extinction. Modern conception of orienting the structure of a zoo can help to check the phenomenon of disappearance of a species from the surface of the earth at least partially. For this, Natural Parks with definite breeding policies are to be established with special care. Scientists in the field are the best persons who are to be depended upon for this purpose

The Darjeeling zoo is paying more attention towards exhibiting the rare and uncommon species which are not found in many of the Indian zoos, with particular reference to Himalayan fauna. Thus it has accommodated—1. Lesser or Red Panda (*Ailurus fulgens*) 2. Barking deer or Muntjac (*Cervulus aureus*), 3. Ussuri tiger, 4. Yak (*Bos grunniens grunniens*), 5. Himalayan langoor (*Presbytis schistaceus*), 6. Goral, Goral or Himalayan chamois (*Nemorhoedus goral*) 7. Himalayan wood owl (*Syrnium nivicolium*), etc.

## SUCCESS IN ADAPTATION

Lesser Pandas have got shelter at this zoo since last eight years. They are very swift runners and fast tree climbers. Confinement to a very limited space like a small cage, where rabbits can be housed satisfactorily, are detrimental for them. As such they have been kept in a natural environment. They are, however, allowed to live in double storied wooden houses. Their special fascination for taking bamboo leaves is very peculiar. During the period from their procurement and till date we could get eleven young ones at our zoo although some mortality took place amongst them.

One male Barking deer with usual tusks came to our zoo who lived in one European family at lower altitude at the foot of the Himalayas for about two years. It was well adjusted to take bread, banana and even tea there. After coming to this altitude and absolutely to a new environment it almost remained without any food on the first day. It was offered the food which it used to take there for a long period. On the second day it started taking little food only. From the third day we offered food containing both the varieties from our source, that is gram, grass, etc. as well as bread and banana. From the fourth day it almost became adjusted to both the types of food. After a week the bread was totally discontinued and it was not unhappy to have our quality of food regularly. It is still living merrily. Ussuri tigers are the ones collected from Soviet Russia. At present we have four tigers. They adjusted so much to the Darjeeling climate that we got cubs at our zoo, although mortality took place in them also.

Out of the two recorded varieties of Yak viz., Wild Yak (*Bos grunniens mutus*) and domesticated Yak (*Bos grunniens grunniens*) we have the latter variety at our zoo. They also became so much adapted that one male young was born at 9 A.M. of 26-4-79. Its mother is successfully and affectionately nursing the same with the help of our assistance.

The male monkey which was received by us during April 1979 as donation from one Indian family is showing no apparent psychic depression for its previous master. It has adjusted itself with the changed type of food, habitat and association. Its company for walking outside the cage is the attendant, with whom he is quite happy. It dislikes young children and females, but always likes adult males. He was very much affectionate to the master of the house where he lived for two years from the very young age. Its previous home was at the foot of the Himalayas.

We have two pairs of Gurals and are remaining happily in a spacious accommodation for a couple of years. On 9-4-79 we could

receive one female offspring out of one pair. It is growing quite satisfactorily. These animals are found at an altitude between 3,000 to 9,000 feet. Both males and females have horns.

Out of a few Rhesus monkeys (*Innus rhesus*) we have for the first time become successful in getting one young one on 31-5-79. Both the father and the mother are residing in one cage. The male being notorious did not injure the baby which is cared and nursed by the another. It is a privileged pride for this zoo to get a baby monkey in captivity where this species is found only upto a height of 7,000 feet from sea level. The altitude of this zoo is near the maximum limiting end for their home.

On 23-5-79 we have given accommodation to one young Himalayan wood owl. It was very nice in its temperament although it is completely carnivorous in its food habit. This nocturnal creature has been kept in an enclosure where direct sunlight does not affect its eyes. In the evening we offer small pieces of beef, which it likes very much. Till to day it does not sharply hide its physique from the visitors but keeps on looking, although everything might not be visible to it during day-time.

Again we could procure one baby female jackal (*Canis aureus*) only on 30-5-79. It is living on beef and milk and has been kept inside a cage. It may be mentioned here that jackals are more common along the foot of the hills than in the Tarai. They ascend the valleys communicating with the plains, but are seldom found above 6,700 feet.

Darjeeling zoo has also arranged to accommodate a variety of birds, namely, Black necked stork, white necked stork, Painted Stork, Demoisille crane, common crane, Ring dove, Rufous-turtle dove, Moor hen, Bar-headed goose, Brahminy duck, Tuffed Pochard, etc.

Apart from these we have also kept a few peacocks and hens which are from the foot of Himalayas. The adaptability which they are showing is not dissatisfactory. It is probably needless to mention the survival of a few types of pheasants collected from Himalayan areas.

Thus the words of renowned ornithologist Salim Ali can be referred in connection with our birds, which are—"Birds, however, are perhaps the class of animals least affected directly by its climatic surroundings. On the whole, they exhibit far less specialization for a high-altitude life in their make up than mammals."

#### FUTURE OBJECTS

Reviewing the idea of adaptability we intend to maintain and if possible breed elephants. Here a question obviously appears before

us spontaneously regarding the possibility of its adaptation. We may recall the observation of Neil Murray about the habitats of the elephants. He says, "The different habitats in which elephants can live cover a broad spectrum, from dense tropical rain forest to near-desert, and from coastal low lands to mountain forests, even extending above the upper limits of tree growth towards the snow-line for example, on the massifs of Mount Kenya, Kilimanjaro and the Ruwenzori Range. Tracks of elephants have been found upto a height of 15,000 feet (4,570 metres) on Kilimanjaro."

Again Sir Frank Fraser Darling has similarly supported the above noted view by observing, "watching the elephants one was conscious afresh that no other animal has such a wide and varied range : no other animal can occupy so many habitats and it is no wonder the elephant is still the most thriving and resurgent species in much of Africa." It is probably not out of the way to mention that we would maintain the species found in India viz., *Elephas maximus*.

With a view to have more close and scientific observation about adaptation at this altitude research problem dealt on physiological laboratory findings is on the way of implementation. We now intend to take the scheme entitled, "Analysis of the contents of blood and urine of Barking deer, Goral, Yak, Spotted deer, Sambar and Lesser Pandas with a view to detecting physiological seasonal variation and ailment, if any."

Establishment of breeding programmes, aquaria for fishes and salamanders are some amongst our future programmes.

## DISCUSSION

To collect, maintain and help the perpetuity of various types of animals including birds in a Zoological Park is a problem by itself. The Zoologists could so far become successful in identifying and naming only about a million types out of ten million species. Thus where simple identification is a task yet to be explored and completed, the job of scientific handling of the known ones is no less important problem. The phenomenon of evolution and adaptation are the two parallel aspects of life who progress like moving picture. The natural environment is another major factor which adds to the problem at certain times during the working of the scientists.

However, although there are reports of the possibility of changes in the climatic condition of Himalayas in future, we do believe that we would be in a position to maintain several species at our zoo which are on the verge of extinction now. When several species from the Himalayas could survive in the zoos of lower altitude and where we

have some reverse information, then in future there is a great scope for the scientists to take up this experiment of adaptation in different altitudes.

### CONCLUSION

For preservation of the fauna there is and there should be some wildlife act. Through this restricted mechanism zoos should get the opportunity to procure animals and birds in an easier way.

To study and collect more scientific data on animal ethology, it is necessary that a co-ordinated work should be established amongst all the Indian zoos. The author, therefore, proposes to establish one "Animal Behaviour Society" in India. It may be recalled here that such society is already functioning in United States of America and in England.

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MORE FIELD OBSERVATIONS ON THE DISTRIBUTION, TAIL CARRIAGE, GROUP COMPOSITION, ETC. IN THE CENTRAL HIMALAYAN LANGUR (*PRESBYTIS ENTELLUS SCHISTACEUS*) AND THE WEST HIMALAYAN MACAQUE (*MACACA MULATTA VILLOSA*) (PRIMATES)

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INTRODUCTION

As a result of recent field work, new information on distribution, body-colour, group size, tail carriage, etc. in two common species of Indian primates, viz., the Hanuman Langur, *Presbytis entellus* (Dufresne), and the rhesus macaque, *Macaca mulatta* (Zimmermann), is provided here.

*Presbytis entellus* : The new observations refer to the subspecies *P. e. schistaceus* (Hodgson). The range is extended to the *sub-terai* region of eastern Uttar Pradesh and to some new localities in southern Himachal Pradesh. Body-colour, group size, group composition, tail carriage, etc. are also discussed.

*Macaca mulatta* : The new observations refer mainly to the subspecies *M. m. villosa* whose range is extended to the *sub-terai* region of eastern Uttar Pradesh; group size, group composition and tail form and carriage are also discussed. The 'subspecies' occurring in southern Himachal Pradesh is briefly referred to.

HABITATS AND METHODS

Observations were made on wild and semi-urbanised populations of *Presbytis entellus* and on wild as well as fully urbanised populations of *Macaca mulatta* in two widely separated areas, as follows (Fig. 1) :—

*Eastern Uttar Pradesh*

Mostly the *sub-terai* region : (i) Gorakhpur and vicinity (c. 26.45 N, 83.24E). City and nearby temples and mango orchards. (ii) Kusmi Forest, 8 km E of Gorakhpur; c. 26.45N, 83.30 E. Young *sal* forest (*Shorea robusta*). (iii) Azamgarh (c. 26.03 N. 83.13 E). City area.

*Southern Himachal Pradesh*

The sub-Himalayan region of Simla, Chail, etc. (iv) Simla and vicinity, c. 31.06 N, 77.13 E (city and nearby hill forests of pine, deodar and oak); altitude c. 2,135 metres : (a) The Mall Road and nearby houses (Simla). (b) Tara Devi (Forest Rest House and nearby forests), 6 km S of Simla. (v) Charhabra (c.31.05 N, 77.22 E), 1 km W of Kufri on the Kufri-Simla Road; altitude 2,600 metres; forests of deodar and oak. (vi) Chail (c. 31.01 N, 77.30 E), c. 30 km E of Simla; altitude 2,400 metres; forest of deodar and oak (vii) Mansaar (30.58 N, 77.13 E), c. 40 km NE of Solan, between Salogra and Kandaghat; altitude 1,440 metres; thin forest of pine and oak.

The Tail Loop Index in *Presbytis entellus* was calculated from lateral photographs.

## FIELD OBSERVATIONS

(A) *Presbytis entellus schistaceus* (Hodgson)

(Synonyms : *nipalensis* Hodgson and *hector* Pocock)

1. *Distribution* (Fig. 1)

Fifteen subspecies are known in the widespread Hanuman Langur, *Presbytis entellus* (Cercopithecidae, Colobinae) which occurs in South Asia, e. g., NW Pakistan, all-India, Nepal, Bhutan, south Tibet, Bangladesh and Sri Lanka. Of these, five occur in the northern half of the range (see Roonwal, in press). These are : *ajax* (Pocock) in the northwest; *schistaceus* Hodgson in the Central Himalayas and its foothills (including the *sub-terai* belt of eastern Uttar Pradesh, present account); *achilles* (Pocock) of Nepal (the highest altitude reached is 4,270 m, vide Bishop, 1978); *lania* Elliot of South Tibet; and *entellus* Dufresne of the plains. If we leave aside the plains-dwelling *entellus* and the little known *lania*, three Himalayan and sub-Himalayan subspecies remain.

The known distribution of *schistaceus* is as follows :— INDIA : (i) Himachal Pradesh: Simla and vicinity; and Molta. 3,000–4,270 m. (ii) Uttar Pradesh : Districts of Dehra Dun, Saharanpur, Pauri, Chamoli, Almora and Naini Tal; and “Oudh” (Ellerman and Morrison-scott, 1951, but no specific localities given). Up to c. 2,680 m. NEPAL : The *terai* and lower hills (the original localities of Hodgson); Nishangarh and Hazaria; Rontang, c. 28.03 N, 85.33 E, Helambu Valley 4,270 m (north-central Nepal, Bishop, 1978).

To these localities should now be added, on the basis of the present field work, the following ones :—

(a) The under-mentioned localities in north-eastern Uttar Pradesh :— (i) Gorakhpur District : Gorakhpur and vicinity (26.45 N, 83.24 E); and Kusmi forest, 8 km east of Gorakhpur. (ii) Azamgarh District : Azamgarh (26.03 N, 83.13 E). (I suspect that *schistaceus* may occur all along the *terai* and *sub-terai* belt of the U.P. below

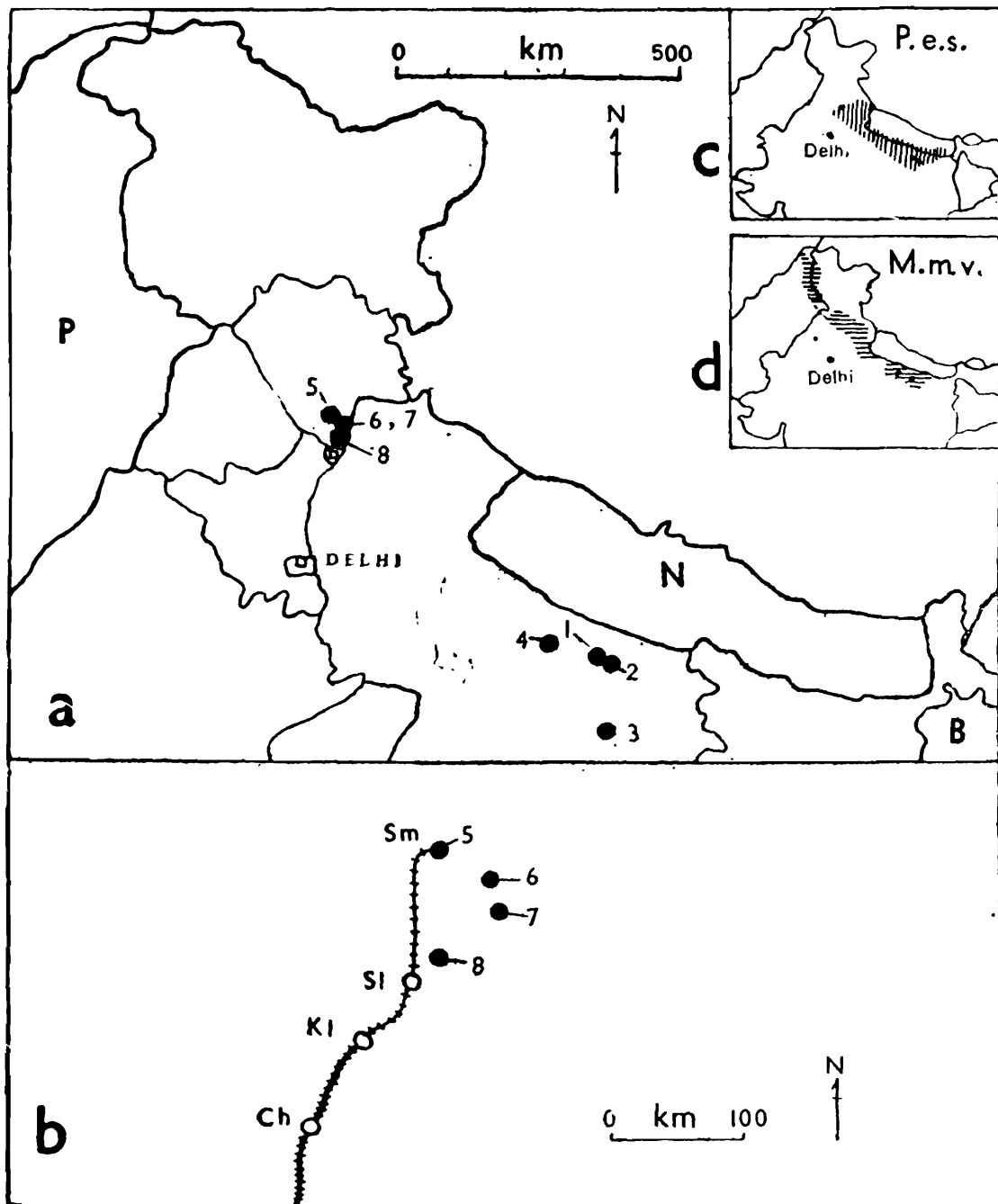


Fig. 1. Maps of North India and neighbouring countries, to show new localities of field work (solid circles). (a) Overall view. (b) Parts of Himachal Pradesh and Punjab, enlarged. (c) Distribution of *Presbytis entellus schistaceus* (P.e.s.). (d) Same, of *Macaca mulatta villosa* (M.m.v.); note apparent discontinuity.

B, Bangladesh; Ch, Chandigarh; Kl, Kalka; N, Nepal; P, Pakistan; Sl, Solan; Sm, Simla. *Observation stations* : (i) Uttar Pradesh : 1. Gorakhpur. 2. Kusmi Forest. 3. Azamgarh. 4. Gonda. (ii) Himachal Pradesh : 5. Simla. 6. Charhabra. 7. Chail. 8. Mansaar.

Nepal, from Bareilly east, but this remains to be proved by actual observations of coat colour, tail carriage, etc.)

(b) The following localities in southern Himachal Pradesh :—  
 (i) Simla District : Simla and its vicinity; Charhabra; and Chail.  
 (ii) Solan District: Sighted briefly between Solan and Kalka (Punjab).  
 Probably the entire forest from Simla to Kalka harbours this subspecies. [The Simla examples were regarded by Sugiyama, 1976, as *P. e. ajax* but are really *P. e. schistaceus* ; they differ from *ajax* is lacking the black on the lower arms and hands and in the tail tip remaining well above the back. Also see Roonwal, 1979 a, b.]

## 2. Body-colour, etc.

Body size, weight and coat colour of *P. e. schistaceus* have recently been summarised (Roonwal, 1979 b). Below are given briefly the coat colour, etc. of the Gorakhpur examples.

