

BIOLOGICAL & TAXONOMIC STUDIES
OF LARVAE AND PUPAE
OF SIMULIDAE OF N.W.F.P.
(PAKISTAN)

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

IN THE NAME OF

'ALLAH'

THE MOST MERCIFUL, THE MOST GRACIOUS.

DEPARTMENT OF ZOOLOGY
UNIVERSITY OF CALICUT
KOCHEER, KERALA

BIOLOGICAL & TAXONOMIC STUDIES
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OF SIMULIIDAE OF N.W.F.P.,
(PAKISTAN)

ABDUL HAMID JAN
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M. Phil



A thesis submitted to the University of Peshawar,
in Partial fulfillment of the requirements for the Degree of
"DOCTOR OF PHILOSOPHY"
in Zoology

DEPARTMENT OF ZOOLOGY
UNIVERSITY OF PESHAWAR
NOVEMBER, 1995.

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THE ELEMENTAL & TAXONOMIC STUDIES
OF LARVAE AND PUPAE
OF SIMULIDAE OF K.A.P.
(PAKISTAN)

BY
MR. NARAYAN JAY

DEDICATION

This thesis is affectionately
dedicated to my parents whose
prayers and good wishes are and
will remain with me, Insha Allah.

Supervisor: Mr. NARAYAN JAY

Mr. NARAYAN JAY

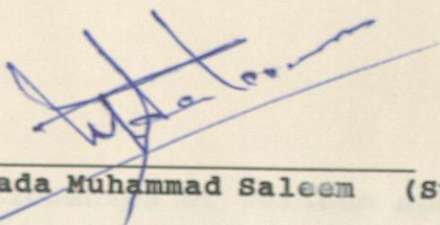
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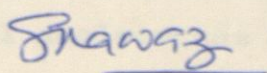
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CLAIM OF ORIGINALITY AND CONTRIBUTION TO KNOWLEDGE

Dr. Pirzada Muhammad Saleem, Professor, Department of Zoology, University of Peshawar who supervised this project with untiring zeal through out. He was the constant source of encouragement and inspiration and provided every laboratory facilities and literature. My special thanks to

Present study is the first comprehensive
his for not leaving me hang about and holding me tight in
Simuliid survey of NWFP Pakistan. Out of 36
the laboratory.

recorded species 8 are new to the Science.

My heartiest appreciation is for Mrs. Sherin Nawaz, Chairperson, Department of Zoology, University of Peshawar for her keen interest in my research, sympathetic attitude.

I also thank Dr. Akram Shah, Zoology Department University of Peshawar, for working as member of Supervisory

The relationships of various species
of Simuliidae have been analyzed. The
Entomology, preimaginal ecology has been studied. The
identification, loan of literature and the type specimens
without which the work would have been impossible, is
gratefully acknowledged.

Finally I wish to extend my sincere appreciation to all my colleagues at the department of Zoology, University of Peshawar, all my friends particularly Mr. Kalsoom, Azam, Farukhan, Saad, Asad and Asghar for cooperation.

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My heartiest appreciation is for Mrs. Sherin Nawaz, Chairperson, Department of Zoology, University of Peshawar for her keen interest in my research, sympathetic attitude.

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ABSTRACT

During a survey of larvae and pupae of the black flies of N.W.F.P., conducted from November 1992 to October 1994, a total of 36 species were recorded from 50 sites. The collection was made from 11 districts and one Agency i.e., Abbottabad, Bannu, Chitral, Charsadda, Dir, Kohat, Mansehra, Mardan, Peshawar, Swabi, Swat and Malakand Agency of North West Frontier Province (Pakistan).

The study included Taxonomy and Ecology of preimaginal stages considering, breeding preferences, substratum preferences, physical parameters of water bodies like water temperature (10-36°C), speed (31-89 cm/sec.), transparency (20-40cm), depth (14-55cm), breeding altitude (285-2800 m), humidity (10-80%) and rainfall (4-100 mm), and chemical parameters like pH (5.7-7.5), $\text{NH}_3\text{-N}$ (.03-.089 ug/cm³), CO_3 (.199-.9 mm/L), HCO_3 (.108-.79 mm/L), Cl (0.061-0.401 mm/L) and Ca^{++} (1.1-3.9 mm/L).

The species recorded in this work are 1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n., 6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16. O. chitraliense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S.

kohatiense sp.n., 20. S. kurense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35. W. turgaica, 36. W. veltistshevi. The type of the specimens (Holotypes) have been deposited in the department of Zoology, University of Peshawar.

The larvae and pupae were collected attached to submerged vegetation like Typha, Potamogeton, Echinochloa, Hydrilla and Cynodon, roots of terrestrial tree, white plastic, sticks, solid rocks, loose rocks or boulders small stone and dead leaves from different water bodies like slow muddy irrigational channel, swift rocky irrigational channel, slow muddy stream, swift rocky or muddy stream, sandy or muddy slow river, swift rocky large rivers, small and large water fall, and rocky hill spring water.

TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	List of Tables	i
	List of Figures	iii
	List of Maps	vii
	List of Abbreviation used in figures	viii
1.0.0	INTRODUCTION	1
2.0.0	Review of literature	5
3.0.0	Material and methods	29
3.1.0	Method for Physical observation	29
3.1.1	Water sampling	29
3.2.0	Physical Parameters	30
3.2.1	Velocity	30
3.2.2	Temperature	30
3.2.3	pH	31
3.2.4	Transparency and Depth of water	31
3.2.5	Humidity	31
3.2.6	Altitude	31
3.3.0	Chemical Parameter	31
3.3.1	Determination of Carbonate CO_3^{2-} And Bicarbonate (HCO_3^-)	32
3.3.2	Determination of Chloride (Cl^-)	32
3.3.3	Determine of Calcium (Ca^{++})	33
3.3.4	Determine of Amonia Nitrogen ($\text{NH}_3\text{-N}$)	33
3.4.0	COLLECTION, PRESERVATION,	34

	IDENTIFICATION AND DRAWING	
3.4.1	Collection	34
3.4.2	Preservation	34
3.4.3	Preparation of slide	35
3.4.4	Examination of the Slide	35
4.0.0	Morphology and terminology	38
5.0.0	STUDY AREA	50
5.1.0	D.I.KHAN DIVISION	50
5.1.1	Bannu District	50
5.2.0	KOHAT DIVISION	50
5.2.1	Kohat District	50
5.3.0	HAZARA DIVISION	53
5.3.1	Abbottabad District	53
5.3.2	Mansehra District	55
5.4.0	MALAKAND DIVISION	56
5.4.1	Chitral District	56
5.4.2	Dir District	56
5.4.3	Swat District	57
5.4.4	Malakand Agency	58
5.5.0	MARDAN DIVISION	59
5.5.1	Mardan District	59
5.6.0	PESHAWAR DIVISION	59
5.6.1	Peshawar District	59
6.0.0	RESULT (TAXONOMIC)	61
6.1.0	GENUS BOOPHTHORA	61
6.1.1	<u>B. erythrocephala</u>	62
6.1.2	<u>B. sericata</u>	64

6.2.0	GENUS <u>Eusimulium</u>	66
6.2.1	<u>E. aureum</u>	66
6.2.2	<u>E. bicorn</u>	69
6.2.3	<u>E. diriense</u> sp.n.	71
6.2.4	<u>E. fontinale</u>	74
6.2.5	<u>E. gvilletense alizadei</u>	75
6.2.6	<u>E. g. gvilletense</u>	77
6.2.7	<u>E. inflatum</u>	79
6.2.8	<u>E. lepnevae</u>	81
6.2.9	<u>E. malakandiense</u> sp.n.	82
6.2.10	<u>E. montium</u>	84
6.2.11	<u>E. planiparum</u>	87
6.2.12	<u>E. pygmaeum</u>	88
6.3.0	GENUS OBOCHOVIA	91
6.3.1	<u>O. albella</u>	91
6.3.2	<u>O. chitrاليense</u> sp.n.	93
6.4.0	GENUS <u>Simulium</u>	95
6.4.1	<u>S. aureohirtum</u>	95
6.4.2	<u>S. austeni</u>	98
6.4.3	<u>S. kohatiense</u> sp.n.	99
6.4.4	<u>S. kurense</u>	102
6.4.5	<u>S. moristan</u>	104
6.4.6	<u>S. multistriatum</u>	106
6.4.7	<u>S. puri</u> sp.n.	108
6.4.8	<u>S. remotum</u>	110
6.4.9	<u>S. swatiense</u> sp.n.	111
6.4.10	<u>S. tumolusum</u>	114

6.4.11	<u>S. warsakiense</u> sp.n.	116
6.4.12	<u>S. xanthogastrum</u>	118
6.5.0	GENUS <u>WILHELMIA</u>	121
6.5.1	<u>W. e. equina</u>	121
6.5.2	<u>W. lineata</u>	125
6.5.3	<u>W. mayariense</u> sp.n.	126
6.5.4	<u>W. mediterranea</u>	129
6.5.5	<u>W. paraequina</u>	131
6.5.6	<u>W. salopiensis</u>	132
6.5.7	<u>W. turgaica</u>	133
6.5.8	<u>W. veltistshevi</u>	135
6.6.0	RESULT (ECOLOGICAL)	138
6.6.1	Ecological observation	138
7.0.0	DISCUSSION	146
7.1.0	Taxonomic correlation	146
7.1.1	Genus <u>Boophthora</u>	146
7.1.2	<u>Eusimulium</u>	146
7.1.3	<u>Obuchovia</u>	147
7.1.4	<u>Simulium</u>	148
7.1.5	<u>Wilhelmia</u>	149
7.2.0	PHYSICAL PARAMETERS	150
7.2.1	Water temperature	151
7.2.2	Water current	153
7.2.3	Climatic factor	155
7.2.4	Altitude and species association	156
7.2.5	Transparency and water depth	158
7.2.6	Substratum	159

7.2.7	Dispersion pattern	161
7.3.0	CHEMICAL PARAMETERS	163
7.3.1	pH	163
7.3.2	Major ions (Ca^{++})	164
7.3.3	Ammonium	166
7.4.0	GENERAL DISTRIBUTION	168
7.5.0	SUMMARY	170
8.0.0	MEDICO-VETERINARY IMPORTANCE	173
9.0.0	SUGGESTION FOR FURTHER WORK	178
10.0.0	REFERENCE	179

LIST OF TABLES

1. Approximate numbers of species in the world fauna.
2. Comparison of character in Eusimulium.
3. Matrix showing percentage in Eusimulium.
4. Comparison of characters of Obuchovia.
5. Matrix showing percentage in Obuchovia.
6. Comparison of character in Simulium.
7. Matrix showing percentage in Simulium.
8. Comparison of character in Wilhilmia.
9. Matrix showing percentage in Wilhilmia.
10. Locality wise distribution in district Swat.
11. Locality wise distribution in Kohat.
12. Locality wise distribution in Dir.
13. Locality wise distribution in different districts.
14. District wise distribution of different Simuliid species.
15. Physical data of water bodies from district Swat.
16. Physical data of water bodies from district Kohat.
17. Physical data of water bodies from district Dir.
18. Physical data of water bodies from different districts.
19. Chemical data of water bodies from district Swat.
20. Chemical data of water bodies from district Kohat.
21. Chemical data of water bodies from district Dir.
22. Chemical data of water bodies from different districts.
23. Breeding preference of Simuliidae.

24. Breeding substratum preference of Simuliidae.
25. Breeding altitude and species association.
26. Seasonal prevalence of Simuliidae.
27. A correlation of rainfall and humidity with different species of Simuliidae.
28. A correlation of other physical parameters.
29. A correlation of chemical parameters (pH) (NH_3).
30. A correlation of chemical parameters (CO_3 , HCO_3).
31. A correlation of chemical parameters (Cl , Ca^{++}).
32. Morphology of *S. vittatum*.
33. Morphology of *S. g. vittatum*.
34. Morphology of *S. vittatum*.
35. Morphology of *S. vittatum*.
36. Morphology of *S. vittatum*.
37. Morphology of *S. vittatum*.
38. Morphology of *S. vittatum*.
39. Morphology of *S. vittatum*.
40. Morphology of *S. vittatum*.
41. Morphology of *S. vittatum*.
42. Morphology of *S. vittatum*.
43. Morphology of *S. vittatum*.
44. Morphology of *S. vittatum*.
45. Morphology of *S. vittatum*.

LIST OF FIGURES

1. General morphology of Simuliid larva.
2. Morphology of *B. erythrocephala*.
3. Morphology of *B. sericata*.
4. Morphology of *E. aureum*.
5. Morphology of *E. bicorn*.
6. Morphology of *E. diriense* sp.n.
7. Morphology of *E. fontinale*.
8. Morphology of *E. gvilletense alizadei*.
9. Morphology of *E. g. gvilletense*.
10. Morphology of *E. inflatum*.
11. Morphology of *E. lepnavae*.
12. Morphology of *E. malakandiense* sp.n.
13. Morphology of *E. montium*.
14. Morphology of *E. Planiparum*.
15. Morphology of *E. pygmaeum*.
16. Morphology of *O. albella*.
17. Morphology of *O. chitrاليense* sp.n.
18. Morphology of *S. aureohirtum*.
19. Morphology of *S. austeni*.
20. Morphology of *S. kohatiense* sp.n.
21. Morphology of *S. kurense*.
22. Morphology of *S. moristan*.
23. Morphology of *S. multistriatum*.
24. Morphology of *S. puri* sp.n.
25. Morphology of *S. remotum*.

26. Morphology of S. swatiense sp.n.
27. Morphology of S. tumolusum.
28. Morphology of S. warsakiense sp.n.
29. Morphology of S. xynthogastrum.
30. Morphology of W. e. equina.
31. Morphology of W. lineata.
32. Morphology of W. mayariense sp.n.
33. Morphology of W. mediterranea.
34. Morphology of W. paraequina.
35. Morphology of W. salopiensis.
36. Morphology of W. turgaica.
37. Morphology of W. veltostshevi.
38. Distribution of Simuliid larvae from Swat and Malakand.
39. Distribution of Simuliid pupae from Swat and Malakand.
40. Distribution of Simuliid larvae from Kohat.
41. Distribution of Simuliid pupae from Kohat.
42. Distribution of Simuliid larvae from Dir.
43. Distribution of Simuliid pupae from Dir.
44. Distribution of Simuliid larvae from different districts.
45. Distribution of Simuliid pupae from different district.
46. Physical data for different water bodies from Swat & Malakand.
47. Physical data for different water bodies from Kohat.
48. Physical data for different water bodies from Dir.
49. Physical data for different water bodies from different district.

50. Chemical data for different water bodies from Swat ($\text{pH} + \text{Ca}^{++}$).
51. Chemical data for different water bodies from Swat ($\text{NH}_3\text{-N} + \text{Cl}$).
52. Chemical data for different water bodies from Swat ($\text{CO}_3 + \text{HCO}_3$).
53. Chemical data for different water bodies from Kohat ($\text{pH} + \text{Ca}^{++}$).
54. Chemical data for different water bodies from Kohat ($\text{NH}_3\text{-N} + \text{Cl}$).
55. Chemical data for different water bodies from Kohat ($\text{CO}_3 + \text{HCO}_3$).
56. Chemical data for different water bodies from Dir ($\text{pH} + \text{Ca}^{++}$).
57. Chemical data for different water bodies from Dir ($\text{NH}_3\text{-N} + \text{Cl}$).
58. Chemical data for different water bodies from Dir ($\text{CO}_3 + \text{HCO}_3$).
59. Chemical data for different water bodies from different districts ($\text{pH} + \text{Ca}^{++}$).
60. Chemical data for different water bodies from different districts ($\text{NH}_3\text{-N} + \text{Cl}$).
61. Chemical data for different water bodies from different districts ($\text{CO}_3 + \text{HCO}_3$).
62. District wise percentage of Simuliidae.
63. Locality wise percentage of Simuliidae from Swat & Malakand.

64. Locality wise percentage of Simuliidae from Kohat.
65. Locality wise percentage of Simuliidae from Dir.
66. Locality wise percentage of Simuliidae from different districts.
67. General Overall percentage of different species of Simuliidae.
68. General overall percentage of Simuliidae (Boophthora, Obuchovia, Wilhelmia).
69. General Overall percentage of Simuliidae (Simulium).
70. General Overall percentage of Simuliidae (Eusimulium).
- 71-72 Simuliid larvae attached to plastic.
73. Simuliid larvae and pupae attached to potomogetan (grass) in bottle.
- 74-75 Simuliid larvae and pupae attached to potomogetan from Kohat.
- 76 Simuliid larvae and pupae attached to potomogetan.
77. Simuliid pupae attached to potomogetan.
- 79-80 Simuliid larvae and pupae attached to typha leaves.
- 81-82 Simuliid pupae attached to typha.
- 83 Simuliid larvae and pupae attached to hydrella and typha.
84. Simuliid pupae attached to Echinochloa.
85. Simuliid larvae and pupae attached to hydrella and typha.
86. Simuliid pupae attached to roots of terrestrial tree.

LIST OF MAPS

1. World wide geographic distribution of Simuliidae.
2. District wise map of N.W.F.P.
3. District wise map of N.W.F.P., showing B. erythrocephala, B. sericata, E. aureum.
4. District wise map of N.W.F.P., showing E. bicorn. dirienne, E. fontinale.
5. District wise map of N.W.F.P., showing E. gvilletense alizadei, E.g.gvilletense, E.inflatum.
6. District wise map of N.W.F.P., showing E. lepnavae, E. malakandiense, E. montium.
7. District wise map of N.W.F.P., showing E. Planiparum, E. pygmaeum, O. albella.
8. District wise map of N.W.F.P., showing O. chitralliense, S. aureohirtum, S. austeni.
9. District wise map of N.W.F.P., showing S. kohatiense, S. kurense, S. moristan .
10. District wise map of N.W.F.P., showing S. multistriatum, S. puri sp.n., S. remotum.
11. District wise map of N.W.F.P., showing S. swatiense, S. tumolusum, S. warsakiense sp.n.
12. District wise map of N.W.F.P., showing S. xynthogastrum, W. e. equina, W. lineata.
13. District wise map of N.W.F.P., showing, W. mayariense, W. mediterranea and W. paraequina.
14. District wise map of N.W.F.P., showing W. paraequina, W. turgaica, W. veltostshevi.
15. N.W.F.P. Map showing Geology.

LIST OF ABBREVIATIONS

USED IN FIGURES 1-38

a	antenna
ch	chitinous frame above posterior sucker of larva
ep	epipharynx
fr	frons
la	labium
md	mandible
mx	maxilla
phs	pharyngeal sclerite
pu	pupa
rf	respiratory filaments of pupa
rp	rectal processes
sm	submentum
tr	trichome
vg	ventral groove of cephalic capsule

CHAPTER - 1

INTRODUCTION

The Simuliidae are small stout-bodied midges generally known as black flies. Not all of them are black but some Neotropical species are even, predominantly yellow or orange in colour. The flies are small, compactly built with a rounded hump back, short broad wings with heavy veins, concentrated near the anterior margin of the wing and body nine to eleven segmented (Puri, 1925).

Female black flies are among the most important insect pests of humans and animals in many parts of the world because of their role as vectors of certain parasites of medical and veterinary importance and due to their irritation, toxic and allergic manifestation of their bite. They feed during the day light hours some time during nights. Not all female black flies bite human, some species feed strictly on birds or other animals and some species do not feed on blood at all. Adult of both sexes imbibe nectar as a source of energy (Smith, 1973).

The greatest public health importance of black flies in their role as vectors of the filarial nematode Onchocerca volvulus, the causative organism of human onchocerciasis ("river blindness"), an ancient malady that still plagues many countries in tropical Africa, Central

America, Northern South America and Yemen where 20 - 30 million people are infected (Crosskey 1967b) the flies also serve as vectors of other filarial nematodes of humans, cattle, ducks, and possibly deer and mouse (Fredeen 1977a). (Peterson 1955). In addition to filarial nematodes, some black flies are known to transmit various avian blood protozoans including the genus Trypanosoma and several species of Leucocytozoon as well as certain viruses pathogenic to various animals (Kiszewski and Cupp, 1986).

The Simuliids are nearly cosmopolitan, being found almost any where if there are suitable rivers and streams for the developmental stages, some forms have colonized remote oceanic islands (Laird 1977b). In general, black flies are only absent from regions that are wholly hostile to them, because of the total absence of running water, polar regions, barren deserts, coral islands or islands of volcanic lavas devoid of streams. Even in hot desert areas black flies can occur in very localized sites where natural water-courses or irrigation channels exist (Laird 1978). Figure 1 displays the geographical distribution of Simuliidae in the world. While approximate number of species and genera/sub-genera are illustrated in table 1.

According to Cross^AKey, (1973) 1,270 species of Simuliidae have been described, he assigned them into 19 genera of which only four, Simulium, Austrosimulium,

ProSimulium, and Cnephia, are of economic importance. The largest and most important genus is Simulium with 1,000 species arranged in 38 sub-genera, and its range is almost fully coincident with that of Simuliidae as a whole. The next largest genus is ProSimulium with about 12% of the species in the family, AustroSimulium with 2%, and remaining 6% distributed among 16 other genera. although Simuliids are distributed widely throughout the world, AustroSimulium is restricted to Australia and New Zealand and ProSimulium and Cnephia to Holarctic region, (Laird 1978).

Black flies of Pakistan are predominantly Palaearctic, with few if any Oriental elements, (Lewis 1973, Saito et. al. 1989). Some attention has been paid to explore Simuliid fauna of this region. Puri (1933), Lewis (1973) and Saito et. al. (1989) are pioneer Simuliid workers in this region reporting 1, 30 and 30 species respectively. Among them Saito et. al. (1989) described 9 new species, 4 unidentified and 17 redescribed with new distributional records. Despite the efforts of several workers, much remains to be learned about the Simuliids of this region. Unfortunately such a comprehensive and systematic work so far has not been done on the group in Pakistan.

Keeping in view the economic losses caused to the live stock and human being, through the mechanical injuries

and diseases transmitted by the flies, a systematic survey of Simuliidae was carried out in N.W.F.P., specially the taxonomic studies of larvae and pupae, with special reference to their distribution, breeding preferences, seasonal variation and the factors that influence distribution.

Long time. Fabricius (1784) for the first time found a Simulium pupa and described it under the name *Simulium*. Verdet (1822), Blanchard (1851) and Westwood (1835) are others of the earlier writers who studied the habits and external structures of the larva and pupa of *Simulium*. Osten-Sacken (1878) and Riley (1884) are also the earliest observers of the habits and structures of larvae of some of the American Simuliidae.

Subbotin (1939-44, 1974, 1979), Stone (1941b, 1943a, 1949b) Crosskey (1961, 1962) and Peterson (1970) are the earlier taxonomists who made higher classification of the world fauna. Crosskey (1963) and Peterson (1970) recognized two subfamilies of Simuliidae: Parasilini and Simuliinae. Stone (1941b) also accepted two subfamilies but considered them to be *Prosimuliinae* and *Simuliinae*. Subbotin (1974) recognized the largest number of subfamilies: Parasilini, Oxymerini, Prosimuliini and Simuliini. Subbotin (1939, 1943, 1944, 1974, 1979) and Stone (1941b, 1943a, 1949b) are the first who studied the habits and external structures of the larvae and pupae of some of the American Simuliidae.

CHAPTER - 2

REVIEW OF LITERATURE

The family Simuliidae has been known in Europe for a very long time. Fabricius (1784) for the first time found a Simulium pupa and described it under the name Tipula sericea. Verdat (1822), Planchon (1844) and Westwood (1848) are others of the earlier writers who dealt briefly with the habits and external structures of the larva and pupa of Simulium. Osten-Sacken (1870) and Riley (1884 and 1886) are among the earliest observers of the habits and structure of larvae of some of the American Simuliidae.

Rubtsov (1959-64, 1974, 1979), Stone (1941b, 1949a, 1949b) Cross^asky (1969, 1980) and Peterson (1978), are the earlier taxonomists who made higher classification of the world fauna. CrossKey (1969) and Peterson (1978) recognized two subfamilies of Simuliidae: Parasimuliinae and Simuliinae. Stone (1941b) also accepted two subfamilies but considered them to be Prosimuliinae and Simuliinae. Rubtsov (1974) recognized the largest number of subfamilies: Parasimuliinae, Gymnopauidinae, Prosimuliinae and Simuliinae. Enderlein (1921, 1930, 1931, 1933, 1934 and 1935) in his series of works divided the family in to seven subfamilies and was the first who worked and classified the Palearctic Simuliid fauna. Subsequent taxonomists in

developing the classification of the families are as follow: Edwards (1931c) divided the genus Simulium in to seven subgenera. Rubtsov (1940b) added a new subgenus (Gnas) and classified black flies fauna of Palearctic region, Smart (1945) raised the genus ParaSimulium into independent subfamily.

The taxonomic studies treatments at the genus were carried out by Stone (1955, 1969), Peterson (1960), Davies (1962), Wood (1963) and Knoz (1965) for Simulium, Peterson (1970) for ProSimulium, Peterson (1977) for ParaSimulium and Wood (1978) for Gymnopais and Twinnia. The other recent worker who contributed some special services in the field of taxonomy at species level are Wilson (1972, Environmentally induced colour variation in Simulium), vajime and Dunbar (1975, Chromosomal identification), Meredith (1987 Chromosome polymorphism Technique), Townson (1987, Biochemical approach to taxonomy of Black flies), Rothfels (1989, Speciation in Black flies), Harnett (1991, molecular approach for diagnosis), Weber (1991, Cytotaxonomic differentiation of species in Wilhelmia), Xiong and Kocher (1991 Cytotaxonomic approach in taxonomy).

The regional distribution of Simuliidae with starting point keys for the area or taxonomic groups are studied as follow:

1. AFROTROPICAL REGION: Chutter (1972^b, South African Simuliid), Crosskey (1960, 1969, 1980, African Simuliid),

Freeman and de Meillon (1953, Ethiopian Simuliid), Lewis and Raybould (1974, Congo, Tanzania and Ghana).

II. AUSTRAL ASIAN REGION: Colbo (1976, Australian Simulium), Crosskey (1967, Australian and Western Pacific Simulium), Mackeras (1952), Smart (1944a, New Guinea fauna).

III. NEARCTIC REGION: Davies et al. (1962, 1977, Eastern Canada and Norway), Davies (1978, New York), Johanson (1903 and 1934, USA), Peterson (1962, 1970, Canada and Alaska) Jamnback (1976, USA and north eastern fauna), Merritt et al. (1978, Michigan), Stone and Snoddy (1969, Alabama fauna), Wood (1978, Eastern Canadian larvae), Wood et al (1963, Ontario), Wygodzinsky and Coscaron (1973, America).

IV. NEOTROPICAL REGION: Coscaron and Wygodzinsky (1972), Dalmat (1955, Guatemalan fauna), Vargas and Diaz (1957, Mexican fauna).

V. PALAEARCTIC REGION: Carlsson (1962, scandinavian fauna), crosskey (1967, Middle East fauna), Davies (1968, British fauna), Davies and Smith (1958, Northern England). Dinulescu (1966, Rumanian Fauna), Edward (1920 British species). Grenier (1953, French fauna), Knoz (1965, Czechoslovakian fauna), Lewis (1973, Pakistani fauna), Peterson (1977b icelandic fauna), Rivoisechi (1978b, Italian fauna), Rubtsove (1940, 1956, 1959-1962, regional fauna, 1962a, 1962b, 1974b, 1974c) Wotton (1978b Finland, 1978c Northern England).

The morphology and biology of blackflies was reviewed by the following workers: Edwards (1915, 1921, 1924) and Puri (1925a-1925b) were the earlier workers to publish the result of microscopic study of morphology of Simuliid flies. The first detailed description and illustration of the larvae and pupae of Indian fauna were provided by Puri (1925b). Numerous authors have dealt with Simuliid biology (Allen 1941, Abdelnur 1968, Anderson and Shemanchuk 1987, Davies et al. 1992, Smart 1934a Tarshis 1973, Wu 1931, Zvyagintzev 1965). The life history of the flies were studied by Cameron (1922), Colbo and Porter (1979), Edwards (1920), Ladle et al. (1977), Puri (1925), Wotton (1976P) and Ecology Adler (1988), Allen (1959), Anderson and Dickle (1960), Beaumont (1975), Chutter (1968), Colbo and Moorhouse (1979), Curry (1972), Dalmat (1954), Davies (1949a, 1953, 1957, 1958, 1963), Ezenwa (1974a), Garm and Vajim (1975), Germain and Griener (1967), Goulding and Deonier (1950), Grenier (1947), Hawkes (1975), Jedlicka (1978a-1978), Jones (1945-1950), Jordan (1974), Kaushik and Hynes (1971), Konurbayev (1978), Maitland and Penney (1967), Marr and Lewis (1964), Matsuo (1978), McCrac (1969), Pentelow (1935), Puri (1925b), Reisen (1977), Rubtsov (1936b, 1947, 1951a), Speir (1976), Usova (1955), Whitton (1975), Williams (1964), Wotton (1979), Zahar (1951), Zvyagintzev (1965).

Larval food, feeding habits and nutrition were studied by Ackermann and Smirnoff (1978), Adamicka (1979), Burton (1973), Carlson et al. (1977), Chance (1970a), (1970b), Craig (1974), (1977b), Davies (1972), Disney (1970), Edler and Carlson (1977), Elouard and Elsen (1977), Elsen (1978), Fallis (1964), Fredeen (1960), (1964), Hinton (1971), Hunter (1977b), (1991), Kurtak (1978), Mc Atec (1932), Meeser (1942), Mokry (1980a - 1980b), Moore (1977), Mulla and Lacey (1976), Peterson (1959), Ross and Craig (1980), Rubtsov (1956), Smart (1943), Serra-Tosia (1967), Underhill (1940), (1945), Wotton ((1976-(1977) and larval interspecific association Disney (1971a - 1972d), Dunbar and Grune^WWald (1974), Wotton (1987).

The colonization of the Larvae and pupae on the substratum were studied by Mokry (1978), Roberts (1992), Wotton et al. (1979). The substrate prevalence, dispersal and distribution was observed by Baldwin et al. (1975), Gross (1972), Lewis (1974b), Phillipson (1956, 1957) and Rubtsov (1964). Work on oviposition of the flies was carried out by Davies (1952), Corbet (1967), Fredeen et al. (1951), Golini and Davies (1975a, 1975b), Hunter (1977a), Lewis (1959), Peschken and Thorstein (1965), Reuter and Ruhm (1976), ruhm (1971) and (1975), Undeen and Nolan (1977).

Method of collection, preservation, rearing etc of Simuliid specimens was studied by Collins et al. (1976),

Davies et al. (1962), Davies and Robert (1973), Davies and Willian (1962), Elsen and Hebrard (1977a - 1977b), fallis et al. (1967), Field et al. (1967), Fredeen (1959, 1961, 1962a, 1977), Frommer et al. (1974), Popapov and Bogdanova (1973), Wood and Davies (1964, 1966).

The larval hatching growth was studied by Bradly (1935b), Carlson et al. (1977), Colbo and Moorhause (1979), Chutter (1972b), Davies (1971), Davies and Smith (1958), Davies and Syme (1958), Hinton (1958, 1964, 1968, 1971), Hocking and pickering (1954), Hunter (1978), Maitland and Penney (1967), Merrit (1978), Neveu (1973a), Obeng (1967), Reisen (1975), Thorup (1974), Ussova (1961), while population dynamic studied by Carlsson (1968), Dalmat (1954), Davies (1950), (1952), Disney (1972b, 1975b), Edward (1920), Obeng (1967), Robtsov (1956), Ross and Merritt (1978) and Zahar (1951).

Seasonal prevalence was studied by Arzube and Shell (1990), Cheke et al (1992), Porter and Collins (1988). Similarly biological control of the flies was studied by Bailey et al. (1974), Batson et al. (1976), Beltaos (1980), Belt and charnetski (1980), Corbet (1958b, 1961b, 1962), Disney (1973, 1975a), Ezenwa (1973, 1974b), Ezenwa and Carter (1975), Ezenwa et al. (1974), Federici (1976), Federic and Lacey (1976), Finney (1975, 1976, 1978), Guillet et al. (1990), Hall (1963), Laird (1978), McMahan (1967), Molloy (1979, 1990), Patrusheva (1966),

Pavlichenko (1977a, 1977b), Peterson (1960), Peterson and Davies (1960), Poinar (1977), Poiner et al. (1976, 1979), Poiner and Ono (1979), Poiner and Takaoka (1979a-1979b, 1981), Rubtsov (1948, 1950, 1957, 1963a-1963b, 1966a-1966c, 1967a-1967d, 1968, 1971, 1972a, 1974a, 1975, 1977 - 1978p) Webster (1914), Welch (1962, 1964), Welch and Rubtsov (1965), Wallace (1971, 1973), Wallace and Hne (1975), Wallace et al. (1973, 1976) and Welling (1977).

The Physico-chemical parameter of larval sites like water current, temperature, pH, conductivity, salinity, hardness, alkalinity, chloride, chlorine, sulphate, sulphide, calcium, magnesium, potassium, sodium, iron, ammonia, nitrite, nitrate, phosphate, oxygen, BOD, colour, turbidity and altitude were studied by Carlsson (1962, 1967, 1968, 1970), Carlsson et al. (1977), Chance (1970), Chutter (1968), Disney (1975b), Glatthaar (1978), Grenier and Rageau (1949), Grenier (1949), Grunewald (1973, 1974, 1976b, 1976c), Granewald et al. (1979), Hauer and Benk (1987), Lewis and Penny (1967), Muirhead-Thomson (1970), Quillevere et al. (1976a, 1977a), Reisen (1974), Wotton (1978a), Zahar (1951).

These flies have been reported as causing grave loss to live-stock from many parts of the world (Anderson et al. 1961, Johnson et al. 1938, Woodman 1948). Schmith (1916) in Hungary reported the swarming of Simuliidae which subsequently killed cattle, donkeys, horses, pigs and sheep

from one to two hours after beings attacked. Fuller and Fry (1991) in South Africa, Madsen et. al. (1991) in Denmark, Rempel and Arnason (1947) in Saskatchewan and numerous American authors gave evidence on similar observations. Black flies also transmit leucocytozone infection and other diseases to turkey (Johnson et. al. 1938, Kiszewski and Cupp 1986, Underhill 1944), duck (Anderson 1968), and water fowl (Anderson et al. 1962, and Roke 1931b).

The medical importance of blackflies as a vector of nematode Onchocerca volvulus in human was studied by Anderson (1968), Barnley prentice (1958), Eichner et al. (1991), Desole and Remme (1991), Duke (1962a, 1962b, 1967, 1968a, 1968b, 1968c, 1970, 1973, 1975), Mc[^]Crae (1966-1968), Strong (1932-1934), Vangas (1945a-1945c), Wanson (1945), Woodman (1948 - 1950) and causes human Onchocerciasis in Albana (Tagboto and Townson 1991) Central America (Strong et al. 1934), Central, West and South Cameroon (Lewis, (1965, 1970), Wahl and Renz (1991). Akogun and Onwuliri (1991), England (Eichler and Nelson 1971), Ethiopia, (Tada 1978b), Ghana (Lewis et al. 1961, Walsh 1978), Guatemala (Deleon 1957, Porter and Collins 1988), Kenya (Mc Mahon 1940), Liberia (Garms, 1973, 1975, 1978, Garms and Voelkev 1969), Nigeria (Cross[^]Key 1954-1957, Lewis 1958), South Africa (De Meillon 1935, Garms and Weyer 1968, Griener et al. 1960), Sudan (Lewis 1953), Tanzania (Hausermaun 1969, Raybould 1967 Wegesa 1970a, 1970b) USSR

(Rubtsov 1968, 1969), Venezuela (Convit 1974, Lewis 1962, 1963), West Africa (Duke et al. 1967, Desole and Remme 1991, Lewis 1966), Western Hemisphere (Hamon 1974a, 1974b, Mallen 1974c) and Western Africa (Lewis and Duke 1966, Quillevère et al. 1976a, Raybould and Grunewald 1975, Vajime and Quillevère 1975).

The following research workers are worth mentioning who contributed by adding new species to this family from their respective areas: Adler (1990), Barnly (1958), Beandein and Will (1965), Becher (1985), Berzina (1953), Craig (1987), Colbo 1976), Datta (1974, 1975), Davies (1950) Davies and Syme (1958), Davies et al. (1962), Debaisieux (1920), De Meillon (1936, 1937a, 1937b, 1940, 1942a, 1942b, 1944, 1950), De Meillon and Hardy (1951), Doby and Saguez (1964), Dunbar (1966), Edwards (1927), Enderlein (1933, 1934, 1935), Fain (1949, 1950a, 1950b), Freeman (1950a, 1954), Friederichs (1920), Gibbins (1934, 1937a, 1937b, 1938a), Golini (1975) Grenier (1947, 1949, 1953), Grenier and Doucet (1949), Grenier and Gvazza (1951), Lewis (1948, 1973) Lewis and Bennet (1974b, 1975) Lewis and Raybould (1974), Lewis and Stan (1968) Mc Crae (1965), Mc Mahon (1947), Meeser (1942) Najera and Vulgono (1961), Nickolson (1950), Pentelow (1935), Peterson (1977a, 1977b), Pomeroy (1920), Puri (1925a, 1932a, 1932b, 1932c, 1932d, 1932e, 1933a, 1933b, 1933d), Rubtsov (1936a, 1939a, 1951a, 1951b, 1952, Skrynnik (1950), Stavi and Knowlton

(1940) Stone (1948, 1949a, 1952), Takahasi (1940, 1941, 1942), Twinn (1936, 1938), Usova (1955), Van Semeren (1944), Vargas (1946), Vargas et al. (1980), Wharton (1949).

Contribution made by the following research workers are in the form of monographs: De Meillon (1944) divided his monographic research work in two parts. In the first part, he studied the bionomics of 24 species of Simulium which he collected from Ethiopia. This study included flies habits, host range, larval ecology, medical and economic significance of Ethiopian Simuliids. In the second part, he provided the taxonomic review of the Ethiopian Simuliidae, gave Key to the genera of this family. He described four new species collected from this region.

Lewis (1948) published his monograph on the Simuliidae of the Anglo-Egyptian Sudan. He presented his work in three different parts. In the 1st part, he gave complete information about the Geology and Geography of the collection sites, clearly showing the details of the sites with well illustrated maps. In the second part he studied the bionomics of 15 species of Simuliidae which he collected from this area. These studies included host range, distribution, abundance in the collection sites, annual variation in number, breeding habits, substrate preference, water bodies prevalence, general habits of the adults, feeding habits of the females and adult range of

flight. In the third part, he discussed a very important issue about the two troublesome species: Simulium damnosum and Simulium griseicollis. He tabulated all the necessary information about the infectious nature of the species, bionomics, control and seasonal prevalence.

Mc Mahon (1951) discovered the early stages of Simulium neavei in phoretic association with crabs of genus Potamon. He claimed this association as first observation. The habits and distribution of the crabs with the description of the male, larva and pupa of S. neavi are included in this work.

Grenier et al. (1960) worked on taxonomic study of West African Simuliidae describing 12 species of genus Simulium. His comparison of setae or scales of abdominal cuticles for final confirmation of west African species with 18 other species from the neighboring countries, is highly appreciated.

The work of Crosskey in the field of Simuliidae is worth mentioning. He published series of research papers: "infection of Simulium damnosum with Onchocerca volvulus (1954)", "Observation on bionomics of adult Simulium damnosum in Northern Nigeria (1955)", "The distribution of Simulium damnosum in Northern Nigeria (1956)", "Man biting behaviour in Simulium bovis in Northern Nigeria (1957a)", "The Simuliidae of northern Nigeria (1957b)", "First results in the control of Simulium

damnosum (1958a)",. "A taxonomic study of the larvae of West African Simuliidae with comments on the morphology of the larval black fly head (1960)". "The classification of Simulium laetrile from Australia, New Guinea and the Western Pacific (1967a)", "The preliminary revision of the black-flies of the Middle East (1967b)", "A reclassification of the Simuliidae of Africa. "Family Simuliidae in Oriental region (1973a)", "Simuliid insects and other arthropods of medical importance (1973b)" and "Simuliidae of Afrotropical region (1980)".

Crosskey (1957) recorded 14 species from Northern Nigeria, showing their distribution by different maps. He correlated his work with species from Ethiopian region which were similar except Simulium kenya being recorded for the first time from west Africa. No new species was found in his extensive survey of about 200,000 square miles. Some notes are included on the breeding habits of all the species from Northern Nigeria particularly the type of breeding site preferred, the altitudes at which breeding occurs and the months in which larvae and pupae had been found. He also discussed the factors which appear to influence their distribution. Among the other factors like climate, altitude, and vegetation zones, in his view, Geology of the country was the most important factor which determined the areas of rivers suitable for breeding.