General colour silver grey, with olive brown to rusty patches on the back. The sides and ventral parts dark slaty; the midventral parts sometimes white, contrasting with the slaty sides. Face and ears black, with long white whiskers and beard (the hairs c. 4 to 5 cm long), forming a frame around the face, but less prominently than in individuals from the north-west (Dehra Dun and Musoorie, see Roonwal, 1979b, Pl. 1). Hairs on head flattened, not raised in a tuft. Hands and feet gray, not black. Tail grey, long and rope-like, with a white terminal tuft. With a pair of rounded perianal callosities (diameter c. 4-5 cm each) which are deep pink in adult males and are similar but less prominent in females; in juveniles and infants they are smaller and dirty white. (The Himachal Pradesh examples were observed less closely. They were broadly similar to the Gorakhpur ones, but the dark slaty sides were not conspicuous.)

## 3. Habits, food, drink and vocalisation

The following observations were made mainly in Gorakhpur and its vicinity. Groups living in orchards were not shy and were used to molestation by people. Watchmen tried to keep them on the move by making a show of using toy catapults; the langurs seem to understand this and move away unhurriedly.

In the Gorakhnath Temple on the outskirts of Gorakhpur, a dumb resident *sadhu* often feeds them at mid-day on dough from wheaten flour (Pl. 2, Fig. 5); neighbouring groups are used to this habit and, with a little calling, 50 or 60 of them would readily assemble at the customary feeding place. Here too they drink from buckets, sucking water like ungulates.

Early morning feeding begins actively about 7 o'clock (early March) on the roosting and other trees and is over by 8 A.M. There is a rest period from 8 to 10.30 A.M. during which the langurs sit on the trees at various heights, and would not be disturbed even if pelted with stones; some actually go to sleep with the eyes closed. About 10.30 A.M. they start coming down one by one and assemble in open places. They may then march elsewhere for foraging. Unfortunately, afternoon observations could not be made.

*Food* : In Gorakhpur, *sheesham* (*Dalbergia sissoo* Roxb.) in young flush seemed to be the favourite food, but mango leaves (*Mangifera indica* Linn.) were also eaten. In Himachal Pradesh the langur ate oak leaves and acorns (*Quercus incana* Roxb., syn. *Q. leucotricophora* A. Camus) but avoided the leaves, etc. of chir pine (*Pinus longifolia* Roxb.) and deodar (*Cedrus deodara* Loudon).

*Vocalisation* : All the groups observed at Gorakhpur and Kusmi were very quiet and peaceful and hardly made any vocalisation except an occasional mild screech; no whoop calls (which are characteristic of males of *P. entellus entellus* in western India) were ever given; this difference is probably subspecific.

#### 4. *Group size and composition*

##### *Eastern Uttar Pradesh :*

A few groups were observed in eastern Uttar Pradesh; all of them were rather small and of the unimale-bisexual type.

(a) Gorakhpur : (i) Near Gorakhnath Temple, c. 4 km NW of Gorakhpur. A group of 29 was observed in a mango orchard in early March. Composition : adults, 1 ♂, 12 ♀♀ (5 with infants); 9 juveniles; 7 free infants. Of the infants, one was black-coated (c. 2 months old), one of intermediate colour (c. 3-4 months), and 5 had grey coats (4-6 months); this would suggest births in early January, November-December and autumn. (ii) Mohaddipur North : A small group of 10 was seen feeding on *sheesham* in young flush. Composition : adults, 1 ♂, 4 ♀♀ (one with a c. 4-month old infant in grey coat); 5 juveniles (1 ♂, 4 ♀♀).

(b) Kusmi Forest (8 km E of Gorakhpur) : A small group of 11 was observed in a young *sal* (*Shorea robusta*) plantation : Composition : adults, 1 ♂, 4 ♀♀ ; 5 juveniles; 1 infant.

(c) Azamgarh : A small group of 11 was noted in a garden in Azamgarh; it often visited human dwellings. Composition : adults, 1 ♂, 4 ♀♀ ; 5 juveniles; 1 infant (B.B. Singh, *pers. comm.*).

##### *Himachal Pradesh :*

A group of about 50 was seen in Tara Devi area near Simla, and

a small one (of 8 or more) at Charhabra, but compositions were not determined.

### 5. Tail carriage

Fresh field data are from eastern Uttar Pradesh, e.g., the districts of Gorakhpur and Azamgarh, and from Himachal Pradesh (Simla, etc.). In all these places, the relaxed tail (during standing and walking) is of Type IB (Roonwal, 1979a, b), i.e., bent in a wide, forwardly directed loop, mostly behind the animal and with the distal tip slightly curved backward and remaining well above the back (Fig. 2; Pl. 1 Figs. 1-6; and Pl. 2, Figs. 6, 7). Under stress, as in running, the loop tends to open out; and during leaps the tail trails behind like a stiff rod (Pl. 2, Figs. 1-3). In repose (sitting), the tail lies behind nonchalantly on the ground or hangs limp and loose (Pl. 2, Figs. 4, 8).

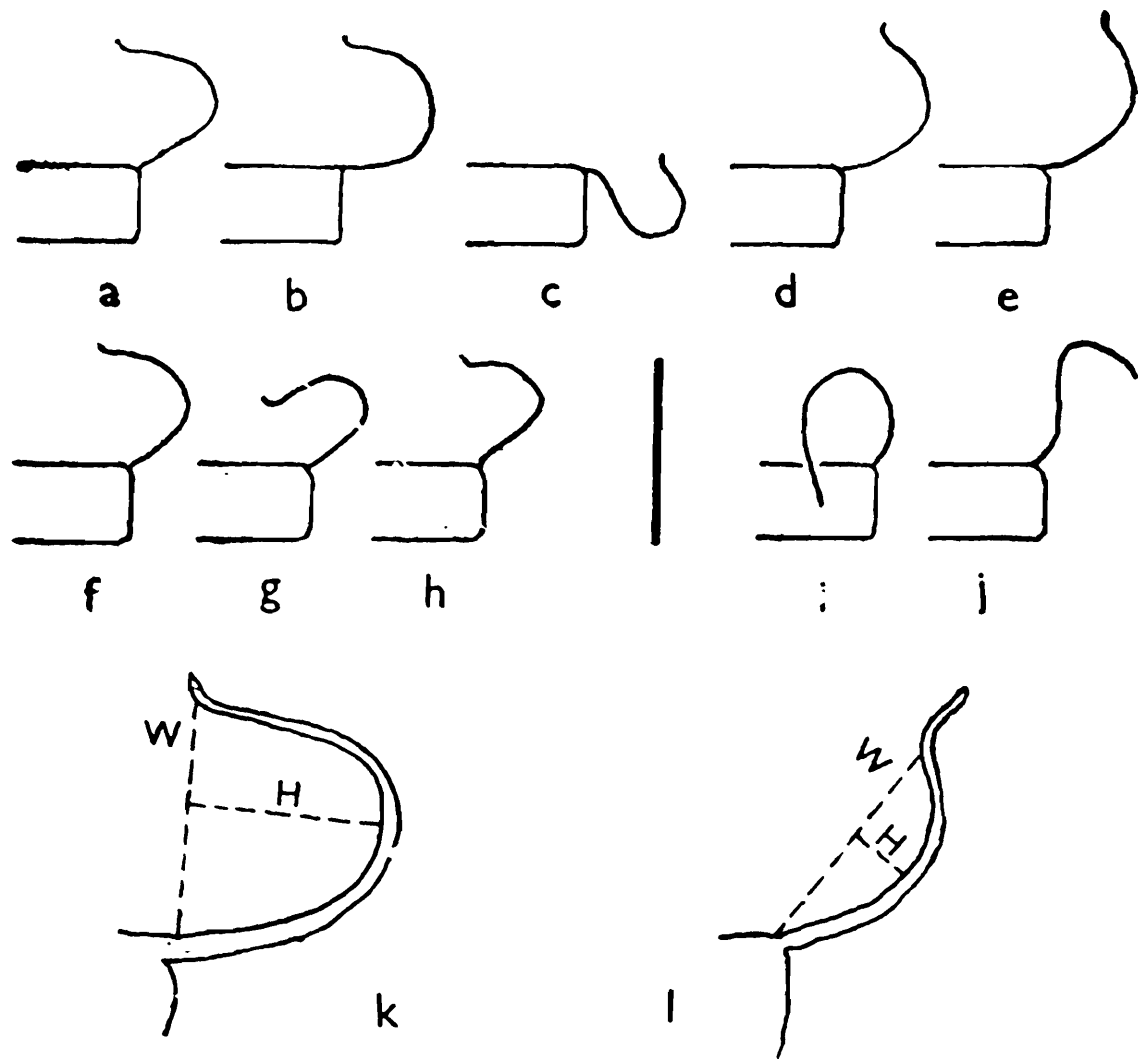


Fig. 2 *Presbytis entellus schistaceus*. Tail carriage in relaxed state (standing, walking), and loop index. (a-e) Various modes of tail carriage at Gorakhpur (Uttar Pradesh). (f-h) Same, in southern Himachal Pradesh (Simla, etc.). (i) Typical Northern Plains Style (Type IA) in *P. e. entellus* (Rajasthan). (j) Same, a Southern Style (Type IIA), Maharashtra, *P. e.* ? subspecies).

H, height; and W, width of tail loop, to measure the Loop Index (W'H).

The relaxed tail loop may range from narrow to wide open, and the Loop Index (Width/Height, see Figs. 2k, l), as measured from lateral photographs, varies in the Gorakhpur examples from 0.8-3.3 (the highest value noted by me earlier, Roonwal, 1979b, was 2.0). In two examples from Simla (H.P.) the index was 0.9-2.0. (For methods of measurement, see Roonwal, 1979a, b.)

## (B) *Macaca mulatta villosa* True

### 1. *Distribution*

The rhesus macaque, *Macaca mulatta* (Zimmermann), is widespread in South Asia (E Afghanistan, NW Pakistan, via N India (south to R. Godavari) to Nepal, Bhutan, Bangladesh and Burma, and further east to Thailand, Vietnam and South China. Four subspecies are recognisable (vide Roonwal and Mohnot, 1977; Roberts, 1977), their known distribution being as follows :—

(1) *M. m. mcMahoni* Pocock. NE Afghanistan and NW Pakistan (Chitral and Dir). (2) *M. m. villosa* True. Western Himalayas, e.g., NW Pakistan (the Kaghan and Neelum Valleys and the Murree Hills) and NW India (southern Kashmir, Upper Punjab, Himachal Pradesh and the Kumaun Hills in Uttar Pradesh. (3) *M. m. vestita* Milne-Edwards. South Tibet (Tengri Nor). (4) *M. m. mulatta* (Zimmermann). The rest of the species range; widespread over the plains.

In recent field work in a *sub-terai* area in the Gorakhpur District, I found, surprisingly, the occurrence of *M. m. villosa* of which a group (with the typical *villosa* tail, see below), was present in the Kusmi Forest a little east of Gorakhpur. About 2 km west of Kusmi, a few individuals of the nominate subspecies, *M. m. mulatta* (with its typical tail) were observed on the edge of the forest. [Dr. Nishit Kumar of the Zoology Department, Gorakhpur University, informs me that also at Gonda, 27.28 N, 82.01 E, in the Gonda District west of Gorakhpur, he found macaques with both types of tail.] It thus seems that : (i) The range of *M. m. villosa* extends east to Gonda and Kusmi; and (ii) these two areas represent the meeting place of the southern or plains form (*mulatta*) and the northern or submontane and *terai* form (*villosa*).

The Himachal Pradesh examples (Simla etc., Pl. 4, Figs. 7-10) seem to be intermediate between *M. m. mulatta* and *M. m. villosa*. Here the tail form and carriage are much as in *mulatta*, but the dominant male (as in *villosa*) does not keep the tail raised (see below).

### 2. *Group size and composition*

Eastern Uttar Pradesh : The single *villosa* group observed at

Kusmi was a small 9-member, multimale, bisexual group composed as follows :— 2 adult males, 2 adult females, 2 subadult females and 3 infants six months to a year old.

Himachal Pradesh : (i) A small group of 10, seen at Mansaar, was composed of a large male, 2 females with infants, 4 juveniles and 3 free infants. (ii) The rhesus is common in Simla and is fully urbanised (cf Roonwal, 1977). It moves freely and fearlessly from house to house and among people on the roads. A small group of 12 was composed of an adult dominant male (as judged by food test), 2 females with a very small (hardly a month old) infant each, 2 old females and 5 juveniles.

### 3. Tail form and carriage

Differences in tail form and carriage between *M. m. mulatta* and *M. m. villosa* have recently been described (Roonwal and Tak, in press).

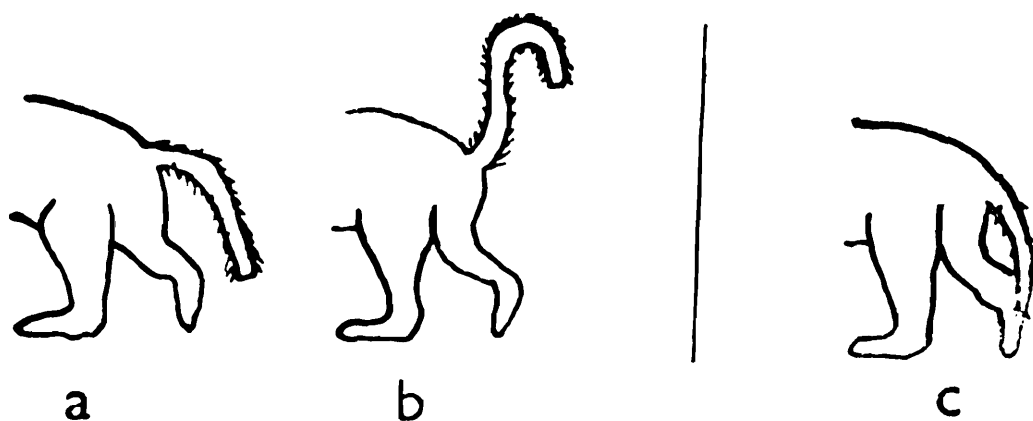


Fig. 3. Tail carriage in *Macaca mulatta*. (a,b) *M. m. villosa*: a, Kusmi Forest, near Gorakhpur, U.P. (elbowed); b, Corbett National Park, Western U.P. (raised, n-shaped). (c) *M. m. mulatta*: Rajasthan (pendant).

In all the adults (including two males) and subadults of the Kusmi group (eastern Uttar Pradesh), the relaxed tail was of the typical *villosa*-type, e.g., olive brown, elbowed (7-shaped), uniformly thick, terminally sharply truncated and with long hairs (Fig. 3a; and Pl. 3, Fig. 2); it was not raised in a n-shape as in some parts of its range (e.g., Kumaon Hills, Uttar Pradesh, Roonwal and Tak, in press; and NW Pakistan, Roberts, 1977; also see here, Pl. 3, Figs. 3-5). In contrast, the tail in *M. m. mulatta* is typically grey, thinner, tapering distally (ending in a weak tuft), moderately hairy and generally wholly pendant (Fig. 3c) (not elbowed), except in the dominant (alpha) male where it is raised vertically with a small, tight, terminal loop.

The Himachal Pradesh examples are intermediate. The tail is olive brown, but otherwise as in *M. m. mulatta*, e.g., pendant (but

elbowed in some), tapering, etc. However, the dominant male (rank determined by food test) did not differ from the rest (its tail was pendant, not raised). It is, therefore, difficult to place these examples subspecifically.

In repose (sitting) the tail in both *M. m. villosa* and *M. m. mulatta* simply lies (as in *Presbytis entellus*) nonchalantly behind the animal on the ground; or, when it is sitting on a ledge or the branch of a tree, the tail hangs down rather stiffly, or, being small, it may rest on the branch itself.

Under stress, as during running and leaping (Fig. 4), the tail remains pendant more or less as in the standing and walking positions, though it may stretch behind fleetingly during take off (Fig 4a). This is in contrast to what happens in *Presbytis entellus* where the tail loop opens out and the tail, during leaps, stretches stiffly, rod-like, behind the animal and perhaps serves as a balancing organ.

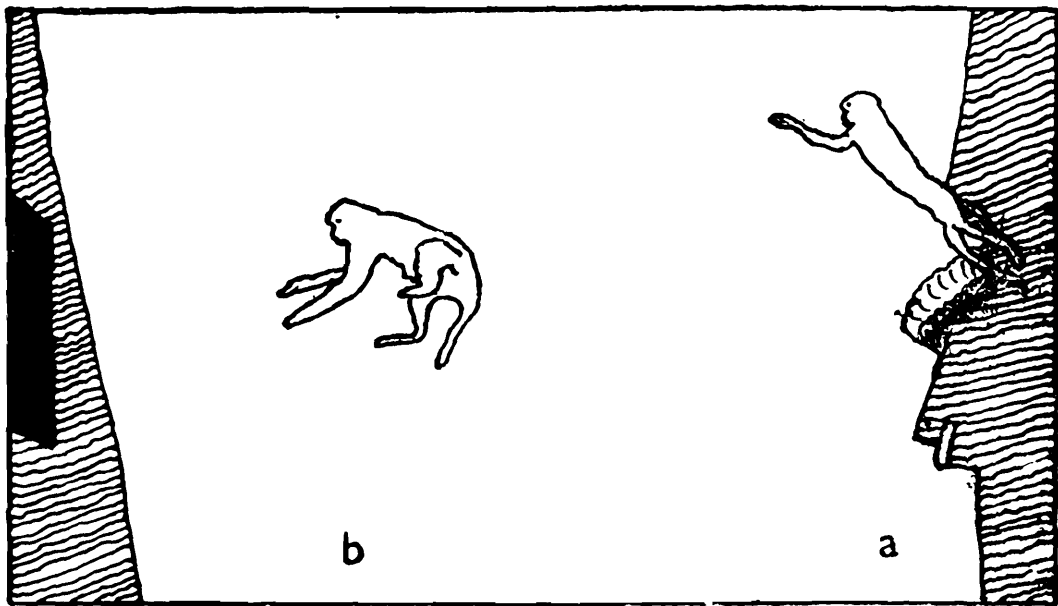


Fig. 4. *Macaca mulatta mulatta*, leaping from house to house across a 7-metre wide street, Maroth, Rajasthan. (From photographs.) (a) Take off (note tail stretched behind). (b) Mid-leap (note pendant tail).

## DISCUSSION

### *Presbytis entellus schistaceus*

About group composition it is interesting that all the four groups seen were unimale-bisexual. Group composition in *P. entellus* has been reviewed by Roonwal and Mohnot (1977) and it seems that there is little regularity in the occurrence of unimale and multimale bisexual groups. In some places only unimales occur, in others only multimales,

and in still others both types. In *P. e. schistaceus*\* at Simla, Sugiyama (1976) found 2 unimale and 6 multimale groups.

Tail carriage in the Gorakhpur examples agrees with the typical *schistaceous* character (Roonwal, 1979a, b); for details of other types, see Roonwal (1979a, and in press; and Roonwal and Makwana (1976, and in press).

In an allied species, *Presbytis geei* Khajuria (the Golden Langur) of Assam, Mukherjee and Saha (1978) state that there is no loop formation and the tail "hangs down while the monkeys are moving on the ground"; and further, that it is "passively tossed sideways during locomotion" (p. 307).

#### *Macaca mulatta villosa*

Group size in the species *Macaca mulatta* has been reviewed by Roonwal and Mohnot (1977) and varies from small (8) to as large as 180, but most of this information refers to the plains form, *M. m. mulatta*. For *M. m. villosa* only limited information is available. In NW Pakistan, Roberts (1977) describes the groups as multimale-bisexual, and their size as small to medium in some places (12-20 in the Margau Hills; usually 35-50) and occasionally large (75-80 in Dunga Gali, Murree Hills). The U. P. group seen by me was small (9 individuals) and unimale-bisexual. In southern Himachal Pradesh small groups (10-12) were unimale-bisexual.

Tail form and carriage in *M. m. villosa* have been described in some detail by Roonwal and Tak (in press) from the Kumaon Himalayas, and both the elbowed type (7-shaped) and the vertically raised and looped type (∩-shaped) were recorded in the normal relaxed or standing state (see Pl. 3, Figs. 3-6). At Kusmi in eastern Uttar Pradesh only the elbowed type was seen in all the adults and subadults (Pl. 3, Fig. 2). In the Simla Hills tail carriage was partly as in *M. m. mulatta*, and the subspecies placement of these examples is difficult.

#### ACKNOWLEDGEMENTS

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\*Sugiyama (1976) regards the Simla examples as *ajax*, but they are really *schistaceus* (see Roonwal, 1979a, b).

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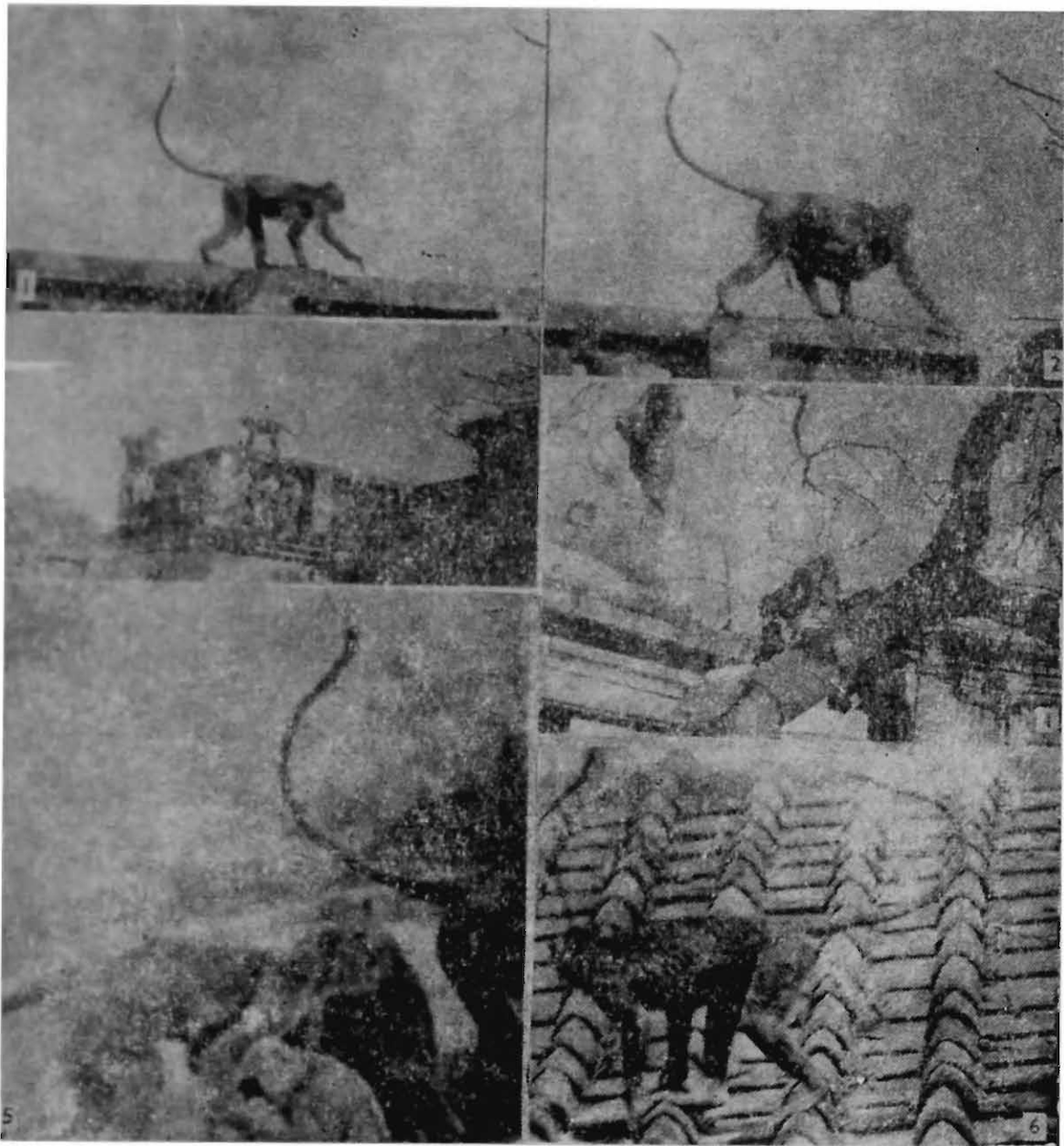
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#### ADDENDUM

The ecology and behaviour of *Macaca mulatta* (subspecies not mentioned, but probably *M. m. villosa* True, as mentioned by Roberts, 1977, in these parts) on a northern spur of the Murree Hills in northern Pakistan at altitudes of c. 1830-2805 m, has been studied by Richar and Iqbal (1979). The vegetation consists of mixed coniferous and deciduous forests. Group size ranges between 25-29 and home ranges of groups overlap widely. The food consists of flowers, leaves, grass, herbs, insects and fungi.

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PLATE I



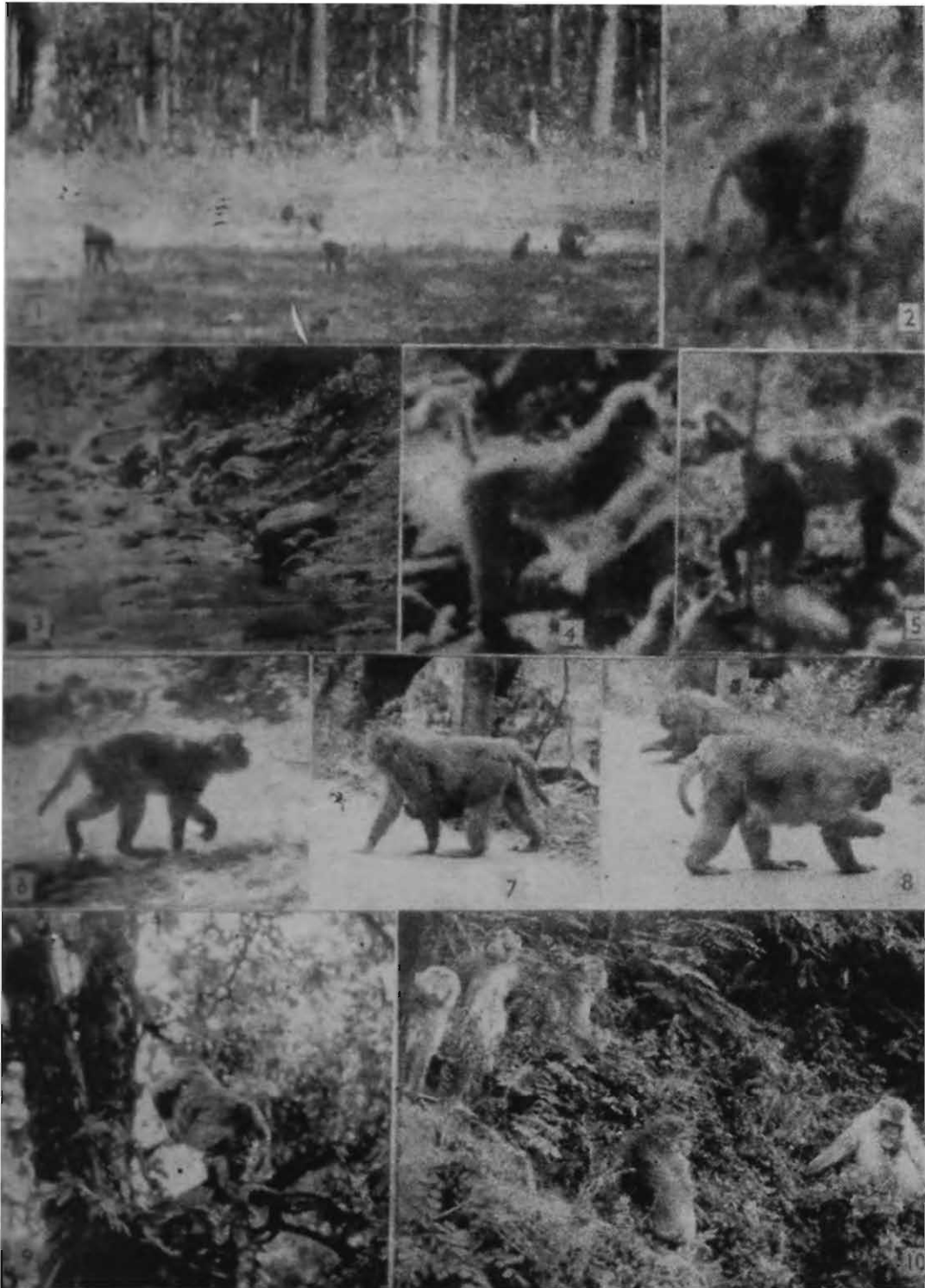
*Presbytis entellus schistaceous* Gorakhpur (Uttar Pradesh), to show relaxed tail carriage (standing, walking). 1. Subadult. 2. Female with infant. 3. Female, standing. 4. Male, descending. 5. A small group; note tail of the male on extreme right. 6. A female, on roof of a house.

PLATE II



*Presbytis entellus schistaceus*. Tail carriage. (1-5, Gorakhpur, Uttar Pradesh; 6-8, Simla, Himachal Pradesh.) 1-3. In mid-leap (3, female with infant). Note stretched, stiff tail, trailing behind. 4. Sitting on a roof, scratching. Tail lies behind nonchalantly on the roof. 5. A dumb *sadhu* of Gorakhnath Temple, feeding wheaten dough to langurs. 6-7. Walking. 8. Sitting on a tree; tail hangs limp.

PLATE III



*Macaca mulatta villosa*. (1, 2, Kusmi Forest near Gorakhpur, Uttar Pradesh. 3-6, Corbett National Park, Western U.P. 7-10, *M. m.* ? subsp., Simla, Himachal Pradesh.) 1. Part of a group. 2. A male, closer view; note elbow and blunt tail. 3. View near Dhikala, with two individuals (one standing, with vertically raised tail). 4. Same, the standing one (male) enlarged; note  $\cap$ -tail. 5. Same area, another individual, walking; note elbow and blunt tail. 6. A female with infant; note elbow and blunt tail. 7. A female with infant; note elbow and blunt tail narrowing distally, not truncated. 8. A dominant male (rank determined by food test); tail nearly as in figure 7. 9. A female with infant, about to take a leap. 10. Part of a group.

## THE ORIGIN AND EVOLUTION OF FRICTIONAL AND ADHESIVE DEVICES IN FISHES INHABITING HILL- STREAMS

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### INTRODUCTION

The fish-fauna of hill-streams offers an unique opportunity to study some of the most remarkable adaptive designs among fishes. It is generally believed that search for food induced the fishes of lowland to enter into swift-currents of hill-streams where in the absence of any serious competition for space and enemies all those that could withstand the force of current shared the advantage of this environment. Among Indian freshwater fishes, members of families Cyprinidae, Psilorhynchidae, Cobitidae, Homalopteridae, Sisoridae, and Pillaiidae have successfully colonised the hill-streams and in doing so many of them have evolved various devices to resist the fast current. This paper deals with structures associated with frictional and adhesive devices among these fishes and attempts to explain their adaptive significance.

### MATERIAL AND ILLUSTRATION

Specimens of the following Indian species of hill-streams have been examined. They are grouped according to the classification of Greenwood, Rozen, Weitzman and Myers (1966). Pillaiidae, the recently discovered family of freshwater fish from India, has been assigned to suborder Mastacembeloidei of the order Perciformes (Yazdani, 1976).

### CYPRINIFORMES

#### CYPRINIDAE

*Diptychus maculatus* Steindachner

*Schizothorax richardsonii* (Gray)

*Schizothoraichthys progastus* (McClelland)

*Ptycobarbus conirostris* Steindachner

*Crossocheilus diplochilus* (Heckel)

*Garra gotyla* (Ham.)

*Parapsilorhynchus tentaculatus* (Annandale)

#### COBITIDAE

*Botia lohachata* Chaudhuri

*Noemacheilus punjabensis* Hora

#### SILURIFORMES

#### SISORIDAE

*Glyptothorax brevipinnis* Hora

*Pseudecheneis sulcatus* (McClelland)

#### PERCIFORMES

#### MASTACEMBELOIDII

#### PILLAIIDAE

*Pillaiia indica* Yazdani

The main outlines of figures of the above-mentioned species and their frictional and adhesive structures have been drawn freehand.

### THE HILL-STREAM ENVIRONMENT

The torrential streams of hills and mountain ranges provide an unusual environment which offers unlimited gradations to aquatic life. The main ecological factors which have greatly influenced its fauna are :

1. *Strength of current*—The force of current of water is one of the most important factors influencing the evolution of fishes in torrential streams. Since the current at the bottom and the sides is much less than that in the mid-stream, most hill-stream fishes either live at the bottom or on the sides of the streams.

2. *Abundance of dissolved oxygen*—The dissolved oxygen is abundant in the hill-streams owing to rapid and constant motion of water. Consequently, the respiratory organs of hill-stream fishes have become reduced and these fishes can only exist in waters with large quantities of oxygen.

3. *Nature of food*—In hill-streams the food consists mainly of algae and slime covering the rocks and stones or microplanktonic organisms in the current. Therefore, the encrusting food has either to be scraped off the substratum or the microorganisms collected from the current.

In addition to above factors, the hill-stream environment is also characterised by the extraordinary clearness, shallowness and low temperature of water, the rocky nature of bottom with large boulders and pot-holes, sometimes interspersed with sandy patches, absence of large predatory forms and least competition for space. The overhanging vegetation along the sides of streams and large boulders as well as pot-holes usually provide an ideal hiding place to small fishes and other aquatic fauna.

### FISH ASSOCIATIONS IN HILL-STREAMS

Hora (1930) gave an account of various associations among the hill-stream fauna. Based on my own field observations in different parts of India such as Khasi and Garo Hills (Meghalaya), Simla hills (Himachal Pradesh) and Western Ghats, I give hereunder four different associations among hill-stream fishes.

1. Free-swimming fishes found in shallow pools and sides of streams. Small free-swimming fishes belonging to the cyprinid genera *Danio* and *Puntius*, occurring in pools and pot-holes in the bed of streams and also along the edges of streams under overhanging vegetation. They are not affected by the swiftness of the current and on the rush of water seek shelter under rocks and stones at the bottom or hide under crevices along the edges of streams.
2. Free-swimming fishes found in deep pools and main streams. Large free-swimming fishes belonging to genera *Tor*, *Acrossocheilus*, *Schizothorax*, *Diptychus*, *Ptycobarbus*, *Labeo*, *Barilius*, found in the course of swift streams. They are capable of progressing against the current.
3. Fishes living on stream bed amongst vegetation, gravel or sand. Fishes living at the bottom found usually along the edges of streams, often in association with submerged vegetation (e. g., species of *Botia*, *Noemacheilus*, *Badis*, *Channa*) and sand or mud (e. g., species of *Lepidocephalus*, *Pillaia*).
4. Fishes living on rock or among pebbles etc. Fishes living at the bottom, found on exposed surface of rocks or among pebbles, shingles and underside of rocks (e. g., cyprinoids of the genera *Garra*, *Parapsilorhynchus*, *Psilorhynchus*, some species of *Noemacheilus*, sisorids and homalopterids (Hora, 1930).