Lewis (1956) published another monograph "Notes on Simuliidae in the Sudan" in which he described 21 species and two "forms" of black flies and brought several changes in names and status of previously recorded species. Simulium alcock Var. henrardi is synonymous with S. alcock, S. rotundum Gibbins becomes S. unicornutum from Rotundum (Sudan), S. nigritarsis Coquillett becomes S. gureosimile pomeroy. His study includes detail notes on the larvae, pupae and adults of the species in Sudan including ecology, behaviour and emergence time of Pupae. He also discussed the problem of S. griseicolle in Angola. He ended his monograph with the Simuliidae of Jebel Marra with geographic description of the area and collection of 7 species previously recorded. He stated that few species occur in Jebel Marra but S. medusacforme var. hargreavesi is abundant. He also recorded emergence time and other features of S. griseicolle from this area.

Crossky (1960) contributed another monograph which is giving comprehensive and complete information about all aspects of larvae, pupae and adults of West African Simuliidae. He divided African Simuliid in to two major divisions A and B. A consists of:

Group 1: (Simulium alcocki, S. johannae, S. schoutedeni,
S. imputane, S. kenya, S. mcMahon),

Group II: (Simulium cervicornutum, S. unicornutum),

Group III: (Simulium ruficorne, S. aureosimile),

Group IV: (Simulium hivsutum, S. adersi, S. bernerii).

DIVISION B:

Group V: (Simulium griseicolle)

Group VI: (Simulium dentulosum, S. loutetense)

Group VII: (Simulium medusaeformis, S. vorax, S. colas-belcouri, S. bovis, S. damnosum).

The start of the monograph is with brief introduction and list of West African Simuliidae. In the middle of his work, he gave morphology of the Simuliid head capsule, larval characters and their taxonomic value. The last part of monograph contains larval descriptions, notes on larval instar, larval classification and key to species groups of Ethiopian Simuliidae and key for identification of larvae of West African black flies.

Fredeen (1964) has contributed to study the food of black flies larvae "Bacteria as food for black flies larvae in laboratory cultures and in natural streams". He has speculated on the importance of bacteria to causes severe Simulium outbreaks and demonstrated enhanced survival of large larvae when a bacterial diet was supplemented by algae.

Wotton (1976a) worked on distribution of black fly larvae in a survey of 12 streams in upper Teesdale streams, Northern England. Of the 35 British species, he recorded 11 species in the study streams and four others from surrounding areas during 3 consecutive Summer seasons.

He gave a detailed description of the stream, larval preference of substratum, zonation of the species, larval hatching and seasonal variation, illustrated by maps and tables. His conclusion was that Eusimulium aureum, among other species, showed substratum preference and zonation in Moss Burn Stream. Large number of larvae hatched from eggs in early Summer.

The monographic contribution of Hansford (1978) is on life history and distribution of Simulium austeni (a man biting species) in relation to phytoplankton in some southern English river. He topographically explained the study area with limnological analysis of the water bodies. Beside his full attention of life cycle of the species, he also recorded other three genera and nine species of the subfamily Simuliinae i.e. Three species of Eusimulium (E. aureum, E. lundstromi, E. venum), 4 species of Simulium (S. austeni, S. argyreatum, S. erythrocephalum, S. ornatum) and 2 species of Wilhelmia (W. equinum, W. lineatum). He concluded that beside other factors like pH, conductivity, alkalinity, Ca, $\text{NO}_3\text{-N}$ and $\text{PO}_4\text{-P}$, phytoplankton is an important factors which influence directly the larval growth of S. austeni.

Richard et al. (1978) published his monograph on larval ecology, including species composition, succession and seasonal abundance of immature Simuliid in the Rose Lake wildlife Research Area in Lower Michigan Peninsula. He

examined physical and chemical characteristic of streams selected and compared in relation to faunal distribution. He also provided standard keys and illustrations for the identification of larvae and pupae of four genera (Prosimulium, Simulium, Stegopterna, Cnephia) and 19 species which he collected from the stream. Two species, Cnephia ornithophilia and Simulium vernum, were recorded for the first time in Michigan.

Cupp and Gordon (1983) in their attempt, published a monograph describing black flies, collected from different localities of Northeastern United States. They presented information concerning 61 species of Simuliidae found within 11 state areas. This research work contained illustrated key for the identification of genera Cnephia, Ectemnia, Greniera, ProSimulium, Simulium, Stegopterna and Twinnia. They also provided characteristic features of the family with special review on biology, medical and Veterinary importance, of these biting flies with distribution illustrated by maps.

Crôg (1987) collected Simuliid fauna from the Society Islands (France). He revised the taxonomy of the Simuliidae of these Islands in French Polynesia, giving his own taxonomic key for identification of genera, subgenera and species. He described 13 new species from the Islands and formulated different grouping of the species from different Islands. His work also included illustrated Keys

for identification of larvae, pupae and adults of Tahitian Simuliidae and information on habits, bionomics, geographical distribution and phylogenetic relationships.

Doisy et al. (1986) collected 14 species in a survey of Simuliids and associated water quality indicators over 2-year period from the Big piney river and other streams (Ozark) in Missouri. Water temperature appeared to be a key factor influencing the distribution and abundance of the species studied. His research work also included substrate preference, water depth for larvae and pupae being found attached to submerged large stones, aquatic plants, sticks and dead leaves.

Kizewski and Cupp (1986) experimentally confirmed the transmission of Leucocytozoon smithi (Sporozoa: Leucocytozoidae) by black flies (Simulium aureum) in New York, USA.

Cross Key (1980) presented an annotated checklist of world Simuliidae for the 1st time in 40 years (i.e. since that of Smart, 1945). All formally described species known up to mid-1985 are included, comprising just over specific/subspecific and 122 generic/subgeneric names: 1461 species were listed as valid on the available evidence. The geographical distribution of each valid species is given in brief. The author's viewpoint is reflected in the ranking of super specific taxa, in that Simulium, for instance, is treated as a broad genus containing subgenera and species

groups. The checklist is introduced with a synopsis, and introduction explaining general points, nomenclature, authors names, classification and geographical information.

Cummins (1975) worked on the functional role of black flies in stream ecosystem stating that as larvae fit into 2 resource-utilization functional groups: (1) filtering collectors or suspension feeders (e.g. Simulium, ProSimulium. Cnephia) and (2) scrapers (e.g. Twinnia, Cymnopais, Crozetie). These and other aspects are discussed with regard to the qualitative and quantitative roles of simuliid utilization of organic matter in running-water ecosystems. Kim et al. (1987) published a comprehensive outcome of the international conference on ecology and population management and annotated world list of black flies held on 28-31 May, 1985.

The blood feeding habits of black flies on different host species (Chicken, rabbits, horses, and different breeds of cattle) were discussed by Schemanchuk (1987).

Adler (1988) gave a general account of the ecology and life history of the Simulium vittatum and ProSimulium mixtum complexes in a stream in central Pennsylvania and of the Simulium tuberosum complex in Alberta. He also discussed the methods of distinguishing cryptic species.

Eymann and Friend (1988) studied the behaviours of larvae of the black flies (Simulium vittatum and Simulium decorum association) which established and exhibited a specific dispersion pattern on natural and artificial substrates. The conclusion was that the dispersion pattern exhibited depends on microhabitate rather than species.

Sasaki et al. (1987) worked on feeding habits of black flies and practically confirmed the ornithophilic nature of Simulium rufibasis in a survey made during late june and mid july from 6 localities in Japan.

Hahn et al (1989) experimentally proved that Simulium jenningsi and S. vittatum causes the epidemiology of potomac horse fever.

Rothfels (1979) interpreted patterns of spatial and temporal relationships among the most closely related species interpreted in terms of sympatric speciation than of allopatric speciation. specific examples are (1) the allotriploid taxa in Gymnopais end other genera, (2) the black fly faunas of geologically recent islands (e.g. Tahiti) and (3) species in ProSimulium onychodactylum, a prototype of a continental multisibling species complex. A model or sympatric speciation is presented which predicts that (1) populations should frequently exhibit sex-chromosome polymorphism, (2) these sex-chromosome

polymorphisms, and autosomal ones, should in some cases display linkage or association.

Ciborowski and Adler (1990) while working on ecological segregation of larval black flies in northern Canada, found 20 species from 20 sites on a stream near: Uranium city in correlation with 16 physical and chemical attributes (1) Stream size (2) pH, conductivity, and turbidity (3) Oxygen saturation and substrate particle size (4) Lake outlets and (5) water current velocity). the conclusion was that Simuliid occupies distinct ecological entities, each adapted to particular suites of environmental variables.

Adler (1990) described two new species Simulium fionae sp. nov. (a member of S. vernum group) from Pennsylvania and Hamshire (North America), S. claricentrum sp. nov. (a member of the S. pictipes group) from Arkansas, Missouri, Oklahoma and Pennsylvania. Bass (1990) reported 12 species of the genus Simulium from Co. Kerry (Iris Republic). Eymann (1991) worked on dispersion pattern exhibited by larvae of black flies, Cnephia dacotensis and S. rostratum. Hunter (1991) worked on black flies feeding habits.

The contribution of Randall et al. (1991) is on the influence of temperature and food quality on the growth of black flies larvae and pupae Simulium vittatum). He made different experiments and gave a qualitative list of the

food material, illustrated with figures. Palmer and Keeffe (1995) worked on distribution and abundance of blackflies in relation to impoundments in the Buffalo river, eastern Cape, South Africa. He recorded 23 species of Simulium and studied the different factors which have direct effect on the distribution of larvae and pupae of blackflies. He also gave information about filter feeding habits of the larvae.

The Simuliid works in India, Kashmir and Pakistan was carried out by the following workers:

Puri (1925a, 1925b, 1926, 1932a-1932e, 1933a-1933d) Published series of reprints on Indian Simuliidae. He was the first person who worked on black flies of this subcontinent and gave first detailed description of the complete larval morphology of Simulium equinum Var. mediterraneum (1925a), Life history and structure of the early stages of this family (1925, 1926), two new species (I) Simulium himalayense and (ii) Simulium nilgiricum from Bombay, India (1932a), Description of males, females and pupae of Simulium rufibasis brunetti from Simla India and three new species (I) S. ramosum (II) S. Christophe and (III) S. nitidithorax from Simla, India (1926), descriptions of males, females and pupae of S. griseifrons and four new species from kandaghat, India (1932c), two new species: S. Howletti and S. hertipannus with a note on S. Ornatum from Northeast India (1932d), Species and varieties of Striatum series (1932c), description of males, females

and pupae of two new species (S. grovelli and S. palniense) from Palni Hills and of male and a pupa of another new species S. tenuitarsis from Bengal (1933a), two new species: S. nodusum and S. novolineatum Frazerpet (1933b), S. aureohirtum and S. aureum with new varieties and record from Erguy, India (1933c).

Datta (1974) described a new species belonging to subgenus Simulium latreille from Darjeeling (India). He identified and named the new species as Simulium nigrifacies with the help of Key of this subgenus for males, females, pupae and larvae. He considered all taxonomic characters and also discussed briefly the breeding habits of the species.

Datta (1975) published an other monograph on "Simuliida, from Assam foot-hills, India, describing seven specific segregates comprising five new species: Simulium kapuri, S. bucolium, S. litoreum, S. unum and two unnamed species.

Edward (1927) was the first to publish two new species of Simulium from Kashmir. Though he was not correct to put the collection site properly. The two new species i.e. Simulium stevensoni and Simulium Kashmiricum. n. were collected from Chilas, near Gilgit which is a part of Northern areas Gilgit rather than Kashmir, Moreover Identification of Simulium stevensoni was made by examining 11 adult female only (mostly more or less damaged), while

that of Simulium kashmiricum by 42 adult females, also damaged.

Puri (1933d) reported S. equinum var. mediterraneum, collected from submerged grass blades in a large irrigation channel in South Waziristan and Rawalpindi, Pakistan. This work also includes a new species: S. Parequinum (description made on male and female, being bred out of isolated pupae collected from a large stream) from Wah, near Hasan Abdal, Pakistan.

The contribution of Lewis (1974a) is worth mentioning. He worked on Simuliid of Pakistan. He was the first to give a list of 31 species, collected from only three areas of Pakistan during May and June 1963, capturing 845 pupae, few larvae and 143 adults. He described 3 new species a few unidentified and un-named. His work includes a taxonomic Key, based mainly for pupae, and described a new subgenus Himalayum for previously unknown male, pupa and larva of Simulium indicum. He also studied the breeding places and provided breeding association of all the species collected. He found S. mediterraneum in polluted water.

Saito et al. (1989) is the second, who published a list of thirty species belonging to 4 genera of black flies, collected in the Northern part of Pakistan in the Summer of 1987 and 1988. Nine of them Eusimulium nemorivagum, Obuchovia albela, O. variegatum, Simulium

griseus, S. barraudi and Wilhelmia veltistshevi were newly recorded from Pakistan.

Ahmad (1992) worked on systematics and ecological study of Simuliidae from district Chitral (N.W.F.P. Pakistan). He collected larvae and pupae and identified them up to the genus level: (I) Schonbaueria (II) Eusimulium (III) Simulium (V) Wilhelmia and (IV) Obuchovia. His work includes 5 genera and 4 species i.e. Eusimulium aureum, Simulium xanthogastrum, Wilhelmia equina and W. mediterranea and chemical analysis of four streams for Ca^{++} , Cl , CO_3 and HCO_3 .

2.1.1

WATER SAMPLING

The sampling of water is done by various methods but one thing is clear that water sampling depends upon the type of water to be taken e.g. there are different methods available for drinking water samples while river and stream water sampling is done by other methods. (Ahmad, 1992). Water samples were taken very carefully directly from origin where larvae and pupae were present. The samples were collected in clean and dry bottles in such a way that no bubbles are allowed on that way a drop of "Tolene" was added to it to prevent microbial infection. The bottles were then transported to the laboratory, filtered through filter paper No. 42, stored in cool place and analyzed for different parameters.

CHAPTER - 3

MATERIAL AND METHOD

A large number of places in the plains and hills of all the districts of N.W.F.P. were surveyed for the collection and ecological observation of Simuliid larvae and pupae. The common rivers, streams and irrigation channels of each district were thoroughly examined as follows.

3.1.0 METHODS FOR PHYSICAL OBSERVATION :

3.1.1 WATER SAMPLING:

The sampling of water is done by various methods but one thing is clear that the water sampling depends upon the type of water to be taken e.g. there are different methods available for drinking water samples while river and stream water sampling is done by other methods. (Khan 1984). Water samples were taken very carefully directly from origin where larvae and pupae were present. The samples were collected in clean and dry 400 ml bottles in such a way that no bubble was allowed in bottle and a drop of 'Toluene' was added to it in order to prevent microbial infection. The bottles were then transported to the laboratory, filtered through filter paper No 40, stored in cool place and analyzed for different chemical parameter.

3.2.0 PHYSICAL PARAMETERS:

Streams were characterized according to their physical features such as Velocity, temperature, (both air and water) pH, Depth, Transparency and Substrate.

3.2.1 VELOCITY:

Velocity of water was measured with the help of stop watch, a piece of paper and a meter rod. The distance between an up-stream and down-stream point was measured with the help of meter-rod in cm. A small piece of paper was dropped at up-stream point, and as soon it touched the water surface, the stop watch was on. As it reached the down stream point, the watch was stopped and the time in second was recorded. This experiment was repeated thrice at different points of stream. The velocity V of the current was calculated in cm/sec by using the formula:

$$V = S/T$$

where:

S = distance in cm between the up and down-stream

T = time in second required for distance ' S '

3.2.2 TEMPERATURE

Water and air temperature was recorded with simple mercury thermometer in degrees centigrade, at the time of sampling at each site. Air temperature was taken in Shadow, while water temperature was noted by dipping the bulb of thermometer in water for 5 minutes.

3.2.3 pH :

pH of the water was determined at the spots by pH paper (China made) having a pH detection range from 5.5-8.5. A solution of 0.50% using Phenolphthaleine and Methyl orange as indicators.

3.2.4 TRANSPARENCY AND DEPTH OF WATER:

Transparency and depth of water was observed directly with folding scale (Ruler) having 80 cm length. The scale was lowered in water until it just disappeared, or touched the substratum. The distance was noted in cm, the process was repeated three times and averaged.

3.2.5 HUMIDITY:

Humidity was measured with the help of Hygrometer and wet-dry bulb theromometer.

3.2.6 ALTITUDE:

Altitude was measured with the help of Altimeter. The nature of the stream bed, and presence or absence of vegetation on the banks and submerged in the water were carefully examined, (Table 23,24).

3.3.0 CHEMICAL PARAMETER:

Water samples for chemical analysis of CO_3 , HCO_3 , Cl and Ca were Sieved with the help of kitchen sieve for removal of part of plant and other substances.

3.3.1 DETERMINATION OF CARBONATE (CO_3^{2-}) AND BICARBONATE (HCO_3^-)

Determination was carried out by titration with 0.01 N solution of H_2SO_4 , using Phenolphthaleine and Methyl orange as indicators.

A 10.0 ml water sample was taken in a conical flask. A few drops of Phenolphthaleine were added to the contents of the flask. This sample was then titrated against 0.01N solution of H_2SO_4 , until the colour just disappeared.

The reading on burette was designated as "y". Then a few drops of Methyl organ were added to the same sample and was again titrated against .01N H_2SO_4 until the pinkish-colour was appeared. The reading noted from burrete was designated as "z".

The process was repeated three times and average reading was taken for getting proper results. Calculations were done with the help of the following formula:

Carbonates(CO_3) Meq/L = $2Y \times N$ of $\text{H}_2\text{SO}_4 \times 100\text{ml}$ of S. H_2O

Bicarbonate(HCO_3^-) Meq/L = $(Z - 2Y) \times N$ of $\text{H}_2\text{SO}_4 \times 100$ ml of S. H_2O

3.3.2 DETERMINATION OF CHLORIDE (Cl^-):

Chloride (Cl^-) was determined by titrating the sample water against .005 N solution of AgNO_3 using Potassium Chromate (K_2CrO_4) as indicator.

A 10.0 ml sample of water was taken in titration flask. 2-3 drops of Potassium Chromate were added to the sample and was titrated against .005N solution of AgNO_3 , until reddish colour was appeared. The practice was repeated three times and average reading was recorded.

The amount of Chloride (Cl^-) was calculated by the following formula:

$$\text{Meq of } (\text{Cl}^-) / \text{L} = \text{ml of } \text{AgNO}_3 \text{ used} - \text{ml of } \text{AgNO}_3 \text{ used for blank water}$$

$$\times .005 \times 1000 \text{ ml of sample water.}$$

3.3.3 DETERMINATION OF CALCIUM BY TITRATING AGAINST 10 N SOLUTION E.D.T.A:

A 100.0 ml sample of water was taken in a conical flask. A few drops of sodium hydroxide solution (4.0N) and 15.0 mg of ammonium murexide were added to the sample as indicator.

The sample was then titrated against .01N E.D.T.A. Until the colour changed from orange red to purple. Change in colour indicated the end point of the reaction. The process was repeated and average recorded.

For the calculation of Calcium (Ca^{++}) following formula was used: $\text{Meq of } \text{Ca}^{++} / \text{L} = \text{volume of E.D.T.A. used} \times \text{N of E.D.T.A.} \times 1000 \text{ ml of sample water.}$

3.3.4 DETERMINATION OF AMMONIA NITROGEN ($\text{NH}_3\text{-N}$):-

The Ammonia Nitrogen was determined with spectrophotometer (spectronic 20).

3.4.0 COLLECTION, PRESERVATION, IDENTIFICATION AND DRAWING:

3.4.1 COLLECTION:

Systematic field collecting programmes were made and regular tours were conducted. A random selection of the common rivers, streams and irrigational channels of each district of N.W.F.P. was taken and the places where larvae and pupae expected were thoroughly examined. The collection was done during November 1992 to October 1994. As black flies larvae and pupae inhabit swift water, so the stones, vegetation and other objects near the water falls and at rapid shoals were mostly searched. They were removed easily from the submerged substrate with brush and fine forceps. As pupae were firmly fixed to their holds, they needed careful side to side pressure to loosen them and prevent pinching and least damage and were picked up by the hind end of the cocoon. The branches of grasses, and other aquatic plants to which the larvae and nymphs were attached, brought to the laboratory for plant taxonomic identification. The abundance of larvae and pupae at the collection sites were studied with Palmer method (Palmer 1994).

3.4.2 PRESERVATION:

Larvae and pupae were brought to the laboratory in glass bottle measuring about 4.5 x 2.0 cm with non-contracted neck and a screw cap, containing Ethyl alcohol

with a minimum of 80% strength but a 95% strength was also used if larvae were wanted with opened head=fans and extruded rectal organs. Alcohol at 70% strength is widely used but is unsatisfactory because water on and in the larvae during collection dilute the alcohol to an unsafe level for preservation. The larvae and nymph were transferred to freshly made 70% alcohol when brought to the laboratory.

Certain characters were best seen in alcohol without mounting like body shape, pigmentation and coloration, presence or absence of ventral papillae, form of the postgenel cleft and secondary lobules in the anal gills. Almost all other characters required slide mounts. Before identification the pupae and larvae were cleaned in 10% KOH (5.6 gm of KOH + 100 ml of water) by boiling for 2-3 minutes, washed with water, dehydrated through graded series of alcohol, clean in clove oil for 24 hours and mounted in thick layer of canada balsam.

The larvae were also placed directly in a drop of glycerine on slide and dissected under bi-nocular microscope with the help of fine needles and brush. Microscopic slides were prepared for the identification as follows.

3.4.3 SLIDES PREPARATION:

The head of the larva was cut and divided laterally, the submentum removed, respiratory filaments

extract and posterior sucker and rectal processes used in preparation of slides. All these parts were mounted in Hoyer's medium (water pure = 50cc, Gumarabic = 30g, Chloralhydrate = 200 g, Glycerin = 220cc). From the pupa respiratory filaments, frontal scleritis, dorsum and abdomen were separated, and the abdomen was cut into dorsal and ventral halves. Measurements of the specimens were taken with micrometer.

For identification purpose head of larva, cephalic fan, antenna, mandibles, submentum, ventral groove, crockets in posterior sucker, number of respiratory filaments in pupa, shape and structure of cocoon and arrangement of spines and hairs on the dorsum of pupa were mostly studied.

Diagrams or sketches of each different parts of the specimen based for identification were drawn on the paper with the help of drawing apparatus.

3.4.4 EXAMINATION OF THE SLIDES OF LARVA AND PUPA

All the slides were examined under a high power compound microscope. Identification up to genera and species level was done with the help of keys (Lewis 1968, 1974 and Rubtsove 1989) and by comparison with original descriptions and type specimens. New species were named according to the International System of Nomenclature. The names were selected from the Source Book of Scientific Names.

Drawings of the antenna, analplate, bristles of flabellum, bristles on back of pupa, epipharynx, frons, genital plate, hooks at end of abdomen of pupa, labium, labrum, mandible, maxilla, palp, posterior end of larva, posterior end of pupa, papillae of hypopharynx, pharyngeal sclerite, respiratory filaments of pupa, rectal processes, submentum, spines on posterior end of larva, spines on abdomen of pupa, trichome and ventral groove of cephalic capsule, larval and pupae body were made with the help of drawing apparatus. Magnification is given along each drawing. The measurements are given in millimeters.

All the species have been described in detail. The description of each species included almost all diagnostic morphological characters, measurements of various body parts, distribution of species in Pakistan and the points of separation of new species from the closely related species.

Tables 2,4,6 and 8 for comparison of characters of species within each genus were prepared. From these Tables, Similarity Matrixes (Tables 3,5,7 and 9) for the respective genera were prepared.

CHAPTER - 4

MORPHOLOGY AND TERMINOLOGY

General shape of body vermiform, with thick thorax and highly dilated posterior end. Head large, with complex and well-developed antennae, oral process, and large filtering organs (flabella) for collecting food, typical of most members of family Simuliidae (subfamily Simuliinae). Head distinctly demarcated from body by constriction. Body indistinctly divided into two segments, rarely with projections on abdominal and lateral sides of last segments, in which case abdominal side of body often flat. Thoracic section with well-developed unpaired "leg" on ventral surface with crown of crochets at apex, making caterpillarlike movement of larva possible over substratum priory covered with secretion from its arachnoid glands. Posterior end of body with well-developed organ of attachment, with disk of numerous crochets used in stabilizing larva both during movement and during rest, sometimes called at posterior end of the body. Body color highly variable even in a single species. Light yellow, ochereous-musty green, brownish, and dark chocolate-brown spots predominate. Head usually darker than body, often black.

Head cylindrical, its length much greater than transverse diameter, and latter slightly less than body thickness. Head tilts slightly along longitudinal axis toward ventral side. Appendages of head situated in anterior part of capsule demarcated by distinct frontal suture into connected on lower side without discernible margin separated by distinct suture, posterior margin of capsule incompletely chitinized.

Frontal scleritis narrow anteriorly, curve downward, fuse with labrum, and further convert into epipharynx of complex structure. Frontal scleritis with dark pigmented pattern, of great importance in species diagnosis. Frontal pattern always closely associated with position of muscles attached to inner surface of frontal sclerites. When the sites of muscle attachment and their areas adjacent to the frons are darkly pigmented, and the remaining area lighter in color, the frontal pattern is called positive. Contrarily, when the frons is more darkly pigmented around the sites of muscle attachment, the frontal pattern is called negative. Depending on the age of the larva and its feeding behaviour, pigmentation may vary highly in the same species, however, the general pattern of markings is constant.

The **antennae** are located on either side of the frons, in the anterodorsal angles of the **genal scleritis**. Antennae long, with at least three segments distinctly

demarcated, 1st segment almost twice thicker and longer than 2nd segment, 3rd segment very small. Usually 1st segment divided by thin constrictions in two parts, but sometimes, into six to seven parts, and hence the antenna as a whole seems to have nine segments. Constrictions often incomplete, reaching only half way, or barely perceptible. If pigmentation is present, it is unique for each species and of taxonomic significance. The relative length of the antennae may serve as a convenient group or generic character and it is more convenient to use not its absolute length, but relative length, compared to the stem of the nearby flabella.

Flabella are complex, multisegmented chitinous structures, located in front of the antennae and immediately below them, which serve the purpose of catching food. They consist of a basal trunk and hairs.

The bristles of the large flabellum are pinnate and curve downward, facilitating the capture of large prey. The large flabellum is followed in the same row by short spatulae which are followed by the small (lower) flabellum consisting of shorter bristles at the S-shaped end of the spiral. The number of bristles in the basal flabellum varies from 5 to 15, in the large flabellum from 20 to 80, in the small flabellum from 15 to 40, spatulae from 5 to 9.

The **labrum** is short, liguliform, and covered with straight hairs and bristles on outer side that extend

forward. Lower margin of labrum passes proximally into **epipharynx** which is a transverse thickening located dorsally above oral cavity. **Hypopharynx** also with a few rows of short bristles that extend backward toward pharynx.

Strong **mandibles** of complex structure occur lateral to the epipharynx, one on each side, toward the lateral margins of the cephalic capsule, which is particularly strengthened here by chitinous thickening. Their apices are directed toward the mouth and are so attached to the cephalic capsule that they move almost in a horizontal plane. Armed with a complex system of brushes and bristles of variable shape and size predominantly on the outer side.

The **hypopharynx** is located under the epipharynx between the maxillae and mandibles. The complex **labium** is located ventrally in relation to the hypopharynx and consists of three sclerites, of which the outer (submentum) is of maximum importance in taxonomy. The shape of this sclerite, the size and number of marginal and medial bristles, and especially the relative size and shape of the nine frontal teeth of hypopharynx are of great diagnostic value.

To distinguish between individual teeth, they have been numbered from 1 to 7 commencing from the middle tooth. The 1st and 5th teeth are usually larger than the others and facilitate orientation and homologization of the

other teeth. The lateral serration of the submentum is rather variable but difficult to study in individual species.

The **ventral groove** of the cephalic capsule is located on the ventral side at the place of articulation between the head and thorax. The variable shape of the ventral groove characterizes individual groups of species. Structural details of the groove, width of groove, and distance up to the posterior margin of the submentum characterize individual species.

The chaetotaxy of the body has not been studied and is not used in taxonomy. The **rectal processes** above the anal opening has shape trilobate, multilobate or, often, comprises a varying number of smaller papillae situated on three basal lobes. Their histological structure unique in each species.

The chitinous structure of the posterior organ of attachment is of rather great taxonomic value, **posterior sucker**. It is located on the last abdominal segment. It is in the form of a disk of crochets with a postanal **chitinous frame** toward the front, the frame consists of two semicircles with a joint for articulation in the middle. The lower and especially the upper branches of the chitinous frame vary markedly in length and details of shape. The number of rows of **crochets** in the disk (30 to

300) and number of **hooks** in each row (8 to 40) are typical for each species.

Pupa completely or partly enclosed in a **cocoon**. The cocoon is woven by the larva prior to pupation and has a roundish opening through which the respiratory filaments or even the pupa protrudes. The exuviae of a pupated larva is also discarded through this opening. It is not difficult to detect during an examination of a freshly pupated larva, and is important for a precise diagnosis of the larva belonging to the pupa of the same species.

The most usual cocoon shape resembles a small hut. Such a cocoon is called **simple**. Cocoons of other shapes result from various modifications and complexities, mainly in the structure of the frontal section of the cocoon. There may be a thickening, the so-called **edging**, or a small projection which converts into a **corniculate process** in some species at the anterior opening. Sometimes there are two corniculate process. The anterior margin of the cocoon may be closed ventrally and an **anteroventral collar** present. A cocoon with an extended collar is termed **shoe-shaped** and with a collar longer than the length of the cocoon itself, **boot-shaped**. Lastly, the cocoon may be **cup-shaped** when, together with the pupa, it is attached in to the substratum by a petiole. Often the collar is woven and the weaving unique for each species. In such cases the

nature of the weaving is of diagnostic value. Quite often the collar or anterior margin of the cocoon contain numerous perforations (openings). Attention should be paid to the number, size, and shape of these openings. In addition to the general shape of the cocoon, the nature of the weaving, thickening and transparency of the walls, nature of the surface, color of the cocoon, its tautness or looseness, the elasticity or friability of the walls, and the presence of inclusions are also of diagnostic value.

In general shape the pupa of black flies resembles the body of an adult insect. **Respiratory organs** that protrude forward are always present in the shoulder fields. These organs are connected basally with the anterior spiracles of an adult insect by a complex tube. The respiratory organs are highly variable in structure, their details typical for each species, and thus of diagnostic and taxonomic importance (in most cases for group diagnosis).

The respiratory organs vary in number from three to four to 150 on each side. The nature of branching is more or less unique for each species, although relatively variable. Branching is by and large dichotomous, but sometimes disorderly, and the branches either extend forward in the same plane or, in the case of haphazard branching, diverge somewhat, individual filaments and their

dendroid groups may originate from the base of the respiratory organ or from a relatively long stem.

Counting of filaments is always done from one side, i.e. for one respiratory organ. A significant species characteristic is the relative length and thickness of the filaments that are unpaired in the dorsal and ventral halves of the organ. The color of the filaments and the surfacial structure and morphological details of the respiratory tubes are constant and unique.

The respiratory organs may also consists of thick vesicular tubes, which are quite variable and always unique for each species in configuration.

The next category of diagnostic characters of the pupa is the structure of the pupal membrane and its chaetotaxy. A distinction should be made between the plaques, leathery spicules, hairs, and bristles (chaetotaxy). Bristles on the dorsum are termed trichome. Plaques are found on the membrane of the head and dorsum. They are larger and thicker on the anterior part of the back than in the posterior region. Their shape varies: conical, tubercular, cylindrical, roundish with apical depression, sometimes with minute medial elevations, and button-shaped. The size, shape, density, and distribution of plaques are of diagnostic value. In addition to these chitinous thickening with (pits of joints)-are found on the head and dorsum. Those on the head may be designated

thus: **facial trichome**- below antennal basal view, **frontal**- on the frontal setae at level of antennae and **tympanic** located almost at same height as preceding ones, but outside suture of frontal sclerite, and lastly, **labial** under the frontal trichome. The number, arrangement, and shape of trichome on the dorsum are unique for each species. A group of **Short bristles** is located before the base of the respiratory filaments.

A definite system of **spicules, hairs, and chaetae** is found on the dorsal and ventral side these structures is to hold the pupal body in the cocoon. Here, as on the dorsum, a distinction must be made between chaetae with theca are mostly of generic and group importance, and spicules of specific value. Chaetal arrangement corresponds to a definite span and a definite number occurs on each margin of the body, predominantly along the posterior margin of the segments. Leathery spinules are predominantly found along the anterior margin of the segments, smaller ones in the middle of the segments, and both in a definite number. For the convenience of diagnosis chaetae may be divided into **dorsal, abdominal, and lateral**. Lateral chaetae may include pleural chaetae in morphological origin and position, and partly tergal and sternal ones.

The group of permanent hooks, typical of the entire family, consists of dorsal and ventral hooks. There

are two rows of hooks on the dorsal side on the 3rd and 4th segments, each row with eight hooks, which have been designated for convenience in the illustration by serial numbers, commencing from the middle, there are one or two hairs or short bristles between the third and fourth hooks. The ventral side of the 5th to 7th segments is also armed with hooks, with four hooks on each segment. Those on the 5th segment are arranged in pairs, while those on the 6th and 7th segments are spaced and almost equidistant. This system of hooks varies in different species and genera only with respect to shape and size of hooks. Sometimes the hooks are bifurcate and various complexities and chitinization exhibited in the basal hooks.

The temporary chaetae on the dorsal and ventral margins, when more or less fully present, are arranged in the same pattern as the hooks. The 1st and 2nd segments have eight hairs or bristles each on the dorsal side, as well as one or two lateral chaetae situated in front of them. Sometimes chaetae are also found on the 5th segment. the 3rd and 4th segments have four chaetae each on the ventral side. The other segments usually lack chaetae or bear only separate pairs in the same longitudinal rows. Accepting the general plan that the dorsal side consists of eight major bristles, first row (from median line) arcostical, second row dorsal, third row dorsocentral and fourth row dorsolateral. The one or two chaetae situated

between the dorsocentral and dorsolateral ones have been labeled **anterodorsal**. Chaetae on the ventral side have been designated: first row (from median line) - **ventral** and second row - **ventrolateral**. There are also two to five chaetae on each **lateroventral margin**, which are usually short, and situated on the lateral end of the Tergal Scleritis covering the Pleuritis, lateral ends of the Sternal Sclerite, and often between these scleritis on the longitudinally striated connective membrane. When the boundaries between scleritis are more distinct, as for example in Prosimulium, more precise designations can be employed : lateral tergal, pleural, and lateral sternal. The system of lateral bristles is highly inconsistent and unique in certain species. Leathery spicules are generally arranged in one transverse row along the anterior margin of the segments on the dorsal side. They reduce in size toward the lateral margin and convert into fields of very minute spicules arranged dorsolaterally and ventrally. The size, shape, and number of these spicules, as well as the size and location of fields of small spicules, are unique in each species and prove helpful in problematical cases of diagnosis of close and difficult-to-distinguish species.

The caudal end of the pupa, 8th and 9th segments, boasts a unique armature. The last or 9th segment has a pair of large **dorsal spines** which are highly developed in

species living in very swift water bodies but weaving an incomplete cocoon. The chaetotaxy of these segments is unique in different groups, and these bristles are difficult to homologize with the chaetae of the segments located in front.

The study area includes eleven districts and one Agency of North West Frontier Province (N.W.F.P.) i.e. Abbottabad, Bannu, Charsadda, Chitral, Dir, Kohat, Mardan, Peshawar, Swabi, Swat and Malakand Agency. Almost all divisions of the Province with their respective districts were thoroughly examined. The selection of the site was made on the accessibility of the area to the author, facility of transport and availability of expected larval and pupal water bodies. The eleven districts included in the survey represented 7 areas as which may be broadly classified as mountainous region named Abbottabad, Chitral, Dir, Kohat, Mardan, Malakand, Swat and 2 arid plain region i.e. Charsadda, Mardan, Peshawar and Swabi. Malakand is discussed separately as the only representative of Agencies. A brief description of divisional and district distribution of these areas is as follows:

1.10 DIRA ISMAIL KHAN DIVISION.

1.1.1 Bannu District: The District lies between $32^{\circ} 14'$ to $33^{\circ} 5'$ North latitudes and $71^{\circ} 45'$ to $73^{\circ} 15'$ East longitudes. The District is bounded in the north by Swat District. The total area of the District is 2727 sq. miles.

CHAPTER - 5

STUDY AREA

The study area includes eleven districts and one Agency of North West Frontier Province (N.W.F.P) i.e. Abbottabad, Bannu, Charsadda, Chitral, Dir, Kohat, Mardan, Peshawar, Swabi, Swat and Malakand Agenc. Almost all divisions of the Province with their respective district were thoroughly examined. The selection of the site was made on the accessibility of the area to the author, facility of transport and availability of expected larval and pupal water bodies. The eleven districts included in the survey represented 7 areas as which may be broadly classified as mountainous region named Abbottabad, Chitral, Dir, Kohat, Mansehra, Malakand, Swat and 4 areas plain region i.e. Charsadda, Mardan, Peshawar and Swabi. Malakand is discussed separately as the only representative of Agencies. A brief description of divisional wise distribution of these areas is as follows:

5.1.0 DIRA ISMAIL KHAN DIVISION.

5.1.1 Bannu District: The district lies between $32^{\circ} 18$ to $33^{\circ} 5$, north latitudes and 70° to $71^{\circ} 51$ east longitudes. The district is bounded in the north by Kohat district. The total area of the district is 2727.7 square kilometers.

The district though surrounded by the mountains on every sides. The Bhattani and Narwat ranges suffer considerably from wind blown sands, forming sand dunes in many places. The average height of the hills is 1280 meters above sea level. The general elevation of the plain is about 305 meters above sea level and temperature is almost the same all over the district. The maximum and minimum temperature in the summer are 39°C and 26.4°C and in Winter 25.3°C and 8.2°C respectively. The average annual rainfall is about 14 mm. Relative humidity ranges from 24% to 67% (Figures for 1987). The collection was made from an irrigation channel at Bannu Bazar.

5.2.0 KOHAT DIVISION.

5.2.1 District Kohat:

Proceeding southward from the Peshawar district, Kohat is the next important plains area which has a productive agricultural area whose crops are produced with the aid of the tract's naturally rich soil covering and a fairly extensive system of irrigation, fed in part by numerous underground Springs as well as from the Kohat Toi River.

As its Pushtu name indicates, this district is essentially rough and hilly in character. The series of 700 meter - 900 meter East-West trending live stone hills of Tertiary age which comprises the great portion of Kohat

district form a distinct Barrier between the Peshawar and Bannu basins which lie to the north and south respectively. To the West the district is interposed between the independent tribal peoples of the Tirah and the northern wazirs, while to the east its hills and their other continuation on Attock are cut by the Indus gorge.

Of all the districts on the Frontier, Kohat probably exhibits the most variations in season, temperature. Winters are quite cool, temperature often sinking to the middle 30's in January and February. It is the Summer, lowerer which is really the drying period. By June most streams have dried in the district and even drinking water becomes scarce. The altitude, rainfall, humidity of the collection sites are shown in the table 16. The collection was made from two common Spring water which later led in to stream formation. These Springs are situated at different localities and differ from each other both physically and chemically.

Spring Boina Sharif is situated at a distance of about one mile from Jungle Khel Kohat. It is bounded all around by a mountainous area. The Spring is covered by thick trees with green vegetation at the bank. This water is used by the people for bathing, washing and specially for irrigation purposes. The width of this Spring is 110 cm. and depth 15 cm. the bottom is stony and silty.

Spring Jungle Khel is situated on the back side of the army fort Kohat. On the side of the Spring there is a mosque. This water is used by the people for bathing, washing and for irrigation. The depth of the Spring is 134 cm and width of the Spring is 3 feet. The bottom is stony. Vegetation are present in and out of the Spring.

5.3.0 HAZARA DIVISION:

5.3.1 Abbottabad:

Of all the districts to the north of the Gomul, Abbottabad is the only one which offers an easily transition both physically and culturally, between the Frontior and Punjab. It is a gate way toward Mansehra district and occupies a central position for Hazara division. Its main physiographic features are:

- a. A forest- Clad mountain chain along its eastern flank overlooking the Jhelum river.
- b. A central low lands and
- c. The disorderly network of hills of Tanawal. Linked with the high kaghan ranges to the north and the Murree hills to the south, the eastern highlands compose more than one half of the district.

The fairly heavy density of population per square mile of cultivated land indicates that cultivation is limited to a few favoured places. These highlands form the

watershed between the Indus and the Jhelum river and consist of a chain of ridges, called by such names as Jhandiami, Miran Jani, Punja Gali Hemmed. In between these places main ridges and the deeply entrenched valleys of the lower Kunhar and Jhelum is very abrupt (about 6,00 ft) the streams run in gorges too deep for irrigation.

Abbottabad city is the administrative centre. Located in addition to the commissioners Office, are the division law courts, revenue, and irrigation departments. The Pakistan military academy at Kakul constitutes one of the hardest single military establishments on the entire Frontier. The soil in the low land is characteristically sandy and full of stones, producing crops little better in quality and quantity than those raised in the poorest hill soils. Thus inferior crops may run as high as 30 percent in many areas of the circle.

Nara Lora circle is a subdued continuation of the hill circles to the north of it. It is drained by the shallow and silt depositing Nilan river which is one of the main tributaries of the Haro. About 1500 feet above the Nilan is the broad Nara ridge which continues south west ward as the Khanpur range. The climate, rainfall and waterbeds of collection sites is given in table 18. The collection was made mainly from an irrigational channel at Main Bazar Abbottabad.

5.3.2 Mansehra District:

The mountainous wastes of the upper Indus basin, and separating the territory of Kashmir from that of Indus Kohistan. In this largely mountainous district (the total area of which is 2300 sq.miles) only 16 percent available for cultivation, and with a climate intensely cold in Winter and to a certain extent shut off from the rain-bearing monsoon. In Summer, it is understandable that agricultural practices here very considerably from other parts of the district. Because the greater part of its area i.e. roughly north of Mansehra City is above 1750 meter in elevation.

The proportion of land under irrigation is no more than 20 percent of the total cultivated area in any one circle.

The importance of irrigation in Mansehra in terms of Increased yields should not be under estimated inspite of the limited scale on which it is practiced.

Stretching westward to the Indus from kanhar valley are a series of parallel ridges which follow the general north-east-south-west strike of the country. Commanding as it does jeepable roads to the kagan (Babusa pass) and to Indus kohistan Jia, Oghi and a metalled road to Kashmir via Garghi Habibullah, Mansehra is undoubtedly the most important centre of communications in entire district.

The collection sites consist of swift rocky stream at Mansehra (proper) and Dodial.

5.4.0 MALAKAND DIVISION.

5.4.1 Chitral District:

Chitral is the northern extreme district of Pakistan in north west. In the east are Gilgit and Swat District. The valleys in Chitral lie between 1219 and 1828 meters above the sea level. Chitral is a land of deep valleys and lofty peaks. It is cut off from the rest of Pakistan by the Lowari Pass. Maximum temperature in Summer is 43.3°C and minimum 5.0°C . The xamimum temperature in Winter is 23.9°C and minimum -12.2°C . The rainfall ranges from 0.6 mm August to 155.7 mm in April with relative humidity ranging from 14% to 72% (Figures 1991). The collection sites consists of a Swift rocky stream at Ashirate, an irrigational channel at Drush, an irrigational Channel at Chitral (proper), Swift rocky stream at Shishi Dara (table 11).

5.4.2 Dir District:

The district Dir is named after the name of the districts headquarter town. It is bounded on the north by Chitral district, on the West by Bajaur and Afghanistan on the South Malakand Agency and East by Swat District. The district lies between $34^{\circ} 40$ to $35^{\circ} 48$ North latitudes and

71° 30 to 72° East longitudes. The total area of the district is 3261.3 square kilometers.

The major part of the district is fairly hilly. The northern portion of the district being mountainous, receives snow fall during the Winter. Mean minimum temperature here is 4.4°C and mean maximum 15.5°C. The southern portion has a mean minimum of 15.5°C and mean maximum of 32.2°C. The rainfall varies from 11.8 mm in January to 120.8 mm in March with relative humidity ranging from 19% to 82% (Figures for 1991).

The collection from district Dir was made from the following localities: River Dir at Lawari Pass, a rocky water fall at Show Dir (Proper), an irrigational channel and small stream at Amirikas, Dir (Proper), Swift rocky Stream at Chukyatan, an irrigational channel at Seiri, a Spring water fall at Darora, Punjkora river at Tamir Gara, irrigational channels at Mayar and Sammar Bagh and an irrigational channel at Chukdara.

5.4.3 Swat District:

The district is situated in the north extremity of Pakistan and within the western most off-shoots of the mighty Himalayas. The district lies between 34° 10 to 35° 52 north latitudes and 72° 06 to 73° 20 east longitudes. The district of Swat is mostly mountainous. The climate of Swat district is moderate.

During Summer it is some what warm in the lower Swat valley, but cool and refreshing further north of Saidu Sharif. Swat has a crisp, invigorating and delightful Winter extending from November to February. Winter rains and snow are received by the district during this season and the begining of Spring, which persists upto the middle of May. Summers are short and mild and the temperature seldom rises above 37.8°C . The rainfall varies from 11.4 mm in January to 115.8 mm in March with relative humidity ranging from 20% to 81% (Figures for 1991).

The collection sites from the district consist: Swift rocky streams at Mingauara and Saidu Sharif, irrigated channels at Daryal, charbagh, Shah Dehri, Aligram, Swift rocky streams at Marghuzar, Dewli, Roringer and river Swat at Kalam.

5.4.4 Malakand Agency:

It is situated at 34° - 33° North latitude and 71° - 56° east longitude. Malakand Agency is mostly composed of fertile land, with high hills. In most part of plain are muddy. There are canal system for irrigation. The climate of Malakand Agency is hot during Summer and Cold in Winter, with temperature range during Winter (0°C - 22°C) and (21.11°C - 37.88°C) during Summer.

The strategic significance of the malakand Agency is controlled all of the power generating establishments connected with the Malakand and Hydro-Electric Scheme.

5.6.0 MARDAN DIVISION.

5.6.1 Mardan District:

The district Mardan derives its name from its head quarters. the district lies between $34^{\circ} 00$ to $34^{\circ} 10$ north latitudes and $71^{\circ} 46$ to $72^{\circ} 47$ east longitudes. The Peshawar valley extends to the district of Mardan and South western half of Mardan district, is mostly plain.

The climate of Mardan is hot during Summer and cold in Winter. The highest temperature are recorded in the month of June and July when it shoots upto 45.5°C . The coldest months are December and January, when the day temperature is about 21.1°C and the minimum frequently falls below freezing point with frost at night. The rainfall ranges from 19.1. mm in November to 208.8 mm in April and the relative humidity ranges 21% to 80% (Figures for 1991). The collection was made from an irrigational channel at Thoro Mayar, Mardan.

5.7.0 PESHAWAR DIVISION.

5.7.1 Peshawar District:

Peshawar is situated at the mouth of the world famous khyber pass. It holds the key to the gateway of the sub-continent. Peshawar district lies between $33^{\circ} 43$ to $34^{\circ} 27$ north latitudes and $71^{\circ} 22$ to $72^{\circ} 15$ east longitudes. The district has an area of 2486.3 square kilometer and is bounded by Mohmand Agency and Mardan district in the North.

The District is surrounded on all sides by hills, except to the East. The temperature ranges from 4.1°C to 40.2°C with extreme temperature -0.3°C. The precipitation ranging from 6.6 mm in the month of June to maximum 64.8 mm in March. The relative humidity ranging from 21% to 83% with diurnal fluctuation (Figure for 1989). The collection was made from irrigational channels at Haji Camp and Worsak Road Peshawar and river Kabul at Worsak.

Family: Simuliidae

Sub-Family: Simuliinae

Genus: *Neorhagothrips* West.

GENERIC CHARACTERISTICS:

Larva: Antennae moderately long, only slightly longer than trunk of scaphite. Marginal teeth of mandibles somewhat spaced. Supra-antennal with well-developed middle and lateral teeth. Ventral groove of scaphite deep, not reaching posterior margin of submentum by a distance almost equal to length of latter. Posterior end of body with two well-developed, widely spaced conical processes on ventral side.

Pupa: Capion simple, tapered, short. Respiratory filaments six on each side. First segment of abdomen without row of spines on dorsal side, with a few, and only 7th to 9th with more or less complete row.

CHAPTER - 6

6.1.0 RESULT (TAXONOMIC)

6.6.1 CLASSIFICATION

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Simuliidae

Sub-Family: Simuliinae

Genus: Boophthora End.

GENERIC CHARECTERS:

Larva: Antennae moderately long, only slightly longer than trunk of flabella. Marginal teeth of mandibles somewhat spaced. Submentum with well-developed middle and lateral teeth. Ventral groove of cephalic, deep, not reaching posterior margin of submentum by a distance almost equal to length of latter. Posterior end of body with two well-developed, widely spaced conical process on ventral side.

Pupa: Cocoon simple, compact, taut. Respiratory filaments six on each side. Fifth segment of abdomen without row of spines on dorsal side, 6th with a few, and only 7th to 8th with more or less complete row.

6.1.1 B. erythrocephala - De Geer 1976, Robtsov 1940b and Grenier 1955 (Fig. 2).

Larva: Body length 5.0 to 5.5 mm. Body color light red or light green, with distinct chocolate-brown transverse bands on abdominal segments. Frontal sclerite with characteristic positive pattern, lateral spots sometimes indistinct. Antennae slender, 1st segment usually equal to 3rd in length, sometimes shorter. Third subapical tooth of mandibles equal to 2nd tooth, or slightly longer. Submentum with minute teeth. Not only 1st to 5th but also 6th to 7th teeth relatively well developed. Ventral groove of cephalic capsule linearly arcuate. Large flabellum with 36 to 54 bristles. Rectal processes simple, slightly branched. Chitinous frame behind rectal processes with simple spinules along outer margin of anterior branches. Posterior sucker with 64 to 76 rows of crochets, with 13 to 16 hooks in each row.

Pupa: Body length 2.5 to 3.0 mm. Length of respiratory filaments 2.5 to 2.7 mm. Cocoon simple, slightly broader in middle than at anterior margin. Respiratory filaments six, arranged in three pairs on very short stems. Upper filament rises sharply upward and thereafter bends forward smoothly and together with next filament located in a vertical plane, next two pairs located in planes almost perpendicular to former.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

New Distribution: Kohat and Mardan (Map.3).

NEW RECORD:

LOCALITY: 1. Jungle Khel Spring

2. Thoro Mayar

Date: I. November 11, 1994, April

4, 1994, July 5, 1994

II. June 5, 1993

BREEDING PREFERENCE: I. Jungle Khel Spring water fall with small pebble and muddy bed. Numerous larvae and pupae attached to long trailing submerged typha plant leaves on April 4 and July 5, 1994 except November (Table 11, 23, 24). II. Slow muddy irrigational channel at Thoromayar (Mardan) under complete shadow of Shishum trees. Twenty five larvae and thirty pupae collected, from submerged trailing leaves of Typha (aquatic plant) (Table 13, 23, 24).

REMARKS: DISTRIBUTION IN PAKISTAN: NOT REPORTED.

The specimens collected from Kohat and Mardan beside significant geographic and seasonal variability, showed some morphological differences in shape of mandible and number of bristles in submentum, but because ^{of} their similarities and other basic taxonomic characters, they were grouped under B. erythrocephala.

6.1.2 Boophthora sericata Meigen 1818, (Fig. 3).

Larva: Body length 6.0 to 7.0 mm. Color whitish-yellow. Pattern of frons distinct, positive, middle spot "shaded" peripherally, spots distinct. Antennae light colored. Submentum with three bristles along each side. Ventral groove of cephalic capsule does not reach posterior margin of submentum by a distance 0.50 its length. Apex of mandibles with widely spaced teeth large flabellum with 35 to 39 bristles. Rectal processes simple. Posterior sucker with 74 to 76 rows of crochets, with 11 to 12 hooks in each row, and 14 to 16 hooks in each ventral row.

Pupa: Body length 3.0 to 4.0 mm. Respiratory filaments 2.5 mm long. Cocoon simple, walls thin, opaque. Respiratory filaments six. Inner filament of second pair thicker than outer. Spinules on dorsal surface of 6th to 8th segments of abdomen 10 to 15, and arranged in one row that is medially interrupted.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

New Distribution: Peshawar.

NEW RECORD:

LOCALITY: Haji Camp Peshawar (Map 3).

DATE: July 8, 1993.

BREEDING PREFERENCE: Slow flowing muddy irrigational channel, highly overgrown with vegetation and silted.

Larvae (10) and Pupae (5) were attached to long filamentous leaves of submerge vegetation (Typha) (Table 13, 23, 24).

REMARKS:

The larvae collected from Mardan and Haji Camp Peshawar closely resemble each other but their separation is made by larger size, color, and unbranched rectal processes of larvae from Haji camp Peshawar and thus identified as Q. sericata.

6.2.0 Genus Eusimulium Roub.

Generic Characters

Larva: Antennae long, notably longer than stem of flabella. Ventral groove of cephalic capsule shallow or barely perceptible, rarely extends beyond 0.50 length of cephalic capsule. Two conical processes located on ventral side at posterior end of body, separated at an angle toward longitudinal axis of body of 40 to 50°. Number of crochets in posterior sucker relatively few; each row often with 10 to 11 hooks.

Pupa: Cocoon simple or with corniculate process. Respiratory filaments more often four, but may be six, eight, 10, and 13 to 14. Abdomen of pupa with spinules on dorsal side of anterior margin of segments, commencing from 5th to 6th segment. Dorsomedian spinules of 1st to 2nd segments much weaker than those on 3rd to 4th segments.

6.2.1 Eusimulium aureum golden blackfly Edwards, 1915,

(Fig. 4).

Larva: Body length about 6.0 to 7.0 mm. General body coloration light, with reddish or chocolate-brown spots and transverse stripes, predominantly on dorsal side. Pattern of frons positive, distinct, middle spots elongated longitudinally and together with lateral spots connected by common darker pigmentation. First and 2nd antennal segments about equal in length, 3rd segment about 0.66 the length of

preceding segments. Large flabellum with 52 to 56 bristles, small flabellum with 34 to 40, spatulae five to seven. Apex of mandibles characterized by strong development of apical tooth, relatively large anterior subapical tooth, and middle subapical tooth shorter than posterior teeth, inner teeth thin, number nine to ten, marginal teeth well developed, with anterior teeth much longer than posterior. Submentum with well-developed middle and 5th lateral teeth, later with well-developed scales up to half their body length. Four to six bristles arranged along sides of submentum in single row and two small bristles in middle part, close to posterior margin. Ventral groove of cephalic capsule square or roundish, and its anterior margin located away from posterior margin of submentum by a distance almost equal to length of later. Rectal processes simple. Posterior sucker with 66 to 80 rows of crochets, with 11-12 hooks in each row.

Pupa: Body length 3.0 to 3.5 mm. Cocoon simple, usually narrow, rarely broadens. Respiratory filaments four. Their length and diameter about 4.5 mm, and diameter more or less similar. All filaments originate almost right from base, but connected in pairs on very short stems. Upper filament of lower pair originates slightly away from vertical plane of three remaining filaments. Abdomen of pupa armed with leathery spinules on dorsal side, arranged

in single row on 6th to 8th segments, spinules on 9th segment very small.

KNOWN DISTRIBUTION IN PAKISTAN: CHILAS, BARA GALI, NATHIA GALI, KALAM (SAITO, 1989) AND LANDI KOTAL (LEWIS, 1973).

NEW DISTRIBUTION: Kohat and Mardan (Map 3).

NEW RECORD

LOCALITY: I. Kohat Bridge stream, 5 kilometer south of Kohat Bazar on Bannu Road. II. Thoro Mayar, Mardan, Irrigation Channel.

DATES: I. August 12, 1993. II. June 5, 1993.

BREEDING PREFERENCE: I Swift Rocky stream with rocky and stony bed, and broken water, just beneath the bridge. 220 larvae and 55 pupae were collected from trailing grasses including Typha and Cynodon. (Table 11, 23, 24).

II. Small irrigation channel with muddy bed. 9 larvae and 4 pupae were attached to submerged Typha plant. (Table 13, 23, 24).

REMARKS: with 10 to 13 hooks in each row.

The larvae collected from Kohat were different and difficult to have clear taxonomic position because of

their confused similarity with Eusimulium azerbaijanicum (Dzhafrov 1953). But they were separated on the basis of the following points.

1. Shape of ventral groove of cephalic capsule
2. Posterior sucker with 64 to 66 rows of crochets, with 10 to 11 hooks in each row.
3. Length and branching pattern of respiratory filaments in pupa.

6.2.2 Eusimulium bicornu bicornute blackfly.

Rubstov Vlasenko, 1935, (Fig. 5).

Larva: Body length about 10 mm. Color dull yellow, with transverse chocolate-brown spots. Head dark, pattern of frons positive in which lateral spots fused with posterior ones. Large flabellum with 28 to 30 bristles, small flabellum with more than 20, bristles and spatulae only six. Mandibles short and obliquely truncated along anterior margin. Apex of mandibles with large apical tooth, thin inner teeth, and relatively large marginal teeth. Submentum with large 1st and 5th lateral teeth, distinct in serration, and close placement of 1st and 2nd lateral teeth. Ventral groove of cephalic capsule usually shallow, irregularly square. Posterior sucker with about 70 rows of crochets, with 10 to 13 hooks in each row.

Pupa: Length ranges from 3.5 to 4.0 mm, of cocoon about 4.0 mm. Cocoon coarsely woven, relatively broad, with

two long corniculate processes along anterior margin. Respiratory filaments four, branched dichotomously, and not in the same plane: upper and lower pairs slant inward near base, but located in more or less single vertical plane toward apex. Upper pair usually thicker than lower. Length of stems relatively highly variable in forms collected from different geographic localities.

KNOWN DISTRIBUTION IN PAKISTAN: BAGHWAR (LEWIS 1973)

NEW DISTRIBUTION: Dir and Swat (Map 4).

NEW RECORD.

LOCALITY: I. Chukyatan stream, 6 km south of Dir (proper).

II. River Swat at Kalam.

DATES: I. February 15, 1994.

II. June 30, 1993.

BREEDING PREFERENCE: I. Swift Rocky stream with broken foamy water. *Cynodon* submerged water carried 150 larvae and 60 pupae collected on February 15 and 10 pupae only in June 30, 1993, (Table 12, 23 and 24).

II. Large river with swift water flow, stony and sandy bed. 15 larvae and 6 pupae were collected from submerged *Echinochloa* (7 larvae and 6 pupae) and *Cynodon* grass (8 larvae only), (Table 10, 23 and 24).

REMARKS: Collections from Swat river at Kalam at the end of June (June 30, 1993) contained empty pupal cases of this species beside 6 pupae collected. Pupae slightly larger, respiratory filaments equal in thickness. Rest of taxonomic characters in pupae and larvae were the same.

6.2.3 Eusimulium diriense, sp. n. (Fig. 6)

Larva: Length about 7.5 - 8.0 mm. Head with brownish cephalic apotome, pattern of frons positive with distinct head-spots. Antenna basically 4-segmented, with 4 secondary annulations, penultimate segment darkened and well above level of cephalic fan stem, other segments brownish. Cephalic fan with approximately 32 filaments. Post-genal cleft minute. Hypostomium with 9 sharply pointed teeth apically, corner and median teeth strongly prominent, six or seven hypostomial setae on each side lying subparallel to lateral margins. Groove of cephalic capsule relatively deep, almost square, but less than length of cephalic capsule. Apex of mandible with short, strong thick tooth, 2nd and 3rd pre-apical teeth almost similar, followed by a row of 9 spine like inner teeth. Thoracic and abdominal cuticle bare. Rectal "gills" with secondary lobules. Anal sclerite with complete posterior arms with which anterior arms united individually. Ventral papillae well developed.

Pupa: Body-length 6.0 - 6.8 mm. Dorsum of head and thorax with profuse disc-like tubercles. Respiratory Head trichomes 3 pairs, 1 pair ventrolateral and 2 pairs antero-lateral, simple, thick and short. Thoracic trichomes 7 pairs, 3 pairs on either side of mid-dorsal line, 2 pairs posterior to gill base, 1 pair posteriorly and 1 pair laterally, of these 3 pairs on either side of mid-dorsal line and 2 pairs posterior to gill base thick, all simple. Filaments 12, arranged in following manner : from a stout stem apparently three primary branches arise, upper primary branch divided into 2 filaments, middle branch secondarily divided into two branches, short dorsal branch and long ventral branch each with an upper filamentous stem and a lower solitary filament, lower primary branch divided into two secondary branches, each of which with 2 filaments at same level.

Tergum 2 with a row of 4 setae and a few accessory setae on each side, tergum 3 and 4 each with 4 branched hooks and a few setae on each side, tergum 6,7 and 8 with approximately 5, 8 and 9 spines respectively on each side of mid-dorsal line. Sternum 4 with a pair of setae on each side, sternum 5 with a pair of branched hooks, close together, on each side near posterior margin, sterna 6 and 7 with same number of hooks on each side but widely spaced. A pair of very minute tail-hooks present. Cocoon slipper shaped, i.e. rim of opening incomplete ventrally, loosely

woven, with a fairly strong anterior margin, dorso-median projection well-developed.

DISTRIBUTION: DIR (Map 4).

LOCALITY: 1. Shaw water fall
2. Swift muddy irrigation channel at Amiri kas, 1 km South of Dir Bazar.

DATES: I. May 20, 1993 II: March 6, 1993, April 29, June 30, July 7, August 25 and September 14.

BREEDING PREFERENCE: I: Large rocky water fall 40 larvae only attached to submerged Cynodon (grass) (Table 12, 23 and 24).

II: Swift muddy irrigation channel. Collection consists of 3 larvae dated March 6, 5 larvae and 20 pupae on April 9, 30 larvae and 11 pupae on June 30, 40 larvae and 19 pupae on July 7, 19 larvae only on August 25 and 19 pupae only on September 14, all attached to Cynodon (aquatic submerged grass) (Table 12, 23 and 24).

REMARKS:

This species closely resemble Eusimalium planiparum (Rubzov) and Eusimulium angusticorn (Rubzov) on the basis of the following characters.

1. Tip of mandible with two mandibular serration,
2nd and 3rd preapical teeth similar and followed

by 7-11 spine like inner teeth.

2. Thoracic and abdominal cuticle bare.
3. Anal sclerite with complete posterior arms with which anterior arms united individually.
4. Groove of cephalic capsule relatively deep, almost square, but less than length of cephalic capsule.

This new species differs from the above species in the following characters:

1. Presence of dorso-median projection in the cocoon.
2. Secondary annulation on the larval antenna.
3. Respiratory filaments 12 and unique in pattern.
4. Fron with specific pigmentation.

6.2.4 Eusimulium fontinal

Radzivilovskaya 1948, (Fig. 7).

Larva: Body length 7.0 to 8.0 mm. Pattern of frons positive. Posterior occipital spot fused with dark pigmentation of posterior margin of frontal sclerite. Second antennal segment slightly longer than 1st, 3rd segment 0.50 of length of 1st. Submentum with larger middle tooth. Posterior sucker with 74 to 80 rows of crochets, with nine to thirteen hooks in each row.

Pupa: Cocoon simple, with edging along anterior margin. Respiratory filaments branched dichotomously,

arranged in pairs in same vertical plane on two short stems, of which lower well distinguished by shorter stem, its length only 2.0 times of its diameter. Plaques on dorsum smaller, diameter of largest plaques 11 to 12 μm .

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION : Roringer Swat and Charsadda (Map.4).

NEW RECORD: I: Roringer and II: Charsadda

DATE: I: June 5, 1993 II: May 13, 1993.

BREEDING PREFERENCE: I: Trickle in stream reduced by removal of water for irrigation with swift flow of water and sandy and stony bed. 30 larvae and 10 pupae were found attached to submerged grass blades of *Echinochloa*, (Table 10, 23 and 24).

II: Slow Irrigational channel with muddy bed. 15 larvae only collected from *Echinochloa*, (Table 13, 23 and 24).

REMARKS: The larvae collected here were closely confused with *Eusimulium longipile* (Rubzou) but the separation is made by larger larval size, large antennal segment 2nd and branching pattern of respiratory filaments.

6.2.5 *Eusimulium gviletense alizadei*

Dzhafarov, 1954a. (Fig. 8).

Larva: Body length 8.0 mm. Pattern of frons positive.

Antennae broaden toward base, 1st segment equal to 3rd segment in length, each only 0.66 length of 2nd segment. Both large and small flabella with 27 to 30 bristles. Marginal teeth at apex of mandibles three. Middle tooth of submentum turned inward and hence looks roundish toward apes, 4th tooth 2.0 times larger than 2nd. Submentum include five bristle along each side and two in middle. Ventral groove of cephalic capsule greater in length than width, its anterior margin almost acutely angled. Distance between anterior margin of groove and posterior margin of submentum almost equal to length of submentum. Rectal processes branched. Posterior sucker with 76 to 78 rows of crochets, with $12 + 1$ hooks in each row.

Pupa: Respiratory filaments 12 on each side. All 12 filaments grouped in bundle on relatively long and thick stem, which branches at different distances from base. All filaments equal in thickness and length with stems and filaments black. Cocoon simple, not covering pupa completely.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

NEW DISTRIBUTION : DIR (Map 5).

NEW RECORD.

LOCALITY: Dir (Lawari Pass)

Date: May 1 1993

BREEDING PREFERENCE: Swift Rocky stream just below the snow

deposits (glacier deposits). Twelve larvae and five pupae attached to small stone, (Table 12, 23 and 24).

REMARKS:

This place of collection was about 150 meter up the stream of the place where E. g. qviletense were found. Both the species closely resemble each other. But these larvae showed some very distinctive features like marginal teeth at the apex of the mandible three, 5 bristle of submentum along eachside and 2 in middle, so the specimens were identified as E.g. alizadei.

6.2.6 Eusimulium g. qvilletense Rubtsov 1951b, (Fig. 9).

Larva: Body length 7.0 mm. Color dirty yellow, head dark chocolate-brown. Pattern of frons positive, indistinct and middle spots more distinct than others. Antenna long, 3 segmented and 2nd segment double in size of 1st and 3rd segments. Large flabellum with 31 to 33 bristles, small flabellum with 26 to 30, spatulae eight. Mandibles narrow in inner half. Apex of mandibles with large apical tooth, anterior subapical tooth equal to posterior apical teeth in length, but 2.0 times thicker, inner teeth nine. Lower margin of mandibles almost at same level before and behind marginal teeth. Submentum with very large teeth, and seven to nine bristles arranged in one to two irregular rows along each side. Rectal processes

branched, and each of three branches with 13 to 15 lobes. Posterior sucker with 72 to 82 rows of crochets, with 11-12 hooks in each row.

Pupa: Cocoon broad, covers body of pupa only up to posterior margin of dorsum. Respiratory filaments 12, grouped in tight bundle, with all originating more or less from base. However, closer scrutiny reveals two distinct groups of five filaments each-one upper, one lower-and two filaments located laterally originate right from base. All filaments about equal in length and thickness, their inner layer covered with minute dark papillae.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

NEW DISTRIBUTION: Dir (Map 5).

NEW RECORD.

LOCALITY: Dir (Darora)

Date: August 5, 1993.

BREEDING PREFERENCE: Small mountainous water fall of tributary stream to Ushery river with algae covered rocky bed, (Table 12, 23 and 24).

REMARKS:

Darora water fall is 28 kilometer from Dir proper toward Peshawar and 1 kilometer east of Darora main Bazar. Four larvae were seen attached to a dead leaf of walnut being stuck between two stones with swift water flow while

5 larvae and 4 pupae were found attached to rock in association with 5 larvae of Simulium tumolusum. The larvae resemble E. montium very closely except the difference in structure of mandibles, posterior sucker and branching of respiratory filaments of pupae.

6.2.7 Eusimulium inflatum

Rubtsov 1951b, (Fig. 10).

Larva: Body length 5 to 5.5 mm. Color chocolate brown, spotty. Head almost black. Pattern of frons positive, and indistinct. Large flabellum with 33 to 40 bristles, small flabellum with 27 to 28. Antennae darkened almost throughout, 1st segment equal to 2nd segment in length. Apex of mandibles with oblong outer teeth. Inner teeth 11 to 12, very small, and approximate. Submentum with highly erect lateral scales compared to middle scales. Ventral groove of cephalic capsule barely perceptible. Cuticle around rectal processes with minute trifid spicules. Posterior sucker with 84 to 94 rows of crochets, with 13 hooks in each dorsal row, and 11 each ventral row.

Pupa: Pupal length about 3.0 mm, respiratory filaments 1.5 mm. Cocoon with corniculate groove in middle, Respiratory filaments six, quite unique in structure and branching. Outer filaments 2.0 to 3.0 times longer than inner, and all of them bulge at base. Filaments connected in pairs on three stems, one extending upward, other

forward, and third downward. Anterior filament attains maximum thickness and length.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

NEW DISTRIBUTION: Kohat (Map 5).

NEW RECORD.

LOCALITY: I. Boina Spring Kohat and
 II. Jungle khel Spring Kohat.

DATE : I. November 11, 1993,
 April 12, 1993 and
 July 18, 1993 and
 II. July 7, 1994.

BREEDING PREFERENCE: I: Small rocky hill Spring Boina sharif Kohat with stony and muddy bed. 13 larvae collected (8 attached to Typha trailing leaf and 5 to stone) on April 4, 44 larvae (all attached to Typha plant) on July 7, 1993 while no collection found on November 11, 1992, (Table 12).
 II: Small water fall of Spring water with feeble and muddy bed, covered almost completely with divided filamentous trailing leaves of Typha. Thirty larvae collected attached to Typha leaves in association with larvae of S. kohatiense sp. n., (Table 11, 23 and 24).

REMARKS:

Larvae collected from Spring Boina sharif differ slightly, in larger number of rows of crochets on posterior

sucker, smaller number of bristle in large flabellum compared to specimens collected from Spring of Jungle Khel Kohat.

6.2.8 Eusimulium lepnevae Rubzov, (Fig. 11).

larva: Body length 5.0 mm. Color chocolate-brown, spotty. Pattern of frons positive totally indistinct, only occipital spots more or less perceptible. Antennae long, slender, first three segments equal in length. Apes of mandibles with unequal-sized outer and relatively smaller apical and subapical teeth, inner teeth six to seven. Ventral groove of cephalic capsule deep, but separated from posterior margin of submentum by a distance 1.5 times greater than length of submentum. Submentum with relatively large 6th lateral teeth.

Pupa: Pupal length 2.8 to 3.0 mm. Length of respiratory filaments 2.5 mm. Cocoon simple, flat, relatively broad, with small projection in middle part. Respiratory filaments six, arranged in form of compact bundle on three very short stems, upper filaments markedly thicker than others. Filaments directed forward in form of compact bundle. Color of filaments dark, with transverse pattern. Head of pupa with two frontal trichomes: trichomes on dorsum simple.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Bannu (Map 6)

NEW RECORD. Length ratio of first three segments 1:1.6:0.6.

LOCALITY: with large coal-beds Bannu site A and Site B.

Date : second, and second small August 22, 1993.

BREEDING PREFERENCE: Bannu main irrigational channel having long aquatic plants and muddy bed. Thirty larvae and only 2 pupae were attached to trailing Typha plants from site A and 40 larvae only from site B, (Table 13. 23 and 24).

REMARKS: with 40-50 rows of 34-40 hooks.

larvae from site B showed a little differences in color of head which was chocolate-light brown instead of clear brown. The rest of characters were the same.

June 19, 1994.

6.2.9 Eusimulium malakandiense Sp.n., (Fig. 12).

LARVA: Body length 8-10mm. Pattern of from positive consisting of 4-9 discrete anteromedian spots, more diffuse and broader posteromedian spots, a single anterolateral spot in line with the eye-spots on either side, and diffuse posteromedian dark patches. Ventral groove large, pointed apically and parallel-sided basally. Postgenal bridge equal in length to hypostomium, with a pale median stripe. Hypostomium with 9 apical teeth, median and lateral teeth slightly produced, lateral serration present but Hypostomium with 9-12 setae in each row, rows divergent from lateral margin of hypostomium. Antenna weakly pigmented except for third segment which is strongly

pigmented. Length ratio of first three segments 1:1.6:0.6. Mandible with large comb-teeth, first comb tooth smaller than second, and second smaller than third, with strongly developed apical tooth and middle subapical tooth smaller than posterior teeth. Abdomen bulbous posteriorly with dark integument. Thoracic and abdominal cuticle with a few scattered simple setae. Ventral papillae absent. Rectal gill with 9-10 secondary lobules on each lobe. Posterior circlet with 260-280 rows of 34-40 hooks.

Pupa: Not found

DISTRIBUTION : Malakand (Map 6).

LOCALITY : Malakand Tunnel Small foot hill Spring.

DATE : June 19, 1994.

BREEDING PREFERENCE : Small rocky hill Spring with swift flow of water. Rocks covered with algae and grass. Four larvae attached to submerged *Echinochloa* leaf, (Table 11).

REMARKS:

This new species is closely related with *Eusimulium aureum* and *Eusimulium krymense* (Rubzov) due to the following characters.

1. Pattern of frons positive
2. Antenna 3 segmented. Length ratio of 1st 3 segments is 1:1.6:0.6.
3. Mandible with strongly developed apical tooth and middle subapical tooth smaller than posterior teeth

4. The shape of chitinous frame above posterior sucker.
5. Arrangement of teeth in hypostomium.

This new species can be separated from the above species on basis of the following points.

1. Ventral groove is large, pointed apically and parallel sided basally.
2. Postgond bridge is equal in length to hypostomium with a pale median stripe.
3. Hypostomium with 9-12 setae in each row and rows divergent from lateral margin of hypostomium.
4. Antennae are weakly and uniformly pigmented except for the 3rd segment which is strongly pigmented.

6.2.10 Eusimulium montium Rabtzov 1947, Robtsov 1951b, (Fig. 13).

Larva: Body length 7.0 to 8.0 mm. Color light yellow, sometimes with transverse dirty grayish bands. Head much darker, dark chocolate brown. Pattern frons positive, on dark background, middle spots fused into single long stripe, posterior margin of head with transverse stripe. Groove of cephalic capsule almost square on lower side, with roundish corners, its depth slightly less than 0.33 longitudinal length of capsule up to submentum. Submentum highly chitinous, with characteristic development of lateral and middle teeth, and four to eight bristles along each side arranged in one to two irregular rows. Ratio

between length of antennal segments: 1 : 1.4 : 8. Basal flabellum with eight bristles, large flabellum with 20 to 25, small flabellum with 36 to 38, spatulae eight. Apex of mandibles with large stout upper apical tooth. Fairly strong projection of outer teeth and posterior margin compared to inner margins characteristic feature of mandibles. Among subapical teeth, middle teeth shorter than lateral, inner teeth 16 to 17. Tip of abdomen in contracted condition with median groove on lower side. Pair of small ventral processes present. Rectal processes minute, branched, each with three branches with 13 to 15 lobes. Skin along sides and above rectal processes covered with minute spinules. Posterior sucker with about 80 rows of crochets, with 12-14 + 1 hooks in each row.

Pupa: Body length 4.5 to 5.0 mm, maximum width of cocoon 2.2 to 2.5, and height of cocoon 1.2 to 1.5 mm. In dorsal view cocoon smooth and broad. Anterior margin of cocoon without edging. In ventral view cocoon with tight-fitting membrane attached to lateral sides on outer upper part about midlength. Waving of cocoon coarse, membrane opaque, and without openings along sides. Respiratory filaments 12, grouped on one thick stem originating near base. Filaments about equal to length of pupa, and dark or even black. All filaments equally thick and long. Branching compact: two outer filaments isolated toward base it self, remainder arranged in two groups of five on upper and lower

sides, which branch dichotomously almost right at base. Anterior margin of dorsum covered with relatively large dark plaques. Trichomes simple and short. Fifth to 8th abdominal segments with spinules arranged in one row extending across anterior margin, i.e., medially interrupted. Fifth segment with eight to ten spinules, their number increasing toward 8th segment up to 20 to 24. Minute combs of very small spinules located along sides of row of spinules. Ninth segment devoid of spinules along outer margin, but with combs of spinules along sides and pair of conical, relatively large spinules at end.

KNOWN DISTRIBUTION IN PAKISTAN: Hunza (Saito 1987), Swat Kalam .(Lewise 1973).

NEW DISTRIBUTION : Dir (Lawari Pass). (Map 6)

NEW RECORD : Dir (Lawari Pass)

Date : 1-5-93.

BREEDING PLACE : Slow sandy medium broken water river with stony bed, snow melt foamy water and no vegetation, (Table 12, 23 and 24).

REMARKS:

A total of 10 larvae and 5 pupae were collected, attached to small stones at Lawari pass station which is 18 kilometer North of Dir proper toward Chitral. The larvae collected showed little differences in shape of ventral

groove and size of the 1st tooth. (in submentum) as compared to the description given for the larvae of this species by Rvbtsov (1987) and Lewis (1974), but due to the body length (8.0 mm), mandible with 16-17 inner teeth and abdominal rows of posterior sucker with 14 hooks, the specimens were identified as Eusimolium montium.

6.2.11 Eusimulium planipuparium

Rubtsov, 1947, 1951b, (Fig. 14).

Larva: Body length 7.0 to 7.5 mm. General color of body dirty greenish or dirty yellow. Head almost entirely black. Pattern of frons positive, indistinct on dark background. Anterior spot faded and usually indistinct. Antennae with four segments, thickened. Large flabellum with 35 to 40 bristles, small flabellum with 30 to 36 bristles. Apex of mandibles with short thick teeth. Groove of cephalic capsule relatively deep, almost square, but less than length of cephalic capsule on lower side. Submentum with large middle tooth, and seven to nine bristles arranged in one to two parallel rows along sides. Rectal processes branched, each with three branches and, in addition to main thick lobe, also with seven to eight short thin lobes. Posterior sucker with 90 rows of crochets, with 13 to 15 hooks in each row.

KNOWN DISTRIBUTION IN PAKISTAN: BABUSAR (SAITO 1988)
AND KALAM (LEWIS 1973).

PRESENT DISTRIBUTION: Dodial (Mansehra) and Kalam (Swat) (Map 7).

NEW RECORD: 1. Swift rocky Stream near Dodial Mental Hospital
II. Tributary to river Swat at Kalam

DATE: I. August 17, 1993
II. May 10, 1993

BREEDING PREFERENCE: I: Swift Rocky Stream with stony bed
43 Larvae and 9 pupae collected attached to trailing, submerged Potamogeton grass, (Table 13, 23 and 24).

II: Swift stony rivulet, tributary to river Swat with stony and sandy bed. The larvae collected (40) were attached to solid rocks and small stones, (Table 10, 23 and 24).

REMARKS: The specimens collected from both the areas closely resembled Eusimulium rangiferinum (Rubzov). Their taxonomic separation was made by their larval body length (7.5 to 8 mm), branching pattern of rectal process with 15 to 16 lobes.

6.2.12 Eusimulium pygmaeum Zetterstedt 1850, Rubtsov 1940b, (Fig. 15).

Larva: Body length 6.0 mm. Color light gray, with dark segmental transverse stripes, which are slightly

interrupted. Head light chocolate brown. Pattern of frons positive and distinct. Occipital spots often continue backward and fuse with occipital dark path along posterior margin of frons. Five distinctly demarcated spots and one dark spot along orbital spots located along sides of cephalic capsule. Ventral groove of cephalic capsule relatively deep, reaching 0.50 length of cephalic capsule. Antennae long, slender, with four segments. Large flabellum varies from 70 to 85 bristles. Middle subapical tooth of mandibles shorter than anterior and posterior teeth. Inner teeth eight to eleven. 1st middle and 5th lateral teeth almost aligned. Four to six bristles located on each side of submentum. Rectal processes branched, each branch with five to seven almost equal-sized lobes. Posterior sucker with 80 to 85 rows of crochets, with 10 to 12 hooks in each row. Conical processes at tip of abdomen on ventral side relatively short.

Pupa: Cocoon simple, without openings along sides, about 3.0 mm long and 1.8 mm wide. Lower wall of cocoon developed only in posterior half, and attached to lateral walls along lateral margins. Walls of cocoon thin, incomplete, and anterior margin without edging or process in middle part. Length of pupa 2.5 to 3.3 mm. Four respiratory filaments located in more or less same vertical plane, on two relatively short stems. Upper filaments often bend sharply at a short distance from base, and directed

forward. Trichomes on dorsum of pupa simple and long. Hooks on abdomen of pupa and segmental cuticular spines highly chitinized. Dorsal hooks on 3rd to 4th segments almost black. Well-developed cuticular spines present on 5th to surface of 4th segment. Length of filaments 2.8 to 3.0 mm, thickness almost equal.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Roringer (Swat) (Map.7).