The fish associations under category 3 & 4 above show distinct adaptation for living at the bottom of rapid streams. However, some fishes of category 2 also exhibit modifications of lips which are believed to be used for adhesion to the rock surface during feeding.

### OBSERVATIONS

We shall now examine the various structures by which the hill-stream fishes have achieved a substantial increase in their frictional and adhesive abilities. Figure 1 and 2, respectively, show the body forms of some hill-stream fishes and the structures connected with frictional and adhesive devices on the underside of head and body.

Unlike free-swimming species, the bottom-living fishes are rather depressed in shape, because depression makes the fish resting on the bottom more stable. They have small swim-bladders and are consequently expected to be denser than the water they inhabit (Jones and Marshall, 1953). This gives the fish the advantage of frictional forces tending to keep it at desired position at the bottom of a stationary water body. But unlike this the frictional forces so developed in hill-stream fishes may not be sufficient to resist the force of current and would, therefore, be expected to warrant a further increase in the frictional force so as to prevent them from being swept away. This can be achieved by these fishes by only three ways: (1) by further increase in weight i. e., by increasing specific gravity or (2) by roughening the ventral surface in contact with the substratum because the roughness of skin would increase friction and make the surface less slippery or (3) by evolving some kind of adhesive device. Since any further increase in the specific gravity would result in substantial loss of swimming ability of these fishes, the natural selection has favoured the evolution of frictional and adhesive devices by virtue of roughening of skin on the underside of the body or providing means for adhesion. In order to understand the actual mechanism of such devices it would, therefore, seem appropriate to consider the basic principles involved in friction and adhesion between two surfaces under consideration.

#### *Friction*

The friction is due largely to atomic and molecular forces of attraction between two surfaces at the points of contact. The *force of friction*, therefore, acts parallel to the surface of contact and opposite to the direction of motion. For example, consider a fish lying on a horizontal surface. If  $m$  is the mass of its body then forces acting on it are its weight  $mg$  acting vertically downwards and the reaction  $R$  balances each other. As the body remains at rest, no friction comes into play. Suppose now a small force  $P$  is applied on the body

parallel to the surface its motion would be resisted by a force  $F$ . The body would continue to be at rest so long as the force  $F$  is equal and opposite to  $P$ . As the value of  $P$  is increased,  $F$  also increases and the body does not move unless a definite amount of force  $P$  is applied. The force  $F$  is called the force of friction. It is a self-adjusting force and increases with the force tending to produce motion to a limit sufficient to prevent motion but in no case does it exceed a maximum value when the body is just at a point of sliding upon another. The maximum of this force exerted when one body is just at the point of sliding upon another is called the *force of limiting friction*. The limiting friction is independent of the area of the faces in contact but depends on the material of the surfaces in contact and the state of their polish so long as the normal reaction remains the same.

The ratio of the limiting friction ( $F$ ) to the normal reaction ( $R$ ) between two surfaces is the co-efficient of friction, denoted by  $\mu$

$$\mu = F/R$$

The value of  $\mu$  is different for different pairs of substances. The known average values of  $\mu$  for rubber on concrete which might roughly correspond to that of fish on rock is 0.70, greased surfaces 0.05, leather on metals 0.56 and rubber on oak 0.46 (White, 1972).

Hora (1923) gave the following formula while dealing with friction in hill-stream fishes.

$$f = \mu p$$

where  $\mu$  is the co-efficient of friction,  $p$  the pressure and  $f$  is equal to the resulting friction.

When co-efficient of friction is high, a slight increase in  $p$  (represented by the rapidity of the flow of water and the consequent force exerted by it on the fish) is likely to develop a higher resulting friction.

In the hill-stream fishes, the co-efficient of friction is increased in several ways *i.e.*, by throwing the skin in folds and ridges and by developing pads, minute spine-like epidermal outgrowths and the papillae. These structures have been further explained below.

(i) *Folds and ridges* : In cyprinids such as *Diptychus maculatus*, *Schizothorax richardsonii*, *Ptycobarbus conirostris*, *Crossocheilus diplochilus*, *Parapsilorhynchus tentaculatus* and *Garra gotyla* irregular folds of skin occur on the underside of head. In some sisorids such as *Glyptothorax* spp. and *Pseudoecheneis sulcatus*, a very well-marked thoracic disc consisting of ridges and grooves is found. In *P. sulcatus*

the skin between thoracic disc and the pelvic is also thrown into fine transverse folds.

(ii) *Pads* : In *Glyptothorax* spp., *P. sulcatus* and members of Homalopteridae (Hora, 1932) pads and pad-like structures occur on the ventral face of paired fins; the pectorals and pelvics are low and horizontally placed, so the pads which are invariably plaited or graduated come in direct contact with the substratum. In *C. diplochilus* and *Noemacheilus* spp., the paired fins are also low and horizontally placed but in them no pad is developed on the ventral face of the fins. However, the fin-rays and fin-membranes of these fishes nevertheless provide a somewhat ridge and groove pattern ventrally.

(iii) *Papillae* : In the hill-stream fishes, minute papillae often occur in area surrounding the mouth. In *D. maculatus*, *S. richardsonii*, *C. diplochilus* and *P. tentaculatus*, the lower labial fold possesses minute papillae externally. In *C. diplochilus*, the fringed upper labial fold is studded with minute papillae. In *G. gotyla*, the free posterior margin of the disc bears large number of papillae. In some sisorids the thick lips are heavily papillated. In *P. sulcatus*, the area around isthmus and branchiostegals bear papillae.

(iv) *Spines and spine-like epidermal outgrowths*: In some members of Cobitidae, a simple or bifid movable spine is present in a groove before or below the eyes. In *Garra* spp., the papillae present on the free posterior margin of the disc bear retroverted spines.

(v) *Body acting as a hook* : While entangling to any branch of aquatic plants, the Indian eel-like fish, *Pillaia indica* is known to keep itself suspended under running water in the manner of a hook (Yazdani, 1977)

#### *Adhesion*

The force of attraction that binds molecules of different kinds is called adhesive force and the phenomenon is called adhesion. This force increases when vacuum is created between the two such surfaces or when another substance is used for sticking the surface together. Among hill-stream fishes, adhesion is known only by vacuum producing devices. These devices can be conveniently divided into four categories : (i) true suckers, (ii) organs composed of grooves and ridges, (iii) irregular grooves and papillae, (iv) underside of body acting as a sucker.

(i) *True suckers* : The sucker consists essentially of a disc which can be laid flat on a plane surface. In order to produce a "vacuum" its central part must be capable of being raised without

disturbing the margins which must remain in close contact with the surface to which it is applied. A complete or a partial vacuum is created in the cavity produced by raising the central part. The suckers belonging to this type are, however, not the normal mode of attachment in hill-stream fishes and so far as known only occur in the cyprinid fishes of the genus *Garra*. But in marine fishes this type of suckers are found in Lampreys (Cyclostomes) and in some gobies (Hora, 1930).

Hora (1930) gave a very plausible explanation for the absence of suckers in the majority of torrential fauna. According to him the current of the sea and the breakers of the sea-shore are different from the flow of a torrential stream in two respects. Firstly, in the case of torrential streams the flow is always in one direction whereas in the sea the current flows in various directions. Secondly, in the sea the currents may attain a considerable swiftness but they hardly rush like that of a torrential stream. Since a sucker can resist pressure from all sides it would be more useful in marine fishes than the fishes of torrential streams where a constant pressure of current exists in one direction only.

(ii) *Organs composed of grooves and ridges* : In some members of Sisoridae, the thoracic discs consisting of grooves and ridges are present. In *P. sulcatus*, the disc is oval and is transversely plaited, whereas in members of *Glyptothorax* the ridges and grooves are situated obliquely in a longitudinal direction.

Hora (1930) believed that in sisorids the grooves on the disc serve a channel for the constant exit of water current from underneath the structure and as a result a partial vacuum is created in the grooves which helps the fish to adhere to the rock surface. He explained, with the aid of hydraulic principle, that if water is allowed to flow through a pipe, of varying diameter a partial vacuum would be formed in its narrower portion. But the position of grooves and ridges on the thoracic discs of sisorid fishes clearly suggests that a constant current of water would not flow through the grooves to form a partial vacuum. However, a more effective vacuum would be developed in the grooves because the water contained in them (grooves) would be drawn out towards the sides of the disc as soon as the fish rests on the rock surface in a fast current. A detailed account of the mechanism of thoracic disc in *P. sulcatus* is being published elsewhere.

(iii) *Irregular grooves and papillae* : Besides increasing the friction, the irregular grooves and papillae are also believed to aid in creating partial vacuum on the underside of fish (Hora, 1930). Supposedly, they serve as channels for constant exit of water current

from underside the resting fish in a fast stream and presumably create a partial vacuum which in turn helps the fish to adhere more strongly to the rock surface.

We shall now examine this possibility according to the principles of hydraulics.

Bernoulli's theorem (Singh *et al.*, 1973) states that at any point in a tube through which an incompressible liquid is flowing, the sum of pressure energy, potential energy, and kinetic energy is constant. This implies that when velocity of flow of liquid increases, the pressure decreases.

The energy possessed by a liquid in motion is divided into :

(a) *Kinetic Energy.* It is due to the inertia of a liquid and is equal to  $\frac{1}{2} m v^2$  where  $m$  is the mass and  $v$  the velocity of liquid. The energy per unit mass is  $\frac{1}{2} v^2$

(b) *Potential Energy.* It is due to the position of a liquid having height  $h$  above the earth's surface. The potential energy per unit mass is  $gh$ , where  $g$  is earth's gravity.

(c) *Pressure Energy.* Since a liquid is subjected to a pressure if  $p$  be the hydrostatic pressure and  $d$  the density of liquid, its pressure energy per unit mass is given by  $p/d$

Hence the total energy at any point per unit mass =  $hg + \frac{1}{2}v^2 + p/d$ . Dividing throughout by  $g$ , we get what may be known as Head of the liquid =  $h + v^2/2g + p/dg$  where  $h$  is called the potential head,  $v^2/2g$ , the velocity head and  $p/dg$ , the pressure head.

These three types of energies possessed by a liquid under flow are convertible into one another. If one type of energy increases, the other decreases. So in case of fast current passing underneath a fish the velocity (hence the kinetic energy) through the grooves or the channels between papillae would be greater, resulting in the decrease of pressure energy (i.e., partial vacuum). The potential energy of water in such a case is expected to remain constant, both outside and inside these structures.

(iv) *Underside of body acting as a sucker :* In Homalopteridae, the adhesion to the substratum is affected by the close application of the ventral surface of body which is flattened and smooth. The paired fins which lie horizontally are pressed into service for adhesion. The pectorals have become modified into two parts (i) the anterior part consisting of horizontal, thick, flat rays provided on the

ventral surface with adhesive pads, which could be applied to the substratum and (ii) the posterior part, consisting of normal, obliquely directed rays which by their constant movement, drive away the water from the under surface of the fish. As a result, the pressure on the under surface is reduced and the fish is able to adhere more firmly to the substratum e.g., *Balitora brucei* (Hora, 1923, p. 594). In most fishes of the family Homalopteridae, the mechanism of adhesion is efficient that the anterior part of the body has become converted into a broad suctorial disc ventrally. In some most specialised genera, the posterior rays of the ventral fins, instead of being turned upwards, are inserted obliquely on the ventral surface and have become united posteriorly. Consequently, the disc is closed at the hinder end and the fish is able to restrict the area for the exit of water. Thus the current flows under the disc at a greater velocity, the pressure is reduced and a partial vacuum created on the principles of hydraulics (Bernoulli's theorem), referred to above. In some members of Homalopteridae such as *Gastromyzon* the pectorals are separated from the ventrals and the lateral flaps of skin between the bases of pectoral and ventral fins complete the disc on the ventral surface. In other genera such as *Beaufortia* and *Sinogastromyzon* the pectorals overlap and, therefore, no lateral flaps of skin are needed.

#### DISCUSSION

The origin and evolution of frictional and adhesive devices in the hill-stream fishes will now be discussed in relation to their associations, as described in the earlier section.

The free-swimming fishes occurring in shallow pools and sides of streams such as species of *Danio* and *Puntius*, possess no frictional and adhesive devices, because they escape the fast current by moving into pools and sides of streams where the current is always slow. Furthermore, since they capture planktonic food in the stream with the aid of their protrusible mouth they hardly need any means for adhering to the substratum.

The free-swimming fishes occurring in deep pools and the main streams such as species of *Acrossocheilus*, *Schizothorax*, *Diptychus*, *Labeo*, and *Barilius*, possess grooves, ridges, papillae and labial folds on the under side of the head. Since these fishes are known to live in torrential streams by their ability to swim against the current and by taking shelter in deep pools, where the current is slow, they do not require any elaborate means to stem the current. However, since they feed on algae and slime covering the rock and stones at the bottom, the frictional and adhesive structures present on the under side of the head seem to ensure fixation of mouth at a desired position during feeding.

The fishes living on stream bed amongst vegetation, gravel or sand such as species of *Botia*, *Lepidocephalus* have spines on the head. The spines seem to help these fishes in getting entangled with any fixed object in their habitat and thus prevent them from being swept away by the fast current. In the eel-like fish *Pillaia indica*, the body is well adapted for borrowing and no structure is developed to obtain advantage of adhesion to the substratum. However as this fish is also known to spend its time outside, it uses its anguilliform body as a hook to hang on to any vegetation under water in such a way that its two halves are more or less balanced. This little fish appears to use this posture for catching live prey from the current.

The fishes living on rocks or among pebbles, etc. in torrential streams such as species of *Garra*, *Psilorhynchus*, *Glyptothorax*, *Pseudocheneis* and members of Homalopteridae, possess well developed structures for adhesion to the substratum. Since these fishes spend most of their time at the bottom and take benthic food, the adhesive devices found in them are well suited for their way of life.

#### CONCLUSION

In hill-stream fishes, the frictional and adhesive devices show clear adaptation to their way of life. In free-swimming forms these devices are restricted to the underside of the head, especially the areas surrounding the mouth, but in predominantly bottom-living forms a variety of frictional and adhesive mechanisms have evolved to ensure firm adherence to the substratum. In these fishes, the frictional devices appear to have originated first and the adhesive mechanisms developed later in the course of evolution to supplement the need for a more effective grip on to the substratum in torrential streams.

In cyprinid fish (*Garra*) the sucker is so designed that a muscular effort is necessary to create the vacuum for adhesion to the substratum. But in sisorids and homalopterids the vacuum is believed to be created on the under side by utilising the energy from the current according to the principles of hydraulics (Bernoulli's theorem). In these fishes the mouth, unlike that of *Garra*, is quite free and can be fully utilised for feeding and respiration. The sisorids and homalopterids appear to be better adapted for life in the torrential streams than the cyprinids of the genus *Garra* and *Parapsilorhynchus*.

#### ACKNOWLEDGEMENT

I am grateful to Dr. T. N. Ananthakrishnan, Director, Zoological Survey of India for giving me an opportunity to work on this problem. I am also thankful to Dr. H. Khajuria, Deputy Director, Zoological Survey of India, High Altitude Zoology Field Station, Solan, for providing facilities.

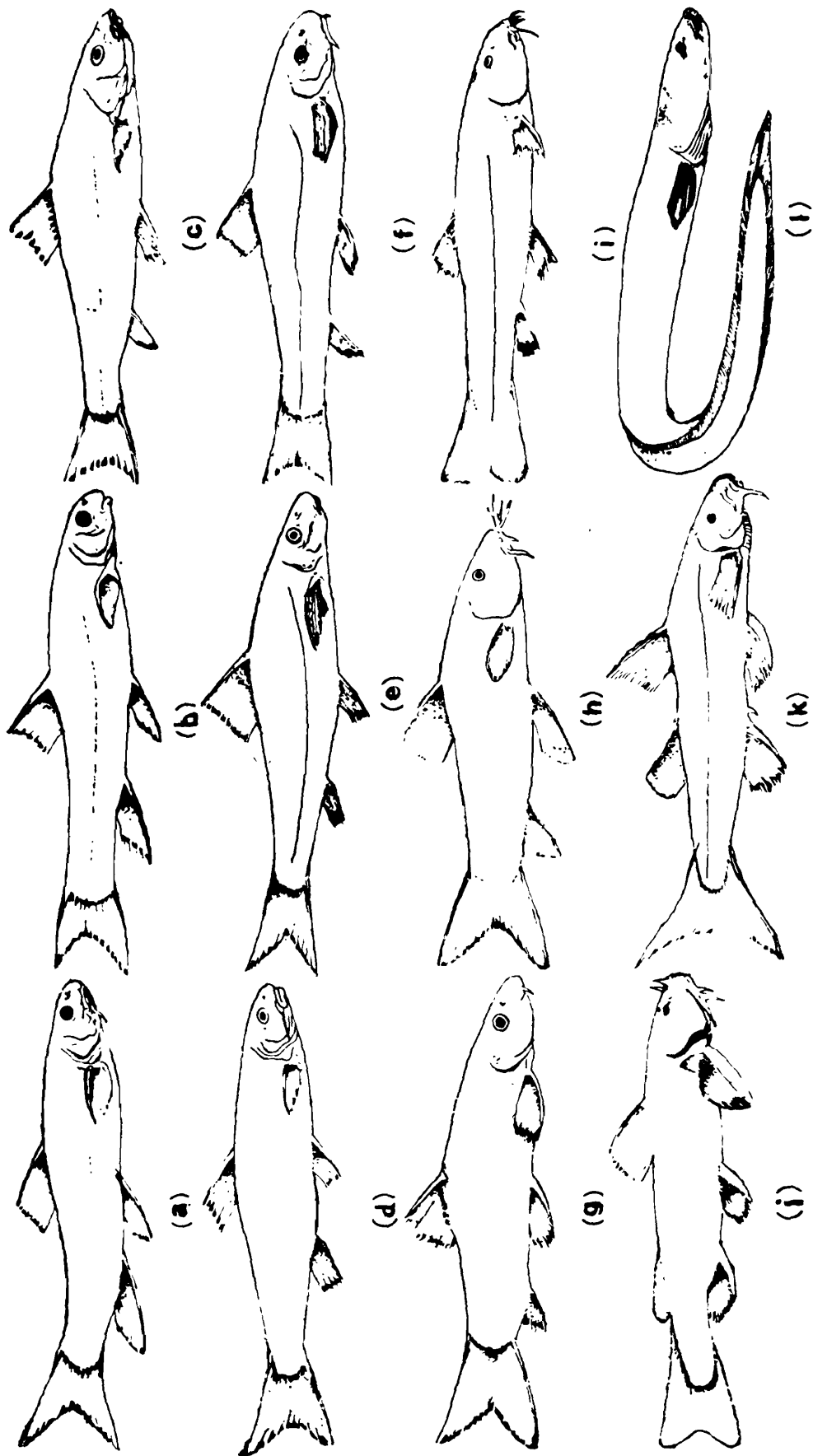


Fig. 1. Body forms of hill-stream fishes. (a), *Diptychus maculatus*; (b), *Schizothorax richardsonii*; (c), *Schizothoraichthys progastus*; (d), *Ptycobarbus controstris*; (e), *Crossocheilus diplochilus*; (f), *Garra gotyla*; (g), *Parapsilorhynchus tentaculatus*; (h), *Botia lohachata*; (i), *Noemacheilus punjabensis*; (j), *Glyptothorax brevipinnis*; (k), *Pseudecheneis sulcatus*; (l), *Pillaia indica*.