NEW RECORD.

LOCALITY: Roringer (Swat)

DATE : June 5, 1993

BREEDING PREFERENCE. Trickle in stream reduced by removal of water for irrigation. Swift flowing water with sandy bed, 40 larvae and 10 pupae attached to submerged grass blades of *Echinochloa*, (Table 10, 23 and 24).

REMARKS:

The larvae collected from this stream closely resemble *E. latipes* in majority of larval character especially in shape of submentum but due to shape of rectal processes, depth and size of ventral groove of cephalic capsule and number of hooks on posterior sucker, the specimens are placed under this species.

6.3.0 GENUS: OBUCHOVIA.

Generic Characters.

Larva: Antennae short and thick, 3rd subapical segment particularly reduced. Submentum very broad in posterior half. Middle tooth of submentum protrudes distinctly above lateral teeth. Bristles along sides of submentum arranged in two to three irregular rows. Ventral groove of cephalic capsule acutely arcuate, does not reach posterior margin of submentum. Mandibles with short apical tooth and along subapical tooth. Posterior sucker with large number of very small hooks-130 to 200 rows, with 20 to 30 hooks in each row. Rectal processes branched.

Pupa: Respiratory filaments six on each side, relatively short. Cocoon boot-shaped or shoe-shaped.

6.3.1 Obuchovia albella light-colored blackly, Rubtsov, 1951b, (Fig. 16).

Larva: Body length 8.5 to 10.0 mm. General body color dirty green. Head almost black. Pattern of frons indistinct, negative. Antennae darkened. Large flabellum with 45 to 50 bristles, and small flabellum with about 30. Apex of mandibles with six to seven inner teeth. Submentum very broad, with more than 20 bristles along sides and two in middle. Cuticle with spicules around rectal processes. Rectal processes branched, each of three branches, in addition to one thick and long lobe, with six to eight thin

and short lobes. Posterior sucker with 220 to 240 rows of crochets, with 28 to 32 hooks in each row.

Pupa: Cocoon shoe-shaped, with margin protruding forward conspicuously. Weaving of cocoon thin, smooth, without edging along anterior margin, and without openings along sides. Length of cocoon 3.5 to 5.5 mm. Respiratory filaments about 0.33 length of cocoon. entirely hidden inside it, equal in thickness, and attenuate toward apex. Lower filament diverges markedly. Trichomes simple. Dorsum covered with dark and curved plaques.

KNOWN DISTRIBUTION IN PAKISTAN: CHILAS (SAITO 1989)

NEW DISTRIBUTION: Chitral (Map. 7)

NEW RECORD.

LOCALITY: Main irrigational channel beneath main Bazar Jama Masjid, Chitral (proper).

DATE: July 4, 1993.

BREEDING PREFERENCE: Slow muddy irrigational channel with shingle muddy bed. Twenty eight larvae (14 attached to *Echinochloa*, 8 to submerged roots of terrestrial plant and 6 to stone), and 46 Pupae (18 attached to roots, the rest to stones) were collected, (Table 13, 23 and 24).

REMARKS:

Various sizes of the larvae from 3.0 to 3.5 mm. at some place of collection were observed. Some specimen

were different in colour of the head but all of them were taxonomically placed under O. albella, due to their basic characters.

6.3.2 Obuchovia chitraliense sp.n. (Fig. 17).

Larva: Body length 6-7.5 mm. Color dark, dirty brown head almost black. Pattern of frons reticulate. Small flabellum reticulate with 48 to 50 bristles, lower flabellum with 33 to 35 spatulae ten. Apex of mandibles with relatively large 2nd inner tooth other teeth curved very broad. Teeth of submentum relatively equal in length. With distinct middle tooth among intermediate teeth poorly developed, seven to ten bristles arranged in one to two unequal rows along each side of submentum. Ventral groove of cephalic capsule arch shaped not reach posterior margin of submentum by a distance equal to 0.50 length of latter. Rectal process unbranch.

Antennae 5 segmented with relatively short but equal 1st and 3rd segments, 2nd and 4th segment almost double length of 1st segment and 5th segment minute. Posterior sucker 140 to 155 rows of crochets, with 20 to 24 hooks in each row. Posterior end of body with eight to ten short chitinous bristles located between sclerotized semicircles and ring of crochets of posterior sucker.

Pupa: Not known

DISTRIBUTION IN PAKISTAN: CHITRAL (MAP 8)

LOCALITY: Chitral Bazar near Jama Masjid.

DATE: July 4, 1993.

BREEDING PREFERENCE: Slow muddy irrigational channel with shingle muddy bed. Seventy five larvae were collected 0 attached to submerged Echinochloa (35), roots of terrestrial tree (20) and small stones (20) (Tables, 13, 23 and 24).

REMARKS: The larvae of this new species were very distinct among the larvae of Obuchovia albella because of their smaller size and other characters. This new species resemble obuchovia margaritae O. albela and O. versicolor very closely on the basis of the following characters:

1. Ventral groove of cephalic capsule deep and arched shaped, does not reach posterior margin of submentum by a distance equal to 0.3 length of the later.
2. Shape and size of submentum and its teeth.
3. The shape of chitinous frame at the posterior end of the larva.

This species can be separated from the above species on the basis of the following points.

1. The structure of the mandible.
2. Shape and pattern of pigments on frons.
3. The characteristic structure of antenna.
4. The unbranched rectal processes.

6.4.0 GENUS: Simulium

GENERIC CHARACTERS:

Larva: Antennae with three segments, 2nd segment with one constriction. Subapical teeth of mandibles graduated from anterior to posterior, their apices located in one straight line. marginal teeth protrude notably above posterior subapical tooth. Ventral groove of cephalic capsule acute, pointed toward front, extends beyond midpoint of cephalic capsule, and sometimes narrow groove reaches posterior margin of submentum. Rectal processes usually branched, rarely simple. Cuticle around base of rectal processes glabrous, rarely with spicules.

Pupa: Respiratory filaments six, eight, ten, rarely twelve, Abdominal tergites armed with row of spicules usually along anterior margin of penultimate (8th) segment, rarely and additionally, on one to two preceding segment, cocoon simple, without collar, rarely with openings along sides.

6.4.1 Simulium aureohirtum Brunetti 1911 (Fig. 18).

Larva: Body length 4.5 to 6 mm., colour varying from dirty cream to pale brownish yellow without any definite markings. Head golden, usually with four dark fairly well-defined spots on the dorsal surface, two elongated, median and one on each side near posterior border of frons. A poorly chitinized area on ventral surface of head-capsule

not very wide, extending anteriorly to even less than half length of head. Antennae long and slender, 4-segmented, 1st segment about 6 times as long as broad, 1st three segments are about equal in length, and 4th is minute. Cephalic fan filaments number about 40. Mandibles with number of teeth in subterminal row variable, usually 6 teeth, gradually decreasing in size. Posterior sucker with about 60 rows, 10-13 hooks in each row. Ventral papillae moderately long and conical.

Pupa: Body length 2.00 to 3.0 mm, and width of cocoon 1.4 to 2.4 mm. Cocoon lighty rellowish brown to dirty brown in colour, of ordinary wall-pocket shape, fairly closely woven, without any windows or interspace in mesh. Anterior barder not thickened and bear a short median rather broad anterior process at its dorsal end, practically covering pupa, its length along its base being about 3.7 mm. and dorsally up to end of median process about 3mm.

Respiratory filaments 6 in number arranged in three stalked pairs- a ventral, an outer, and a dorsal pair, stalks comparatinely stout, widely divergent, with surface covered with minute tubereles.

Integument of the head and thorax is light brown, sparsely covered with moderate-sized disc-like trubercles. The head bears the usual three pairs, while the thorax has five pairs of trichomes dorsally, short and simple.

KNOWN DISTRIBUTION IN PAKISTAN: NATHIA GALI (SAITO
1989) AND MANSEHRA
(LEWIS 1973)

NEW DISTRIBUTION: Kohat (Map 8).

NEW RECORD.

LOCALITY: I. Jungle Khel small Spring
water fall.
II. Kohat large turbid water
stream 1 km south of Kohat
city, on Rawalpindi road
near mosque.

DATES: I. July 5, 1994.
II. February 15, 1993.

BREEDING PREFERENCE I. Small water fall of Jungle Khel
Spring water, after the water used for people both and
small vehicle wash, with stony and muddy bed. Numerous
larvae and pupae were collected attached to long trailing
leaves of Typha, (Table 11, 23 and 24).

II. Large muddy stream with polluted (turbid) water.
20 larvae were collected attached to Potamogeton submerged
grass, (Table, 11, 23 and 24).

REMARKS: The larvae of this species were unique in their
taxonomic characters, like shape, and size of mandible

ventral groove, and specific pigmentation on frons. Pupae were also well distinguished by the branching pattern of respiratory filaments.

NEW DISTRIBUTION:

Aligarh (Swt) (Map 2)

6.4.2 Simulium austeni Edwards 1915, (Fig. 19).

Larva: Body length 5.5 to 6.0 mm. Color light. Pattern of head negative, area of attachment of muscles not pigmented. Pattern of frons H-shaped, with short anterior and broadened posterior parts of spot. Third antennal segment slightly shorter than 1st and 0.66 length of 2nd. Large flabellum with 43 to 48 bristles. Apex of mandibles with six to seven inner teeth, three to four terminally broadened bristles located along sides of mandible. Each branch of rectal processes with five to seven lobes. Band of spicules, predominantly solitary, located around rectal processes. Branched anterior end of chitinous frame with 10 to 20 minute spicules. Posterior sucker with 70 to 74 rows of crochets, with 11 hooks in each row.

Pupa: Body length about 3.0 mm. Length of respiratory filaments about 2.0 mm. Respiratory filaments six, located on three short stems. Stems of upper and lower pairs diverge at an angle of 100 to 140°. Color of respiratory filaments dark brown, surface smooth. Lower filaments much thinner and only 0.66 length of upper. Stem of lower pair of filaments thinner and longer than the other two, with middle stem shortest and thickest. Abdomen with

spicules along anterior margin of 7th and 8th segments. Trichomes simple. Cocoon simple with edging in front.

KNOWN DISTRIBUTION IN PAKISTAN: NOT reported

NEW DISTRIBUTION: Aligam (Swat) (Map.8)

NEW RECORD.

LOCALITY: Aligam irrigation channel near High school.

DATE: June 2, 1993

BREEDING PREFERENCE: Small irrigational channel with muddy and sandy bed. 102 larvae and 80 pupae were collected attached to submerged roots and potomegoton (Grass), (Table 10, 23 and 24).

REMARKS:

The specimens closely resemble Simulium truncatum in colour and other characters but their distinction as Simulium austeni is made by their size and large flabellum with 46 - 50 bristles of larva and branching pattern of respiratory filaments in pupa.

6.4.3 Simulium kohatiense sp. n., (Fig. 20).

Larva: Body length 2.5 to 4.5 mm. color light greenish yellow. Antennae light colored, 4-segmented, basal segment about two-thirds length of second segment and 2nd segment twice as longer as 3rd segment. Pattern of frons positive with two distinct pigments, on lateral side of

genal schlerite behind eye spot, anterior larger than posterior. Apex of mandibles with long bifurcated apical tooth. Ventral groove pointed apically. Submentum with 9 rather blunt apical teeth, medium tooth produced, lateral serrations 3 to 5 and a row of 3 to 5 bristles on each side. Posterior sucker with 70 to 90 rows of crochets, and 17-20 hooks in each row. Posterior branches of chitinous frame slightly larger than anterior ones: Rectal processes simple.

Pupa: body length 4 mm. by 2mm., respiratory filaments 0.6 to 0.9 mm., about two third in length of cocoon, 6 in number, ist 2 arising independently from main stem, while others in pairs. Integument of head and thorax light brown, with minute disc like tubercles. Head bears usual three pairs of short Trichomes, four pairs dorsally and six pairs laterally on thorax. Abdomen with a row of five to six sensory hairs on each side of segment 2, a row of backwardly directed cuticular spines along anterior border of segment 7 and 8, a few minute spines on segment 6 and poorly developed sub-terminal spines on segment 9 wall pocket shaped, Cocoon simple, with thin smooth walls, not covering pupa completely, brown in colour and tightly waven particularly in posterior half.

DISTRIBUTION IN PAKISTAN: KOHAT (Map 9)

LOCALITY: Army camp stream from Jungle
by the following Khel Springs water, Kohat.

DATE :	November 22, 1993	May 25, 1994
	December 10, 1993	June 21, 1994
	January 15, 1994	July 28, 1994
	February 1, 1994	August 12, 1994
	March 26, 1994	September 9, 1994
	April 20, 1994	October 8, 1994

BREEDING PREFERENCE: Swift flowing stream with muddy substratum, highly overgrown with long aquatic plants (Potamogeton). Numerous larvae and pupae found (over clustered) attached to trailing long potamogeton during all months of the year except April and May, (Table 11, 23, 24).

REMARKS:

This species is closely related with Simulium kurense (Rubzov) and Simulium worsakiense sp.n. on the basis of the following characters.

1. Antennae light in colour, 4 segmented, basal segment about two thirds the length of the 2nd segment and 2nd segment twice as long as 3rd segment.
2. Pigmentation in frons about similar.
3. Similar shape and pattern of teeth in submentum.
4. Posterior branches of chitinous frame slightly larger than anterior ones and identical in shape.
5. Rectal processes simple.

This species can be separated from the above two species by the following basic points.

1. Shape of the cocoon with characteristic number and branching of respiratory filaments.
2. Mandible with bifurcated apical tooth in larva.
3. Smaller body size.
4. The two distinct pigments on lateral side of larval genal sclerite, anterior longer than posterior.

6.4.4. Simulium kurense Rubtsov and Dzhafarov, 1951, (Fig. 21).

Larva: Body length 5.0 to 6.0 mm. Color light, with transverse brownish stripes along dorsal side. Frontal sclerite darkened only along occipital margin. Second antennal segment almost twice longer than 1st. Large flabellum with 30 to 37 bristles. Submentum with five to six bristles arranged one irregular row along each side. Ventral groove of cephalic capsule almost reaches posterior margin of submentum. Posterior sucker with about 94 to 100 rows of crochets, with 18 to 19 hooks in each row. Rectal processes simple.

Pupa: Body length about 3.0 mm. cocoon shoe-shaped, with short woven collar. Weaving of cocoon thin, color white, and walls opaque. Respiratory filaments eight, about equal in length and thickness, and grouped in pairs on four short stems. Length of filaments almost equal to 0.331 length of pupa. Four upper filaments separated from four

lower Stems of lower filaments longer by 0.33 to 0.50 stems of upper ones.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Dir, Chitral (Map 9)

NEW RECORD.

LOCALITY: I. Irrigational channel at Samar Bagh Bazar Bridge

II. Tributary to main stream of shishi Dara (Chitral) near Mosque.

DATE: I. June 1, 1994. II: May 7, 1993.

BREEDING PREFERENCE: I. Small irrigational channel with muddy bed and submerged aquatic plants of Potamogeton with 30 larvae attached and Cynodon with 24 larvae and 4 pupae attached, (Table 12, 23 and 24).

II. A Tributary to main stream of shishi Dara with muddy substratum. Among the larvae collected, 35 were attached to submerged Echinochloa and 10 to long exposed submerged root of walnut tree, and 13 pupae attached only to Echinochloa, (Table 13, 23 and 24).

REMARKS:

The larvae from Chitral and Dir showed little differences in larval colour and size but the rest of all basic characters were the same.

6.4.5 Simulium moristans Edwards 1915, Rubtsov
1940b, (Fig. 22).

Larva: Body length 5.5 to 6.0 mm. Pattern of frons consists of two large indistinct spots joined medially, but anteriorly indistinct. Large flabellum with 50 to 60 bristles. Ventral groove of capsule not reach posterior margin of submentum by a distance equal to 0.33 length of latter. Submentum with three to four bristles located along each side. Rectal processes branched, lateral branches with four lobes, middle branch with three. Posterior sucker with 64 to 66 rows of crochets, with 9-11 hooks in each row.

Pupa: Body length 3.0 mm. Cocoon simple, without openings. Respiratory filaments eight on each side, arranged almost in single vertical plane. Fourth filament from top notably thicker than the others, lower two pairs of filaments half thickness of fourth filament, and located on stems of varying length.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED.

NEW DISTRIBUTION: Kohat, Swabi and Swat

(Map.9).

NEW RECORD.

LOCALITY: I. Hangu main bridge stream, 1 km from
Hangu Bazar toward Kohat.

II. Topi (Swabi) irrigational channel near
Topi Qubristan.

III. Aligram irrigational channel, near

Simulium Govt. Primary School.

DATES: I. June 20, 1993. II. June 2, 1993 III. June 2, 1993.

BREEDING PREFERENCE: I. A large stream with sandy and muddy bed and swift flowing water. 32 larvae were collected from submerged potomogetan plant, (Table 11, 23 and 24). II. Topi (Swabi) irrigational channel with stony bed and muddy banks. 33 larvae and 14 pupae were collected attached to Potomogeton leaves, (Table 13, 23 and 24). III. Aligram irrigational channel with sandy and muddy bed. 50 larvae and to pupae were collected attached to submerged Potomogeton plant, (Table 10, 23 and 24).

REMARKS:

The specimens collected from different water bodies at different times showed markedly variabilities in the following characteristic.

1. Branching of respiratory filaments of pupae,
2. Number of bristles in flabella and
3. Crochets in sucker of larva.

But they were grouped together under Simulium moristans by their characteristic basic H - shaped frons with thin longitudinal lateral spots in larva and with only one of lower pair of filaments, located on long stem in pupa.

6.4.6. Simulium multistriatum Rubtsov 1951b, (Fig. 23).

Larva: Body length about 6.0 mm. body color grayish-white, with dark transverse chocolate-brown spots. Pattern of frons negative, indistinct, diffuse. Basal flabellum with nine bristles, large flabellum with 40 to 44, small flabellum with 20 to 28, spatulae six. Teeth of submentum very short, broad, and with outer scales over greater part of basal length. Lateral teeth protrude above middle ones. Anterior margin of groove of cephalic capsule not reaching posterior margin of submentum by a distance equal to 0.50 height of latter. Rectal processes branched, each of three branches with seven to eight lobes. Skin around rectal processes with single, double, and triple spicules. Chitinous frame with five to six short hairs located between posterolateral branches of semicircular

halves and crochets of posterior sucker with 90 to 92 rows of crochets, with 18 to 10 hooks in each row.

Pupa: Body length about 3.0 mm. Anterior lower margin of cocoon elongated toward front, often closed on lower side in form of more or less distinct collar with openings along sides. Anterior margin either smooth or, rarely, woven, Pupa protrudes slightly out of cocoon. Respiratory filaments eight, located on three very short stems. Upper filaments thicker and notably longer than lower filaments, their length about equal to maximum

diameter of pupa. Filaments converge apically. Surface of pupa with very minute tubercles. Abdominal tergites armed with spines (14 to 20), commencing from 8th segment.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Kohat (Map 10)

NEW RECORD.

LOCALITY: Army camp stream from Jungle Khel
Spring water, Kohat.

DATE: June 9, 1994.

BREEDING PREFERENCE: Swift flowing stream with muddy substratum, highly overgrown with long submerged Potamogeton (grass). About 200 larvae and 80 pupae collected among numerous larvae of Simulium Kohatiense sp.n., (Table 11, 23 and 24).

REMARKS:

The species was confused with Simulium kohatiense sp. n. but the following basic taxonomic characters separated the species:

1. Colour of the larvae
2. The rectal process with 3 branches and each branch with 8 to 9 lobes.
3. The structure and shape of cocoon and respiratory filaments.
4. Larger body size of pupae.

6.4.7 Simulium Puri sp.n. (Fig. 24).

Larva: Body length 3.8 to 4.0 mm, colour pale dirty brownish yellow. Head light golden brown, uniform in colour, with no markings. Antennae 4-segmented, basal segment about two-thirds in length of second, which divide into two segments about its middle with incomplete division, 3rd segment a little longer than first. Cephalic fans filaments 35 on each side. Mandibles carry three small teeth in sub-terminal row, arrow of 7 spine-like process of inner border, and cluster of hairs behind terminal teeth. Submentum with 9 teeth in front row, arrow of four on each side with 1st and 5th tooth longest, 4th medium and 3rd smallest and 3 bristles in arrow on each side.

Pupa: Body length 2.4 to 2.7 mm. cocoon dirty yellow, wall pocket shaped, closely woven, with out any interspace or widows in mesh. Integument of head and thorax brown. Respiratory filaments short, 4 in number, arising in form of 3 divergent branches. Lower most filaments and stems 2.0 times thicker at base than upper filaments, middle filament medium. Trichomes on head and thorax very short and simple with dorsal group of four pairs on thorax, a pair of strongly chitinized hooks on ventral surface of segment 4 and poorly developed row of backwardly directed cuticular spine along anterior border. Subterminal spines absent.

DISTRIBUTION: TAMARGARA (DIR), ROSTUM (SWABI)
(Map 10).

LOCALITY AND DATE: I. Tamargara bridge toward Jandool
dated may 2, 1993 and June 6,
1993.

II. Rostum Qubristan stream, 1 km
east of Rostum bazar on June 28,
1994.

BREEDING PREFERENCE: I: Tamargara sandy and stony bank of
Pun kora river (large river) with slow flow of water.

Larvae and pupae were collected as: 5 larvae and 2 pupae
attached to small yellow stone, 2 larvae only from yellow
stone and 3 larvae and 3 pupae from pure white stone,
(Table 12, 23 and 24).

II: Swift rocky broken water stream, with a collection of
41 larvae and 40 pupae attached to 2 white marble stones,
(Table 13, 23 and 24).

REMARKS:

This new species is comparable with S. polare Rubsov, S. angustifilum Rubzov and S. tumulosum Rubzov due to some of the body characters in larva and pupa but it can be separated from them on basis of the following differences.

1. Shape of ventral groove which is rectangular deep and reaches almost to the posterior margin of submentum.
2. Mandibles bear arrow of spine like inner teeth.
3. Submentum with a row of 4 teeth serration on each side and 4 bristle in a arrow on each side.

4. Shape of cocoon and respiratory filaments unique.

6.4.8 Simulium remotum Rubzov (Fig. 25)

Larva: Body length 4.0 to 5.0 mm. Pattern of frons positive, frontal sclerite darkened along posterior margin. Ventral groove of cephalic capsule broad and deep, slightly short of reaching posterior margin of submentum. Submentum with three bristles along each side and two in middle. Large flabellum with 36 to 38 bristles. Rectal processes branched, lateral branches with six to seven lobes, middle branch with six lobes, of which one notably thicker and longer than the others. Posterior sucker with 58 to 60 rows of crochets, with 13 + 1 hooks in each row.

Pupa: Body length about 2.8 to 3.0 mm. cocoon with one large opening along each side and three to four minute openings in front of large one. Respiratory filaments six, located on three widely separated stems. Lower pair notably thinner than upper, average length of filaments slightly more than half length of pupa.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Stat and Swabi (Map 10).

NEW RECORD.

LOCALITY: I. Charbag (Swat),
II. Shah Derhi (Swat)
III. Zaida (Swabi)

DATE: I. August 24, 1993.

II. June 15, 1993.

III. May 15, 1993.

BREEDING PREFERENCE: I: Long irrigation channel along the main road with muddy bed, slow flowing water. Larvae and pupae were collected from submerged grass blades (Typha) under the thick shade of walnut tree as follow: 15 Larvae and 30 Pupae attached to grass blades and 5 larvae attached to dead submerged leaves of walnut tree. (Table 10, 23 and 24).

II: Irrigation channel with rocky and muddy bed and swift flowing water. 9 Larvae only were collected attached to aquatic plant (Typha). (Table 10, 23 and 24).

III: Small irrigation channel with muddy bed. 80 larvae and 14 pupae collected attached to submerged Typha leaves. (Table 13, 23 and 24).

REMARKS:

The specimens collected from Charbag differ in size as compared to larvae from Zaida but as a whole, based on structure of pupa, especially the cocoon, they all belong to Simulium remotum. This species is similar to Simulium subvariegatum (Rubz) but it is distinguished by positive pattern of frons of larva and branching lobes of rectal processes.

6.8.9 Simulium swatiense sp. n., (Fig. 26).

Larva: Body length 6.5 to 7.5 by 2 to 2.5 mm.

Pattern of frons negative with light-colored spots on dark background. colour dark dirty brown with black head. Second antennal segments 2.0 times longer than 1st segment. Large flabellum with 38 to 41 bristles, small flabellum about 29 to 31. Apex of mandibles with large apical shape tooth and obtuse marginal teeth. Submentum large, concave with smaller and pointed teeth central large, pointed tooth and two long bifurcated bristles on each side. Ventral groove of cephalic capsule with acute angles, arched and pointed toward front. Rectal process complex, thick, with 28 filaments arising from a central knob like papillae from three separate position making triangle. Belt of spinules, consisting predominantly of minute thick, short, spaced spinules, encircles rectal processes. Posterior sucker with 80 to 90 rows of crockets, with $12 + 1$ hooks in each row.

Pupa: Body length 5.5 by 1.5 to 2.0 mm. Respiratory filaments 12 in number about half the length of pupa. Integument of head and thorax brown. Head bears 2 pairs of short trichomes, 3 pairs dorsally and 5 pairs laterally on thorax. Abdomen with a row of 9 to 10 sensory hairs on each side of segment 2, a row of minute and pointed spines on 6, 8 and 9.

Cocoon simple with unique structure as inverted J. shaped, loosely woven with two prominent openings (windows) on left and three on right anterior side and wide spaces at posterior. It covers pupa completely with two

prominent long anterior processes and free fibers coming out of cocoon at posterior end.

DISTRIBUTION IN PAKISTAN: SWAT (Map 11).

LOCALITY: I. Marghozor stream near the Mosque beneath the road and irrigation channel, 1/2 a kilometer down the stream.

DATE: June 8, 1993

BREEDING PREFERENCE: Marghozar stream: swift flowing rocky stream with stony bed. Ninety larvae and 40 pupae were collected attached to white stones (10 larvae, 40 pupae) and 2 white submerged thick plastics (20 larvae only) II: Marghozar irrigation channel: small channel under thick shadow of trees with stony and sandy bed. 15 larvae and twenty pupae were attached to white roots of terrestrial plant. (Table 10, 23 and 24).

REMARKS:

This species closely resemble Simulium multistriatum (Rubzov) and Simulium pallus (Rubzov) on the basis of the following characters

1. Shape and size of ventral groove
2. The shape and size of submentum, particularly the bifurcated bristles on each side.
3. The shape and size of mandible.
4. The branched rectal process partly similar.

5. The shape of chitinous frame.

This species differ from above species on the basis of the following points

1. The unique and complicated shape of cocoon of the pupa.
2. The branching pattern and number of respiratory filaments.
3. The size, shape and number of segments in antenna.

6.4.10 Simulium tumulosum Rubzov, Rubtsov 1989, (Fig. 27).

Larva: Body length about 6.0 mm. Color dirty green, dark. Large flabellum with 36 to 40 bristles. Ventral groove of cephalic capsule acutely angled, does not reach posterior margin of submentum by a distance less than half length of latter. Each lobe of rectal processes with seven to eight branches. Posterior sucker with 68 to 74 rows of crochets, with 12 + 1 hooks in each row.

Pupa: Body length 3.0 to 3.2 mm. Cocoon simple, with edging along anterior margin. Respiratory filaments six, located on three short stems. Two upper pairs of respiratory filaments branch in horizontal plane, lower pair on longer stem in vertical plane.

KNOWN DISTRIBUTION IN PAKISTAN : NOT REPORTED.

NEW DISTRIBUTION : Dir, Swat (Map 11).

NEW RECORD:

LOCALITY WITH DATE: I. Darora (Dir) Bridge water fall

August 5, 1993.

II. Seiri (Dir) bridge irrigational

Channel August 1, 1993.

November 15, 1993.

III: Daryal (Swat) Irrigational

channel, June 14, 1994.

IV. Aligram (Swat) irrigational

channel, near Government Primary

School, June 2, 1993

SUBSTRATUM PREFERENCE: I. Darora Bridge large water fall is 22 km South of Dir (proper) and 1 km North of Daroro main Bazar, with rocky bed, mostly covered with algae. Only 5 larvae seen attached to dead leaf suspended in swift flowing water, (Table 12, 23 and 24).

II. Seiri Bridge irrigational channel is 15 km South of Dir (proper) with sandy and muddy substratum and swift flowing water. 400 larvae and 30 pupae attached to submerged filamentous leaves of Cynodon collected on August 1st and 10 larvae and 4 pupae only collected on November 15, 1993, (Table 12, 23 and 24).

III: Daryal irrigational channel is near main Jama mosque with slow flow of water and muddy bed. 180 larvae and 10 pupae were attached to Cynodon submerged plant, (Table 10, 23 and 24).

IV. Aligram (Swat) irrigational channel, with sandy and muddy bed. 20 larvae and 15 pupae were collected attached

to submerged leaves of *Cynodon* (grass), 10 larvae and 5 pupae collected from roots of apple plant, (Table 10, 23 and 24).

REMARKS:

These specimens collected resemble closely *Simulium Vulgare*, especially, the larvae from Aligam were highly confused but the separation was made by their longer size, larger flabellum with 45 bristles and characteristic size of respiratory filaments in pupa.

6.4.11 *Simulium worsakiense* sp. n., (Fig. 28).

Larva: Body length 5.9 - 6.5 mm. Head capsule brown in colour, pattern of frons positive, some time very pale. Lateral side of head with a row of three pigmented spots below and behind eye-spots. Eye-spots fully developed. Ventral groove pointed apically, constricted basally. Postgenal bridge equal in length to hypostomium. Hypostomium with 9 rather blunt apical teeth, only median tooth produced, 3-5 lateral serration, 5-7 bristles in each row, rows divergent. Antennae longer than stem of cephalic fan, weakly pigmented and length ratio of first three segments 1:1:0.5. Outer margin of mandible not strongly arched, first three comb-teeth sub-equal in size and with a long, thin posterior serration followed by a very small serration. Cephalic fan with 50-53 primary rays. Posterior

sucker with 70 to 90 rows of crochets and 18-21 hooks in each row. Chitinous framed and rectal processes similar in shape as in Simulium kohatiense sp. n.

Pupa: Cocoon 3.5 x 1.2 mm., not covering the pupa completely with dorsal end 2.5 mm, brown in colour, wall-pocket shape and loosely woven particularly in anterior half but no 'windows' or wide spaces in web. Its anterior margin thickened into a moderately strong rim with no floor in anterior half of cocoon.

Respiratory filaments about half as long as pupa, 6 in number, arranged in three pairs, upper and lower pairs with short stalks while middle pair arises partially directly from main stem. Filaments all spread out near their origin and uppermost filament more or less at right angle to lower most one.

Integument of the head and the thorax light brown, with minute dislike tubercles scattered all over. Head bears three pairs of short trichomes, four pairs dorsally and six pairs laterally on thorax and abdomen with a row of six to seven sensory hairs on each side of segment 2, 3 and 4. On segments 7 and 8, a row of backwardly directed cuticular spines along anterior border present, a few minute spines on segment 6 and a pair of poorly developed sub-terminal spines on segment 9.

DISTRIBUTION IN PAKISTAN: WARSAK (PESHAWAR) (Map 11).

LOCALITY: River Kabul at warsak, just

beneath the Rest House of
the irrigational Departments

DATE: July 30, 1993.

BREEDING PREFERENCE: Sandy and stony Bank of large river with swift flow of water. 19 larvae and 10 pupae collected attached to trailing grass of *Echinochloa*, (Table 13, 23 and 24).

REMARKS:

This species is comparable with *Simulium kohatiense* (new species) and *Simulium kurense* (Rubzov) due to some of the body characters in larva and pupa as mentioned earlier but it can be separated from them on basis of the following differences.

1. Shape of cocoon, branching pattern and number of respiratory filaments.
2. Shape and pattern of teeth in mandible.
3. A row of three pigmented spots below and behind eye-spots and
4. Size and water body difference in larvae and pupae.

6.4.12. *Simulium xanthogastrum* Rubtsov, 1951b, (Fig. 29).

Larva: Body length 5.0 to 6.0 mm. Pattern of frons negative, indistinct. Large flabellum with 40 to 44 bristles, lower flabellum with 23 to 25, basal flabellum with eight to nine, spatulae six. Teeth of submentum short. Ventral groove of cephalic capsule roundish, extends beyond

midpoint of length of cephalic capsule. Posterior end of body with very sparse short hairs. Rectal processes branched: each of three branches with 12 to 13 lobes, of which one lateral lobe and middle part of posterior lobe thicker than the others. Skin around rectal processes with numerous single, double, and triple spinules. Chitinous frame at posterior end of body with six to eight spinules located between its posterior branches and crochets of posterior sucker, of which one slightly larger spinule occurs between bases of chitinous semicircles. Posterior sucker with 88 to 90 rows of crochets, with 14 to 16 hooks in each row. Larvae and pupae collected were mostly

Pupa: Body length 2.5 to 3.0 mm. Cocoon simple often, anterolateral margins highly elongated toward front. Respiratory filaments eight. Trichomes simple and branched, five trichomes located along median line of dorsum. Plaques on dorsum very minute and uniformly scattered along anterior margin of dorsum and on head. Dorsal side of abdomen of pupa with spines on last two abdominal segments-7th and 8th.

KNOWN DISTRIBUTION IN PAKISTAN : KALAM (SWAT) (SAITO 1989), CHILAS, MARGHUZAR (SWAT), (LEWIS 1973).

NEW DISTRIBUTION: Warsak (Map 12).

NEW RECORD.

LOCALITY: Genus: *Wilhelmsia* End. River Kabul at Warsak,
 Generic Character: just beneath the Rest
 Larva: Submentum with House of Irrigational
 height of sub-mentum only 1.40 to Department.

DATE: July 30, 1993.

BREEDING PREFERENCE: Sandy and stony Bank of large river
 with swift flow of water. Collection consisted of 4 larvae
 and 10 pupae attached to trailing grass of *Echinochloa*,
 (Table 13, 23 and 24).

REMARKS: The larvae and pupae collected were mostly
 similar to *S. multistriatum* (Rubtsov 1951b) but they are
 separated because of three branches of rectal processes,
 each with 12 lobes and ventral groove of cephalic capsule
 roundish which extends beyond midpoint of length of
 cephalic capsule.

Larva: Pattern of spots positive, shaded. Large
 submentum with 12 to 15 bristles; Submentum protrudes
 forward in form of large ridge. Thorax relatively
 with 20 to 25 rows of tubercles, with 20 + 1 bristles in each
 dorsal row, and 24 + 1 in each ventral row.

Pupa: Body length 1.5 to 2.0 mm; cocoon dark-
 colored, finely woven, interior surface without ridges; does
 not distinctly protrude forward, and opening on upper side.

6.5.0 Genus: Wilhelmia End. its characterised by highly bulging
Generic Character.

Larva: Submentum with broad anterior margin; height of sub-mentum only 1.40 to 1.50 times greater than distance between lateral (5th) teeth. Apices of teeth on mandibles (apical, subapical, and inner) aligned. Rectal processes simple, without ring of spinules. Abdominal processes on posterior end of body absent. Posterior sucker with broad ring of crochets: 90 to 120 rows, with 20 to 30 hooks in each row.

Pupa: Cocoon with collar. Respiratory filaments six to eight on each side, bulge, Two filaments (upper and lower) thicker and attached directly to body of pupa; remaining four to six filaments directed forward and arranged in two rows.

6.5.1 Wilhelmia e. equina (Horse blackfly), (Fig. 30).
Linnaeus, 1746, Edwards, 1921, Rubtsov, 1940b. (Fig. 30).

Larva: Pattern of frons positive, shaded. Large flabellum with 46 to 53 bristles. Submentum protrudes forward in form of large median tooth. Posterior sucker with 90 to 100 rows of crochets, with 20 + 1 hooks in each dorsal row, and 24 + 1-2 in each ventral row.

Pupa: Body length 3.6 to 4.0 mm. cocoon boot-shaped, finely woven, anterior margin without edging, does not distinctly protrude forward, and opening on upper side

almost round. Respiratory filaments characterized by highly bulging six middle branches, absence of conspicuous constriction at base and, often attenuation toward apex. Upper branches (of six middle ones) shorter and thinner than others.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Kohat, Mardan, Mansehra, Shabqadar, Peshawar, Mingora, Bannu, Swabi (Map 12).

NEW RECORD:

- LOCALITY AND DATE: I. Large turbid stream, Kohat 1 km South of Kohat city: February 15, 1995.
- II. Small irrigational channel at Thoromayar: June 5, 1993.
- III. Swift cold water rock stream near senior civil judge office Mansehra: March 20, 1993 and August 17, 1993.
- IV. Small irrigation channel near jarandow kali, shabqadar: July 7, 1993.
- V. Irrigational channel near Haji Camp, Peshawar: July 8, 1993.
- VI. Swift rocky irrigational channel, beneath saidu College, Mingora

Swat: December 28, 1992.

VII. Irrigational channel, 1 km east of main Bannu Bazar: August 23, 1993.

VIII. Irrigational channel, 1 km north of Zaida Main Bazar: May 15, 1993.

IX. Swift rocky broken water stream thor Dher: August 20, 1993.

X. Small irrigational channel near Kababian, Warsak road, Peshawar: July, 1993.

BREEDING PREFERENCE I. Large muddy stream with polluted water. 45 larvae were attached to long submerged Potamogeton (grass), (Table, 11, 23 and 24).

II. Small irrigational channel with muddy bank under complete shadow of shishum trees, 19 larvae and 4 pupae were attached to trailing leaves of Typha, (Table 13, 23 and 24).

III. Swift rocky stream with stony, rocky and muddy bed 58 larvae and 8 pupae were collected attached to Cynodon submerged grass, (Table, 13, 23 and 24).

IV. Small irrigation channel with muddy bed. 10 larvae and 3 pupae attached to Cynodon submerged grass, (Table, 13, 23 and 24).

V. Irrigational channel with slow water flow, muddy bed and bank 5 larvae and 20 pupae were collected attached to leaves of Typha, (Table, 13, 23 and 24).

VI. Swift rocky irrigational channel 6 larvae and 3 pupae were collected attached to submerged Cynodon grass, (Table, 10, 23 and 24).

VII. Irrigational channel with muddy bank. Only 5 larvae collected from submerged Typha plant, (Table, 13, 23 and 24).

VIII. Slow muddy irrigational channel covered with thick shadow of shishum plants 97 larvae and 14 pupae collected attached to submerged leaves of Typha plant, (Table, 13, 23 and 24).

IX. Swift rocky stream with broken water and muddy bed. 7 larvae and 3 pupae were attached to Potamogeton submerged plant and only 3 larvae attached to a dead leaf, (Table, 13, 23 and 24).

X. Small irrigational channel near Kababian, with muddy bed. 40 pupae only were collected attached to submerged Echinochloa, (Table, 13, 23 and 24).

REMARKS:

Undoubtedly an aggregate species, represented by a large number of forms collected from a large area of distribution in different geographic locations and different water bodies. The most distinct differences are

seen in the pupal stage - in structure of respiratory filaments. Some of the specimen very closely resemble Wilhelmia bianchii (Rubz) and Wilhelmia ivashentzovi (Rubz) but their separation and putting them under this single species is based on the following characters.

1. Posterior sucker with 20 hooks in each row in larva.
2. Lower branch in respiratory filaments equal to lateral branches in thickness or slightly thinner.

6.5.2 Wilhelmia lineata Meigen, 1804. (Fig. 31).

Larva: Body length 5.0 to 6.0 mm. Color light yellow. Pattern of frons positive, anterior spot indistinct. Large flabellum with 46 to 50 bristles. Antennae with relatively short apical and subapical segments and elongated 2nd segment. Submentum with broad lateral margins; 1st, 4th and 5th teeth protrude above others. Ventral groove of cephalic capsule broad, short, not reaching anterior margin of submentum by a distance equal to 0.40 length of submentum. Posterior sucker with 108 to 120 rows of crochets, with 26 to 30 hooks in each row.

Pupa: Body length about 3.0 mm. Cocoon boot-shaped, with very short collar and barely raised in front. Respiratory filaments short, six anterior filaments grouped compactly near base, differ slightly in thickness and

attenuate toward base. Three inner filaments notably shorter than three outer.

KNOWN DISTRIBUTION IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Chitral (Map 12).

NEW RECORD.

LOCALITY: Mian irrigational channel, beneath main Jama Masjid, Chitral Bazar.

DATE: May 14, 1993.