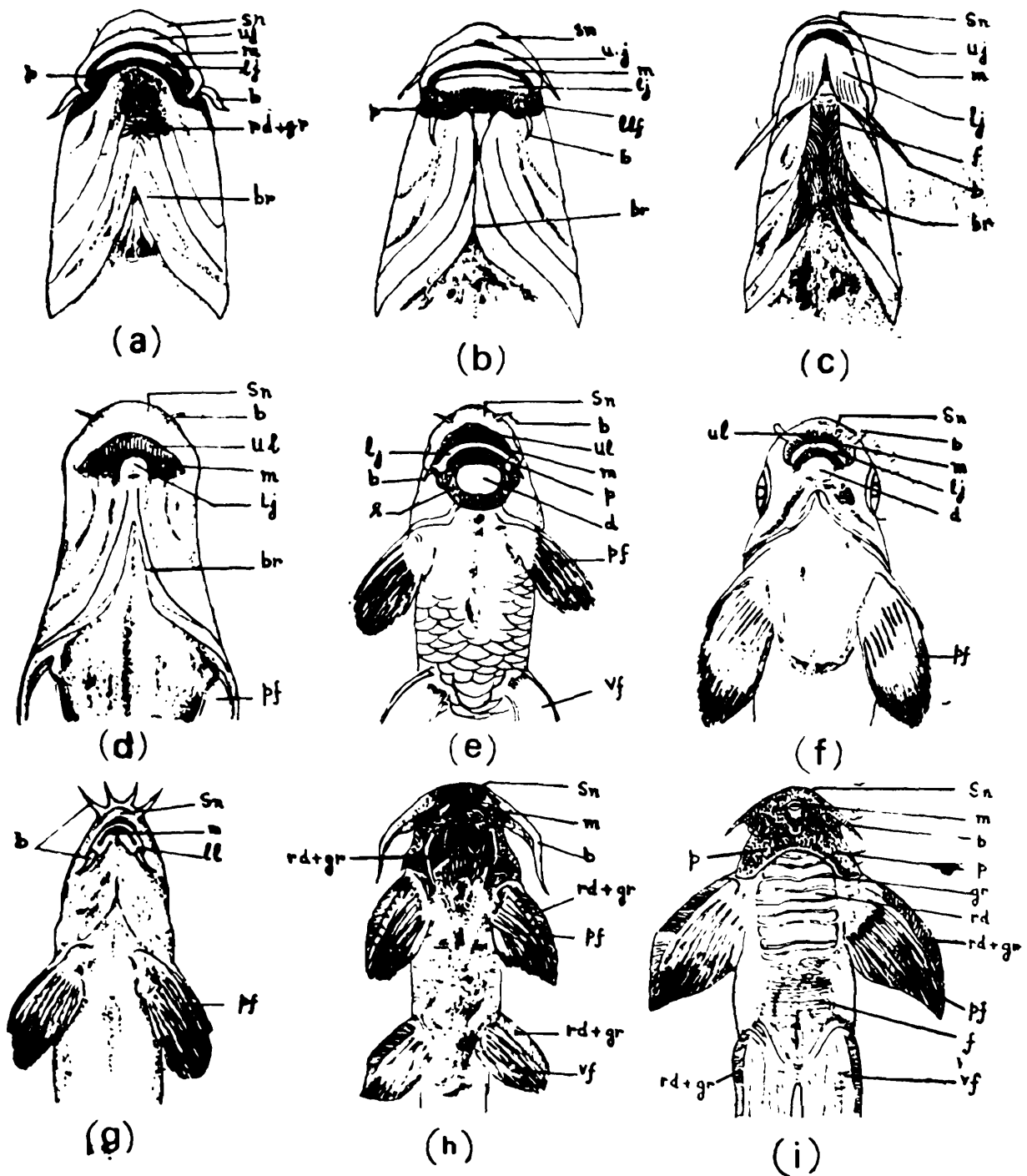


Fig. 2. Ventral views of head and anterior part of body of hill-stream fishes, showing structures connected with frictional and adhesive devices. (a), *D. maculatus*; (b), *S. richardsonii*; (c), *P. controstris*; (d), *C. diplochilus*; (e), *G. gotyla*; (f), *P. tentaculatus*; (g), *N. punjabensis*; (h), *G. brevipinnis*; (i), *P. sulcatus*; Abbreviations: b, barbel; br, branchiostegal rays; d, disc; f, skin folds; gr, groove; lj, lower jaw; ll, lower lip; llf, lower labial fold; m, mouth; p, papillae; pf, pectoral fin; rd, ridge; s, sucker; sn, snout; uj, upper jaw; ul, upper lip; vf, ventral fin.

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**PRELIMINARY OBSERVATIONS ON THE POSSIBLE IMPACT  
OF SALAL DAM CONSTRUCTION ON HIGH ALTITUDE  
FISHES OF RIVER CHENAB**

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**INTRODUCTION**

For the purpose of irrigation, flood control, navigation, generation of power, etc., several major Indian rivers are being utilised for dam construction. As a result, the riverine environment is being interfered with and the fishery resources are greatly affected. The effect of such interference may be harmful, beneficial or indifferent, depending on the particular situation and the fish fauna of the river concerned.

Dams may act as physical barrier to migration by preventing access of fish to their usual breeding, rearing and feeding grounds. They may also bring about substantial changes in the ecology of the original river both above and below the dam site. These changes may include conversion of the running water into a water-body of slow discharge characteristics, radical transformation of long established ties and interrelationships between organisms and creation of a reservoir which would make available large areas of water for colonisation by suitable species. In addition, the reduction of flow in the residual river below the dam would also alter the ecology which may result in change of species composition in the affected area.

The Salal dam, under the Salal Hydro-electric project of the Govt. of India, is under construction on the river Chenab near Riasi in the Udhampur district of Jammu & Kashmir. Recently, a faunistic survey of Salal dam site was conducted by us with an object to assess the impact of dam construction on the general fauna with special reference to fishes. Preliminary observations made on the possible effect of dam on the high altitude fishes of river Chenab are presented in this paper.

**MATERIAL AND METHOD**

Fishes were collected by cast nets as well as bag nets from the main river, several pools and various tributaries, covering a distance of about 25 km along the course of the river Chenab. Those living

among small stones, pebbles, under big rocks, etc., were collected by the method of dredging, diverting the channel in streams and trapping in fine mesh nylon nets, as described by Tilak (1972). Some freshly caught fishes were also purchased from the fish market, Riasi. The gut contents of some food fishes were examined to ascertain their feeding habits.

### THE RIVER CHENAB

The R. Chenab is one of the important constituents of the Indus drainage system of the Himalayas (Menon, 1962). It is formed by the union of Chandra and Bhaga rivers in Himachal Pradesh. The R. Chandra originates from a huge snowbed on the southeastern side of the Bara Locha pass whereas the R. Bhaga rises in the Surajdal or Lake of the Sun, situated on the summit of the Bara Locha pass at an altitude of about 5000 metres. The joint river, known for some distance as Chandrabhaga in Himachal Pradesh, passes through the famous Pangi valley and enters the J. & K. State where it is called Chenab. It flows down through mountainous region of Doda, Udhampur and Jammu districts of J. & K. and ultimately enters the lowland, a little after Riasi, and flows into the plains. The R. Tawi which is the major tributary of Chenab, emerges out from a glacier tank at the top of Mahakailash Choti in J. & K. State and flows down along the circuitous hilly path and ultimately enters the low land at Jammu and finally joins the river Chenab. The course of these rivers, as illustrated by Tilak (1977) is reproduced in Fig. 1

### THE FISHES OF RIVER CHENAB

Although 94 species are known to occur in the Indus drainage system of the Himalayas (Menon 1962), no proper account of fishes of the R. Chenab is available. However, Tilak (1971) recorded 38 species of fishes from the river Tawi which is an important tributary of this river and *Diptychus maculatus* (Cyprinidae) from the river Chandrabhaga in Himachal Pradesh (Tilak & Husain, 1977). We have recorded only 10 species of fish from the R. Chenab near Salal dam site, of which *Schizothoracichthys progustus* and *Noemacheilus punjabensis* are recorded first time from Indus drainage and the J. & K. State, respectively. A classified list of species of fishes occurring in the Chenab (including Chandrabhaga) are given below. The classification followed is that of Greenwood, Rosen, Weitzman and Myers (1966).

Order : CYPRINIFORMES

Family : CYPRINIDAE

(i) *Barilius bendelisis* (Ham.) (ii) *B. vagra* (Ham.) (iii) *Diptychus maculatus* Steindachner (iv) *Labeo dero* Ham. (v) *Puntius ticto* (Ham.),

- (vi) *Schizothoracichthys progastus* (McClelland), (vii) *Schizothorax richardsonii* (Gray), (viii) *Tor putitora* (Ham.)

Family : COBITIDAE

- (ix) *Noemacheilus botia* (Ham.), *N. punjabensis* Hora

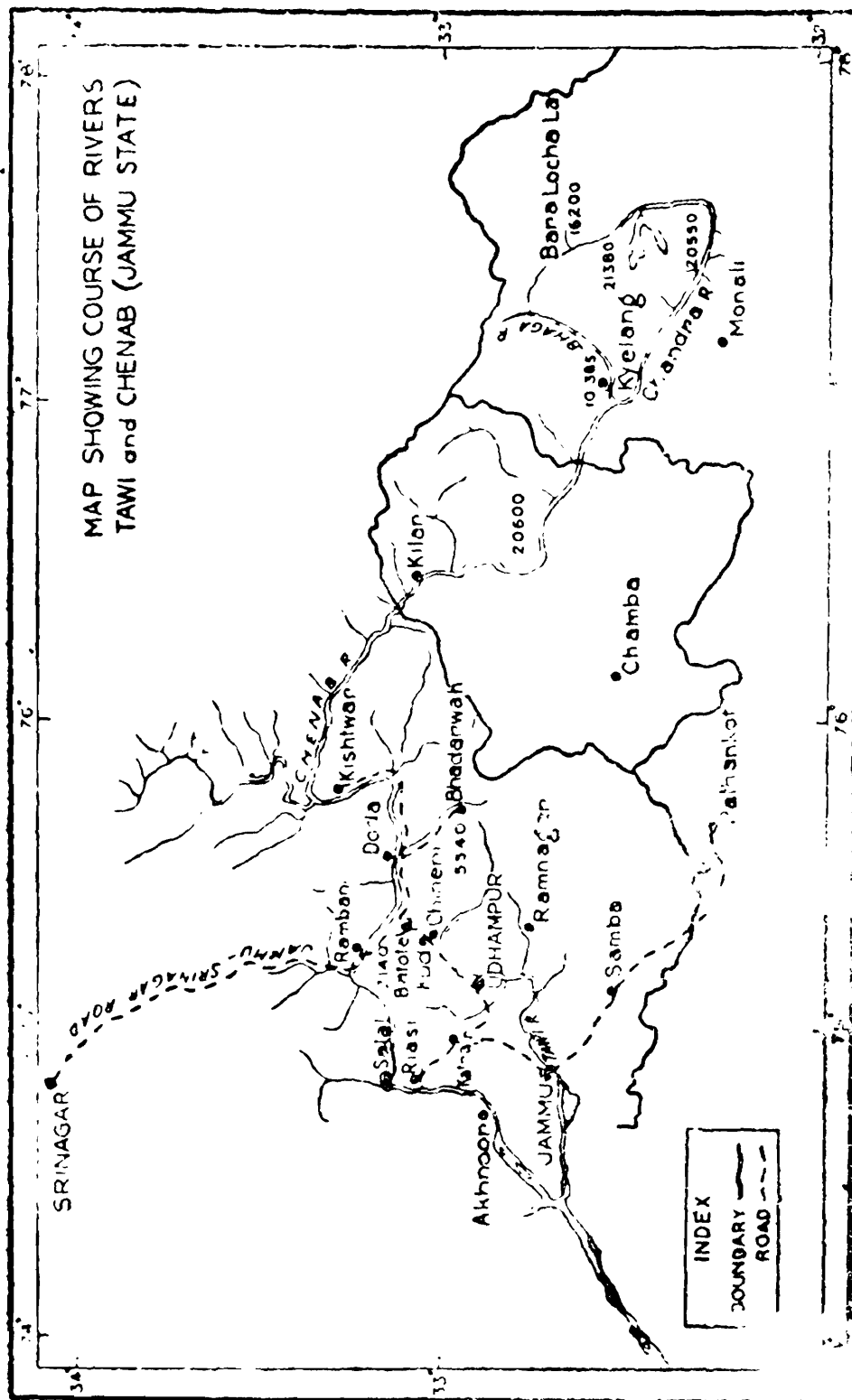


FIG. 1

Fig. 1. Map showing course of rivers Tawi and Chehab (Jammu State) (After Tilak, 1977).

Order : CHANNIFORMES

Family : CHANNIDAE

(xi) *Channa orientalis* Bl. & Schn.

Except for *P. titco*, all the species of Cyprinidae in the above list constitute important food fishes, which are adapted to living at high altitudes.

### NATURAL HISTORY OF HIGH ALTITUDE FISHES

The natural history of strictly high altitude fishes is inadequately known. However, information on the habits of some commercial species are available since some of them also occur in the lowlands (Jhingran, 1975).

According to known habits the high altitude fishes can be broadly grouped into (i) local residents, which prefer to remain confined within a restricted area (ii) local migrants, which perform seasonal migration within short distances for feeding, breeding, etc., for example *Tor* spp., *Labeo dero*, etc.

An account of habits of some of the important food fishes occurring in the river Chenab are given below.

1. *Tor putitora* : The *putitor mahseer*, also called golden or common Himalayan mahseer is a free-swimming fish with omnivorous habits. It migrates from the main rivers to the tributaries for spawning during monsoon months and the spent fish return in October-November.

2. *Labeo dero* : A free-swimming fish inhabiting rapids and pools in the main river. It feeds mainly on insects and planktons and is found to be associated with *Tor putitora*. It breeds during monsoon months and migrates upstream in search of breeding grounds.

3. *Schizothoracichthys progastus* : Regarded as true snow trout, this species occurs from the head waters of the Ganga to Sadiya in Upper Assam through Nepal and Darjeeling. It possesses non-suctorial lower lip and is a bottom feeder.

4. *Schizothorax richardsonii* : This species, called snow trout, prefers rapids and pools of torrential streams of temperature range 8° to 22°C. In streams of Himachal Pradesh it occurs at altitudes ranging from 1,180 m to 3,000 m. It possesses a suctorial lower lip and is a bottom feeder. It spawns during March to June in water temperatures of 14° to 21°C.

5. *Barilius bendelisis* : A free-swimming fish occurring in small, slow and clear gravely streams. An important game fish known to breed in the month of November (Shaw & Shebbeare, 1938).

### THE SALAL DAM

The imaginary model of Salal dam site before and after the dam construction as visualised after the survey, is reproduced in Fig. 2. The Salal dam is being constructed at a place about 21 km from Riasi where the R. Chenab, flowing in deep valleys, form a characteristic loop in its course (Fig.2). The hills surrounding the dam site reach an elevation of over 1,500 metres above mean sea level. The dam has been designed to consist of two parts viz., a concrete dam and an earthen dam. The concrete dam is proposed to be of spillway type (i.e., a dam where the river water level, after rising to the maximum height of the dam, would overflow and fall on the other side) and the earthen dam, also called Rockfill dam, would block the present course of the river. Above the dam, the area upto 20 km along the river course is expected to be under water after the formation of the reservoir, whereas below the dam the flow of water in the residual river would ultimately become normal after a slight reduction during the period of reservoir formation. The diversion tunnel, by the side of the concrete dam is supposed to maintain adequate flow of water in the residual river till the water level in the reservoir attains such a height that it starts flowing over the concrete dam.