BREEDING PREFERENCE: Main irrigational Channel with small stony, and rocky bed with stony and muddy bank. 5 larvae attached to Echinochloa while 6 larvae and 9 pupae attached to submerged exposed roots of trees, (Table, 13, 23 and 24).

REMARKS:

These specimens resembled *wilhelmia veltistshevi* (Rub2) but due to number hooks of head of larvae and pattern of respiratory filaments in pupae (3 inner filaments notably shorter than 3 outer), they were taxonomically placed under *wilhelmia lineate*.

6.5.3 *Wilhelmia mayarience* sp. n. (Fig. 32).

Larva: Body length 3.0 to 4.5 mm by 1.5 to 2.0 mm. Pattern of frons positive. Colour pale yellow with prominent eye spots. Antennae segmented and slender with 1st segment slightly swollen near base and nearly equal in size to 3rd

segment. Second segment almost double in size of 1st segment while 4th minute. Large flabellum with 50 to 60 bristles, small flabellum with 37 to 40. First and 4th to 5th teeth of submentum slightly larger than others. Ventral groove of cephalic capsule small, arched. Rectal process simple, thick and consists of 3 processes prominent at posterior end. Posterior sucker with 90 to 104 rows of crochets, with 18 to 27 hooks in each row.

Pupa: Body length 2.0 to 3.0 mm by 0.8 to 1.0 mm. Respiratory filaments 0.5 to 0.7 mm, short, 12 in number, 6 on each side arising as shown in Fig. Integument of head and thorax light brown. Head bears 2 pairs of long trichomes, 3 pairs dorsally and 5 pairs laterally on thorax. Abdomen with a row of four to five sensory hairs on each side of segment 2, a row of small cuticular spines of segment 6, 7 and poorly developed spines on segment 8 and 9. Cocoon simple, with two lateral processes at anterior side, wall pocket shaped with thin smooth wall and about two third of pupa exposed at anterior side. Its anterior margin thickened into a moderately strong rim with no floor in anterior half of cocoon.

DISTRIBUTION IN PAKISTAN: DIR

LOCALITY: Mayar (Dir) (Map 13).

DATES: March 3, 1994 April 16, 1994

May 1, 1994 June 1, 1994

July 8, 1994

August 29, 1994

September 15,

October 16, 1994.

BREEDING PREFERENCE: Kundi Irrigation channel, with swift water flow, sandy and muddy bed, over grown with submerged grass (Hydrella), fully loaded with larvae and pupae. Some larvae and pupae were also attached to stones. The number of larvae and pupae collected were: March larvae 40, April 150 larvae and 100 pupae, May 200 larvae and 120 pupae, June 35 larvae and 100 pupae, July 10 larvae and 35 pupae, (Table, 12, 23 and 24).

REMARKS:

This species closely resemble. Wilhelmia lineata (Meigen) and W. mediterranean (puri) on the basis of the following characters:

1. Submentum partially similar
2. The mandible, its shape and pattern of teeth.
3. Shape and size of ventral groove and
4. Respiratory filaments in pupae, their pattern and number.

This species is separated from the above species on the basis of the following characters.

1. The size and shape of the cocoon of pupae.
2. The pigmentation on frons.
3. Rectal processes.
4. Size and water bodies habits of larvae and pupae.
5. Pigmentation, number and size of segments of antenna.

6.5.4 Wilhelmia mediteranea Mediterranean blackfly
Puri, 1925a, Rubtsov, 1951b, (Fig. 33).

Larva: Body length 5.0 to 7.0 mm. Pattern of frons positive, distinct, on light background. Second antennal segment 1.5 times longer than 3rd segment. Large flabellum with 40 to 50 bristles, small flabellum with 27 to 30. First 4th and 5th teeth of submentum slightly larger than others. Ventral groove of cephalic capsule deep and broad and not reaches posterior margin of submentum by a distance almost equal to 0.50 height of latter. Posterior sucker with 104 to 124 rows of crochets, with 22 to 32 hooks in each row.

Pupa: Body length 2.8 to 3.0 mm, rarely upto 4.0 mm. Cocoon with short collar, usually without edging along margins. Middle six respiratory filaments highly constricted toward base among them, outer three filaments slightly longer than inner ones, and lower filaments 1.5 to 2.0 times longer than upper.

KNOWN DISTRIBUTION IN PAKISTAN: RAWALPINDI (PURI 1933B AND LEWIS 1973), CHILAS AND SWAT (LEWIS 1973).

PRESENT DISTRIBUTION: Swat and Swabi (Map 13)

NEW RECORD:

LOCALITY: I. Rocky irrigational channel near Saidu Baba Ziarat (Swat).

II. Marghozar irrigational channel,

half a kilometer down the main

Marghozar Mosque.

III. Thordhere rocky stream (Swabi)

DATES: I. June 3, 1993.

II. June 8, 1993.

III. August 20, 1993.

BREEDING PREFERENCE I. Small rocky irrigational channel and muddy bed. 40 larvae and 3 pupae were attached to *Cynodon* submerged grass, (Table 10, 23 and 24).

II. Small irrigational channel in a sheltered wooded valley with sandy and stony bed. Only 20 larvae were collected, attached to grass blades of *Cynodon*, (Table 10, 23 and 24).

III. Swift rocky stream with broken water, rocky and muddy bed. 15 larvae and 10 pupae were collected attached to submerged *Potamogeton*, (Table 13, 23 and 24).

REMARKS:

The structure of the respiratory filaments is the most unique and distinctive of this species, and is generally well expressed and relatively constant through out the three different areas of distribution of this form. The upper and lower of the six middle filaments display maximum variability. Three specimen from Saidu showed some bulging and much longer outer filaments. Larvae were identical.

5.5.5 Wilhelmia paraequina Puri, 1933, (Fig.34).

Larva: Body length 5.0 to 7.0 mm. Pattern of frons positive, distinct. Second antennal segment 1.5 times longer than 1st segment, 1st segment slightly longer than 3rd. Large flabellum with 45 to 48 bristles, and small flabellum with 30 to 32. Ventral groove of cephalic capsule broad, roundish, does not reach posterior margin of submentum by a distance equal to 0.50 height of latter. Groove about equal in width and depth. Posterior sucker with 116 to 130 rows of crochets, with 22 to 24 hooks in each dorsal row, and 25 to 28 hooks in each ventral row.

Pupa: Length of cocoon 2.6 to 3.0 mm. Length of collar along lower margin 2.0 to 2.4 mm. Walls thin, smooth, and without openings and edging along anterior margin. Respiratory filaments similar to those of W. Veltistshevi. Distinguished by slightly less bulging and greater length of lower branches.

KNOWN DISTRIBUTION IN PAKISTAN: SKARDU (SAITO 1989) AND

CHILAS (SAITO 1989 AND

LEWIS 1973).

NEW DISTRIBUTION: Chitral Ashirat

NEW RECORD.

LOCALITY: Ashirat stream

DATE: May 3, 1993.

BREEDING PREFERENCE: Swift rocky stream with broken, foamy

water and stony bed. 69 larvae and 15 pupae were collected attached to small stones, (Table 13, 23 and 24).

REMARKS: Larva with large and spade like on sides, self

REMARKS: Larva with large and spade like on sides, self

The specimens were markedly distinguished and identified except a few larvae from the same collection which were closely confused with wilhelmia mediterranea but they were separated because of the characteristic number of 116 to 130 rows of crochets in posterior sucker.

The larvae collected from this area closely

6.5.6 Wilhelmia salopienis Rubtsove 1989, (Fig.35).

Larva: Body length 5.0 to 7.0 mm. Frons darkened, with indistinct positive pattern. Antennae with short apical segment. Large flabellum with 38 to 40 bristles. Submentum broad. Ventral groove of cephalic capsule roundish. Posterior sucker with 90 to 94 rows of crochets, with 16 to 24 hooks in each dorsal row, and 22 to 26 hooks in each ventral row. Rectal processes simple and thick.

Pupa: Body length 2.5 mm. Cocoon boot shaped. Respiratory filaments of pupa as shown in Fig. 35. Six anterior respiratory filaments broaden slightly toward base. Lower outer filaments 2.0 times longer and notably thicker than upper ones. Frontal sclerite of cephalic capsule of pupa with three pairs of bristles.

KNOWN DIST IN PAKISTAN: NOT REPORTED

NEW DISTRIBUTION: Swat (Map 14).

NEW RECORD: Dewli (Swat)

DATE: May, 5, 1993.

BREEDING PREFERENCE: Small tributary stream with stony bed, covered with herbage and apple trees on sides; Swift flowing crystal clear water. 150 larvae and 90 pupae collected attached to small stones and rocks. (table 10, 23 and 24).

REMARKS:

The larvae collected from this area closely resemble Wilhelmia balcanica in most of their taxonomic characters but they are separated on the basis of the following basic points:

1. Branching pattern of respiratory filaments in pupa
2. Ventral groove of cephalic capsule is distinct toward front.

6.5.7 Wilhelmia turgaica Rubtsov, 1940b, Rubtsov, 1951b, (Fig. 36).

Larva: Body length 4.0 to 5.0 mm. Pattern of frons positive. Large flabellum with 37 to 38 bristles, small flabellum with 13 to 15, spatulae six. Submentum and groove of cephalic capsule shallow and often indistinct due to broad and gradual thinning of chitinous cover from posterior margin of submentum toward posterior margin of cephalic capsule. Posterior end of body with two dark

chocolate-brown spots, equal in size and eroded along margins. Rectal processes without leathery spinules but posterior end of body on dorsal side with minute trifid hairs. Posterior sucker with 108 to 112 rows of crochets, with 20 hooks in each dorsal row, and 30 in each ventral row.

Pupa: Body length 2.5 to 2.8 mm. Cocoon boot-shaped. Lower margin of collar usually spoon-shaped. Walls of cocoon thin, translucent, smooth, without openings along sides. Branching and shape of respiratory filaments shown in Fig.36. Filaments elongated from top side downward, which is readily seen in outer filaments; lower outer filaments 2.0 times longer than upper, and lower inner, on the average, 25% longer than upper.

KNOWN DISTRIBUTION IN PAKISTAN: CHANGA GALI (SAITO 1989) AND SWAT (LEWIS 1973).

PRESENT DISTRIBUTION: Chitral and Swat (Map 14).

NEW RECORD:

LOCALITY: I. Small Rocky irrigational channel near Saidu Baba Ziarat.

II. Ashirat stream

DATE, I. June, 3, 1993.

II. May 3, 1993.

BREEDING PREFERENCE: I. Small Rocky irrigational channel with stony and muddy bed. only 25 larvae were collected from submerged Cynodon grass.

II. Swift Rocky stream with broken, foamy water and stony bed. 30 larvy and 5 pupae were found attached to small stone.

Chitral (Map 14)

NEW RECORD:

REMARKS:

LOCALITY: Larvae from Chitral were lighter in colour and smaller in size as compare to specimen collected from Saidu Sharif, but the other basic taxonomic characters were the same.

6.5.8 Wilhelmia veltistshevi Rubtsov, 1940b (Fig. 37).

Larva: Body length 5.0 to 6.0 mm. Pattern of frons positive, usually on dark background. Body color often greenish. Large flabellum with 42 to 48 bristles. First to 4th teeth of submentum protrude above 5th teeth. Ventral groove of cephalic capsule broad, roundish. Posterior sucker with 106 to 115 rows of crochets, with 20 to 25 hooks in each row. Body of larva covered with trifid hairs at posterior end.

7. Large river with sandy and stony bed. 25 larvae and 10

Pupa: Body length 2.8 to 4.5 mm. Cocoon with distinct longer collar. Respiratory filaments six relatively shorter and thicker, more or less uniform in

length, highly constricted near base, and attenuate markedly toward apex. collected from *Echinochloa* submerged grass. (Table 13, 23 and 24).

KNOWN DISTRIBUTION IN PAKISTAN: SKARDU (SAITO 1989).

NEW DISTRIBUTION N.W.F.P: Abbottabad, Dir and Chitral (Map 14).

NEW RECORD: Larvae in size of larvae and pupae with those from Dir and Chitral. Interestingly, the species showed far

LOCALITY: I. Irrigational channel Abbottabad Bazar.
 II. Punjkora river at Tamirgar Main Bridge.
 III. Irrigational channel beneath Drosh Main Bazar.

DATE: I. May 18, 1993.
 II. May 2, 1993.
 III. May 3, 1993.

BREEDING PREFERENCE: I. Small irrigational channel with slow flowing water, muddy bed, 40 larvae and 5 pupae attached to *Echinochloa* submerged grass, (Table 13, 23 and 24).

II. Large river with sandy and stony bank. 25 larvae and 15 pupae attached to small stones were collected, (Table 12, 23 and 24).

III. Medium size irrigation channel with muddy bed and 110 larvae and 15 pupae collected from *Echinochloa* submerged grass, (Table 13, 23 and 24).

REMARKS:

The form in the collections of Abbottabad showed little differences in size of larvae and pupae with those from Dir and Chitral. Interestingly, the species showed far and wide distribution in different water bodies, markedly in temperature regime and other properties.

6.6.0 RESULT (ECOLOGICAL)

6.6.1 ECOLOGICAL OBSERVATION

The ecological observations based on collection of larval and pupal stages of each species with information about their breeding preferences, species association, seasonal abundance, and physical and chemical characteristic of water bodies in correlation with species distribution summarized in tables 10 to 31.

Table 11 gives information about locality wise distribution, with number of larvae and pupae of different species of Simuliidae, collected from different parts of district Swat and Malakand Agency. A total of 13 species collected from district Swat has a highest number of larvae and pupae of Simulium tumolusum (180 larvae and 10 pupae) from Daryal and lowest number of wilhelmia e. equina (10 larvae only) from Mingaulara and only four larvae of Eusimulium malakandiense from Malakand (Fig. 38, 39).

Localitywise distribution with number of larvae and pupae in table 11 showed a total of 9 species from district Kohat with numerous larvae and pupae of Boophthora erythrocephole and Simulium Kohatiense Sp.n. from jungle Khel Kohat and lowest number (13 Larvae and 5 pupae) of Eusimulium inflatum from Bannu Road Kohat (Fig. 40, 41).

A total of 12 species of Simuliid larvae collected from different localities of district Dir showed a highest number of larvae (400) of Simulium tumolusum from

Seiri and pupae (200) of Eusimulium diriense from Mayar and a lowest number of larvae (5) of S. tumulosum and pupae (5) of E. montuim from show (Dir) (Table 12, Fig. 42, 43).

Table 13 shows distribution of different species of Simuliidae in different districts: Abbottabad (one species: Wilhelmia veltistshevi with 40 larvae and 46 pupae), Bannu (two species: E. planiparum with 30 larvae and 9 pupae and W. e. aquina with 5 larvae only); Charsadda (two species: E. fontinale with 15 larvae and 10 pupae and Wilhelmia e. equina with 10 larvae and 3 pupae), Chitral (seven species: Obuchovia albela with 28 larvae and 46 pupae, O. chitraliense sp.n. with 50 larvae and 20 pupae, Simulium kurense with 45 larvae and 13 pupae, S. kurense with 45 larvae and 13 pupae, Wilhelmia lineata with 11 larvae and 9 pupae, W. paraequina with 69 larvae and 15 pupae, W. targiaca with 230 larvae and 5 pupae and W. veltistshevi with 110 larvae and 15 pupae), Mansehra (only one species: Wilhelmia e. equina with 58 larvae and 8 pupae), Mardan (three species: B. erythrocephala with 25 larvae and 30 pupae, E. aureum with 9 larvae and 4 pupae, W. e. equina with 19 larvae and 4 pupae), Peshawar (three species: S. xanthogastrum with 4 larvae and 10 pupae, S. warsakiense with 19 larvae and 10 pupae and W. e. equina with 5 larvae and 20 pupae from Haji Camp and 40 pupae only from Kababian, Warsak Road), and Swabi (four species: S. moristum with 33 larvae and 14 pupae, S. puri sp. n. with

111 larvae and 40 pupae, S. remotum with 80 larvae and 14 pupae and W. e. equina with 97 larvae and 14 pupae from Zaida and 10 larvae and 3 pupae from Thordir (Fig. 44, 45).

Table 14 includes district wise distribution of different species of Simuliidae from all districts, showing mountainous and plain area distribution. Tables 15-18 shows physical parameters of different water bodies in different district i.e. Swat and Malakand (Table 15 Fig. 46), Kohat (Table 16 Fig. 47), Dir (Table 17 Fig. 48), and other districts.

Table 18 Fig. 49) Table 19-22 summarizes its chemical parameters, Table 19 in Swat (Fig. 50, 51, 52), Table 20 in Kohat (Fig. 53, 54, 55), Table 21 in Dir (Fig. 56, 57, 58) and Table 22 in other districts (Fig. 59, 60, 61).

Breeding preferences of Simuliid larvae and pupae of all districts of N.W.F.P summarized in table 23, including irrigational channels, streams, rivers, hilly water falls and rocky hill Spring water. Most of species confined to irrigational channels particular slow muddy irrigational channel, second most preference observed in swift rocky stream, and least preference for swift stony or rocky bed river. Simuliid larval and pupal substratum holds preference and dispersion pattern summarized in table 24, shows submerged vegetational holds and other holds as follow: eight species with their hold to Typha plant (Fig.

81-85), nine to Potamogeton (Fig. 73-77), twelve to Echinochloa (Fig. 84), two to Hydrella (Fig. 83-85), six to Cynodan, seven to roots of terrestrial tree, one to white plastic (Fig. 71-72), two to sticks, two to solid rocks, two to loose rock, twelve to loose small stone or boulder, and four to dead leaves. Six species exhibited clustered dispersion pattern (clustered), 24 species non clustered and 5 species both. Table 25 shows altitude preference range and species association. A total of five species considered as exclusively high altitude species of group A (above 2000 meter), six species as low land species and rest with a range of 500 - 2000 meters. Some species presented different attitude range like B. erythrocephala, E. aureum, S. moristan and W. e. equina from group C and D, S. puri sp. n., W. salopiensis from B and C, S. multistriatum from B and D and W. mediterranea from B, C and D. This table also shows species association as follow: almost all species exhibited some type of larval or pupal or both association with other species except E. bicron, E. gvilletense alizadei, E. kurense, E. malakandiense, E. mayariense, E. planiparum and W. salopienesis found in isolation. Temperature (with a range of 4°C-29°C), humidity

Table 26 shows seasonal prevalence of Simuliidae (in comparison with humidity and rainfall). Seasonal wise species divided into group A (Winter species), B (Spring species) and C (Summer species). Almost all species found

in Spring season except E. fontinale and E. g. alizadei (Winter species), S. worsakiense sp.n. and S. xanthogastrum (Summer species), S. inflatum, S. kohatiense sp.n. and W. e. equina showed their prevalence for all three seasons, and E. bicron, E. montium, E. planiparum, S. austeni, S. remotum, S. swatiense sp.n., S. tumolusum, W. mayariense sp.n and W. mediterranea for Spring and Summer.

Humidity and rainfall also grouped into A, B and C with ranges shown in table 27. Regarding humidity, S. austeni, S. kohatiense sp.n, S. moristan, W. e. equina and W. mediterranea found in all groups (ABC), E. aureum, E. inflatum, E. planiparum, S. tumolusum in (AB) and E. bicron, S. remotum, W. turgaica and W. veltistshevi in group BC while rain fall presented E. inflatum, W. e. equina in all groups, B. erythrocephala, E. bicron, E. fontinale, E. planiparum, S. kohatiense sp.n., S. kurense, W. mediterranea, W. turgaica and W. veltistshevi in group BC and E. diriense sp.n. and S. austeni in group AD. Table 28 shows other physical parameters of larval breeding sites like:

- I. Water temperature (with a range of 4°C-29°C), maximum number of species in found in range 10-29°C, only six species in range 4-9°C and E. planiparum and S. kohatiense sp.n. tolerating a wide range of 4°C-29°C. Boophthora erythrocephala, E. inflatum and S.

tumolusum showed a range of 10-27°C and E. bicron, E. diriense sp.n., E. g. gvilletense, E. montium, S. remotum, W. mediterranea and W. veltistshevi with 4-19°C.

- II. Water current: (with range of 0.35 - 0.92 m/sec.). Ten species found in swift water flow (0.66 - 0.92 m/sec.), Ten species in range .5 - .65 m/sec. and nine species in slow range 0.35 - 0.50 m/sec. Among them S. kurense, S. tumolusum, W. e. equina and W. mediterranea found in a wide range of 0.35 - 0.92 m/sec. while E. bicron and E. g. gvilletense in 0.5 - 0.92 m/sec. and E. fontinale, S. austeni, S. remotum and W. veltistshevi in 0.35 - 0.65 m/sec.
- III. Water depth: (with range 14 - 55 cm) three species in range 14 - 24 cm while majority of species in range 25 - 55 cm. E. bicron, S. puri sp.n., S. remotum, S. swatiense sp.n., W. e. equina, W. mediterranea and W. veltistshevi in a range of 25 - 55 cm, while S. puri sp.n., S. remotum and W. mediterranea in 14 - 39 cm.
- IV. Transparency: (with range 5 - 40 cm) Majority of species with range 21 - 40 cm, Wilhelmia e. equina in wide range of 5 - 40 cm, Boophthora erythrocephala, E. inflatum, E. malakandiense sp.n., S. remotum and S. swatiense sp.n. S. swatiense sp. n. in 21 - 40 cm, and W. mediterranea in range 5 - 29 cm.

- V. Altitude: (with range 200 - 2800 m above sea level) E. bicron, E. diriense sp.n., E. planiparum and S. multistriatum considered as high altitude species (with range above 2000 m) and Boophthora erythrocephala, B. sericata, Eusimulium aureum, E. fontinale, E. inflatum, E. lepnevae, Simulium aureohirtum, S. kohatiense sp. n. and S. kurense as low altitude species (200 - 499 m) and rest having an intermediate range while S. moristan, S. puri sp.n., S. remotum, S. tumolusum, W. e. equina and S. warsakiense sp.n. presented a wide range of 200-1999m.
- VI. Hydrogen ion concentration: (with range 5.8 - 8.0): Boophthora erythrocephala, E. diriense sp.n., E. inflatum, S. multistriatum, S. xanthogastrum and S. warsakiense sp. n. considered species with a high acidity and PH range 5.6 - 6.5 and Obochovia albela, O. chitrاليense sp. n., W. mayariense sp. n., W. paraequina and W. turgaica as with high alkalinity and PH 7.0 - 8.0, remaining intermediate in PH range.
- VII. Major ions: Ca^{++} (with range 1.1 - 3.9 mm/l) with maximum species in range 2.0 - 3.5 mm/l, Cl (with range 0.05 - 0.46 mm/l) with maximum number of species in range 0.16 - 0.38 mm/l, CO_3 (with range 0.199 - 0.90 mm/l) and maximum number of species in range 0.3 - 0.69 mm/l, HCO_3 (with range 0.108 - 0.79 mm/l) and maximum number of species in range 0.108 - 0.29 mm/l,

and $\text{NH}_4 - \text{N}$ (with range 0.031 - 0.99 mg/l with maximum number of species in range 0.055 - 0.08 ug/l. Figure 67 shows district wise overall percentage of Boophthora, Obuchovia and Wilhelmia with highest value in W. e. equina (75.0%) and lowest value of 8.3% in B. sericata, O. albella, W. lineata, W. mayariense sp.n., W. paraequina and W. salopiensis. Figure 67 shows such a percentage in Eusimulium with highest value of 16.6 in E. aureum, E. bicorn, E. fontinale, E. planiparum with highest value and lowest in E. diriense sp.n., E. gvilletense alizadei, E. g. gvilletense, E. inflatum, E. lepnevae, E. malakandiense sp.n., E. montium and E. pygmacum. Figure 68 shows highest percentage of 25 in S. moristam and lowest in S. austeni, S. kohatiense sp., S. multistriatum, S. swatiense sp.n. and S. warsakiense (8.33%). Figure 62 shows percentage of total number of species found in a district with highest number of species from district Swat (36.11%) and lowest number (2.77%) from Abbottabad, Charsadda and Malakand. Figure 63 shows such a percentage from district Swat and Malakand with highest value from Aligam (8.33%), Fig. 64 Kohat with highest value of 8.33% from Jungel Khel, Fig. 65 from Dir with highest value of 5.5% from Darora, Tamirgara, Samar Bagh and Chudara.

CHAPTER - 7

DISCUSSION

The present study relates to the Simuliid preimaginal taxonomy and ecology including Hydrochemical and Physical characteristics of larval sites, covering all districts of N.W.F.P. Pakistan. A total of thirty six species described belong to five genera of Simuliidae namely Boophthora, Eusimulium, Obuchovia, Simulium and Wilhelmia. Among them, 6 species were new to the science and 30 species already known but the description been improved with new distributional records and breeding preference. The discussion is taken as follows:

7.1.0 TAXONOMIC CORRELATION:

7.1.1 Genus Boophthora:

Only two species of the genus are newly recorded in the present survey in N.W.F.P. Pakistan with very clear taxonomic identification B. erythrocephala and B. sericata has been recorded in northern part of USSR and Eastern siberia (Rubtsov 1940). The species are newly reported from Pakistan in the present work.

7.1.2 Genus Eusimulium:

The genus Eusimulium has a wide range of distribution in the world and also in Pakistan. Lewise

(1973) reported 7 species of the genus from Pakistan and two species unidentified. Saito et al. (1989) raised the number of the species to 8 by reporting 7 species of the genus in which 4 were already described by lewise and 2 unidentified. The author has collected 2 new species, 3 already known and 7 newly reported species of this genus. Thus raising the number of species to 17 in this genus from Pakistan.

A comparison of important taxonomic characters was made among all the seventeen species collected in the present survey (Table 2 & 3). E. diriense sp.n., shares 70.5% of characters with E. planiparum, 64.7% with E. angusticorn and 52.9% each with E. g. gvilletense and E. fontinale. E. malakandiense sp.n. has a semilarity of 80% each with E. aureum and E. krymense, 60% each with E. gvilletense alizadei and E. montium and 50% each with E. planiparum, E. angusticorn, E. lepnevi, E. fontinale and E. nemorivagum.

7.1.3 Genus Obuchovia:

Only two species O. albela and O. versicolor are known so far, in this genus from Pakistan (Saito 1989). Ahmad (1992) collected some pupae from Chitral and identified them up to the genus level "Obuchovia" but failed to identify them up to species level. The author collected larvae and pupae from the same sites from

Chitral. One group belong to O. albela while the other was a new species and being identified as O. chitraliense sp.n. on the bases of comparison made. Therefore the species of this genus were increased to 4 in Pakistan.

A comparison among 4 closely resembling species of this genus was made (Table 4 and 5). The new species shares 63.6% of characters with O. margaritae and 27.2 each with O. albela and O. versicolor.

7.1.4 Genus Simulium:

The genus has a world wide distribution and also very common in Pakistan. Edward (1927) was the 1st who reported 2 species of this genus from Pakistan. Puri (1933) reported 2 species and Lewis (1972) 1 species from the country, thus making a list of 5 species in Simulium. Lewis (1973) later on added 9 more species and Saito et al. (1989) 2 species to the annotated list of this genus, thus making a total of 16 species in Pakistan. In the present survey, a total of 12 species were collected which included 4 new species, 2 already known species and 6 newly reported from N.W.F.P. Pakistan thus raising the species of this genus to 26.

A comparison was made between the taxonomically important characters of 15 relevant known species of this genus in Pakistan, namely S. puri sp.n., S. kohatiense sp.n., S. swatiense sp.n., S. warsakiense sp.n., S. multistriatum,

S. xanthogastrum, S. pullus, S. kurense, S. polare, S. angustifilum, S. tumolusum, S. austeni, S. austeni, S. moristan and S. remotum (Table 6 and 7).

S. puri sp.n. shares 77.7% of characters with S. pullus, 72.2% each with S. multistriatum and S. kurense and 66.6% each with S. kohatiense sp.n., S. tumolusum and S. moristan, S. kohatiense sp.n has its nearest position in sequence with S. warsakiense sp. n. (72.2%), S. polare (66.6%), S. tumolusum (66.6%), S. xanthogastrum (61.1%) and S. kurense (61.1%). Similarly S. swatiens sp.n. closely resemble S. kurense by sharing 72.2% characters, S. xanthogastrum and S. angustifilum by 61.1% characters each. S. warsakiense sp.n. shares 72.2% of Character each with S. kohatiense sp.n. and S. austeni and 61.1% with S. angustifilum.

7.1.5 Genus Wilhelmia:

Lewis (1973) has reported 3 species of the genus from Pakistan (W. mediterranea, W. paraequina and W. turgaica). Saito (1989) also reported the same species with new locality record from Northern part of Pakistan. W. mediterranea, W. equina and an other unidentified species were also reported by Ahmad (1992) from Chitral. In the present survey, eight species of this genus were observed which included two species newly reported from Pakistan, five species already known in Pakistan but have new

locality record and one new species from Mayar, Pakistan. Thus the total number of species of Wilhelmia in Pakistan has been increased from 3 to 6 in the present work.

A comparative study was made among eight relevant species of this genus including W. mayariense sp. n. in some important characteristic as shown in Table 8 and 9. The result of the study was that W. mayariense sp.n. resemble W. lineata and W. mediterranea by Sharing 70% characters each, W. salopiensis and W. veltistshevi by 41% and W. e. equina, W. paraequina and W. turgaica by 35% characters each.

7.2.0 PHYSICO-CHEMICAL PARAMETERS OF SIMULIID LARVAL AND PUPAL SITES:

All natural fresh waters contain dissolved and particulate inorganic and organic compounds, and gases which vary greatly depending on place (Geology, Topography, (climate), season, depth, and biota. These compounds are vitally important to the existence of aquatic organisms and there is an intensive and continuous exchange of ions and gases between the latter and the surrounding water. It is therefore likely that the immature stages of Simuliidae, which colonize various kinds of waters all over the world, are influenced by their physico-chemical environment. A coorelation between physico-chemical parameters of the aquatic environment and its blackfly fauna is rarely fully

documented, and virtually no laboratory experiments have been conducted, except as regard temperature (Mokry 1976a, Ross and Merritt 1978), pH, conductivity and nitrogen compounds (Grunewald 1978, Grunewald and Grunewald 1978). Such a work has not been done at all in Pakistan, Particularly in N.W.F.P.

The Simuliid survey was based on the collection of preimaginal stages of each species and their ecological information been obtained on their breeding preferences are summarized in table 10 to 31 and figure 38-70. A negative sign in the table indicates that the condition concerned is not a usually preferred one, not that the species is never found under this condition.

7.2.1 Water Temperature:

Water temperature is an important ecological factor in lotic habitate and its effect on benthic organism is very complex. It has great effect on the solubility and release of gases like Oxygen, Nitrogen, Carbondioxide and Nitrogen. It also affects calcium and has direct and indirect effect on water pH, density and viscosity which lay an important role in aquatic ecosystem (Ross and Merritt 1978).

Temperature of water is the most important physical factor regulating larval black fly population dynamics, determining hatching time and developmental rates

(Davies and Smith 1938 Wotton 1978c, William and Hynes 1971). It has a direct effect on larval growth. Winter conditions have shown to severely retard growth and to delay pupation (Thorup 1974, Ross and Merritt 1978). Hynes and Williams (1962) suggested that temperature may be a factor in the zonation of species in river (Germain et al. 1968) and affect to population of succeeding larval generation (Ruhm and Hechler 1974, Hechler and Ruhm 1976).

In the rain forest zone, the water temperature of the small heavily-shaded streams harbouring larvae and pupae of S. Yahense have been found to be lower or with a mean value of 25°C (Grunewald 1976b), Quillevère et al (1976c, 1977a). Ahmad (1992) reported variation in the air temperature of collection sites of the four Simuliid species from Chitral from 10°C to 24°C and water temperature with range 6 - 19°C.

In the present survey the surface water temperature at all localities were studied in relation to air temperature. The water temperature at all sites was much less than the air temperature which was probably due to trees or other vegetation present on the sides of the stream, shading the stream preventing the water from warming by the sun. Second reason is that water molecules are always in motion. Water temperature plays a major role in determining hatching pupation, and emergence of black flies. This survey presented three groups of species

regarding temperature tolerance. (Table 28). Seventeen species were observed in group A (20 - 29°C), maximum number of species i.e. 29 in group B (10-19°C) and 6 species in group c with lowest range of temperature (4-9°C). Among them Boophthora erythrocephala, E. inflatum , S. kurense , S. moristan, S. remotum, S. tumolusum , S. swatiense sp. n. , Wilhelmia e. equina , W. mediterranea and W. veltistshevi were recorded from A and B, E. bicron , E. g. gvilletense, E. diriense sp. n. and E. montium from group B and C and S. kohatiense sp. n. can tolerate a very wide range of temperature from 5-27°C, (Table 28). The district Swat and Malakand presented a range of 8-25°C (Fig. 46), Kohat (12-38°C, Fig. 47), Dir (5-25°C, Fig. 48) and other districts (18-28°C Fig. 49).

7.2.2. WATER CURRENT:

Another major parameter affecting organisms in lotic habitats is water current. Blackfly larvae depend upon a particular current velocity not only for their feeding activities but also for preventing the accumulation of a region of depleted water around them in consequence of their metabolism (Ruttner 1926, Wu 1931). It plays a very important role in distribution of Simuliid larvae (Ulfstand 1967, Elsen and Hebrard 1977b, Colbo and Morhouse 1979a). The optimum velocity of different species ranged from 0.4 m/s (Carlsson 1968) to 2.40 m/s (Elsen and Hebrard 1977b

and Palmer and O' Keeffe 1995). Ahmad (1992) studied Simuliid species in nine different streams of lower part of Chitral with velocity of water ranging 39 to 91 cm/sec.

On the basis of differences in water current, the species in the present survey were divided into three main groups as shown in table 28 and figure 46-49. Group A contains the species which can dwell in fast flowing water with a range of 0.66 - 1.2 m/s, group B species has a velocity range 0.51 - 0.65 m/s and species of group C are slow flowing water (.35-.50 m/s).

A total of fifteen species were found in group A, nineteen species in group B and seventeen species in group C. Among them Simulium tumolusum, Wilhelmia e. equina and W. mediterania were found in all groups while Eusimulium fontinale, S. austeni, S. remotum and W. veltistshevi from group B and C, E. bicron and E. g. gvilletense from group AB and S. kurense from group AC. Flow of water of different water bodies at different stations has been summarized in figure 46-49. Figure No.46 shows highest speed (70 cm/s) of water from Saidu Station and lowest (35 cm/s) from Shah Dheri. Similarly highest water current (40 cm/s) was observed at Jungel Khel station, (0 cm/s) Kohat and lowest one at Boina station (Fig. 47). Figure 48 showed highest water current at Chuckyatum station and lowest one at Chakdara station (42 cm/s) and figure 49 from different

districts presented highest water current at Chitral (89 cm/s) and lowest at Topi (31 cm/s).

7.2.3 Climatic factors:

The climatic factors in general seem to have little direct effect upon Simuliid distribution except the rain fall which is responsible for the continuous flow of the breeding places (Cross Key 1957). Pupae of Simulium alcocki, S. unicornutum, S. adersi and S. damnosum have been collected in all months of the year (Cross Key 1957). Majority Simuliid species breed from May to June (Cross Key 1957, Ahmad 1992 and Palmer 1994).

The seasonal prevalence of Simuliida in relation to rain fall and humidity is shown in table 26. Seasonal wise, the species are divided into Winter season species A (November-February) Spring season species B (March-May) and Summer season species C (June-October). Boophtora erythrocephala, E. inflatum, S. kohatiense sp. n. and Wilhelmia e. equina were found in all the three seasons, E. fontinale in Winter and Spring while E. bicron, E. planiparum, E. montium, Simulium aureohirtum, S. remotum, S. tumolusum, S. kohatiense sp.n., S. swatiense sp. n., W. mediterranea and W. mayariense sp. n. in Spring and Summer. Almost all species were recorded in Spring season except sp. S. xanthogastrum and S. worsakiense sp. n. which were only found in Summer season.

Table 27 shows the humidity and rain fall ranges. In the present survey it was observed that nine species are considered to be present during high rain zone (above 80 mm), twenty nine species in low range (0-29 mm) and sixteen species in medium range (30-79 mm). E. bicron , E. inflatum , S. kohatiense sp. n. , and Wilhelmia e. equina were found with highest range of (0-80 mm) and E. diriense sp.n. Simulium aureohirtum , S. remotum and S. tumolusum in group A and D. The Humidity is also divided in to group A (65-100%), B (25-64%) and C (5-24%) with nine, thirty three and five species each respectively. E. inflatum , Simulium aureohirtum and Wilhelmia e. equina were found in high range (5-100%). While Eusimulium aureum, E. planiparum, S. moristan, S. tumolusum and W. mediterranea observed only in group (5-64%) and Boophthora erythrocephala and S. kohatiense sp. n., with range (40-100%). figure 46-49 showed highest humidity at stations Mingora, Jungel Khel, Chukdara and Warsak.

7.2.4 Altitude and species association:

Altitude is also a factor which plays an important role in Simuliid distribution. (Lewis 1948, 1957 and Laird 1988). Cross Key (1957) has given some information about the breeding altitude of the 14 species of Simuliidae which he studied in Norther Nigeria with a range of 150 - 4000 feet above sea level. He also gave species association

and notes on preferred pupal attachments, Simuliid breeding places and pupal dispersion.

In the present work, a comprehensive list of breeding altitude and species association is given in table 25. Altitude wise, species are divided into group A, B and C. E. bicron , E. planiparum, E. diriense sp.n. and S. multistriatum were considered as high altitude species and Boophthora erythrocephala, B. sericata, Eusimulium aureum, E. fontinale , E. inflatum, E. lepnevae, Simulium aureohirtum , S. moristan, S. remotum and S. kohatiense sp.n. as low altitude and the rest having an intermediate range. E. planiparum was found both in group A and B, S. kurense , S. tumolusum , Wilhelmia e. equina in group BC, S. moristan, S. puri sp.n. and S. remotum in BD and W. mediterranea in group BCD.

The common or usual association of the species are also given in the same table (table 25). Almost all the species exhibited some type of association with larvae or pupae or both of some other species except E. bicron , E. gvilletense alizadei , E. pygmaeum , Eusimulium aureum, E. montium , S. kurense , S. kohatiense sp. n., W. salopiensis, and W. mayariense sp. n. Boophthora erythrocephala was found on the same hold with Eusimulium aureum, E. inflatum , Simulium aureohirtum , S. kohatiense sp. n. and Wilhelmia e. equina , B. sericata with S. moristan E. fontinale, with E. pygmaeum, and Wilhelmia e.

equina, E. g. gvilletense with E. montium and S. tumolusum and zttt, E. lepnevae with W. e. equina E. pygmaeum with W. mediterranea, E. diriense sp.n. with S. multistriatum, O. albella with O. chitrاليense sp.n. and W. lineata, S. austeni with S. moristan and S. puri sp.n., S. moristan also with S. tumolusum, S. puri sp.n. with W. turgaica, S. remotum with W. e. equina, S. xanthogastrum also with S. austeni, S. swatiense sp.n. with W. e. equina, W. mediterranea with S. puri sp.n., W. e. equina, W. turgaica and W. paraequina with W. turgaica.

6.2.5 Transparency and depth of water:

Transparency is the direct indication of the amount of solid suspended matter in water which gives a rough measure of light penetration (Stoker et al. 1972). and directly affect of aquatic ecosystem, in decreasing the rate of photosynthesis of aquatic plants (Coke 1954). The adverse effect of suspended matter occur directly on the filter feeders like black flies larvae because their feeding mechanism is choked. (Palmer and O'Keeffe 1995) . Ahmad (1992) collected the Simuliid larvae and pupae from nine different streams in Chitral with transparency range from 5-25 cm and depth range from 10 - 30 cm.

According to the depth of the water at which collection was made, species presented three distinct groups: A includes species collected at range of 40-55 cm

depth, B with range 25 - 39cm and C at 14 - 24 cm. Only two species (E. g. gvilletense and S. kurense) were found with a range of 14 - 39 cm and S. tumolusum found in group A and C. Majority of species presented a range of 25-39cm. while S. moristan, S. puri sp.n., S. remotum, S. swatiense sp. n., Wilhelmia e. equina and W. veltistshevi had a range of 25-55 cm (Table 28).

6.2.6 Substratum:

Substratum is the place where most of the animals find their food and a second essential requisite in that it should provide protection against enemies. The distribution of Simuliidae is undoubtedly governed by the localisation of suitable breeding grounds. The majority of species require a specialised habitate, usually directly influenced by some ecological factors (Laird 1981). The growth of certain vegetation provide substrate and suitable environment for some Simuliids and also alter flow pattern in the stream which in turn affect certain Simuliid species (Harrod 1964b, Patrusheva 1966, Ruhm 1968, 1970).