As the rockfill dam is higher than the concrete dam it would completely stop the flow of water along the original course of the river and as a result a small portion of the river loop would become dry. The river course would also become straight at the dam site as soon as the water in the reservoir starts flowing over the concrete dam. The reservoir is not likely to be wide because at dam site the river flows through a narrow passage between very steep hills.

### IMPACT OF SALAL DAM ON FISHES

Consequent to Salal dam construction and reservoir formation a great deal of ecological changes would occur in the river both above and below the dam. The section of the river above the dam would get converted into a water body of slow discharge characteristics, thereby transforming the existing ties and interrelationship between fishes and other organism. As a result many of the riverine species adapted for living in shallow running water would be forced to abandon the almost stationary and deep water of lacustrine characteristics. It would affect the bottom living forms more strictly than the free-swimming ones as the former would be deprived of abundant oxygen under such a depth of the reservoir. The free-swimming fishes of

typical hill-streams are likely to occupy surface layers of the reservoir as it would contain more oxygen dissolved from the atmosphere. Since

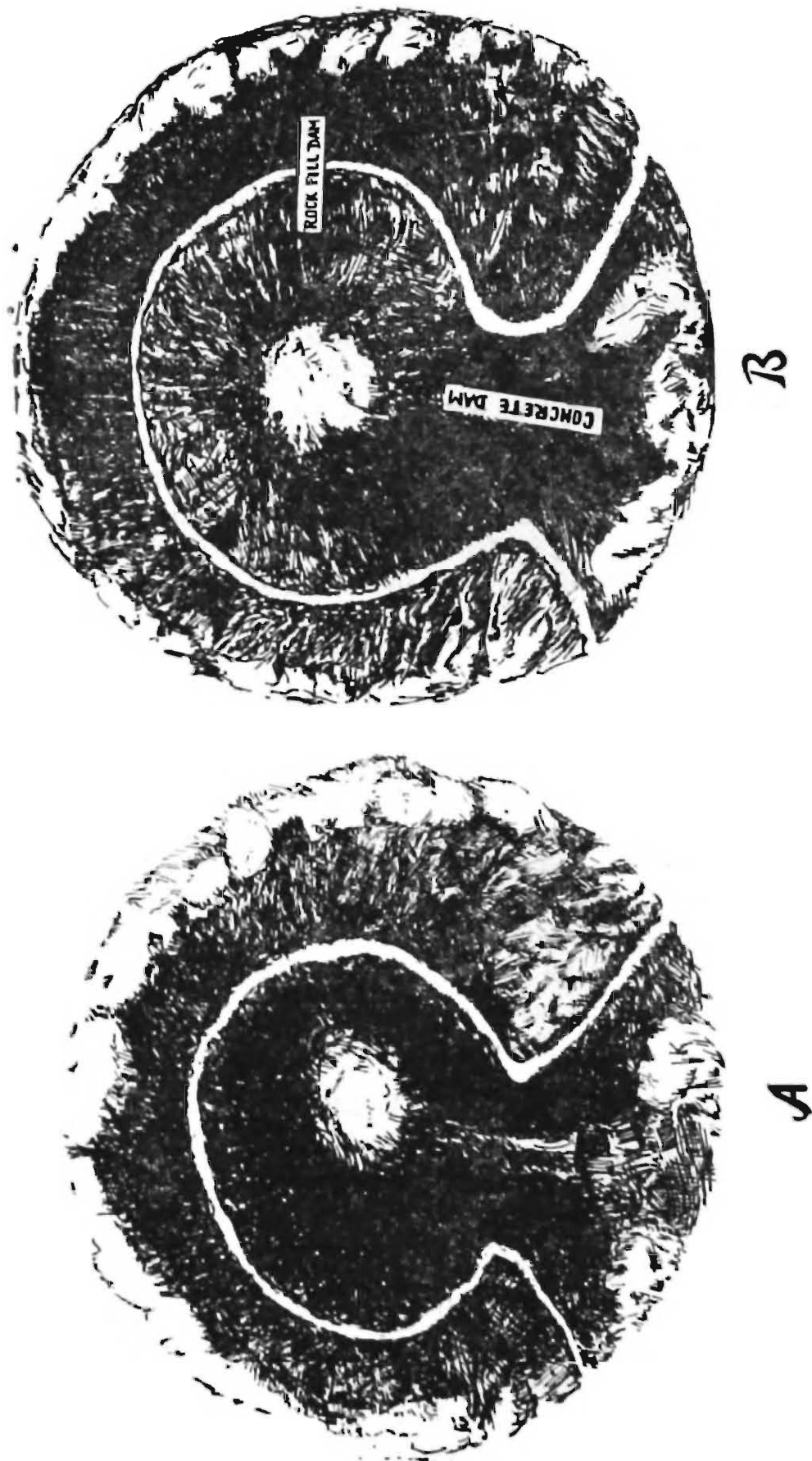


Fig. 2. Drawings from an imaginary model of Salal dam site. A, site before dam construction; B, site after dam construction.

most free-swimming fishes of hill-streams feed on algal slime they would also be forced to migrate from there as the growth of algae under such a depth may be quite poor for want of sufficient sunlight and effect of heavy silting at the bottom. As regards the section of the river after the dam there would ultimately be some alteration in its ecology owing to reduced flow of water maintained through the diversion channel during the filling up of the reservoir. But it would return to its near normal condition as soon as the river flow gets normalised and the water starts flowing over the dam, and the diversion channel gets closed.

In addition to the above, the migration in fishes for feeding, spawning and over wintering are likely to be affected and the food fishes such as mahseers and snow trout and *Labeo dero* may either be forced to find alternative route to other tributaries for the purpose or may fail to survive in the section of the river below the dam. Most food fishes recorded from the river Chenab are by habit migratory type and therefore they may fail to cross the barrier owing to dam and finally get wiped out of the river. However, the population of mahseer in the section of the river above the dam may well colonise the reservoir as this species is equally successful in the riverine and lacustrine environment. The reservoir would also offer opportunity for introducing certain other species of food fishes which are known to survive well in Govind Sagar reservoir in the R. Sutlej which is one of the most important reservoirs of the Indus river system (Jhingran, 1975).

### SUGGESTIONS

Since consequent to dam construction and reservoir formation the migratory fishes would fail to cross the barrier, it is suggested that suitable type of fishways may be provided in the dam to facilitate upstream migration of those fishes. Jhingran (1975) has given account of five principal type of fishways used all over the world. Of these the pool design type of fishways which are the oldest and most widely used may prove suitable for the Salal dam. The reservoir formed consequent to dam construction should be utilised fully for culturing suitable species of food and game fishes.

### ACKNOWLEDGEMENT

We are thankful to Dr T.N. Ananthkrishnan, Director, Zoological Survey of India, for providing us an opportunity to survey the Salal dam site and to Dr. H. Khajuria, Deputy Director, of this Station for giving facilities. We are also thankful to the authorities of Salal Hydro-electric Project, Jyotipuram (J. & K) for permitting us to survey the area from ecological point of view.

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## EVOLUTION OF EXTRA-ORAL FOOD-TRAPPING DEVICE IN SOME HIGH ALTITUDE CYPRINIDS

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### INTRODUCTION

Of all the ecological factors the strength of current, the high percentage of dissolved oxygen and the nature of food appear to have greatly influenced the evolution of fishes in hill-streams (Hora, 1930). The food mainly consists of algae covering rocks and stones and insect larvae, especially of Ephemeroptera and Chironomidae.

The majority of fishes inhabiting hill-streams feed on algae and slime, but some also strain microplanktonic food organisms out of the current. While in most of these fishes the lower jaw is designed to scrap off algae and slime from the bottom, no special organ is so far known among them for filtering food organisms out of the fast current. Since these fishes feed at the bottom with their mouth adhering to the rock surface they can hardly be expected to utilise their mouth opening for intake of planktonic organisms with the respiratory current.

In the course of our studies, however, we have discovered that in most high altitude cyprinids a groove, here termed as supralabial groove, appears to function as a food-trapping device. We present in this paper an account of this groove in some high altitude cyprinids and attempt to explain its adaptive value.

### MATERIAL AND METHOD

The preserved specimens of the following Indian species have been examined. The supralabial grooves of these species have been carefully examined to record their contents.

#### Family CYPRINIDAE

1. *Parapsilorhynchus tentaculatus* (Annandale)
2. *Garra gotyla gotyla* (Ham.)

#### Sub-family SCHIZOTHORACINAE

3. *Schizothorax richardsonii* (Gray)
4. *Diptychus maculatus* Steindachner
5. *Ptycobarbus conirostris* Steindachner
6. *Schizothoraichthys progastus* (McClelland)

The illustrations have been made free hand and are semidiagrammatic.

### OBSERVATIONS

The following observations have been made on the feeding habits, the jaw structure and the supralabial grooves of the above mentioned species.

*Feeding habits*: The natural history of most high altitude cyprinids is not properly known. However, we give hereunder an account of their feeding habits based on the available informations (Jhingran, 1974) as well as our own observations in the field.

The high altitude cyprinids are predominantly bottom-feeders and possess sucker or sucker-like structure on the chin for adhering to the rock surface because otherwise it would be difficult to take bottom food in a fast stream. They can be grouped in two categories according to their feeding habits.

(i) Fishes feeding mainly on algae and slime, e.g. *P. tentaculatus*, *G. g. gotyla*, *S. richardsonii*, *D. maculatus*.

(ii) Fishes feeding both on microplanktonic organisms and algal slime, e.g., *S. progastus*, *P. conirostris*. Some organic matter and sand particles trapped inside the supralabial groove of these species have been found by us.

*The jaws*: In most high altitude cyprinids the mouth is ventral and the lower jaw is hard, strong and its free end is sharp and shovel-like. The upper jaw does not bite against the lower but is modified to form a somewhat vertical plate in front of it. The scrapped off algae and slime are, therefore, prevented from being washed away by the current and are taken inside the mouth with the help of respiratory current which presumably flows from its corners.

Correlated with the feeding habits the lower jaw of bill-stream fishes can also be grouped into two categories.

(i) Free end of lower jaw sharp and razor-edged; the mouth-opening ventral as is found in species feeding mainly on algae and slime (*P. tentaculatus*, *G. g. gotyla*, *S. richardsonii* and *D. maculatus*).

- (ii) Free end of lower jaw somewhat blunt; the mouth-opening subterminal as is found in species feeding both on microplanktonic organisms and algae (*S. progastus*, *P. conirostris*).

*The supralabial groove* : The supralabial groove of some high altitude cyprinids is shown in Fig. 1. The groove is poorly developed in *P. tentaculatus* and *G. g. gotyla*. It is completely overhung by the supralabial fold which is fringed. However, the groove is well-marked in *S. richardsonii* and *D. maculatus*. It is fairly deep and is covered by a fleshy flap in *D. maculatus*. The groove is most developed and contains a deep cavity in *S. progastus* and *P. conirostris*. It contains a comb-like appendage and a cover of fleshy flap in *P. conirostris*.

### DISCUSSION

Since the availability of food is almost restricted to the bottom in a hill-stream, the high altitude cyprinids, both free-swimming and benthic, are predominantly bottom feeders. The position of mouth-opening and the mechanism of the jaws in these fishes also appear to be ideally suited for taking food from the bottom. Although some cyprinids possessing terminal mouth are capable of taking bottom food in still waters of lowlands by adjusting their bodies almost at right angles to the bottom (Alexander, 1966), their counter parts in the running streams of high altitude are, however, at a disadvantage to act so because of the force of current. In order to overcome this problem most cyprinids of high altitude have evolved some mechanism for adhering temporarily to the stream bed for the purpose of feeding. While the fishes such as *P. tentaculatus*, *S. richardsonii* and *D. maculatus* which possess ventral mouth with sharp-edged lower jaw are well adapted for feeding at the bottom, the other species such as *S. progastus*, *P. conirostris* which are provided with subterminal mouth with lower jaw unsuitable for scrapping off algae from the rock surface have also to rely partly on other food items like insect larvae, etc. Since there is no arrangement for trapping such food items in the pharynx these fishes appear to have evolved supralabial grooves to trap microplanktonic organisms extra-orally. This device may not require any extra effort on the part of the fish since the current is expected to pass through the grooves and any organism detected therein may be easily filtered, to be taken in the mouth later. The development of comb-like appendages inside the supralabial groove of *P. conirostris* appears to ensure a more efficient food-trapping than in other species where no such an appendage occurs.

The supralabial groove is present in cyprinids of lowlands but in them the groove acts primarily for accommodating the retracted upper jaw. It has lost its main function owing to remarkable modification of upper jaw in high altitude fishes, and appears to have

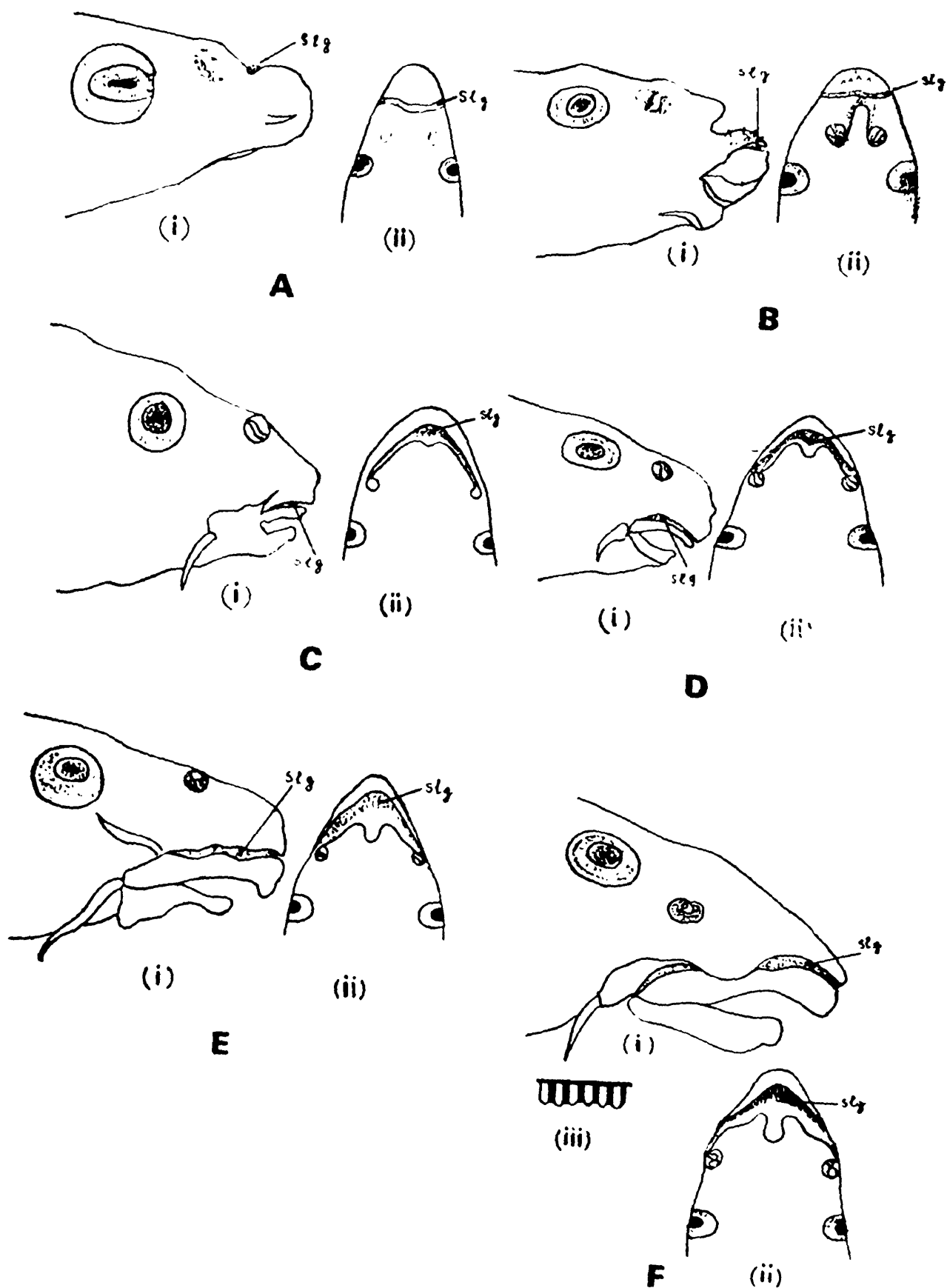


Fig. 1. Outlines of head of some high altitude cyprinids showing the supralabial groove. A, *Parapsilorhynchus tentaculatus*; B, *Garra g. gotyla*; C, *Schizothorax richardsonii*; D, *Diptychus maculatus*; E, *Schizothoracichthys progastus*; E, *Ptycobarnus conirostris*. (i) & (ii) in each species show lateral and dorsal views of head. F (iii) shows the diagrammatic transverse section of the comb-like appendage described in the text. Abbreviation : s.l.g., supralabial groove.

acquired the new function i.e. food-trapping in the course of evolution of hill-stream fishes.

### CONCLUSION

For the purpose of feeding in the hill-stream environment, the high altitude cyprinids have undergone three distinct modifications in the course of their evolution : modification of protrusible upper jaw into a somewhat fixed vertical plate in front of the lower jaw, development of a shovel-like lower jaw for scrapping off algae and slime from the rock surface, and modification of supralabial groove into a channel where food organisms are believed to be filtered out of the current. The supralabial groove is most developed in those cyprinids which possess subterminal mouth and blunt-edged lower jaw. It seems, therefore, reasonable to believe that the evolution of extra-oral food-trapping device in these fishes has provided a more efficient mechanism to collect microplanktonic food from the current than those species which are highly specialised for scrapping off algae.