A unique type of research survey was carried out for the first time in the present work. The substratum preferences for larval and pupal attachment of particular species were thoroughly observed through out the province (Table 24). Most of the species were found attached to submerged trailing vegetation. Some of the species gave

their exclusive preference for only a specific submerged vegetation: Eusimulium inflatum, E. lepnevae and S. remotum for Typha plant, (Fig. 79-82), S. kohatiense sp. n for Potamogeton, E. pygmacum, E. malakanien sp.n., S. xanthogastrum and E. fontinale for Echinochloa and Wilhelmia mayariense sp.n. for Hydrilla only (Fig. 83-85). Others have their preference for roots of terrestrial plant (Fig. 86), submerged white plastic (Fig. 71-72), sticks, rocks and stones of different sizes and dead leaves. Interestingly, S. puri sp.n. was found from two different localities. The larvae and pupae, despite the availability of other holds, had characteristic preference for white smooth surface stones or rocks only.

Table 23 shows the breeding preferences of all the species of Simuliidae including irrigational channels, streams, rivers, hilly water falls and rocky hill Springs. Among the 36 species collected, fifteen species showed their preference for slow muddy irrigational channels, eleven for Swift rocky or muddy irrigational channels, six for sandy or muddy streams, thirteen for swift rocky streams, one for sandy or muddy small river, one for swift rocky small river, three for slow sandy or muddy large river, three for swift rocky large river, four for small rocky or muddy hilly water fall, three for large rocky water fall, and two for rocky Spring water.

Wilhelmia e. equina and Boopthora crythrocephola were the only species which were collected from all types of water bodies except the river and hill Spring while Eusimulium fontile, Obuchova chitralli, Simulium austeni, S. remotum, Wilhelmia paracquina and W. mayariense were only confined to irrigational channels, E. planiparum, S. puri sp.n., S. xanthogastrum, S. worsakiense and W. vehistshevi only to rivers, E. pygmaeum, W. paraequina and W. galopiense only to stream.

7.2.7 Dispersion pattern:

Lewis (1975), while working on the depth of water in relation to colonization, found that most larvae become attached to tiles near the surface, where the current was much faster than at the bottom. He further stated that groups exhibiting a spaced dispersion pattern existed in microhabitats with lower water velocities (4.6 - 5.1 cm) and with lower percentage of Cnephia dacotensis (14.9%) while clumped dispersion were found in higher water velocities (5.2 cm/Sec.) and with higher percentage of C. dacotensis (80.5%). Similarly most of the species in the collection of Crosskey (1957), in a survey from Northern Nigeria showed non clustered dispersion pattern. The same observations were also noted by Colbo and Moorhouse (1979) and Colbo (1979a). Colbo (1979a) further stated that the size of the clear area around the larvae varies with size

and current velocity. Eymann (1991) reported that groups of larvae of the same complex in Simulium rostratum (i.e. Simulium venustum in Verecundum complex) exhibited spaced dispersion pattern, groups of only larvae of Cnephia dacotensis (Simuliidae) showed banded or clumped dispersion pattern while larvae of both groups together exhibited spaced or clumped dispersion pattern.

In the present survey the larval and pupae dispersion was thoroughly observed (Table 24). Larvae and pupae were regarded as clustered when they occurred in large number immediately adjacent to one another and non clustered (as in case of majority of species) when they occur in numbers but lie spaced out along the leaf blades or other chosen holds. Almost all species showed non clustered dispersion pattern except Boophthora erythrocephala, Eusimulium inflatum, E. aureohertum, Simulium kurense, S. tumolusum, S. kohatiense sp.n. and Wilhelmia mayariense sp.n. (Table 24).

It has been noted that shady and heavily wood area have an impoverished blackfly fauna (Zahar 1951, Bishop 1973b, Colbo and Moordouse 1979). In the present survey, majority of the species were collected from the breeding sites, heavily covered with thick shade of trees, Boophthora erythrocephala, Eusimulium aureum, Wilhelmia e. equina from Mardan, E. aureum, E. inflatum, aureohirtum, S. kohatiense sp. n. and Wilhelmia e. equina from Kohat,

Obochovia albela, O. chitraliense n. and W. lineata from Chitral.

Algae covered stones in certain season in many areas, preventing Simuliid attachment altogether (Sommerman et al. 1955, Chutter 1968, Colbo 1974). These results were also confirmed by the present survey at Darora water fall and show Dir water fall. No larvae or pupae were found on stones or rocks covered with thick layer of algae despite the collection of Eusimulium g. gviletense and Simulium tumolusum made from the same collection site from adjacent rocks and dead leaves.

7.3.0 Chemical Parameters

7.3.1 Hydrogen ion concentration (pH):

Hydrogen ion concentration is an other very import factor which effect Simuliid larval and pupal distribution. On the basis of differences in pH, Grunewald (1976a) grouped the Simuliid species in to group I Simulium yahense, S. sanctipauli and S. menge with high acidity and pH ranging 5.7 - 6.2), group II (S. damnosum, S. sirbanum and S. Squamosum with weak acidity and ranging 6.1 - 7.6) and group III (S. kibwezi and S. kisiqwani with high alkalinity and pH ranging 7.7 - 10.0). This grouping was also supported by the work of Quillevere et. al. (1976 c and 1979). Ahmad (1992) reported a PH ranging of 6 - 7.5 from different localities in district Chitral for Eusimulium

aureum, S. xanthogastrum Wilhemia e. equina and W. mediterranea.

In the present survey, PH range of 5.8 - 8 was observed. On the basis of gross differences in Hydrogen ion concentration, the Simuliid species are divided in to 3 groups:

A: with high acidity and PH range 5.6 - 6.5

(Boophthora erythrocephala, E. inflatum, E. diriense sp.n., S. tumolusum, S. xanthogastrum and S. worsakiense sp. n.).

B: with weak acidity and PH range 6.6 - 6.9 (majority of species as shown in the table 29).

C: with high alkalinity and PH ranging 7.0 - 8.0 Obochovia albela, O. chitralliense sp. n., W. paraequina W. turgaica, W. veltistshevi and W. mayariense sp. n.). The fluctuation of pH at different localities is also shown in figure 50, 53 and 56.

7.3.2 MAJOR IONS:

Disney (1975b) found that calcium and Carbonate were the dominant cations and anions in the larval sites of Simulium dammosum in kumba area of west Camerron. Calcium corhonates and some other oins were dominant in the breeding sites of Simuliid species (Grunewald 19769, Qui llevere et. al. 1977a). Ahmad (1992) also found Co_3 , HCO_3 , cl and Ca^{++} concentration of 9 Simuliid larval collection

sites from Chitral ranging 0.442 - 0.642, 0.0388 - 0.388, 0.05 - 0.223 and 1.57 - 2.15 respectively.

In the present work, the major ions studied as chemical parameters for Simuliid larvae and pupae were Ca^{++} , Cl , CO_3 and HCO_3 , resulting in four distinct grouping of Simuliid species. In case of Ca^{++} concentration, most of the species had a range of 2.0 - 3.5 mm/l while only seven species had a range of 3.5 - 3.9 mm/l and nine species with a range 1.1 - 1.9 mm/l. Wilhelmia e. equina was observed in group ABC, E. inflatum, S. puri sp. n. found in group A, B, E. g. gvilletense, S. tumolusum in group B, D, sp. E. bicron, S. kurense, W. mediterranea in group B, C, W. veltistshevi, in group B, C and D and W. turgaica in group A, C. Similar observations were also observed for Cl ion concentration with seven species each from group A and D and majority of species from group B and C. The species presenting a wide range of Cl ion concentration were S. moristan and Wilhelmia e. equina group (group ABC), S. kurense (group BD) E. planiparum, S. tumolusum, W. turgaica and W. veltistshevi (group BC), S. remotum (group BCD), E. inflatum (group AC) and E. g. gvilletense, E. diriense sp. n. (group CD).

The concentration of CO_3 and HCO_3 also play a distinct role in grouping of Simuliid species (as shown in table 30). A highest number of species were found in group B of CO_3 (15 species) and lowest number (9 species) in C.

Among them W. veltistshevi had a wide range of group ABC, Boophthora erythrocephala and Eusimulium aureum of group AB, S. tumolusum in group ABD, S. puri sp. n. in group BC, W. mediterranea in group BCD, E. fontinale and S. kurense in group CD and S. swatiense sp. n. and W. turgaica in group AD.

The highest number of species, in case of HCO_3 (eighteen species) were observed in group C (with range of 0.108 - 0.29 mm/l) and lowest number (five species) in group B while wilhelmia e. equina was found in all the four group (ABCD), W. veltistshevi in group ABC, E. bicron and S. kurense in group BD, S. puri sp. n. in group BC, S. moristan, S. remotum and W. mediterranea in group CD and S. swatiense sp. n. and W. turgaica in group AD. Locality wise CO_2 and HCO_3 fluctuation is shown in figure 52 (for district Swat), fig. 55 (for Kohat), fig. 58 for Dir and fig. 61 for other districts.

7.3.3 AMMONIUM:

Ammonium concentration always remains low at Simuliid larval sites. The highest concentration recorded by Grunewald (1976a) was 1.158 $\mu\text{g NH}_4 - \text{N/L}$ at a Sanje Site in East Africa. Quillever et. al. (1976c) also found Ammonium concentration exceeding $1\mu\text{g/l}$ at a larval habitate of Simulium soubrense in Ivory coast. Grunewald (1976a) reported a PH value of 7.5 and an Ammonium content of 2.296

ug NH_4 - N/l caused by flow of polluted water in Kibwezi river, Kenya where he collected S. adersi and S. hargreavesi. Experimentally it was proved that the Ammonium level of 0.6 ug NH_3 /l caused mortality rate of 48.3% after two hours and 100% after four hours in the laboratory experiment for Boophthora erythrocephala. The highest concentration of 3.164 ug/l was found for S. squamosum in the rain forest zone of cameroon (Grunewald 1978).

In the present survey Simuliid were found from different water bodies having a range of ammonium ion contraction 0.031 - 0.99 ug/l. On the basis of different Ammonium ion concentration in different waterbodies, 3 groups of species were noted: group A with range 0.81 - 0.99 ug/l (including least number of species 6.) group B with 0.055 - 0.08 ug/l (highest number of species 19) and group C with 0.031 - 0.054 (18 species) Among them, Wilhelmia e. equina was found with a wide range of 0.031 - 0.99 ug/l while Boophthora erythrocephala, E. fontinale and S. swatiense sp. n. with 0.055 - 0.99 and W. mediterranea and W. turgaica range 0.031 - 0.08 ug/l figure 51 shows NH_3 -N fluctuation in water bodies from district Swat and Malakand, Fig. 54 from Kohat, Fig. 57 from Dir and Fig. 60 from other districts.

XI GENERAL DISTRIBUTION:

The distribution of larvae and pupae of different species of Simuliidae regarding locality wise collection in each district with collection date and number of larvae and pupae is summarized in table 11 to 13 and Fig. 63-65, district Swat (table No.10 and Fig. 65), district Kohat (table No.11, Fig. 65) district Dir (table No.12, Fig. 65) and districts Charsadda, Chitral, Mansehra, Mardan, Peshawar and Swabi (table No.13 and fig. 66). The highest number of species collected from different areas were: Aligram (S. austeni, S. moristan, S. tumolusum) in district Swat, Jungle Khel (Boophthora erythrocephala, E. g. gvilletense, E. inflatum) in district Kohat, Lawari and shaw (E. gvilletense alizadei, E. diriense sp.n, E. montium, S. multistriatum) in district Dir, Zaida (S. remotum and W. e. equina) in district Swabi, Chitral proper (Obochovia albela, O. chitraliense sp. n., W. lineata) in district Chitral Thoromayar (Boophthora erythrocephala, Eusimulium aureum, Wilhelmia e. equina) in district Mardan, Warsak (S. xanthogastrum, S. worsakiense sp. n.) in district Peshawar, Bannu (E. lepnevae, Wilhelmia e. equina) in Bannu, Abbottabad (W. veltistshevi) in district Abbottabad and Dodial (E. planiparum) in district Mansehra.

District wise Simuliid distribution of the whole province is given in table 14 and Figure 62. A highest

number of species were recorded from district Swat (13 species) and Dir (12 species) while other districts showed the Simuliid distribution as Kohat (8 species), Chitral (7 species), Swabi (5 species), Peshawar (3 species), Mardan (3 species), Bannu (2 species), Charsadda (2 species), Mansehra (2 species), Abbottabad (1 species) and Malakand (1 species). Wilhelmia e. equina was recorded in all districts of the province except Abbottabad, Chitral, Dir and Malakand, while the rest of the species are shown in the table 14.

Regarding district wise percentage of Simuliid distribution, W. e. equina was recorded from maximum number of districts (75.0%) while the other species presented different ranges from 8.33 to 25% (Fig. 68-70). Overall percentage of different Simuliid genera is shown in Fig. 67 which indicated 33.33% in Eusimulium and Simulium, 22.22% in Wilhelmia and 5.55% in Obuchovia and Boophthora.

CHAPTER - 8

SUMMARY

Blackflies of the family Simuliidae are the most important insect pests of human and animals in many parts of the world because of their role as vectors of certain parasites of medical and veterinary importance and due to their irritation, toxic and allergic manifestation of their bites.

The immature stages of these flies (larvae and pupae) were collected with Palmer method (1994) from eleven districts and one Agency i.e, Abbootabad, Mansehra, Bannu, Kohat, Dir, Swat, Chitral, Mardan, Swabi, Peshawar, Charsadda and Malakand Agency of N.W.F.P., Pakistan.

The study included taxonomy and ecology of preimaginal stages considering, breeding preferences, substratum preferences, physical parameters of water bodies like water temperature (4-27°C), speed (35-95 cm/sec.), transparency (5-40cm), depth (14-55cm), breeding altitude (200-2800 m), humidity (5-100 mm) and rainfall (4-100) and chemical parameters like pH (5.6-8), $\text{NH}_3\text{-N}$ (.03-.99 ug/l), CO_3 (0.199-0.9 mm/l), HCO_3 (.108-.79 mm/l), Cl (1 .05-.46 mm/l) and Ca^{++} (1.1-3.9 mm/l).

A total of 36 Simuliid species belonging to four genera namely Boophthora, Eusimulium, Obuchovia, Simulium

and Wilhelmia were recorded. Among them eight species were new to the science, two species belonging to genus Eusimulium, one to Obuchovia, four to Simulium and one to Wilhelmia.

The species recorded in this work are 1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicron, 5. E. diriense sp.n., 6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16. O. chitrاليense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S. kohatiense sp.n., 20. S. kurense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35. W. turgaica, 36. W. veltistshevi. The type of the specimens (Holotypes) have been deposited in the department of Zoology, University of Peshawar.

The larvae and pupae were collected attached to submerged vegetation like Typha, Potamogeton, Echinochlora, Hydrilla and Cynodon, roots of terrestrial tree, white plastic, sticks, solid rocks, loose rocks or boulders small stone, dead leaves from different water bodies like slow

muddy irrigational channel, swift rocky irrigational channel, slow muddy stream, swift rocky or muddy stream, sandy or muddy slow river swift rocky large rivers, small and large water fall, and rocky hill Spring water.

CHAPTER - 9

MEDICO-VETERINARY IMPORTANCE

OF BLACKFLIES

Blackflies harm man and domestic animals mainly by blood sucking, biting, causing pain, and transmitting diseases.

Blackflies as bloodsuckers: The harmful effect of blackflies is related to insect attack on the eyes, ears, and nose, which causes reduction in human efficiency. The bites of blackflies during blood-sucking are usually painless, but subsequently become painful and poisonous, causing burns, pruritus, tumor, local rise in temperature and, with multiple bites, a general increase in body temperature and various manifestations of toxicity right up to the death of non immunized animals. Even in immunized cattle infection is evidenced in reduced efficiency, milk production, and meat productivity, as well as fatigue and susceptibility to diseases. Individual differences in resistance to the effect of the poisonous saliva of blackflies are sometimes highly variable and can reverse markedly depending on the duration of adaptation to the bites of blackflies. (Rubtsov 1989).

It has been observed that animals with dark coats are attacked more often than those with light coats (Breev,

1950). Temperature, light, wind, physiological condition of the insect, and other factors exert considerable influence. (Fredeen 1977b).

In cattle and horses the parts of the body suffering the greatest injury are the head, especially under the jaw and inner side of the ears, neck, dewlap, udder, nipples, and preputium. (Gorban'and Vorob'ev, 1949). The results is tumor development, local and general (with severe injury), increase in temperature occur, with the temperature dropping by more than 10° when the tumor reduces, accompanied by a general weakness. Sick animals have no appetite and stand with their head low and the front legs wide apart. Movement is wobbly. Respiration is labored and hoarse. Often a frothy serous fluid is discharged from the nostrils. The pulse is feeble and slow and cardiac activity weak. In very serious cases death occurs with the external manifestation of asphyxia, often within six to seven hours, rarely after seven to thirteen hours from an attack by blood sucking blackflies (Welling 1977).

Dissection of animals dyeing due to bites of blackflies reveals various changes in the internal organs. Swelling, edema, which bulges like a mass of jelly, hypodermal tissues infiltrated with blood, expansion of lungs, and frothy edema in the bronchi, hemorrhage, and infiltration in blood and other organs-intestinal tract,

liver, and kidneys. Abdominal cavity filled with large quantity of serious straw-yellow exudate. Subcutaneous fat, ligaments, and abdomen slightly icteric (yellowish). Liver significantly enlarged, vessels replete with blood. Gall bladder (in cattle) filled with bile and enlarged. Spleen slightly enlarged and replete with blood. Lymph nodes swollen. Sometimes the milk of animals attacked by blackflies contains blood, mucus, and infiltrates, (Rubtsov 1989).

The toxic material is saliva. The poisonous nature of the saliva of various blackflies is not the same. These flies are not strictly specialized in selection of prey. The same species attack man as well as domestic animals: cattle, horses, donkeys, goats, sheep, and very rarely dogs. Blackflies are specific vectors of several diseases of man in the tropics and many diseases of domestic animals and birds in both tropical and temperate latitudes. Among the pathogens for which blackflies act as specific carriers, roundworms of the genus Onchocerca and protozoa of the genus Leucocytozoon are the most important (Johnson et. al. 1938).

Human onchocerciasis is an important disease of man, which is not directly fatal but causes untold misery in certain tropical areas of Africa and central America. It has been estimated that there are 30,000,000 people suffering from Onchocerciasis in Africa. In certain areas

of Mexico and Guatemala 20% of infected individual develop eye lesions and a proportion of these become totally blind. In central America Onchocerciasis is present in Mexico, Guatemala, Venezuela, Colombia and Brazil, (Hernet 1991).

Onchocerciasis tumors, caused by *Onchocerca* in horses and cattle, are a universal problem. Onchocerciasis weakens the animal, reduces its productivity, and cause tumors that are difficult to cure, especially in horses (Rubtsov 1952). In recent years Onchocerciasis in several domestic animals, cattle, horses, and reindeer has become widespread in Europe and Asia, and the infection often quite extensive-up to 80% of cattle herds, (Rubtsov 1989).

Blackflies are vectors of blood Protozoa which cause several types of hemosporidiasis in birds. One such disease causes fever in domestic ducks, turkeys, pigeons geese, and hens. Some of the blood parasites, for example Leucocytozoon anatis from ducks, have been more or less studied in detail and transmission of parasites by a particular species of blackfly confirmed experimentally. Hemosporidiasis are pathogenic and cause mass mortality among birds, (Kiszewski 1986).

In addition to the specific diseases mentioned here, blackflies, according to some reports, like other bloodsuckers, may also serve as vectors of Siberian Ulcer, Glanders, Tularemia, Leprosy, Plague, and many other endemic infectious diseases. It has been demonstrated

experimentally (Parker, 1933) that blackflies may serve as carriers of Tularemia during primary feeding on the infected animal and secondary feeding of an instituted female on a healthy animal. Similar reports are available with respect to Siberian ulcer, (Rubtsov 1989).

All the foregoing leads to the conclusion that the medico-veterinary and sanitary-epidemiological importance of blackflies deserves much greater attention.

Simuliid fauna, the following strategies are proposed.

1. To continue such a systematic Simuliid survey in this area.
2. To examine the Simuliid pathogenicity both in animals and man.
3. To control the Simuliid adults, larval and pupal population, biologically and chemically through insecticides, predators and parasites.

CHAPTER - 10

SUGGESTIONS FOR FURTHER WORK

The future of Simuliid work in Pakistan is very promising because very little work has been done in this area. For the future, to advance the understanding of Simuliid fauna, the following strategies are proposed.

1. To continue such a systematic Simuliid survey in this area.
2. To examine the Simuliid pathogenesis both in animals and man.
3. To control the Simuliid adults, larval and pupal population, biologically and chemically through insecticides, predators and parasites.

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Table 1: Approximate numbers of species and genera of blackflies currently recognized in the world fauna, arranged alphabetically by zoogeographical region. (Crosskey, 1973).

Region	Total number of species	No. of species	Number of genera/subgenera
Afrotropical	166	155	15
Australasian	102	78	7
Nearctic	147	75	22
Neotropical	300	257	21
Oriental	110	110	6
Palearctic	485	366	22
World fauna	1270	1000	80

Table 2 : Comparison of characters in species of the genus Eusimulium

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LARVA																	
Body length 7.5-10 mm.	+	+	+	+	-	-	-	-	+	-	-	-	+	-	+	+	+
Pattern of frons Positive.	+	+	+	+	+	+	-	+	+	-	+	+	-	+	-	+	+
Corner and median teeth pointed and produced	+	+	+	+	+	+	+	-	-	+	-	-	+	-	-	-	-
Antenna 4 segmented with secondary annulation present	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Mandible shape as Fig. 6	+	-	+	+	-	-	+	-	-	+	-	-	-	+	-	-	-
Ventral groove large and pointed apically.	+	+	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-
Thoracic and abdom- inal setae present	+	+	+	+	-	-	-	-	+	-	-	-	+	-	+	+	+
Anal Sclerite as Fig. 6	+	-	+	+	-	-	-	-	+	+	-	-	+	-	+	-	+
PUCHA																	
Body length 6-6.8 mm	+	.	.	-	-	-	-	-	+	-	-	-	+	-	+	+	-
Cocoon slipper shaped	+	.	.	-	-	-	-	+	-	-	-	-	-	+	-	-	-
Cocoon tightly woven	-	.	.	-	-	-	+	+	-	+	-	-	+	-	-	-	-
Head trichomes 3 pairs.	+	.	.	+	+	-	+	-	-	-	-	+	-	-	+	-	-
Respiratory filaments arise in form of bundle.	-	.	.	+	+	-	+	+	+	-	+	+	-	-	-	-	-
Dorso median projection on cocoon present.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Contd.

Whereas:

- | | |
|---------------------------|--------------------|
| 1. E. diriense | 10. E. inflatum |
| 2. E. Malakandiense | 11. E. lepnevi |
| 3. E. planiparum | 12. E. pygmacum |
| 4. E. angusticorm | 13. E. fontinale |
| 5. E. aureum | 14. E. balbosum |
| 6. E. krymense | 15. E. latipes |
| 7. E. bicorn | 16. E. nemorivagum |
| 8. E. gvilletense alizadi | 17. E. montium |
| 9. E. g. gvilletense | |

Table 3 Matrix showing percentage of similarities in species of the genus Eusimulium

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
X																
40	X															
70.5	50	X														
64.7	50	70	X													
17.6	80	90	58.3	X												
17.6	80	37	52.2	88.2	X											
35.3	30	60	64.5	64.7	52	X										
23.5	60	70	52.2	64.7	64.7	52	X									
52.9	40	70	58.3	41.1	42	42	41	X								
47.1	20	70	70.5	52	52	26.4	41	58.8	X							
35.3	50	40	64.5	76.4	76.4	64	76.4	70.5	52	X						
35.3	40	30	52.2	76.4	64	64	64	58.8	41	76.4	X					
52.9	50	80	58.3	35.3	42	58.8	42	64	70.5	42	35.2	X				
35.3	40	50	52.2	58.8	70.5	58.8	70.5	52	64	82.3	52	41	X			
40.1	40	50	42	52	52	42	41	70.5	52	52	64	76.4	42	X		
35.3	50	50	42	52	70.5	42	52	76.4	42	42	70.5	64	64	82	X	
40.1	60	50	64.7	64	76.4	41	52	64	52	52	52	58	58	58	70.5	X

Species Nos.

- | | |
|---------------------------|--------------------|
| 1. E. diriense sp.n. | 10. E. inflatum |
| 2. E. Malakandiense sp.n. | 11. E. lepnevi |
| 3. E. planiparum | 12. E. pygmacum |
| 4. E. angusticorm | 13. E. fontinale |
| 5. E. aureum | 14. E. balbosum |
| 6. E. krymense | 15. E. latipes |
| 7. E. bicorn | 16. E. nemorivagum |
| 8. E. gvilletense alizadi | 17. E. montium |
| 9. E. g. gvilletense | |

Table 4: Comparison of characters in species of the genus Obuchovia

Character	1	2	3	4
LARVA				
Submentum broaden toward front form acute angle.	+	+	+	+
Body length 6-7.5 mm	+	-	+	-
Antennae short and thick.	+	+	+	+
Middle tooth of submentum protrudes distinctly.	-	+	-	+
7-10 bristle present.	+	-	+	-
Ventral groove deeply arched.	+	-	+	-
Chitinous frame with 140-155 rows of crochet with 20-24 hookin each row.	+	-	+	-
Structure of mandible as Fig. 17	+	+	-	-
From pigmentation as in Fig. 17	+	-	-	-
Rectal processes unbranched.	+	-	-	-

Whereas:

1. O. Chitraliense 2. O. albela 3. margaritae 4. O. versicolor

O. Chitraliense

O. albela

O. margaritae

O. versicolor

Table 5: Matrix showing percentage of similarities in species of the genus Obuchovia

	1	2	3	4
1	X			
2	27.2	X		
3	63.6	27.2	X	
4	27.2	81.8	45.5	X

Whereas:

- 1 O. Chitraliense
- 2 O. albela
- 3 O. margaritae
- 4 O. versicolor

Table 6: Comparison of Characters in species of the genus Simulium

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LARVA															
Body length 2-4 mm	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-
Body length 5-7 mm.	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+
Pattern of front positive.	-	+	-	+	-	-	+	-	-	+	+	-	-	-	+
Second antenal segment 2 time longer than 1st.	-	-	+	-	+	-	-	-	-	-	-	+	+	-	-
Ventral groove shallow pointed forming arch.	+	+	+	+	-	+	-	-	-	-	+	+	-	+	-
Rectal process complex.	-	-	+	-	+	+	-	-	+	+	+	-	+	+	+
Posterior sucker with 70-90 chrocoet and 12-25 hooks in each row.	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-
Mandible shape as Fig. 20	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
PUPA															
Body size 2-4mm	+	+	-	+	+	-	+	-	-	+	+	+	+	+	+
Trichomes 3-4 pairs.	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-
Cocoon simple, dorsally J Shaped with windows.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
Cocoon simple wall pocket.	+	+	-	+	-	-	-	+	+	-	+	+	+	+	-
Cocoon cover pupa completely.	+	+	+	-	-	+	+	+	+	+	+	-	+	+	-
Respiratory filaments 6.	-	+	+	+	-	+	-	-	-	+	+	+	+	-	+
Shape of respiratory filaments as in Fig. 24	+	-	-	-	-	+	+	-	-	-	+	-	-	-	-
Altitude range 500-1500.	+	-	+	-	+	+	+	+	+	+	+	-	+	+	+
Water body habits, muddy stream attached to vegetation.	-	+	+	-	-	+	+	-	+	-	+	-	-	+	-

Contd.

Whereas:

1. S. puri
2. S. kohatiense
3. S. swatiense
4. S. worsakiense
5. S. multistriatum
6. S. xanthogastrum
7. S. pollus
8. S. Kurense
9. S. palare
10. S. angustifilum
11. S. Tumolusum
12. S. aureohirtum
13. S. austeni
14. S. moristan
15. S. remotum

Table 7: Matrix showing percentage of similarities in species of the genus Simulium.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	X														
2	66.6	X													
3	44.4	44.4	X												
4	61.1	72.2	50	X											
5	72.2	61.1	61.1	44.4	X										
6	77.7	44.4	44.4	41.1	61.1	X									
7	72.7	61.1	72.2	44.4	55.5	50	X								
8	61.1	66.6	33.3	38.8	55.5	72.7	61.1	X							
9	72.2	55.5	61.1	61.1	50	66.6	55.5	88.8	X						
10	55.5	55.5	44.4	50	77.7	61.1	66.6	55.5	66.1	X					
11	66.6	66.6	50	50	66.6	55.5	55.5	66.6	72.2	77.7	X				
12	61.1	55.5	38.8	72.2	72.7	44.4	50	61.1	72.2	72.2	72.2	X			
13	55.5	44.4	38.8	38.8	77.7	61.1	66.6	66.7	72.2	83.3	77.7	72.2	X		
14	66.6	50.0	55.5	50	61.1	27.7	61.1	38.8	50	72.2	50	66.6	50	X	
15	38.8	33.3	38.8	38.8	38.8	72.2	44.4	44.4	44.4	83.3	50	50	72.2	50	X

Whereas:

1. *S. puri*
2. *S. kohatiense*
3. *S. swatiense*
4. *S. worsakiense*
5. *S. multistriatum*
6. *S. xanthogastrum*
7. *S. pullus*
8. *S. Kurense*
9. *S. polare*
10. *S. angustifilum*
11. *S. Tumulosum*
12. *S. aureohirtum*
13. *S. austeni*
14. *S. moristan*
15. *S. remotum*

Table 8: Comparison of characters in species of the genus Wilhelmia

Characters	1	2	3	4	5	6	7	8
LARVA								
Pattern of frons positive	+	+	+	+	+	+	+	+
Color pale yellow	+	+	-	+	-	-	-	+
Antennae 4 segmented and shape as shown Fig. 32	-	-	-	-	+	+	+	+
Shape of submentum as Fig. 32	+	+	-	-	+	-	-	+
Shape of mandible and pattern of teeth as shown in Fig. 32	+	+	-	-	-	-	-	+
Ventral groove arcuate and shallow.	+	+	-	-	-	-	-	+
Rectal process present.	+	+	+	+	+	+	+	+
Posterior sucker 90-104 rows of crochets with 18-27 hooks in each row.	-	+	+	-	+	-	-	+
PUPA								
Respiratory filaments 6 on each side and short.	+	+	-	+	+	.	-	+
Integument of head and thorax chocolate colour.	-	+	+	-	-	.	-	+
Head with 3 pairs of trichomes.	-	-	+	+	+	.	-	-
Abdomen with 4-5 pairs of trichomes.	-	+	-	+	+	.	+	-
Cocoon shape as Fig. 32	-	-	-	-	-	.	-	+
About two third of pupa out of cocoon.	-	-	-	-	-	.	-	+
Cocoon with collar rim.	+	-	-	+	+	.	+	+

Whereas:

1. *W. lincata*
2. *W. mediterium*
3. *W. equina*
4. *W. paraequina*
5. *W. salopiensis*
6. *W. turgaica*
7. *W. veltistshevi*
8. *W. mayariense*

Table 10: Locality wise distribution of different species of *Stenobothrus* from District Swat and Malakand Agency.

Table 9: Matrix showing percentage of similarities in species of the genus Wilhelmia.

	1	2	3	4	5	6	7	8
1	X							
2	76.5	X						
3	47.1	59	X					
4	64.7	53	59	X				
5	53	41.1	59	76.5	X			
6	52.9	41.1	82.3	65	64.7	X		
7	58.8	41.1	64.7	70.5	70.5	82.3	X	
8	70	70	35.2	35.2	41.1	35.0	41.1	X

Whereas:

1. *W. lineata*
2. *W. mediterranea*
3. *W. equina*
4. *W. paraequina*
5. *W. salopiensis*
6. *W. turgaica*
7. *W. veltistshevi*
8. *W. mayariense*

Table 10: Locality wise distribution of different species of Simuliidae from District Swat and Malakand Agency.

Locality	Station No.	Date	No. of larvae/No. of pupae of different species.													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ringora	1	28.12.93	-	-	-	-	-	-	-	-	-	-	$\frac{6}{3}$	-	-	-
Wadi	2	3.6.93	-	-	-	-	-	-	-	-	-	-	-	$\frac{40}{3}$	-	-
Wadi	3	3.6.93	-	-	-	-	-	-	-	-	-	-	-	-	-	$\frac{25}{0}$
Beral	4	14.6.94	-	-	-	-	-	-	-	-	-	$\frac{180}{10}$	-	-	-	-
Barghatar	5	8.6.93	-	-	-	-	-	-	-	-	$\frac{9}{40}$	-	-	-	-	-
Barghatar	6	8.6.93	-	-	-	-	-	-	-	-	$\frac{15}{20}$	-	-	$\frac{20}{0}$	-	-
Barikot	7	1.5.93	-	-	-	-	-	-	-	-	-	-	$\frac{10}{0}$	-	-	-
Wadi	8	5.5.93	-	-	-	-	-	-	-	-	-	-	-	-	$\frac{150}{9}$	-
Barbagh	9	24.8.93	-	-	-	-	-	-	-	$\frac{20}{30}$	-	-	-	-	-	-
Baripar	10	5.6.93	-	$\frac{30}{10}$	-	-	$\frac{40}{10}$	-	-	-	-	-	-	-	-	-
Baridari	11	15.6.93	-	-	-	-	-	-	-	$\frac{2}{0}$	-	-	-	-	-	-
Wagrama	12	2.6.93	-	-	-	-	-	$\frac{102}{80}$	$\frac{50}{70}$	-	-	$\frac{30}{20}$	-	-	-	-
Wadi	13	12.6.93	$\frac{15}{6}$	-	-	$\frac{40}{0}$	-	-	-	-	-	-	-	-	-	-
Wadi	14	12.6.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malakand	15	19.6.94	-	-	$\frac{4}{0}$	-	-	-	-	-	-	-	-	-	-	-

1. E. hiron 2. E. fontinale 3. E. malakandiense sp.n. 4. E. planiparum 5. E. pygmaeum 6. S. austeni 7. S. moristan 8. S. remotum
9. S. swaticum sp.n. 10. S. tumolusum 11. W. e. equina 12. W. mediterranea 13. W. salopiensis 14. W. turgaica

Table 11: Locality wise distribution of different species of simuliidae from District Kohat.

Locality	Station No.	Date	1	2	3	4	5	6	7	8	9
Jungle Khel	16	20.4.93	α/α	-	-	$\frac{100}{80}$	-	-	-	-	-
		5.7.93	α/α	-	-	$\frac{30}{20}$	α/α	-	-	-	-
		11.11.92	7/0	-	-	-	α/α	-	-	-	-
	17	10.12.93	-	-	-	-	-	-	-	-	-
		15.1.94	-	-	-	-	-	-	-	-	-
		1.2.94	-	-	-	-	-	$\frac{800}{80}$	-	-	-
		26.3.94	-	-	-	-	-	-	-	-	-
		20.4.94	-	-	-	-	-	-	-	-	-
		25.5.94	-	-	-	-	-	-	-	-	-
		9.6.94	-	-	-	-	-	$\frac{200}{0}$	-	$\frac{200}{80}$	-
		8.7.94	-	-	-	-	-	$\frac{\alpha}{50}$	-	-	-
		12.8.94	-	-	-	-	-	$\frac{\alpha}{100}$	-	-	-
		10.9.94	-	-	-	-	-	$\frac{\alpha}{80}$	-	-	-
		8.10.94	$\alpha/0$	-	-	-	-	$\frac{\alpha}{120}$	-	-	-
		22.11.94	-	-	-	-	-	$\frac{\alpha}{0}$	-	-	-
		8.10.93	-	-	-	-	-	-	-	-	-
		22.11.93	-	-	-	-	-	-	-	-	-
Kohat stream on Pindi road	18	15.2.93	-	-	-	-	-	-	-	-	$\frac{10}{4}$
		9.3.93	-	-	-	-	$\frac{20}{0}$	-	-	-	-
		9.6.93	$\frac{30}{0}$	-	-	-	-	-	-	-	-
		20.11.92	-	-	-	-	$\frac{0}{5}$	-	-	-	-
Kohat stream on Bannu road Boina spring	19	12.8.93	-	-	$\frac{84}{20}$	-	-	-	-	-	-
	20	20.4.93	-	-	-	$\frac{44}{68}$	-	-	-	-	-
		5.7.93	-	-	-	$\frac{13}{5}$	-	-	-	-	-
Hangu stream	21	20.6.93	-	$\frac{60}{50}$	-	-	-	-	$\frac{32}{0}$	-	-

Where α is numerous and

1. B. erythrocephala
2. B. sericata
3. E. aureum
4. E. inflatum
5. S. aureohirtum
6. S. kohatiense sp.n.
7. S. moristan
8. S. multistriatum
9. W. e. equina.

Table 12 Locality wise distribution of different species of simuliidae from District Dir.
No. of Larvae/No. of Pupae, species No.

Locality	St. No.	Date	1	2	3	4	5	6	7	8	9	10	11
Lawari Pass	22	1.2.93	-	-	<u>28</u> 15	-	-	-	-	-	-	-	-
Lawari Pass	23	1.2.93	-	-	-	-	<u>10</u> 5	-	-	-	-	-	-
Shaw	24	2.5.93	-	<u>40</u> 0	-	-	-	-	-	-	-	-	-
Amirikas	25	6.3.93	-	<u>10</u> 0	-	-	-	-	-	-	-	-	-
		2.4.93	-	<u>5</u> 20	-	-	-	-	-	-	-	-	-
		20.5.93	-	-	-	-	-	-	-	-	-	-	-
		30.6.93	-	-	-	-	-	-	-	-	-	-	-
		2.7.93	-	-	-	-	-	-	-	-	-	-	-
		28.8.93	-	-	-	-	-	-	-	-	-	-	-
		4.9.93	-	-	-	-	-	-	-	-	-	-	-
		25.10.93	-	-	-	-	-	-	-	-	-	-	-
		7.11.93	-	-	-	-	-	-	-	-	-	-	-
		6.12.93	-	-	-	-	-	-	-	-	-	-	-
		20.1.94	-	-	-	-	-	-	-	-	-	-	-
		15.2.94	-	-	-	-	-	-	-	-	-	-	-
		15.6.94	-	-	-	-	-	-	-	-	-	-	-
		20.9.94	-	-	-	-	-	-	-	-	-	-	-
Chukyatan	26	2.2.93	<u>150</u> 60	-	-	-	-	-	-	-	-	-	-
		3.6.93	<u>0</u> 10	-	-	-	-	-	-	-	-	-	-
Seiri	27	1.8.93	-	-	-	-	-	-	-	<u>400</u> 30	-	-	-
		15.11.92	-	-	-	-	-	-	-	<u>10</u> 4	-	-	-
Darora	28	5.8.93	-	-	-	<u>28</u> 32	-	-	-	<u>5</u> 0	-	-	-
Tamirgara	29	5.12.92	-	-	-	-	-	-	-	-	-	-	-
		6.1.93	-	-	-	-	-	-	-	-	-	-	-
		15.2.93	-	-	-	-	-	-	-	-	-	-	-
		16.3.93	-	-	-	-	-	-	-	-	-	-	-
		26.4.93	-	-	-	-	-	-	-	-	-	-	-
		2.5.93	-	-	-	-	-	-	<u>120</u> 0	-	-	-	<u>15</u> 25
		6.6.93	-	-	-	-	-	-	<u>0</u> 20	-	-	-	-
		29.8.93	-	-	-	-	-	-	-	-	-	-	-
		15.9.93	-	-	-	-	-	-	-	-	-	-	-
		16.10.93	-	-	-	-	-	-	-	-	-	-	-
		29.11.93	-	-	-	-	-	-	-	-	-	-	-
Mayar	30	5.12.93	-	-	-	-	-	-	-	-	-	-	-
		6.1.94	-	-	-	-	-	-	-	-	-	-	-
		15.2.94	-	-	-	-	-	-	-	-	-	-	-
		13.3.94	-	-	-	-	-	-	-	-	-	<u>140</u> 0	-

		16.4.94	-	-	-	-	-	-	-	-	-	<u>50</u>	-
		1.5.93	-	-	-	-	-	-	-	-	-	100	-
		1.6.93	-	-	-	-	-	-	-	-	-	<u>200</u>	-
		8.7.93	-	-	-	-	-	-	-	-	-	120	-
		29.8.94	-	-	-	-	-	-	-	-	-	<u>35</u>	-
		15.9.94	-	-	-	-	-	-	-	-	-	200	-
		22.10.94	-	-	-	-	-	-	-	-	-	<u>10</u>	-
		29.11.94	-	-	-	-	-	-	-	-	-	35	-
Samar Bagh	31	1.6.93	-	-	<u>54</u>	-	-	<u>54</u>	-	-	-	-	-
					4			6					
Chokdara	32	26.8.93	-	-	-	-	-	-	-	-	-	-	-
		28.9.93	-	-	<u>90</u>	-	-	-	-	-	-	-	-
					10								

Whereas:

1 is E. bicorn, 2 is E. diriense sp.n. 3 is E. gvilletense alizadei, 4 is E. g. gvilletense,

5 is E. montium, 6 is S. Kurens, 7 is S. multistriatum, 8 is S. puri sp.n. 9 is S. tumolusum, 10 is Wilhelmia c. equina, 11

is W. mayariense sp.n.