### ACKNOWLEDGEMENT

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## EFFECT OF HIGH ALTITUDE FACTORS ON THE LEECH FAUNA

By

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This report is based on the author's as well as others extensive faunistic surveys of the High Altitude areas of Himachal Pradesh. The surveys reveal a complete absence of leech in these areas. Even the local people have never seen any leech there. An attempt is made to correlate the absence of leeches in the districts of Kinnour, Lahaul-Spiti, and Pangi and Bharmour areas of Chamba district with certain high altitude factors. The natural balance of ecosystem which has a direct bearing over the existence of certain fauna and flora is in turn influenced by the high altitude factors. The major high altitude factors are temperature, rainfall and vegetation. Of all these areas only the entire Lahaul-Spiti is above the timber line. The major portion of these districts lie about 3,000 m above sea level.

The aquatic leeches have been recorded upto 1,500 m and the terrestrial forms upto 3,000 m. For the survival of leeches, a minimum temperature of 10°-20°C is necessary (Moore, 1927) and sufficient rainfall is also required. But at higher elevations the maximum water temperature is between 5°C to 10°C, and rainfall is scanty or almost nil, which is not at all suitable for the existence of aquatic leeches.

At slightly lower altitude (2,500 m) in the western Himalayas, particularly in Himachal Pradesh, only two terrestrial species, viz. *Haemadipsa zeylanica zeylanica* (Moquin-Tandon) and *Haemadipsa zeylanica agilis* Moore are found. An interesting behavioural phenomenon was observed by the author and his colleague, Shri R.N. Mukherjee, in the districts of Sirmour and Solan of Himachal Pradesh. These leeches were found coming to the host by looping and jumping over small bushes from quite long distances. This strange behaviour has not been so far reported among the forms of the plains, which is an indication that some sense organ of the hill form is more developed due to paucity of host in hilly region.

In concluding, it is remarked that if any leech is found at higher altitudes it may be due to chance occurrence alongwith the migration

of their host, i.e., sheep, goat, etc. The author is highly grateful to the Director Zoological Survey of India and the Officer-in-Charge, High Altitude Zoology Field Station, Solan, for providing facilities in the compilation of this report.

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## MASS MIGRATION OF EARTHWORMS IN THE SIMLA HILLS

By

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### INTRODUCTION

During the faunistic survey of the Simla Hills between 1976 to the middle of 1979, the authors observed a peculiar phenomenon of mass migration of earthworms. Although there are records of mass migration of earthworms from Yunnan Province in China and Chin Hills in Burma (Gates, 1933; 1972), so far this phenomenon has not been reported from the Indian region. An attempt is, therefore, made to correlate the phenomenon with certain environmental factors.

The Simla Hills lie in the western part of the Middle Himalayas. The vegetation consists mostly of grasses on the southern slopes and patches of forests of oak, pine and cedar on the northern slopes. The climate of the area can be divided into four distinct seasons, viz., 1) very cold with frequent rains and occasional snow from middle of December to March, 2) hot and dry from April to middle of June, 3) hot with heavy rains from middle of June to middle of September, 4) cold and dry from middle of September to middle of December.

### HABITATS OF EARTHWORMS

The following account is based on species occurring in and around Solan.

1) *Perionyx excavatus* Perrier — Soil near manure piles; under logs and stones near water bodies; under decaying organic matter in grasslands on hill slopes; kitchen drainage. Elsewhere, this species is also known to inhabit under bark of standing and fallen trees, debris in axils of plantain leaves and in forks of trees, on epiphytic ferns in rain forests, leaves of aquatic plants, under moss and ferns on spray-drenched rocks by waterfalls (Gates, 1972).

2) *Amyntas diffringens* (Baird) .— Soil under decaying organic matter in grasslands on hill slopes; in compost, under stones on stream banks. Elsewhere, *A. diffringens* is also known to live in soil with large admixture of bark, muddy pools, under logs, in rotten wood, cultivated fields, forests, gardens, soil around roots of potted plants, axils of plantain leaves and caves (Gates, 1972).

3) *Aporrectodea trapezoides* (Duges):— Soil around roots of potted plants and forest litter.

4) *Octolasion tyrtaeum* (Savigny). — Soil under forest litter, compost and decaying wood.

5) *Eisenia foetida* (Savigny). — Under bark of rotten tree stumps, in decaying fallen logs, leaf mould, compost and kitchen drainage.

6) *Drawida japonica* Michaelsen. — Soil in gardens and cultivated fields, and under forest litter.

### OBSERVATIONS

Early in the morning on certain days in April after the winter and in late September or early October after the summer rains, a large number of earthworms belonging to *Perionyx excavatus* Perrier and *Amyntas diffringens* (Baird) have been found in patches on the roads at Solan (altitude approx. 1500 m), Sanwar (altitude approx. 1250 m) and Tara Devi (alt. approx. 2300 m). From four different areas, each measuring about 10 sq. m, a total of 712, 635, 780 and 569 immature and adult worms were collected respectively. They were moving down-hill and some were also seen tumbling down from the banks above onto the road. A number of them were found to be dead and some were in a state of desiccation. By evening time no worms were seen. At these places, the hills are mostly covered with grass and a few small bushes. The top layer of about 30-60 cm soil is sandy loam deposited on a rocky stratum. During the rainy season both *Perionyx excavatus* and *Amyntas diffringens* are found in good number in soil under decaying matter on hill slopes covered with grasses and bushes. They are mostly absent at these places during the dry season when they are to be found concentrated in large number under stones and decaying organic matter near streams, pools and drains. At the beginning of the rainy season a number of worms of these species are also seen wandering on the roads but they are moving mostly up-hill.

### DISCUSSION

Soil moisture, pH, temperature, aeration and carbon dioxide, organic matter and food supply are the probable environmental factors that influence the seasonal activity of the earthworms (Edwards & Lofty, 1977). In tropics, the soil moisture is the most important factor controlling the earthworm activity (Gates, 1961). Water constitutes 75-90% of body weight of earthworms (Grant, 1955) and prevention of water loss is a major problem of earthworm survival (Edwards & Lofty, 1977). Hence, some degree of moisture is essential in the soil for the earthworms to exist therein. During the

adverse condition of drought, the soil at surface becomes very dry and the species of earthworms that normally live near the surface migrate for aestivation to deeper soil where some moisture is retained even during the dry season (Edwards & Lofty, 1977). There are instances of earthworms aestivating at depths of 2.7 m (Stephenson, 1930; Gates, 1972).

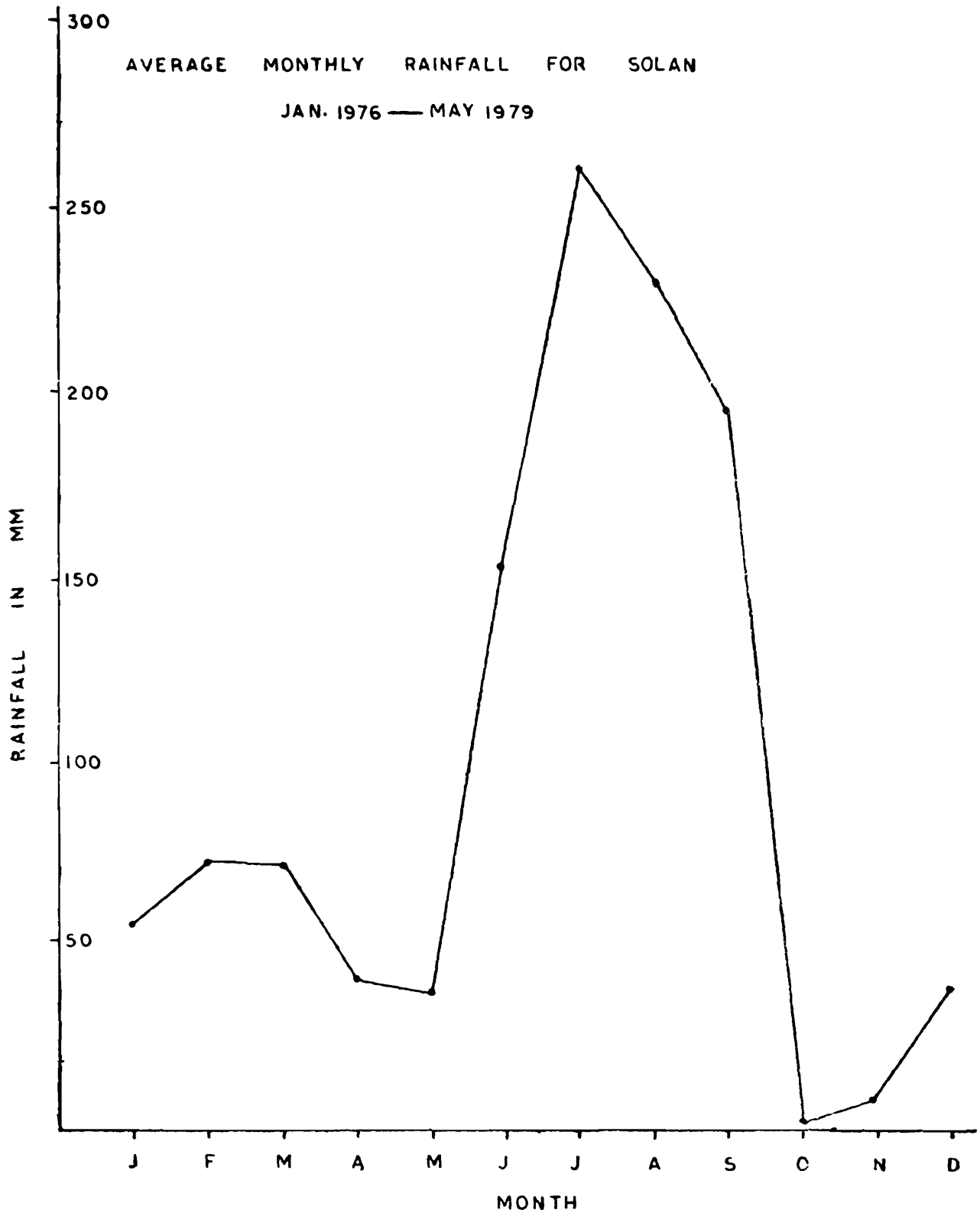


FIG. 1

Figure 1 shows the monthly average rainfall for the last 3½ years at Solan. There are two distinct rainy seasons, viz., winter rains (middle of December to March) and summer rains (middle of June to middle of September) intervened by dry periods. It is interesting to note that the mass migration of *Perionyx excavatus* and *Amyntas diffringens* in the Simla Hills coincides with the onset of the dry season. During the drought, the top 30-60 cm layer on sandy loam soil on hill slopes cannot retain water for longer periods and it becomes unsuitable for the survival of earthworms. Below this layer the stratum is rocky and the worms are unable to move deeper. Alternatively, they leave their habitat in grasslands on hill slopes and migrate down-hill to those places where some moisture is still retained. This view is supported by the fact that during the period of drought the population of *Perionyx excavatus* and *Amyntas diffringens* is negligible on the hill slopes, whereas they are found concentrated in large number at places which are located down-hill. At the beginning of rainy season, they again move up-hill probably in search of grasslands where suitable moisture is available and plenty of organic matter has accumulated during dry season. It is to be noted that Gates' (1938, 1972) report of mass migration of earthworms during the drought is also based on a *Perionyx* species (probably *excavatus*) and the phenomenon is probably attributable to depletion of moisture in soil. *Perionyx excavatus* and *Amyntas diffringens* prefer soils with considerable amount of moisture (Gates, 1972).

Both *Perionyx excavatus* and *Amyntas diffringens* are exotic to the Simla Hills. The original home of the former is presumably in the eastern Himalayas and that of the latter in China. They are believed to have been transported to various parts of the world unintentionally by human agency through the soil around the roots of exotic plants (Gates, 1972). Other exotic earthworms, viz., *Aporrectodea trapezoides*, *Octolasion tyrtaeum*, *Eisenia foetida* and *Drawida japonica* also occur at Solan. They were not found to be involved in mass migration as some moisture is retained in their habitats even during the dry period. Probably, they can withstand drought better than *Perionyx excavatus* and *Amyntas diffringens*. Gerard (1960) also showed that some species of earthworms can cope with dry conditions better than others.

It is intended to carry out further investigations on this phenomenon of mass migration in earthworms by marking and recapturing technique.

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Dr. G M. Yazdani, Superintending Zoologist, High Altitude Zoology Field Station, Zoological Survey of India, Solan for their encouragement and valuable suggestions.

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STUDIES ON THE BIOECOLOGICAL CORRELATION OF  
NON-INSECT FAUNA OF SUBMOUNTAIN RANGES  
OF THE KASHMIR VALLEY

By

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The main purpose of the paper is to introduce the non-insect pests which stand unexplored hitherto from most parts of Indian region including Kashmir. The objectives are to explore this economically important fauna of submountain ranges so that their importance could be felt in the economy of agriculture and sustained work could be carried out further. In this study a rodent *Rhizomys chotta*; Crustaceans-*Triops cancriformis kashmirensis*, *Branchinecta* sp., *Metoporiorthus pruinosus* and *Oniscus asellus*; Annelids-*Allolobophora nocturna*, *Bimastus parvus*, *Lumbricus terrestris* and *Tubifex* sp. and Mollusca *Lymnaea stagnalis*, *L. auricularia*, *Planorbis corneus* and *Corbicula* sp. have been reported as pests affecting the range and agroecosystem. Their habit, habitat, distribution and bioecological correlations under Kashmir conditions have been described.

INTRODUCTION

In recent years much attention is being given towards economic Zoology in India and this branch is developing into a discipline of its own place. Entomologists and Zoologists have mainly studied arthropods and vertebrates which directly and indirectly are concerned with man. But most of the other invertebrate groups which have direct bearing on the crop productivity remained obscure. The stray records are scattered in obscure journals and are not easily accessible to later workers. However, their habit, habitat and ecological correlations with agroecosystem and the role they play in the economy of agriculture and plant growth has hardly been studied. Although Srivastava and Awasthi (1958) were first workers to indicate the problem arising out of the non-insect pests in India, which made Misra (1961) to feel to have discourses on them. Srivastava (1964), located some economically important non-insect fauna of India which drew the attention of workers i.e. Jotwani *et al.* (1968) and Rangaswami (1969) to study economic losses of rats and millipedes respectively. Credit of compiling this scattered information into a book "Economic Zoology" goes to Srivastava (1977).

## OBSERVATIONS

## RODENTIA

Earlier records of bamboo rat species as pests of crops from Asia were: *Rhizomys sinensis* from China, *R. sinensis wardi* (Burma), *R. pannosus* (Siam and Malaya), *R. pruinosis* (Yunnan & Assam) and *R. (Cannomys) bodius* from Nepal, although *R. sumatrensis* has been reported from India. From Kashmir Hodgson reported *R. bodius* from Kumaun and Kashmir. Besides *Microtus blythi* a himalayan vole and *Mus musculus homourus*, a field rat, there exist no record of bamboo rat from Kashmir. The present species *Rhizomys chotta* is first record of the genus. The morphological features of the new species have been studied by Rishi (1976).

The rodent is an inhabitant of the soil, living solitarily in the burrow of its own construction. It spends almost entire life underground in the open fields. But occasionally comes out to the surface to forage for winter food during summer and fall months. During fall months the green vegetation becomes scarce in Kashmir, stored bulbs, fallen apples and potato tubers are stored as winter food in the burrows. The rodent burrows into the cultivated fields and fruit orchards, causing maximum damage to the roots of young apple trees which are nibbled and cut with chisel shaped incisors thereby causing complete destruction of the root system. They also gnaw the bark of these trees at ground level. On night's forage they invade the adjacent potato and sugar beet fields. They remain active almost throughout year and feed under snow cover in dead winter even under surface temperature of  $-4^{\circ}\text{C}$ . They do not hibernate.

The animal digs with their strong fore claws clean cut cylindrical tunnels averaging 2-3 inches in diameter. The entire burrow system extends at an average 40-70 ft. The individual burrows are often extensive and of two types-long and shallow, and deep ones varying 6-10 inches. The latter tunnels are usually used for shelter with chambers for food storage, resting and latrines. The main tunnel has many vertical laterals. Each rodent lives within its own characteristic system of burrows.

The presence of these pests in the field or orchards could be easily located by the presence of mounds of fine soil heaps on the edge of a slope or ridge. Sexes live separately within adjacent burrows, but join at mating times, i.e. May to July. Female gives birth to 1-3 litters and the number of young varies 3-8. The new born are blind and hairless. At an average 10-15 have been observed covering an acre of cultivated field. In damaging capacity and behaviour they resemble Pocket Gopher Genus *Geomys* of Western countries, viz. Canada.

## CRUSTACEA

Records of *Triops* (*Apus*) spp. viz. *Apus cancriformes*, *A. glacialis*, *A. equalis*, *A. oryzaphagus* were made by Packard (1871) from American region. Le Conte (1946) reported *Triops longicaudatus* as pest in rice fields of California. From Indian region are known *Apus sudanicus* and *A. asiaticus*; Tiwari (1951) reported two new species, viz. *Apus movliensis* and *Apus orientalis*. Barnard (1929) reported *Apus cancriformis* from Punjab and Kashmir, while *Triops cancriformis* var. *himalayana* was reported by Packard from Himalayan regions. Das (1970) reported *Apus kashmirensis* from Kashmir. Rishi (1976) reported a new sub-species *Triops cancriformis kashmirensis* as a serious pest in the paddy seed beds from Kashmir. The crustaceans affect both germinating paddy seeds and seedlings in the nursery beds in April to May, causing severe damage to an extent of 60-80%. Under severe infestations resowing of seeds is necessiated. Damage is caused by their dotting movements which dislodge the entire seed and seedlings from the muddy loose soil. Seedlings and seeds float on the surface of the water without germination. The adults also nibble the coleoptile of emerging seeds or some times gnaw the seeds with the mandibles.