Table 13:

Locality wise distribution of different species of Simuliidae in different District:

Sl. No.	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
33	5.8.93	<u>25</u> 30	<u>2</u> 4	-	-	-	-	-	-	-	-	-	-	-	<u>19</u> 4	-	-	-	-	-
34	4.6.93	-	-	-	-	-	-	-	-	<u>33</u> 14	-	-	-	-	-	-	-	-	-	-
35	15.5.93	-	-	-	-	-	-	-	-	-	-	<u>80</u> 14	-	-	<u>97</u> 44	-	-	-	-	-
36	20.8.93	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>10</u> 3	-	<u>15</u> 10	-	-	-
37	28.6.93	-	-	-	-	-	-	-	-	-	<u>111</u> 40	-	-	-	-	-	-	-	-	-
38	22.8.93	-	-	-	<u>30</u> 2	-	-	-	-	-	-	-	-	-	<u>5</u> 0	-	-	-	-	-
39	20.3.93	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>58</u> 8	-	-	-	-	-
40	17.8.93	-	-	-	-	<u>43</u> 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	18.5.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>40</u> 46
42	8.7.93	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>5</u> 20	-	-	-	-	-
43	18.7.93	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>0</u> 40	-	-	-	-	-
44	30.7.93	-	-	-	-	-	-	-	-	-	-	-	<u>19</u> 10	<u>4</u> 10	-	-	-	-	-	-
45	7.7.93	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>10</u> 30	-	-	-	-	-
46	13.5.93	-	-	<u>15</u> 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	3.5.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>69</u> 15	<u>30</u> 5	-
48	3.5.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<u>99</u> 15
49	4.5.93	-	-	-	-	-	<u>28</u> 46	<u>50</u> 20	-	-	-	-	-	-	-	<u>11</u> 9	-	-	-	-
50	7.5.93	-	-	-	-	-	-	-	<u>45</u> 13	-	-	-	-	-	-	-	-	-	-	-

1 is Simulium erythrocephala, 2 is Eusimulium aureum, 3 is E. fontinale, 4 is E. lepnevae, 5 is E. planiparum, 6 is Obuchovia albella, 7 is Simulium kurense sp.n., 8 is S. kurense, 9 is S. moristan, 10 is S. puri sp.n., 11 is S. remotum, 12 is S. worsakiense sp.n., 13 is S. asurum, 14 is Wilhelmia e. equina, 15 is W. lineata, 16 is W. mediterranea, 17 is W. paraequina, 18 is W. turgaica, 19 is W. sp.

Table 14: District wise distribution of different species of Simuliidae in N.W.F.P.

Sp.No	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
1	-	-	-	+	-	-	-	-	-	+	-	-
2	-	-	-	+	-	-	-	-	-	-	-	-
3	-	-	-	+	-	-	-	-	-	+	-	-
4	-	-	+	-	-	-	+	-	-	-	-	-
5	-	-	+	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	+	-	-	-	+	-
7	-	-	+	-	-	-	-	-	-	-	-	-
8	-	-	+	-	-	-	-	-	-	-	-	-
9	-	-	-	+	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	+	-	-	-	-
11	-	-	-	-	-	+	-	-	-	-	-	-
12	-	-	+	-	-	-	-	-	-	-	-	-
13	-	-	-	-	+	-	+	-	-	-	-	-
14	-	-	-	-	-	-	+	-	-	-	-	-
15	-	+	-	-	-	-	-	-	-	-	-	-
16	-	+	-	-	-	-	-	-	-	-	-	-
17	-	-	-	+	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	+	-	-	-	-	-
19	-	-	-	+	-	-	-	-	-	-	-	-
20	-	+	+	-	-	-	-	-	-	-	-	-
21	-	-	-	+	-	-	+	-	-	-	-	+
22	-	-	-	+	-	-	-	-	-	-	-	-
23	-	-	+	-	-	-	-	-	-	-	-	+
24	-	-	-	-	-	-	+	-	-	-	-	+
25	-	-	-	-	-	-	+	-	-	-	-	-
26	-	-	+	-	-	-	+	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	+	-
28	-	-	-	-	-	-	-	-	-	-	+	-
29	-	-	+	+	+	-	+	+	+	+	+	+
30	-	+	-	-	-	-	-	-	-	-	-	-
31	-	-	+	-	-	-	+	-	-	-	-	+
32	-	-	-	-	-	-	-	-	-	-	-	-
33	-	+	-	-	-	-	+	-	-	-	-	-
34	-	-	-	-	-	-	+	-	-	-	-	-
35	-	+	-	-	-	-	+	-	-	-	-	-
36	+	+	+	-	-	-	-	-	-	-	-	-

Whereas:

- | | |
|-----------------|-------------|
| 1 is Abbottabad | 8 Bannu |
| 2 Chitral | 9 Charsadda |
| 3 Dir | 10 Mardan |
| 4 Kohat | 11 Peshawar |
| 5 Mansehra | 12 Swabi |
| 6 Malakand | |
| 7 Swat and | |

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n., 6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16. O. Chitraliense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kurense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35. W. turgaica, 36. W. veltistshevi.

Physical data for different water bodies from District Swat and Malakand Agency.

Locality	Station No.	Date	Rain mm	Humidity %	Air temperature °C	Water temperature °C	Water current cm	Water depth cm	Transparency cm	Altitude
Mingora	1	28.12.93	110	60	15	10	60	40	31	1000
Saidu	2	3.6.93	9.9	46	28	16	70	35	28	1000
Saidu	3	3.6.93	9.9	46	28	16	70	35	28	1000
Daryal	4	14.6.93	18	45	25	20	45	40	30	800
Marghozar	5	8.6.93	9	48	27	21	55	35	28	1500
Marghozar	6	8.6.93	10	48	27	23	55	35	28	1500
Barikot	7	1.5.93	10	40	25	18	40	40	30	1000
Dewli	8	5.5.93	14	45	27	19	60	40	30	1000
Churbagh	9	24.8.93	88	54	32	21	48	35	29	1200
Roringar	10	5.6.93	10	48	45	23	60	38	32	1000
Shahdheri	11	15.6.93	12	49	42	20	48	30	26	1000
Aligrama	12	2.6.93	14	50	48	19	35	45	38	1000
Kalam	13	12.6.93	40	54	40	10	55	50	40	2800
Kalam	14	12.6.93	40	54	42	12	43	50	40	2800
Malakand	15	19.6.93	18	49	40	12	60	25	25	1200

Where as NH_4N is in ug/cm^3 , CO_3 , HCO_3 , Ca and Cl is in mm/l .

Table 16: Physical data for different water bodies from district Kohat.

Locality	Station No.	Date	1	2	3	4	5	6	7	8
Jungle Khel	16	20.4.93	5	45	20	13	400	45	25	45
		5.7.93	67	80	40	21	400	45	25	45
		11.11.92	2	60	25	15	400	45	25	40
	17	1.2.93	23	22	21	18	400	65	20	45
		9.6.93	36	20	39	30	400	65	20	45
		8.7.93	67	40	40	35	400	65	20	45
		12.8.93	57	60	39	36	400	65	20	45
		10.9.93	23	30	37	30	400	65	20	45
		8.10.93	7	20	34	30	400	65	20	45
		22.11.93	2	10	28	22	400	65	20	45
Kohat stream on Pindi road	18	15.2.93	23	22	19	13	400	65	25	45
		9.3.93	64	50	25	20	400	65	25	45
		9.6.93	36	20	40	25	400	65	25	45
		20.11.92	2	10	25	20	400	65	25	45
Kohat stream on Bannu road	19	12.8.93	15	65	30	20	400	41	20	45
Boina spring	20	20.4.93	5	10	20	18	500	40	30	40
		5.7.93	60	50	25	20	500	40	30	40
Hangu stream	21	20.6.93	6.6	45	32	23	450	55	20	35

Where 1 is Rain fall , 2 Humidity , 3 Air temperature , 4 Water temperature, 5 Altitude, 6 Water current, 7 Transpirancy and 8 Water depth.

Table 17: Physical data for different water bodies from district Dir.

Name	St. No.	Date	1	2	3	4	5	6	7	8
Lawari pass	22	1.2.93	15	25	10	5	3000	62	30	36
	23	1.2.93	15	25	10	5	3000	62	30	36
Shaw	24	2.5.93	151	40	22	10	2200	45	32	39
	25	6.3.93	111	40	15	9	2200	45	32	39
	25	2.4.93	163	40	16	10	2200	45	32	39
Chukyatan	26	2.2.93	108	25	12	5	2200	90	30	38
	26	3.6.93	12	8	28	18	2200	90	30	38
Seiri	27	1.8.93	96	65	28	20	1800	55	20	20
	27	5.11.92	102	65	20	10	1800	55	20	20
Darora	28	5.8.93	60	45	25	10	1800	70	15	18
Tamirgara	29	2.5.93	18	35	30	16	700	50	40	45
	29	6.6.93	30	40	36	28	700	50	40	45
Mayar	30	13.3.93	110	60	18	15	900	78	27	30
	30	16.4.93	30	30	20	16	900	78	27	30
	30	1.5.93	15	25	25	15	900	78	27	30
	30	1.6.93	40	45	25	15	900	78	27	30
	30	8.7.93	96	50	30	17	900	78	27	30
Samar Bagh	31	1.6.93	11	40	28	20	900	50	30	30
Chukdara	32	26.8.93	30	60	30	22	600	42	20	25
	32	28.9.93	69	67	32	22	600	42	20	25

Where 1 is Rain fall (mm), 2 Humidity (%), 3 Air temperature (°C),

4 Water temperature (°C), 5 Altitude (m), 6 Water current (cm), 7 Transpirancy (cm)

and 8 Water depth (cm).

Table 18: Physical data for different water bodies from different Districts of NWFP.

Localities	St. No.	Dates	1	2	3	4	5	6	7	8
Mardan	33	5.6	13	40	43	22	450	41	30	40
Topi	34	4.6	11	35	44	24	450	31	30	45
Zaida	35	15.5	8	35	30	18	450	42	30	45
Tordher	36	20.8	56	70	38	25	350	80	20	40
Rostum	37	28.6	8	45	40	25		85	30	35
Bannu	38	22.8	48	60	33	25	285	42	30	30
Mansehra	39	17.8	66	58	30	22	1400	80	25	35
Mansehra	39	20.3	48	56	18	15	1400	80		
Dodhial	40	17.8	60	70	28	19	1400	82	30	36
Abbottabad	41	18.5	18	40	27	19	1100	60	31	37
Haji camp	42	8.7	14	75	40	25	450	45	30	38
Kababian	43	18.7	16	65	38	27	450	48	25	39
Warsak	44	30.7	16	60	30	14	550	60	30	38
Shabqadar	45	7.7	26	80	32	22	350	55	30	39
Charsadda	46	13.5	18	45	28	20	450	55	30	38
Ashirat	47	3.5	45	30	25	15	1400	85	24	30
Drosh	48	3.5	49	25	25	15	1000	65	20	49
Chitral proper	49	4.5	44	25	25	18	1600	89	25	35
Shishi Dara	50	7.5	43	30	30	17	1300	93	18	20

Whereas:

1 is Rain fall, 2 Humidity, 3 Air temperature, 4 Water temperature, 5 Altitude, 6 Water current, 7 Transpirancy and 8 Water depth.

Chemical data for different water bodies from District Swat and Malakand Agency.

Salinity	Station No.	Date	pH	NH ₃ N	Co ₃	HCO ₃	Cl	Ca ⁺⁺
Agora	1	28.12.93	6.6	0.069	0.0631	0.118	0.398	2.899
Agora	2	3.6.93	7	0.055	0.0662	0.117	0.381	2.019
Agora	3	3.6.93	6.8	0.056	0.0661	0.109	0.309	1.891
Agora	4	14.6.93	6.5	0.058	0.0619	0.118	0.281	2.911
Agora	5	8.6.93	6.5	0.059	0.0612	0.118	0.281	2.911
Agora	6	8.6.93	6.3	0.058	0.0652	0.118	0.209	2.891
Agora	7	1.5.93	6.6	0.056	0.0612	0.119	0.209	2.891
Agora	8	5.5.93	6.9	0.056	0.0661	0.121	0.208	2.798
Agora	9	24.8.93	6.8	0.059	0.0621	0.219	0.198	2.918
Agora	10	5.6.93	6.4	0.058	0.0619	0.211	0.099	3.019
Agora	11	15.6.93	6.5	0.056	0.0619	0.199	0.209	2.991
Agora	12	2.6.93	6.6	0.056	0.0709	0.119	0.207	2.191
Agora	13	12.6.93	6.6	0.059	0.0592	0.181	0.188	2.191
Agora	14	12.6.93	6.6	0.059	0.0592	0.181	0.88	2.191
Agora	15	19.6.93	5.9	0.048	0.0612	0.189	0.198	2.019

Where as NH₃/N is in ug/cm³, Co₃, HCO₃, Ca and Cl is in mm/l.

Table 20: Chemical data for different water bodies from district Kohat.

Locality	Station No.	Date	pH	NH ₃	Co ₃	HCo ₃	Cl	Ca ⁺⁺
Jungle Khel	16	20.4.93	6.5	.086	.812	.419	.401	3.819
		5.7.93	6.3	.086	.812	.419	.401	3.819
		11.11.92	6.9	.086	.812	.419	.401	3.819
	17	1.2.93	7.2	.081	.819	.411	.399	3.918
		9.6.93	6.8	.081	.819	.411	.399	3.918
		8.7.93	6.8	.081	.819	.411	.399	3.918
		12.8.93	6.7	.081	.819	.411	.399	3.918
		10.9.93	6.5	.081	.819	.411	.399	3.918
		8.10.93	6.9	.081	.819	.411	.399	3.918
		22.11.93	7.5	.081	.819	.411	.399	3.918
Kohat stream on Pindi Road	18	15.2.93	6.8	.088	.791	.331	.398	3.981
		9.3.93	7.0	.088	.791	.331	.398	3.981
		9.6.93	7	.088	.791	.331	.398	3.981
		20.11.92	7.2	.088	.791	.331	.398	3.981
Kohat stream on Bannu road	19	12.8.93	6.5	.069	.812	.411	.398	3.391
Boina spring	20	20.4.93	6.2	.069	.811	.398	.218	2.989
		5.7.93	6.6	.069	.811	.398	.218	2.989
Hangu stream	21	20.6.93	6.8	.068	.881	.299	.319	3.089

Where as NH₃/N is in ug/cm³, Co₃, HCo₃, Ca and Cl is in mm/l.

Table 21: Chemical data for different water bodies from District Dir.

Locality	St. No.	Date	pH	NH ₃ -N ug/cm ³	CO ₃ mm/l	HCO ₃ mm/l	Cl mm/l	Ca ⁺⁺ mm/l
Lawari pass	22	1.2.93	5.7	.035	.589	.121	.119	1.121
	23	1.2.93	5.7	.035	.589	.121	.119	1.121
Shaw	24	2.5.93	6.1	.046	.541	.119	.219	1.999
	25	6.3.93	6.7	.046	.541	.198	.199	1.881
Chukyatan	25	2.4.93	6.6	.046	.541	.198	.199	1.881
	26	2.2.93	6.8	.048	.519	.219	.198	2.981
Seiri	26	3.6.93	6.5	.048	.519	.219	.198	2.981
	27	1.8.93	6.8	.048	.511	.219	.211	3.009
Darora	27	15.11.92	6.8	.048	.511	.219	.211	3.009
	28	5.8.93	6.8	.046	.498	.211	.211	3.091
Tamirgara	29	2.5.93	6.8	.049	.411	.301	.379	3.398
	29	6.6.93	5.9	.049	.411	.301	.379	3.398
Mayar	30	13.3.93	6.0	.051	.495	.211	.351	3.391
	30	16.4.93	6.5	.051	.495	.211	.351	3.391
	30	1.5.93	6.9	.051	.495	.211	.351	3.391
	30	1.6.93	6.8	.051	.495	.211	.351	3.391
Samar Bagh	30	8.7.93	7.0	.051	.495	.211	.351	3.391
	31	1.6.93	6.9	.050	.491	.251	.341	3.391
Chukdara	32	16.8.93	6.8	.051	.459	.311	.319	2.818
	32	28.9.93	6.7	.051	.459	.311	.319	2.818

Table 22: Chemical data for different water bodies from different districts.

Localities	St. No.	Dates	pH	NH ₃ -M	HCO ₃	CO ₃	cl	Ca
Mardan	33	5.6	6.6	.079	.619	.411	.401	3.918
Topi	34	4.6	6.9	.078	.599	.421	.399	3.212
Zaida	35	15.5	7.0	.072	.602	.391	.318	3.181
Tordher	36	20.8	6.8	.053	.401	.602	.299	3.331
Rostum	37	28.6	6.0	.049	.391	.598	.297	3.911
Bannu	38	22.8	6.8	.059	.419	.669	.381	3.314
Mansehra	39	17.8	6.2	.059	.391	.569	.219	2.811
		20.3	6.8	.059	.391	.569	.219	2.811
Dodhial	40	17.8	6.8	.058	.301	.591	.129	2.919
Abbottabad	41	18.5	7.0	.054	.410	.569	.119	2.811
Haji camp	42	8.7	7.0	.081	.413	.781	.319	3.25
Kababian	43	18.7	7.0	.080	.391	.791	.318	3.121
Warsak	44	30.7	6.2	.084	.411	.692	.229	2.998
Shabqadar	45	7.7	7	.089	.412	.719	.312	2.991
Charsadda	46	13.5	7	.088	.301	.719	.281	2.991
Ashirat	47	3.5	7	.049	.209	.779	.061	1.616
Drosh	48	3.5	7.5	.052	.199	.519	.219	1.991
Chitral proper	49	4.5	7.6	.051	.199	.498	.143	2.191
Shishi Dara	50	7.5	7.2	.049	.299	.461	.155	2.091

Table 23: The breeding preferences of the simuliidae of NWFP Pakistan.

	Irrigational Channels		Stream		Small median River		Large river		Hilly water full		Rocky hill spring
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1	+	-	-	-	-	-	-	-	+	-	-
2	+	-	-	-	-	-	-	-	-	-	-
3	+	-	-	+	-	-	-	-	-	-	-
4	-	-	-	+	-	-	+	-	-	-	-
5	+	+	-	-	-	-	+	-	-	+	-
6	+	-	+	-	-	-	-	-	-	-	-
7	-	-	-	+	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	+	-	-
9	-	-	-	-	-	-	-	-	-	+	+
10	+	-	-	-	-	-	-	-	-	+	+
11	-	-	-	-	-	-	-	-	-	-	+
12	-	-	-	-	+	-	-	-	-	-	-
13	-	-	-	-	-	-	-	+	-	-	-
14	-	-	-	+	-	-	-	-	-	-	-
15	+	-	-	-	-	-	-	-	-	-	-
16	+	-	-	-	-	-	-	-	-	-	-
17	-	-	+	-	-	-	-	-	+	-	-
18	+	+	-	-	-	-	-	-	-	-	-
19	-	-	+	+	-	-	-	-	-	-	-
20	+	-	+	-	-	-	-	-	-	-	-
21	-	+	-	+	-	-	-	-	-	-	-
22	+	+	-	-	-	-	-	-	-	-	-
23	-	-	-	+	-	-	+	-	-	-	-
24	+	+	-	-	-	-	-	-	-	-	-
25	-	+	-	+	-	-	-	-	-	-	-
26	-	+	-	-	-	-	-	-	+	-	-
27	-	-	-	-	-	-	-	+	-	-	-
28	-	-	-	-	-	-	-	+	-	-	-
29	+	+	+	+	-	-	-	-	-	-	-
30	-	-	-	+	-	-	-	-	-	-	-
31	-	+	-	-	-	-	-	-	-	-	-
32	+	+	-	+	-	-	-	-	-	-	-
33	-	-	-	+	-	-	-	-	-	-	-
34	-	-	+	+	-	-	-	-	-	-	-
35	-	+	-	+	-	-	-	-	-	-	-
36	+	-	-	-	-	-	+	-	-	-	-

Whereas:

I. is slow muddy Irrigational channel II. Swift muddy or rocky Irrigational channel III. Slow muddy stream IV. Swift rocky stream V. Sandy or muddy small-medium river VI. Swift stony or rocky small-medium river VII. Slow sandy or muddy large river VIII. Swift rocky large river IX. Small rocky or muddy hilly water fall X. Large rocky hilly water fall XI. Rocky hill spring.

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n., 6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16. O. Chitraliense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kureense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35. w. turgaica, 36. W. veltistshevi.

Table 24: The breeding substratum preferences for larval and pupal attachment of simuliidae of NWFP.

No. of species	I	II	III	IV	V	VI	VII	VII I	IX	X	XI	XII	XIII	XIV
1	+	-	+	-	-	-	-	-	-	-	-	-	-	-
2	-	-	+	-	-	-	-	-	-	-	-	-	-	+
3	+	+	+	-	-	-	+	-	-	-	-	-	-	-
4	-	+	-	-	+	-	+	-	-	-	-	-	-	-
5	-	+	-	-	-	-	+	-	-	-	-	-	-	-
6	-	+	-	-	+	-	-	-	-	-	-	-	-	-
7	-	+	-	-	-	-	-	-	-	-	-	-	-	+
8	-	+	-	-	-	-	-	-	-	-	-	-	+	-
9	+	-	+	-	-	-	-	-	-	-	-	-	-	-
10	-	+	+	-	-	-	-	-	-	-	-	-	-	-
11	-	+	-	-	+	-	-	-	-	-	-	-	-	-
12	-	+	-	-	-	-	-	-	-	-	-	+	-	-
13	-	+	-	+	-	-	-	-	-	-	-	+	-	+
14	-	+	-	-	+	-	-	-	-	-	-	-	-	-
15	-	+	-	-	+	-	-	+	-	-	-	-	-	+
16	-	+	-	+	+	-	-	+	-	-	-	-	-	+
17	+	-	+	+	-	-	-	-	-	-	-	-	-	-
18	-	+	-	+	-	-	-	+	-	-	-	-	-	-
19	+	-	-	+	-	-	-	-	-	-	-	-	-	-
20	+	-	-	+	+	-	-	+	-	-	-	-	-	-
21	+	+	-	+	-	-	-	-	-	-	-	-	-	-
22	+	-	-	+	-	-	-	-	-	-	-	-	-	-
23	-	+	-	-	-	-	-	-	-	-	-	-	-	+
24	-	+	+	-	-	-	-	-	-	-	-	-	+	-
25	-	+	-	-	-	-	-	+	+	-	-	-	-	+
26	-	+	-	-	-	+	-	+	-	-	-	-	+	-
27	-	+	-	-	+	-	-	-	-	-	-	-	-	-
28	-	+	-	-	+	-	-	-	-	-	-	-	-	-
29	+	+	+	+	-	+	+	-	+	-	-	-	+	-
30	-	+	-	-	+	+	-	+	-	-	-	-	-	-
31	+	-	-	-	+	-	-	-	-	-	-	-	-	+
32	+	+	-	+	-	-	+	-	-	-	-	-	-	-
33	-	+	-	-	-	-	-	-	-	-	-	-	-	+
34	-	+	-	-	-	-	-	-	-	-	+	-	-	+
35	+	+	-	-	-	-	+	-	-	-	+	-	-	+
36	-	+	-	-	+	-	-	-	-	-	-	-	-	+

Contd.

Whereas

I is clustered II is non clustered III is typha IV is potamogeton V is echinocloa VI is hydra VII is cynodon VIII is root of terrestrial tree IX is white plastic X is stick XI is solid rock XII is loose rock XIII is dead leave XIV is small stone and

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16.
- O. Chitraliense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kureense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30.
- W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35.
- W. turgaica, 36. W. veltistshevi.

Table 25: The breeding altitude and species association of different species of simuliidae of N.W.F.P.

Sp. No.	Non breeding altitude (Meter above sea level)				Species No. associated
	A (Above 2000)	B (1000-1999)	C (500-999)	D (200-499)	
1	-	-	+	+	3, 9, 17, 29
2	-	-	+	-	21
3	-	-	+	+	1, 29
4	+	-	-	-	-
5	-	+	-	-	22
6	+	-	-	-	14, 29
7	-	+	-	-	-
8	-	+	-	-	12, 26
9	-	-	+	-	1, 17
10	-	-	-	+	29
11	-	+	-	-	-
12	+	-	-	-	8
13	-	+	-	-	-
14	+	-	-	-	32
15	-	-	-	+	16, 30
16	-	+	-	-	15,30
17	-	+	-	-	1, 9, 29
18	-	+	-	-	21, 23
19	-	+	-	-	22
20	+	-	-	-	-
21	-	-	+	+	2, 18, 26
22	-	+	-	+	5, 19, 29
23	-	+	+	-	36, 18
24	-	+	-	-	29
25	-	+	-	-	29
26	-	-	-	+	8, 18, 21
27	-	+	-	-	28
28	-	+	-	-	27
29	-	+	+	+	1,3,6,10,17,22,25,24,32
30	-	+	-	-	15, 16
31	-	+	-	-	-
32	-	+	-	-	14, 32, 35
33	-	+	-	-	35
34	-	+	+	-	-
35	-	-	-	+	32, 33
36	-	-	+	-	23

Contd.

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
11. E. malakandiense sp.n., 12. E. montium,
13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
16. O. Chitrاليense sp.n., 17. Simulium aureohirtum,
18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kurense,
21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n.,
24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum,
27. S. worsakiense sp.n., 28. S. xanthogastrum,
29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n.,
32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
35. w. turgaica, 36. W. veltistshevi.

TABLE 26: The seasonal prevalence of different species of Simuliidae of N.W.F.P.

	Winter November-February	Spring March - May	Summer June-October
1	+	+	+
2	-	+	-
3	-	+	-
4	-	+	+
5	-	+	-
6	+	+	-
7	+	-	-
8	+	-	-
9	+	+	+
10	-	+	-
11	-	+	-
12	-	+	+
13	-	+	+
14	-	+	-
15	-	+	-
16	-	+	-
17	-	+	+
18	-	+	-
19	+	+	+
20	-	+	-

Contd.

21	BLE 27	-	+	-
22		-	+	-
23	Rain Fall in mm	-	+	-
24	above 80	-	+	+
25		-	+	+
26		-	+	+
27		-	-	+
28		-	-	+
29		+	+	+
30		-	+	-
31		-	+	+
32		-	+	+
33		-	+	-
34		-	+	-
35		-	+	-
36		-	+	-

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n., 6. E. fontinale, 7. E. gvilletense alizadei, 8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae, 11. E. malakandiense sp.n., 12. E. montium, 13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella, 16. O. Chitraliense sp.n., 17. Simulium aureohirtum, 18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kureense, 21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n., 24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum, 27. S. worsakiense sp.n., 28. S. xanthogastrum, 29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n., 32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis, 35. W. turgaica, 36. W. veltistshevi.

TABLE 27: A correction of rain fall and humidity range with different species of Simuliidae of N.W.F.P.

	Rain Fall in mm			Humidity in %		
	A	B	C (law)	A	N	
	above 80	40-64	5-39	5-39	40-64	65-100
1	-	+	+	-	+	+
2	+	-	-	+	-	-
3	+	+	-	+	+	-
4	-	+	+	-	+	+
5	+	-	+	-	+	-
6	-	+	+	-	+	-
7	-	-	+	-	-	+
8	-	-	+	-	-	+
9	+	+	+	+	+	-
10	-	+	-	-	+	-
11	-	-	+	-	+	-
12	-	-	+	-	+	-
13	-	+	+	+	+	-
14	-	-	+	-	+	-
15	-	+	-	-	+	-
16	-	+	-	-	+	-
17	+	-	+	+	+	+
18	-	-	+	-	+	-
19	-	+	+	+	+	+
20	-	+	+	-	+	+
21	-	-	+	+	+	+
22	+	-	-	-	-	+
23	-	-	+	-	+	-
24	-	-	+	+	+	+
25	-	-	+	+	+	-
26	-	-	+	+	+	-
27	-	-	+	-	+	-
28	-	-	+	-	+	-
29	+	+	+	+	+	+
30	-	+	-	-	+	-
31	-	-	+	-	-	+
32	-	+	+	+	+	+
33	-	+	-	-	-	+
34	-	+	-	-	-	+
35	-	+	+	-	+	+
36	-	+	+	-	+	+

Contd.

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
11. E. malakandiense sp.n., 12. E. montium,
13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
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27. S. worsakiense sp.n., 28. S. xanthogastrum,
29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n.,
32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
35. W. turgaica, 36. W. veltistshevi.

Table 28: A correlation of physcial parameters (water temperature, speed, transpirancy and Depth) with different species of simuliidae of N.W.F.P.

	Water temperature			Water speed			Transpirancy			Depth		
	A 20-27	B 16-19	C 4-9	A 66-92	B 51-65	C 35-50	A	B	C	A	B	C
1	+	+	-	-	+	+	+	+	-	+	-	-
2	+	-	-	-	+	-	-	-	+	-	+	-
3	-	-	+	-	-	+	+	-	+	+	-	-
4	-	+	+	+	+	-	+	-	-	-	+	+
5	-	+	+	-	-	+	+	-	-	-	+	-
6	+	-	-	-	+	+	+	-	-	-	+	-
7	-	-	+	+	+	-	+	-	-	-	+	-
8	-	+	+	+	+	-	-	-	+	-	+	+
9	+	+	-	-	+	+	-	+	-	+	-	-
10	+	-	-	-	-	+	+	-	-	-	+	-
11	-	+	-	+	-	-	+	+	-	-	+	-
12	-	+	+	-	+	-	+	-	-	-	+	-
13	+	-	+	+	-	-	+	-	-	-	+	-
14	-	-	-	-	+	-	+	-	-	-	+	-
15	-	+	-	+	-	-	-	+	-	+	-	-
16	-	+	-	+	-	-	-	+	-	+	-	-
17	+	-	-	-	+	-	-	+	-	+	-	-
18	-	+	-	-	+	-	+	-	-	+	-	-
19	+	+	+	+	-	-	-	-	+	+	+	+
20	+	-	-	+	-	-	+	-	+	-	+	-
21	+	-	-	-	+	-	+	-	+	+	-	-
22	-	+	-	+	-	-	+	-	-	-	+	-
23	-	+	-	+	-	+	-	+	-	+	+	-
24	-	+	+	-	+	+	-	+	-	+	+	-
25	-	-	+	-	+	+	+	+	-	+	+	+
26	+	+	-	+	+	-	+	-	+	+	-	+
27	-	+	-	-	-	+	+	-	-	-	+	-
28	-	+	-	-	-	+	+	-	-	-	+	-
29	-	+	+	+	+	+	+	+	+	+	+	-
30	-	+	-	+	-	-	-	+	-	-	-	+
31	-	+	-	-	-	+	-	+	+	-	+	-
32	-	+	+	+	+	+	-	+	+	+	+	-
33	-	-	+	+	-	-	-	+	-	-	-	+
34	-	-	+	-	+	-	+	-	-	+	-	-
35	-	-	+	+	-	-	-	+	-	-	+	-
36	-	+	+	-	+	+	+	-	+	+	-	+

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
11. E. malakandiense sp.n., 12. E. montium,
13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
16. O. Chitrاليense sp.n., 17. Simulium aureohirtum,
18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kurense,
21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n.,
24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum,
27. S. worsakiense sp.n., 28. S. xanthogastrum,
29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n.,
32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
35. w. turgaica, 36. W. veltistshevi.

Table 29: A correlation of chemical parameters (pH & NH₃-N) with different species of simuliidae of NWFP.

Sp. No.	Hydrogen ion concentration			NH ₃ -N		
	A (7.0-7.9)	B (6.6-6.9)	C (5.6-6.5)	A (.081-.99)	B (.055-.080)	C (.031-.054)
1	-	-	+	+	+	-
2	+	-	-	-	+	-
3	-	+	-	-	+	-
4	-	+	-	-	+	-
5	-	-	+	-	-	+
6	-	+	-	+	+	-
7	-	+	-	-	-	+
8	-	+	-	-	-	+
9	-	-	+	-	+	-
10	-	+	-	-	+	-
11	-	+	-	-	-	+
12	-	+	-	-	-	+
13	-	+	-	-	+	-
14	-	+	-	-	-	+
15	+	-	-	-	+	-
16	+	-	-	-	-	+
17	-	+	-	-	-	+
18	-	+	-	-	+	-
19	-	+	-	-	+	-
20	-	+	-	-	+	-
21	-	+	-	-	-	+
22	-	-	+	-	+	-
23	-	+	-	-	-	+
24	-	-	-	-	-	+
25	-	+	-	-	+	+
26	-	-	-	+	-	-
27	-	-	+	-	+	+
28	-	-	+	+	-	-
29	-	+	-	+	-	-
30	-	+	-	+	+	+
31	-	+	-	-	-	+
32	-	+	-	-	+	-
33	+	-	-	-	+	+
34	-	+	-	-	-	+
35	+	-	-	-	+	-
36	+	-	-	-	-	+

Contd.

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
11. E. malakandiense sp.n., 12. E. montium,
13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
16. O. Chitrاليense sp.n., 17. Simulium aureohirtum,
18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kurense,
21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n.,
24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum,
27. S. worsakiense sp.n., 28. S. xanthogastrum,
29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n.,
32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
35. W. turgaica, 36. W. veltistshevi.

Table 30

A correlation of chemical parameter (CO_3 and HCO_3) with different species of simuliidae of NWFP.

Sp. No.	CO_3				HCO_3			
	A (.7-.9)	B (.5-.69)	C (.3-.49)	D (.19-.29)	A (.6-.79)	B (.5-.6)	C (.3-.49)	D (.19-.299)
1	+	+	-	-	-	-	+	-
2	+	-	-	-	-	-	-	+
3	+	+	-	-	-	-	+	-
4	-	+	-	-	-	-	-	+
5	-	+	-	-	-	+	-	-
6	-	-	+	+	+	-	-	-
7	-	+	-	-	-	-	-	+
8	-	-	-	+	-	-	-	+
9	+	-	-	-	-	-	+	-
10	-	+	-	-	+	-	-	-
11	-	+	-	-	-	-	-	+
12	-	+	-	-	-	-	-	+
13	-	-	+	-	-	+	-	-
14	-	-	-	+	-	-	-	+
15	-	-	-	+	-	-	+	-
16	-	-	-	+	-	-	+	-
17	+	-	-	-	-	-	+	-
18	+	-	-	-	-	-	+	-
19	+	-	-	-	-	-	+	+
20	-	-	-	+	-	-	+	-
21	+	-	-	-	-	-	+	+
22	-	+	-	-	-	-	+	+
23	-	-	+	-	-	+	+	+
24	-	-	+	-	-	-	-	+
25	-	+	+	-	+	-	-	-
26	+	+	-	+	-	-	-	+
27	-	-	+	-	+	-	-	-
28	-	-	+	-	+	-	-	-
29	+	+	+	-	+	+	+	+
30	-	-	-	+	-	-	+	-
31	-	-	+	-	-	-	-	+
32	-	+	+	-	-	-	+	+
33	-	-	+	-	+	-	+	-
34	-	+	-	-	-	-	-	+
35	-	+	+	-	-	-	-	+
36	-	-	+	+	+	+	+	-

Contd.

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
11. E. malakandiense sp.n., 12. E. montium,
13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
16. O. Chitrاليense sp.n., 17. Simulium aureohirtum,
18. S. austeni, 19. S. Kohatiense sp.n., 20. S. Kurense,
21. S. moristan, 22. S. multistriatum, 23. S. puri sp.n.,
24. S. remotum, 25. S. swatiense sp.n., 26. S. tumolusum,
27. S. worsakiense sp.n., 28. S. xanthogastrum,
29. Wilhelmia e. equina, 30. W. lineata, 31. W. mayariense sp.n.,
32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
35. w. turgaica, 36. W. veltistshevi.

Table 31

A correlation of chemical parameter (Cl and Ca^{++}) with different species of simuliidae of NWFP.

Sp. No.	Cl mm/l				Ca^{++} mm/l			
	A (.6-.79)	B (.16-.26)	C (.27-.38)	D (.39-.46)	A (3.5-3.9)	B (2.9-3.5)	C (2.0-2.89)	D (1.1-1.9)
1	+	-	-	-	+	-	-	-
2	+	-	-	-	-	+	-	-
3	+	-	-	-	+	-	-	-
4	-	-	+	-	-	+	+	-
5	-	-	+	+	-	-	-	+
6	-	+	+	-	-	+	-	-
7	-	+	-	+	-	-	-	+
8	-	-	+	+	-	+	-	+
9	+	-	+	-	+	+	-	-
10	-	+	-	-	-	+	-	-
11	-	-	+	-	-	+	+	-
12	-	-	+	-	-	-	-	+
13	-	+	+	-	-	+	-	-
14	-	-	+	-	-	+	-	-
15	-	-	+	-	-	-	+	-
16	-	-	+	-	-	-	+	-
17	+	-	-	-	+	-	-	-
18	-	-	+	-	-	+	-	-
19	+	-	-	-	+	-	-	+
20	-	+	-	+	-	+	-	-
21	-	+	+	-	-	+	-	-
22	-	+	+	-	-	-	-	+
23	-	+	-	-	-	+	-	-
24	-	-	+	+	-	+	-	-
25	-	-	-	-	-	+	-	-
26	-	+	+	-	-	+	-	-
27	-	+	+	-	-	-	+	-
28	-	-	+	-	-	-	+	-
29	+	+	+	-	+	+	+	-
30	-	-	+	-	-	-	+	-
31	-	+	-	-	-	+	-	-
32	-	+	-	-	-	+	+	-
33	-	-	+	-	-	-	-	+
34	-	-	+	-	-	-	+	-
35	-	+	+	-	-	-	+	+
36	-	+	+	-	-	-	+	+

Contd.

Whereas

1. Boophthora erythrocephala, 2. B. sericata, 3. Eusimulium aureum, 4. E. bicorn, 5. E. diriense sp.n.,
6. E. fontinale, 7. E. gvilletense alizadei,
8. E. g. gvilletense, 9. E. inflatum, 10. E. lepnevae,
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13. E. planiparum, 14. E. pygmaeum, 15. Obuchovia albella,
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32. W. mediterranea, 33. W. paraequina, 34. W. salopiensis,
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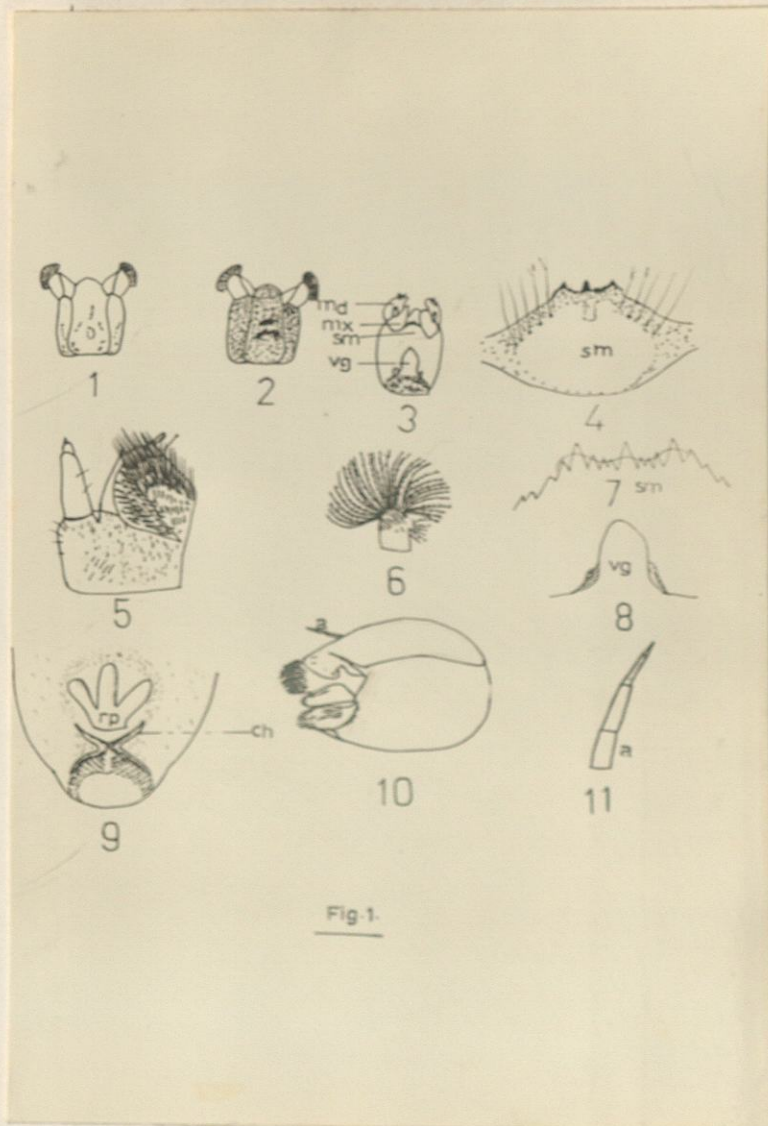


Fig.1.