*Branchinecta* mostly occurs in the paddy fields grown in the hilly terraces. The shrimps predominate in the paddy fields in which organic compost has been added as manure. *Metoponorthus pruinosus* and *Oniscus asellus* are the commonest crustaceans distributed in the wood lands, under bark, stones and decaying logs. They mostly feed on decaying cellulose, organic matter and forest litter. Dark, damp and rich in decaying organic matter favour its population increase. However, they are also found under dwellings having earthen floor. Though omnivorous it is suspected that *Metoponorthus* is predaceous on some micro fauna.

## ANNELIDS

Annelidan species *Allolobophora nocturna*, *Bismastus parvus*, *Lumbricus terrestris* and *Tubifex* sp. are the commonest and most widely distributed species in the mountain and submountain areas of the valley. Their distribution mostly depends on the physical and chemical characteristics of the soil, type of vegetation and land management. Their activities in the field are seasonal. *Allolobophora nocturna* predominates in the humid saline top soil surface in the arable lands rich in minerals especially in calcium. *Lumbricus terrestris* is restricted to drier uncultivated soils having leguminous vegetation of *Trifolium*. This species mostly lives in organic horizons and ingests little mineral matter as compared to *A. nocturana*. *Bismastus parvus*

is distributed in golf grounds and pasture lands both in the valley and high elevations. The maximum population built up is in spring and autumn between 10 to 25°C, whereas at temperature between 30-35°C in July-August they mostly undergo diapause (aestivation) which is correlated with rise in temperature and fall in the soil moisture. The production of faeces in the form of 'worm casts' on the soil surface is maximum in spring and autumn and is correlated with the soil temperature and moisture contents which remain quite favourable during these seasons.

*Tubifex* is abundant in drainage pits, sewage pools and natural water reservoirs rich in submerged and terrestrial vegetation growth. They act as effective natural agents of sewage disposal and water pollution control under Kashmir conditions.

### MOLLUSCA

Molluscan species *Planorbis corneus* and *Corbicula* predominate in the paddy field beds. These cling and crawl on the tender nursery or transplanted paddy seedlings. Tender shoots are cut by their crawling. In the water having acidic pH these species are mostly found in permanent water channels adjacent to fields which are rich in submerged and surface vegetation. However, they are restricted mostly to swampy and marshy lands and damage cucurbit crops. *Limax* sp. and *Achatina* sp. have been noticed among marshy vegetation in the floating vegetable lands and at Gulmarg areas (10,000ft) in large numbers. Further studies on their ecological correlations with vegetation are in progress.

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## ALTITUDINAL IMMOBILIZATION OF THE GIANT AFRICAN LAND SNAIL, *ACHATINA FULICA* BOWDICH

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Studies on the distribution and population of land snails are very limited and restricted mostly to the snails inhabiting islands and plains. Nothing is known on the bioecology of high altitude molluscs from India and abroad. The giant African land snail, *Achatina fulica*, though a native of the plains of Kenya, East Africa has been able to invade India, both plains and the hilly tracts, upto a certain altitude which perhaps regulates the mobilization of this snail species. With a view to understand the altitudinal effect on this snail species extensive field observations were made from different parts of India for the last six years, 1974 to 1979, both in the plains and at different elevations which formed the basis of this paper.

### MATERIALS AND METHODS

The methods for the study of distribution and population of *A. fulica* were similar to those applied by Raut (1979). Meteorological data and the height of the areas surveyed have been collected from different meteorological stations, Government of India.

### OBSERVATIONS

Survey on the distribution of *A. fulica* has revealed that this snail species is restricted to eastern and southern India, and to Andaman and Car Nicobar Islands. It is a common garden pest in all the districts of West Bengal (except Purulia and a part of Darjeeling); in and around Gauhati, Bamangola and Jorhat of Assam; Nongpoh and Phulbari of Meghalaya; Dimapur and Chumukdemia of Nagaland; Imphal of Manipur; Kumarghat of Tripura; the whole of north Bihar, and Bhagalpur, Santalpargana, Singhbhum districts of south Bihar; Balasore, Mayurbhanj, Keonjhar and Cuttack of Orissa; Palghat and Trichur of Kerala; and Coimbatore, South Arcot and Chengalpattu of Tamil Nadu. However, the snails have never been found to an altitude beyond 1200 m.

Population densities of this snail from different areas exhibit a marked variance from one infested pocket to the other. In plains of West Bengal, Bihar, Orissa and Assam the population of this snail was estimated as 24 to 36 with an average 32 snails per square metre of

the infested pockets. With the increase in altitude the population decreased gradually. There were 26, 20, 17, 13 and 11 at altitudes of 31 m (Jorhat), 50 m (Gauhati), 595 m (Kumarghat), 850 m (Imphal) and 1166 m (Nongpoh) respectively (Fig. 1). No infestation was observed from Kurseong (alt. 1600m), Darjeeling town (alt. 2000 m) and Kalimpong (alt. 1209 m) of West Bengal, Shillong (alt. 1500 m) of Meghalaya, Kohima (alt. 3000 m) of Nagaland and Ootacamund (alt. 2249 m) of Tamil Nadu.

The various bioecological factors like temperature, humidity, rainfall, soil, vegetation, atmospheric pressure and oxygen tension taken into consideration in relation to elevation are as follows :

*Temperature* : Temperature in plains and also at an altitude of 50 m is almost similar with remarkable fluctuation in seasonal and diurnal temperatures. With the increase in altitude the temperature falls down and reaches to 4° C, 3.3° C and 2° C at Kumarghat, Imphal and Nongpoh respectively during winter. It is to be noted here that in these areas, night temperature fluctuates between 0.2° C to 9.2° C with an average 4.8° C in winter (Table-I). The temperature, sometimes as low as 1° C, prevails for more than 5 to 15 hours at Nongpoh. With the advent of unfavourable climate the snails try to burrow deep into the soil upto 12 cm in some cases, though aestivation on the surface is not uncommon. Some individuals aestivate in soil between 2 cm to 12 cm for which the soil temperatures at different depth have been taken into account (Table-II).

*Humidity* : Relative humidity in the plains varies greatly from season to season depending on the amount of rainfall, rate of evaporation and wind velocity. During summer and winter it is appreciably low while in monsoon it is very high. This offers a suitable living condition to terrestrial snails. The humidity at nights in areas above 500 m is about 95% during rains and in winter, while in summer it is only about 85% in an average.

*Rainfall* : Rain throughout the year is the characteristic feature of the high altitudes. In an average the annual precipitation in plains and also upto an elevation of 50 m is about 1800 mm to 2200 mm. In 500 m and above the rainfall is higher and sometimes it prevails round the year while in extreme cases, particularly at Imphal, *A. fulica* infested areas remain sometimes submerged for a period of 8 to 19 hours and 3 to 9 hours during monsoon and winter respectively.

*Soil* : In India, the giant snail infested areas are characterised by different kinds of alluvial soils. The role of soil in the distribution of *A. fulica* has been discussed by Raut (1981).

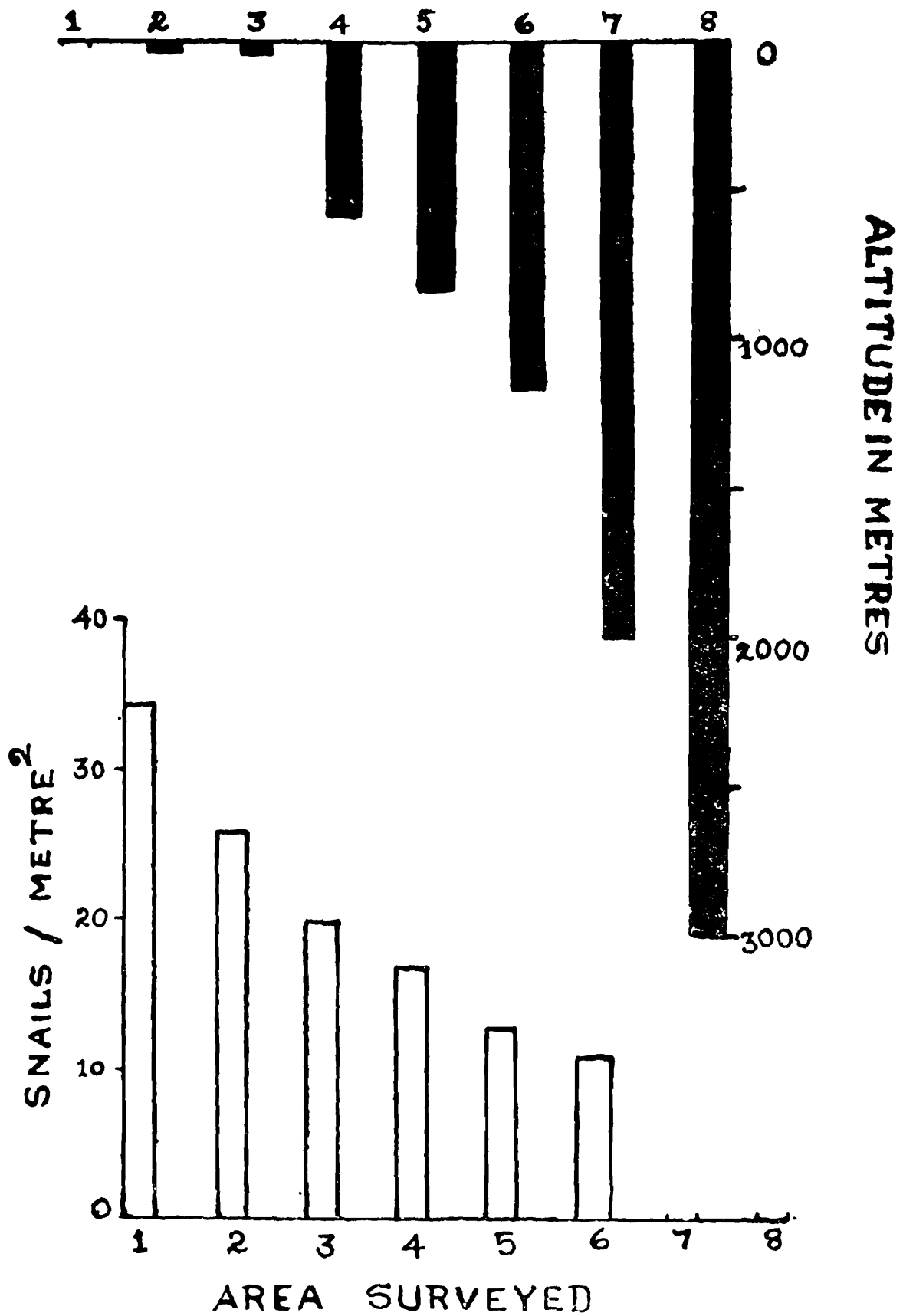


Fig. 1. Histogram showing population densities of *Achatina fulica* in relation to different altitudes. (1=Plain lands, 2=Jorhat, 3=Gauhati, 4=Kumarghat, 5=Imphal, 6=Nonghop, 7=Darjeeling, 8=Kohima).

TABLE I. Monthly Mean Maximum and Mean Minimum Temperature (°C) at Different Altitude.

Altitude In Metres	Mean Temp ( C)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Sea Level	Max.	28.4	30.8	34.9	39.7	40.6	35.7	33.3	32.2	32.6	29.6	28.0	26.4
	Min.	12.5	15.3	20.0	24.2	25.9	26.2	25.4	24.9	22.3	16.2	14.0	12.1
31	Max.	23.3	25.0	28.5	30.5	29.8	31.8	32.7	32.1	32.2	30.8	27.2	24.4
	Min.	11.6	13.2	16.6	20.1	21.8	24.0	24.5	24.1	24.5	21.5	15.1	12.6
50	Max.	23.4	26.7	30.0	31.9	31.1	31.2	31.7	32.1	31.7	30.1	27.5	24.8
	Min.	9.8	10.6	16.0	20.0	22.8	24.9	25.7	25.8	24.2	22.1	17.3	11.5
595	Max.	20.1	18.8	24.2	26.4	28.1	29.1	26.4	27.4	28.5	27.7	24.5	21.7
	Min.	7.9	8.2	14.8	19.2	21.2	20.2	18.2	19.6	18.5	16.4	15.8	11.2
850	Max.	20.4	21.4	24.6	27.1	28.4	29.5	27.8	26.8	27.9	27.8	24.9	22.6
	Min.	6.1	9.6	13.5	16.8	17.0	20.1	19.9	22.1	21.1	14.1	8.2	6.8
1166	Max.	21.1	22.9	25.8	27.9	28.9	27.6	27.7	26.4	26.9	25.6	24.0	20.1
	Min.	4.1	9.2	12.9	15.2	18.1	20.2	20.9	19.1	17.4	12.8	10.8	3.8

TABLE II. Soil Temperatures (°C) at Different Depth in Different Elevation.

Depth of Soil (cm)	Altitude in Metres					
	500—1000		1001—2000		3000—3500	
	Mean Maximum	Mean Minimum	Mean Maximum	Mean Minimum	Mean Maximum	Mean Minimum
Surface	32.8	18.2	29.1	10.6	26.8	7.8
2	28.5	10.2	24.8	4.2	24.1	3.0
4	26.1	12.0	22.1	5.8	20.1	3.6
6	25.4	13.4	21.3	7.4	19.2	5.1
8	22.3	14.6	19.5	10.3	18.1	8.0
10	21.0	15.1	18.2	12.0	17.0	9.1
12	24.4	16.4	17.0	13.4	16.0	12.0

*Vegetation* : The areas inhabited by this snail, both in plains and hills, are rich in different kinds of vegetations. However, the giant snails usually live in the agri-horticultural gardens and have wide range of food acceptability.

*Atmospheric pressure and oxygen tension* : The atmospheric pressure and oxygen content of air fall with the increase of altitude (Table-III). At an elevation of about 600 m above sea level, atmospheric pressure is only about half to that at sea level. The fall in atmospheric pressure with increase of altitude is, however, not uniform at all elevations.

TABLE III. Atmospheric Pressure and Oxygen Tension at Different Elevation.

Altitude in Metres	Atmospheric Pressure in mm of Mercury	Percentage of Oxygen Tension to that at Sea Level
Sea level	760.00	100.00
300.00	735.00	95.10
1000.00	673.90	88.60
1520.00	631.60	82.00
2000.00	595.00	78.20
3000.00	519.40	68.50

Oxygen, about one-fifth of the air at sea level, becomes increasingly deficient with the altitude along with the reduction of atmospheric pressure and rarefaction of the air in high altitudes.

## DISCUSSION

Under favourable conditions *A. fulica* remains active throughout the year. In India, in the plains the activity of *A. fulica* is restricted to monsoon only for a period of four months, July to October, while in high altitudes it may extend so long as the rain continues. From the present study it appears that there are certain factors which inhibit the distribution and propagation of *A. fulica* in high altitudes. It is evident that the temperature is the most important factor limiting dispersal and propagation of *A. fulica* in high altitude, characterised with a low temperature, about 1° C or below. *A. fulica* became inactive when temperature dropped to 8° C (Raut, 1977). With the lowering of temperature the snails go off feed at temperature below 7° C (Raut, 1977). In an experiment Raut (1977) observed that the giant African snails require a temperature at least 15° C for mating and for the development of embryo.

The snails are nocturnal and during winter the night temperature in plains prevails around 12° C while at 850 m (Imphal) and 1166 m (Nongpoh) the same is found 6° C and 4° C in average respectively. Such low temperatures are not favourable for normal activity of the snail species under study and a continuous exposure to such low temperatures is fatal to the snails. That is why the population density of the snail species gradually decreases with the altitude and fall of temperature. As regard the temperature, one would not have expected any snail there. But, snails do exist, only because of their habit of burrowing by which they can minimise the adverse effect of cold to a certain extent. This is quite evidenced from the study of population density of *A. fulica* at Nongpoh, Imphal and Kumarghat. It is sure that after certain height the weather would be too adverse for the giant snails to lead a life. This is apparent from the deaths of snails at an altitude of 1219.2m in Ceylon (Green, 1910) and failure to reproduce at an altitude 2011.68 m at Musuri in India (Benson, 1858). They are confined to 609.6 m and 913.6 m in Mauritius and Java respectively (Mead, 1961). In all cases it is reported that the snails failed to face the severeness of winter weather. Chock and Nakao (1951) and Raut (Unpublished) showed that exposure to 50°, 40°, 30° and 20° F was fatal for a good number of *A. fulica*. However, the solitary report of Bruggen (1977) on the occurrence of *Achatina machachensis* (Smith) in the mountains of Basutoland at an altitude of 1700 m raises the question whether *A. fulica* could ever be able to conquer such altitude is yet to be known.

Despite the snails are garden pests, they have got a wide range of foodplant acceptability including wild plants (Raut, 1977). Vegetations and soils are considered to be important limiting factors (Raut, in

press), next to temperature. But the type of vegetation is not so important in survival of this species. However, the type of soil is important as they are found largely in alluvial or mixed red soils. Boycott (1934) and Wolda *et al.* (1971), however, did not consider vegetation as the limiting factor for dispersal of European snails.

Regarding the impact of atmospheric pressure and oxygen tension, though not studied properly in molluscs, are considered to be contributing factors limiting the distribution of snail in high altitudes. Although according to Mani (1962) increasing oxygen deficiency of the air at high elevations does not seem to have any appreciable effect on insects. Dahr (1927) and Liebsch (1928) studied the effect of oxygen tension on terrestrial pulmonate *Arion*, (Helicidae) putting them in an atmosphere of 90 to 96% oxygen but they did not find any cognizable difference.

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