Fig.1 General appearance of Simuliid larva 1. Head darsal view, (positive pattern) 2. Head darsal view, (negative pattern) 3. Cephalic capsule, (Ventral view) 4. Submentum 5. Outer view of maxilla 6. Flabella 7. Submentum enlarged 8. Ventral groove 9. Posterior end of larval body 10. Laeral view of larval hand with out flabella 11. Antenna

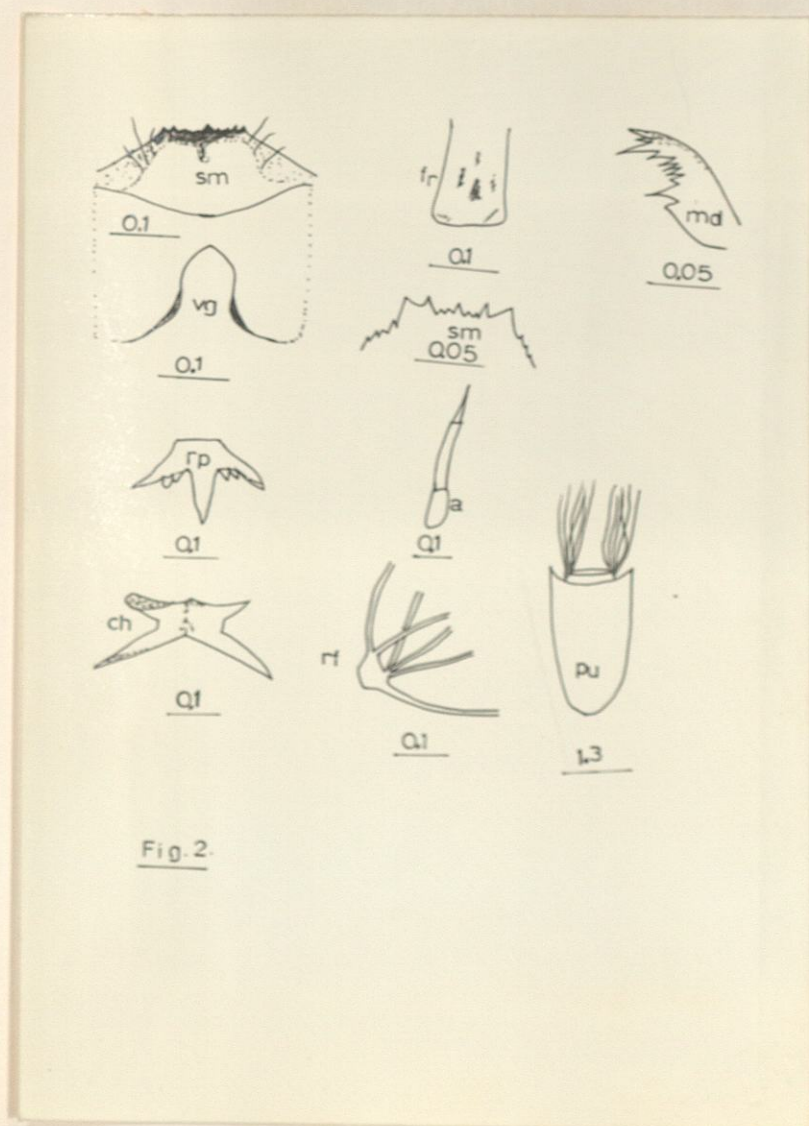


Fig. 2.

Figure # 2

Boophthora erythrocephala

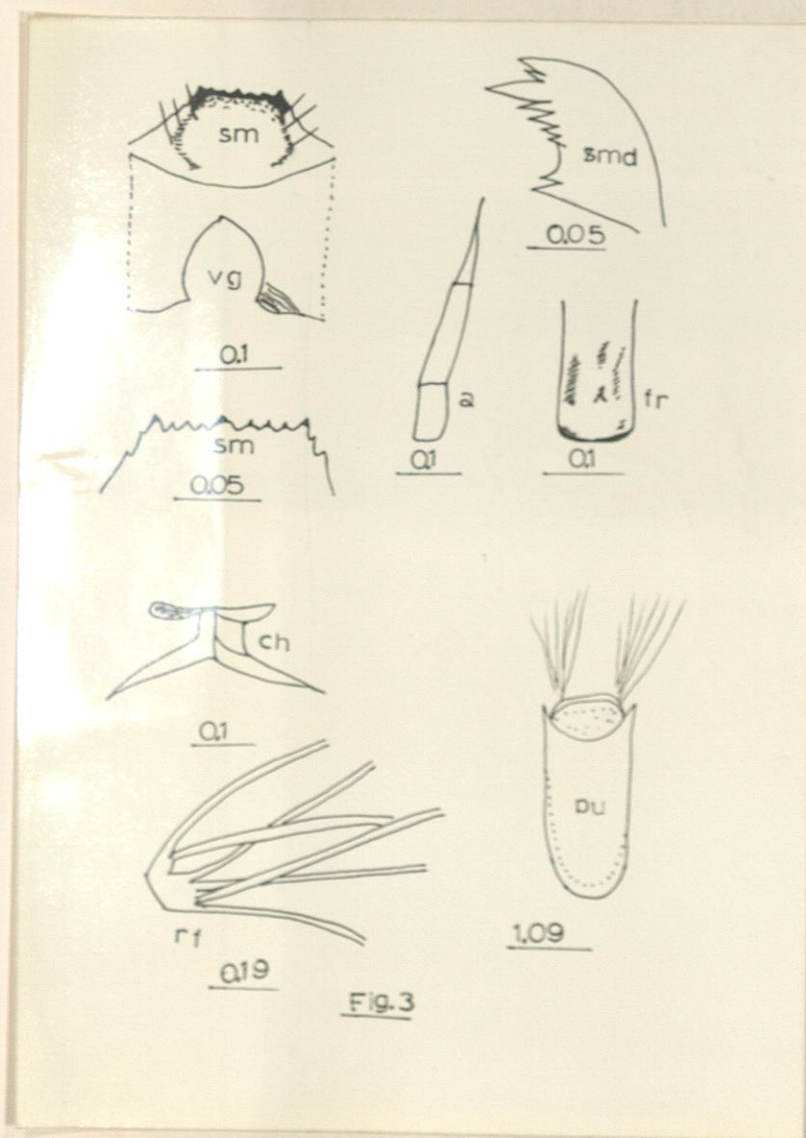


Figure # 3

B. sericata

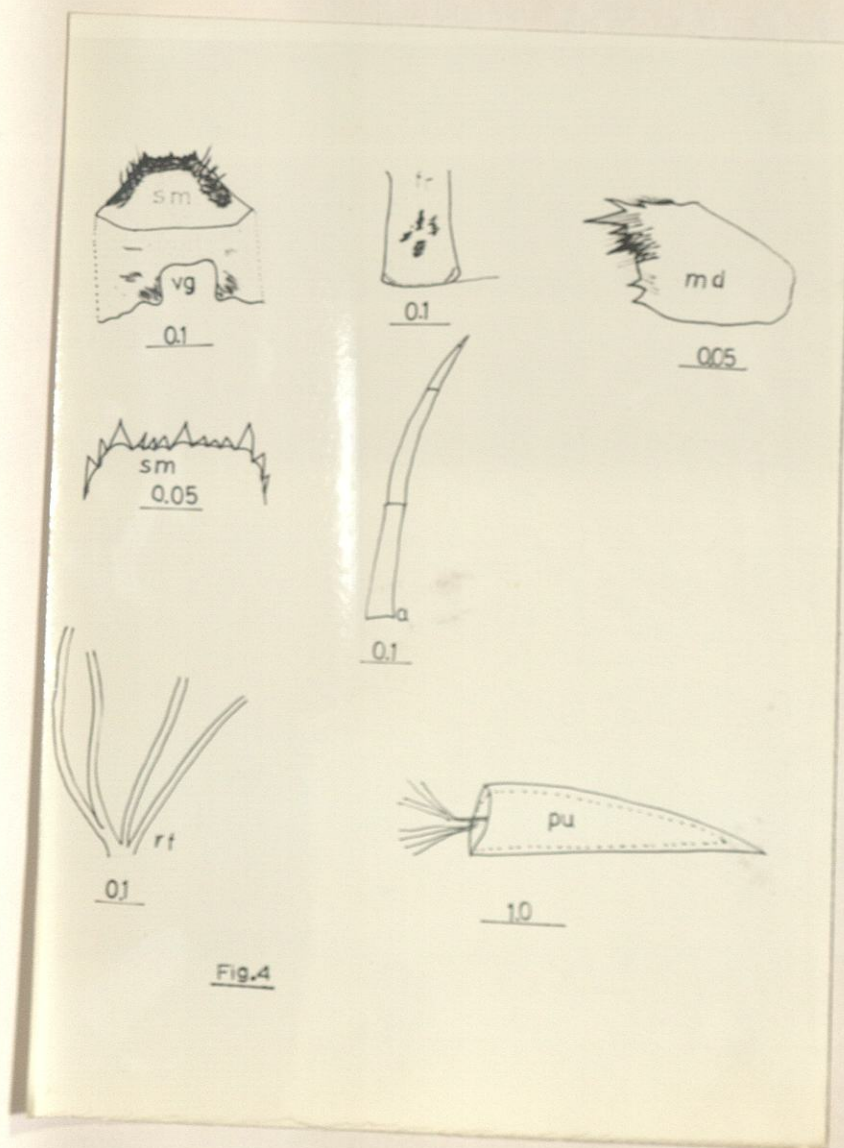


Figure # 4

Eusimulium aureum

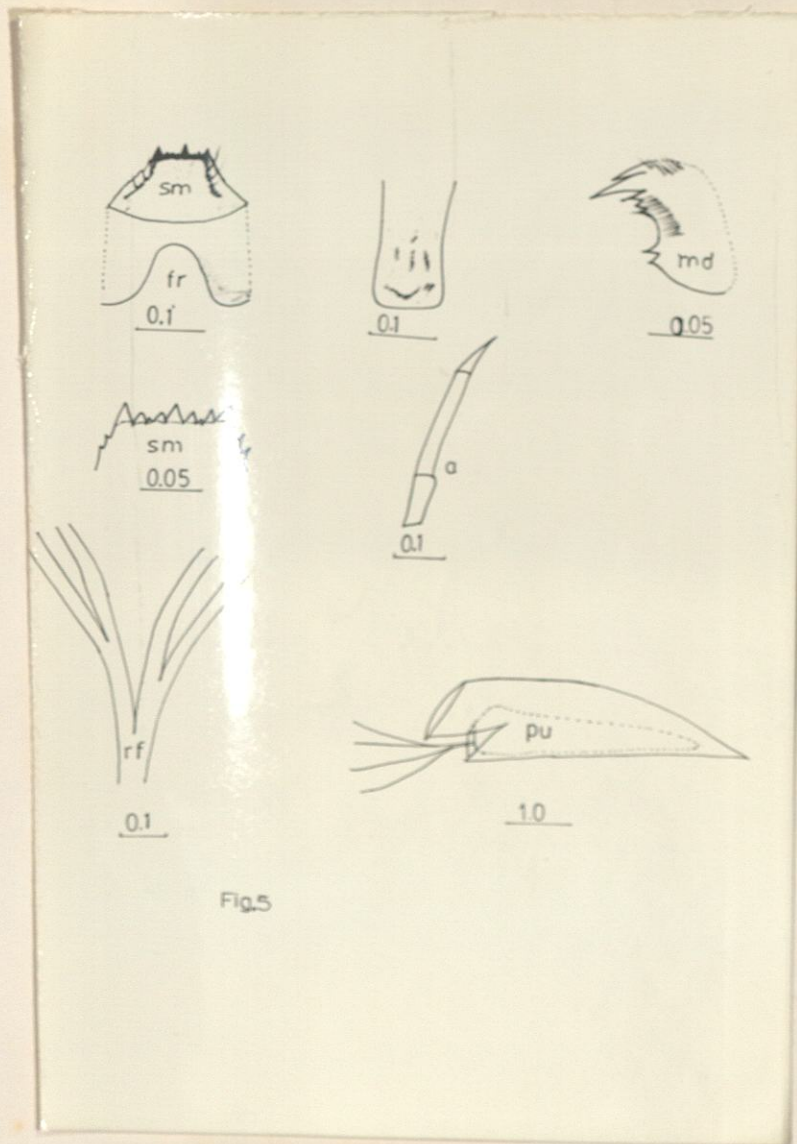


Fig.5

Figure # 5

E. bicron

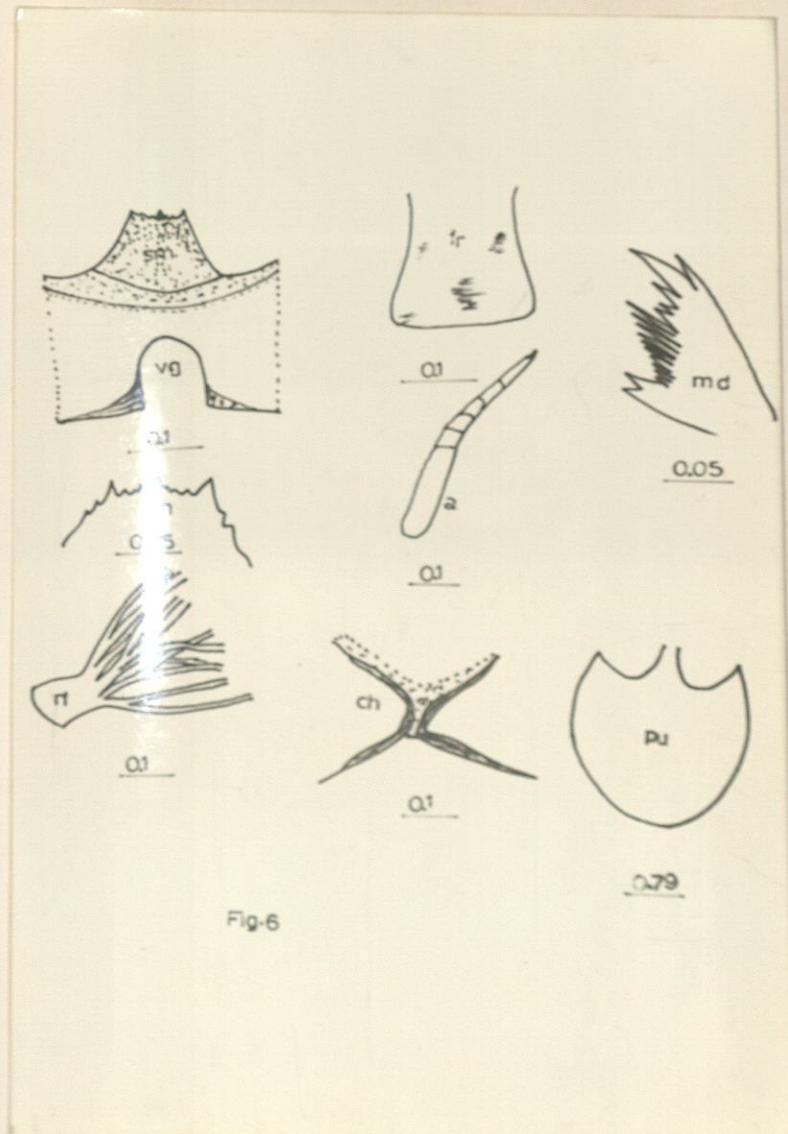


Figure # 6

E. diriense sp.n.

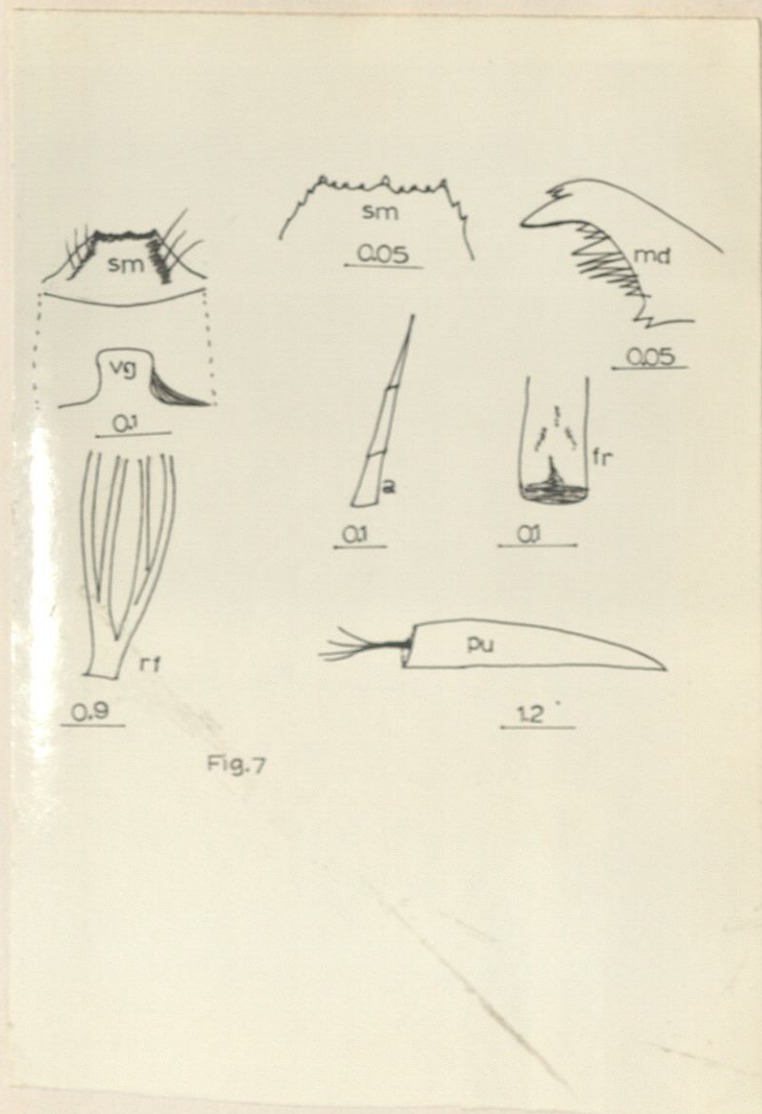


Fig.7

Figure # 7

E. fontinale

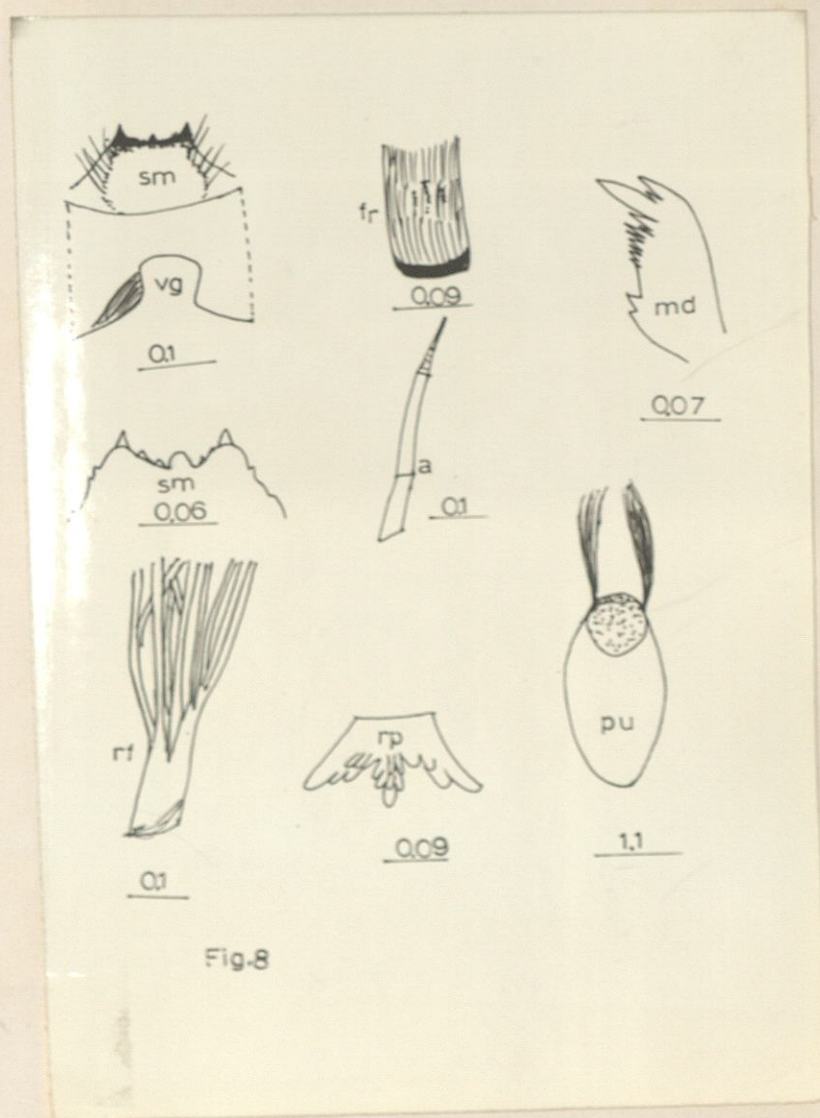


Fig.8

Figure # 8

E. gvilletense alizadei

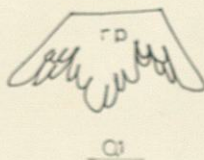
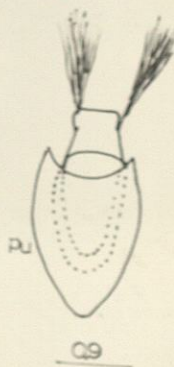
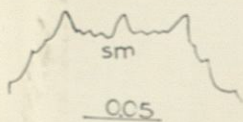
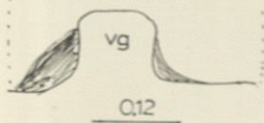
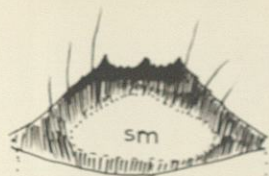


Fig9

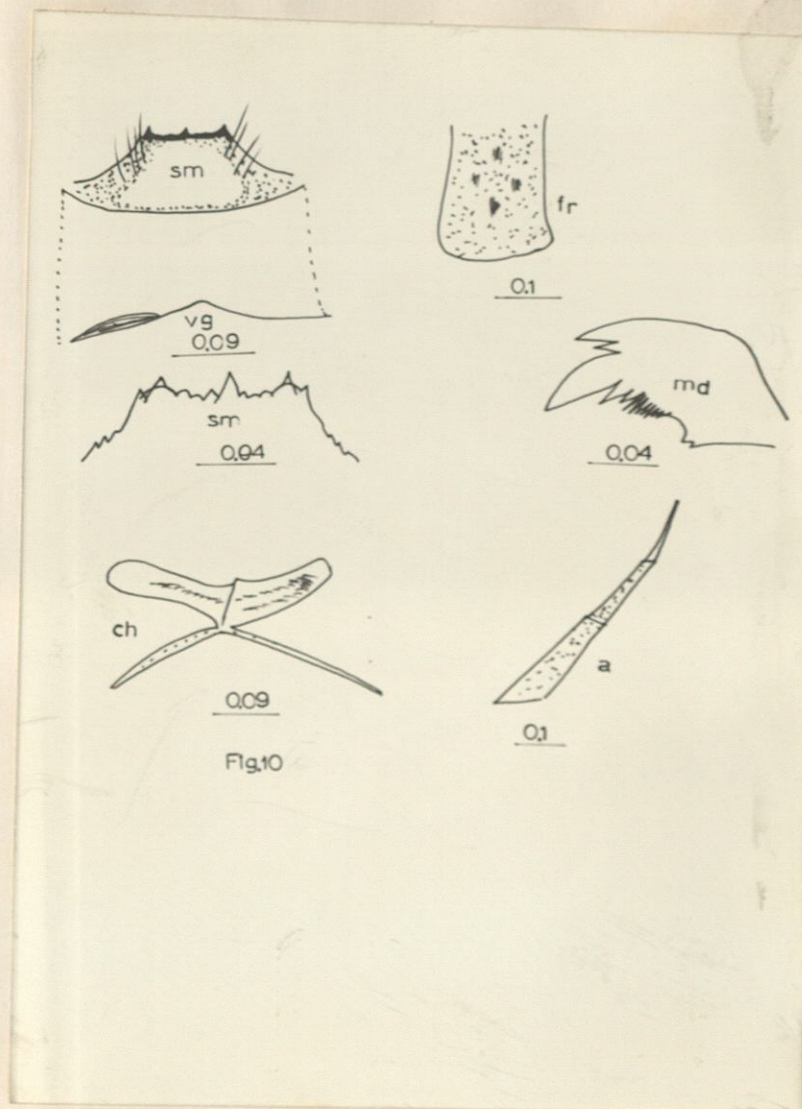


Figure # 10

E. inflatum

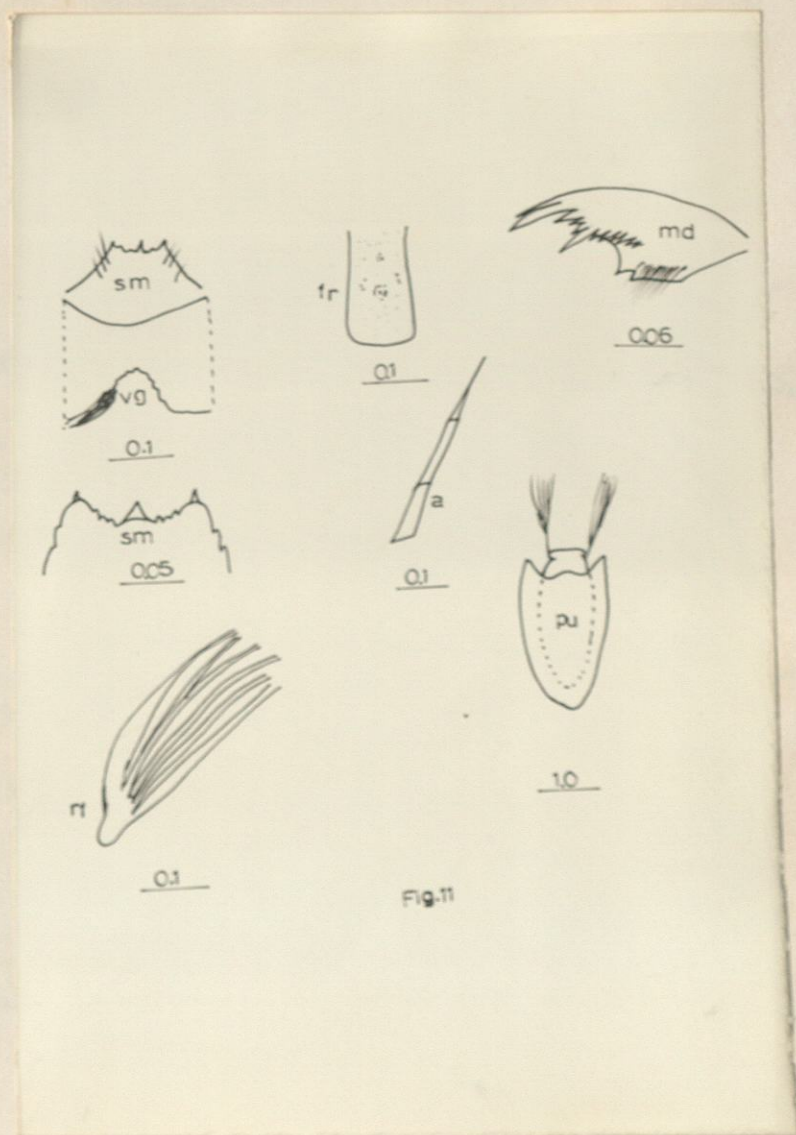


Figure # 11 E. lepnevae

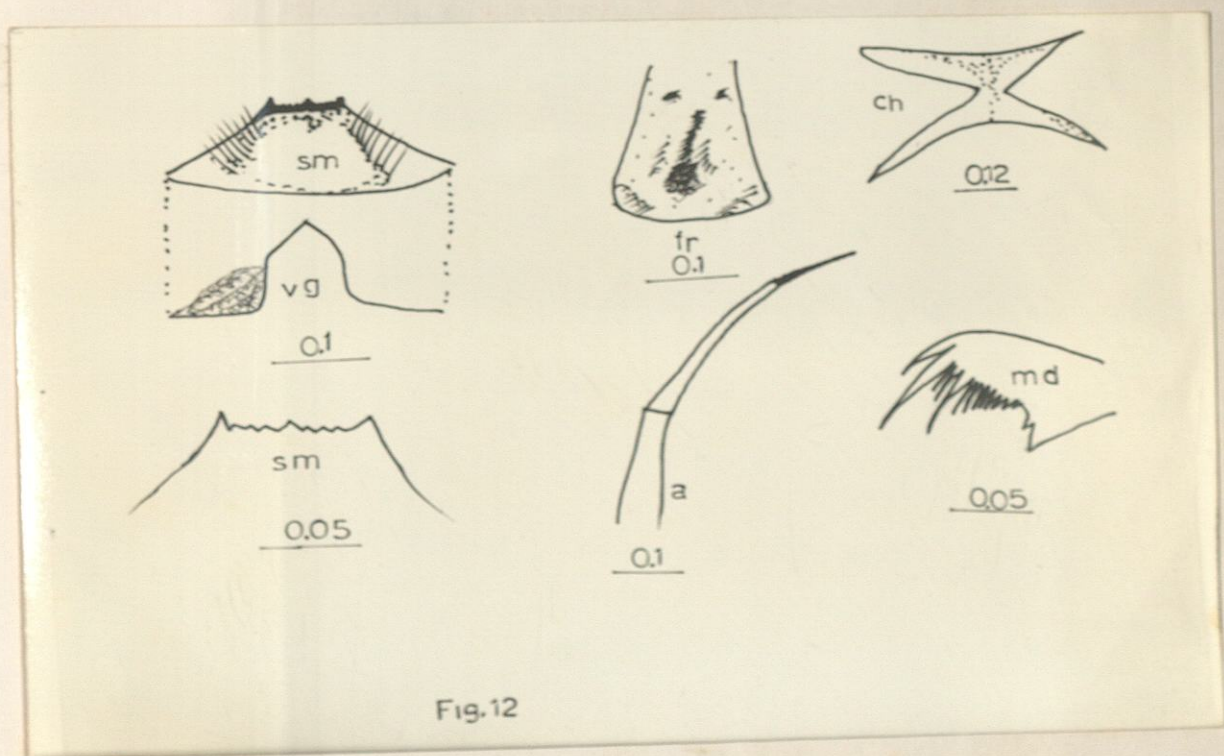


Figure # 12

E. malakandiense sp.n.

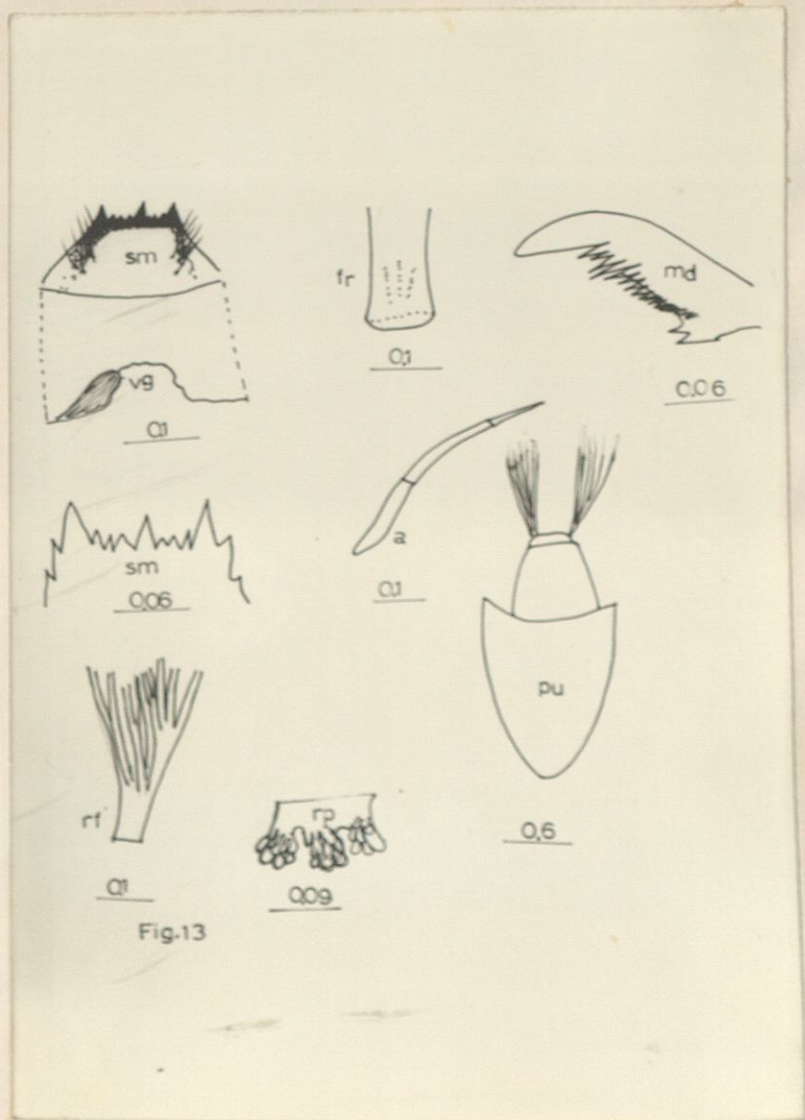


Figure # 13

E. montium

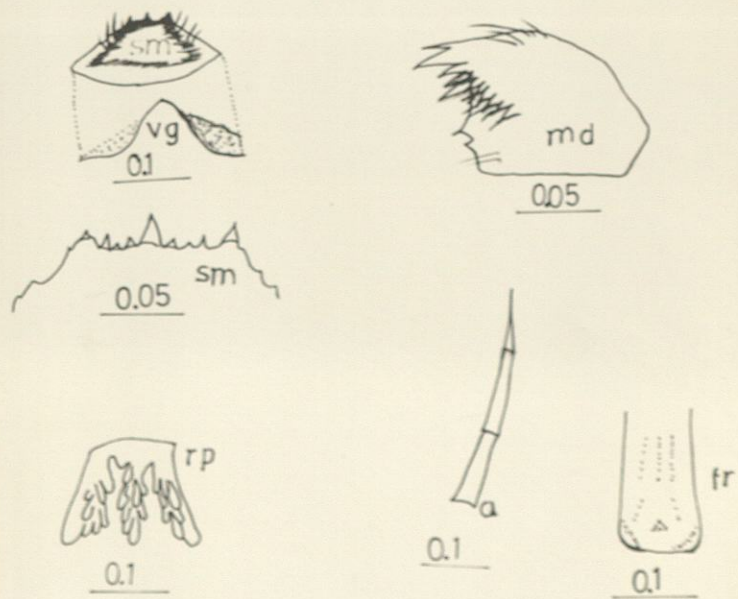


Fig.14

Figure # 14

E. planiparum

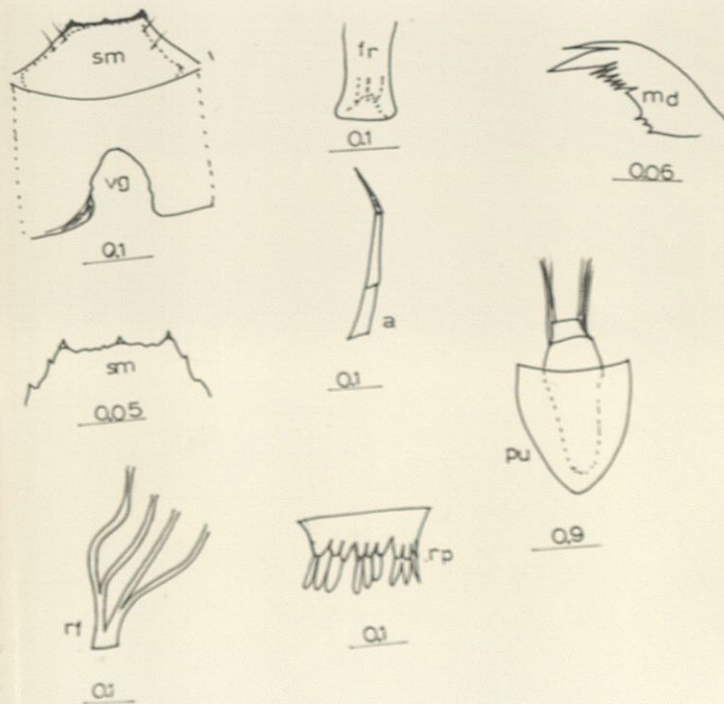


Fig.15

Figure # 15

E. gygmacum

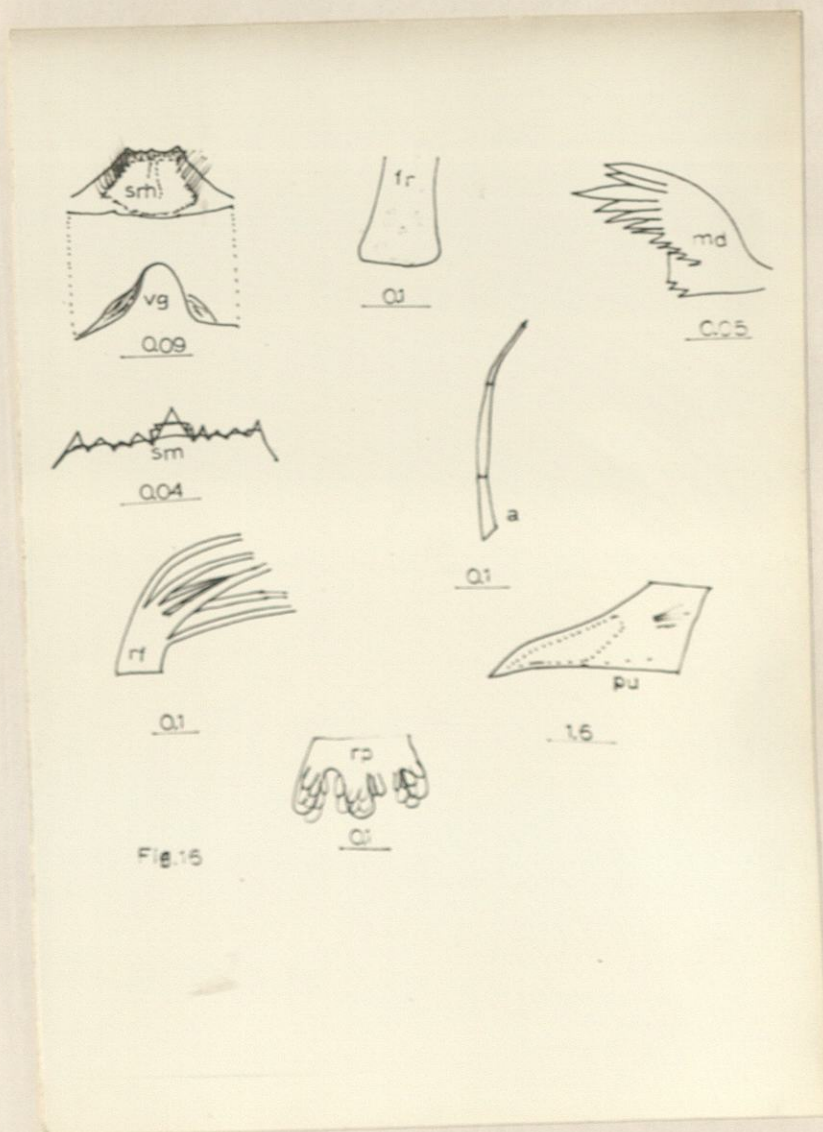


Figure # 16

Obuchovia albella

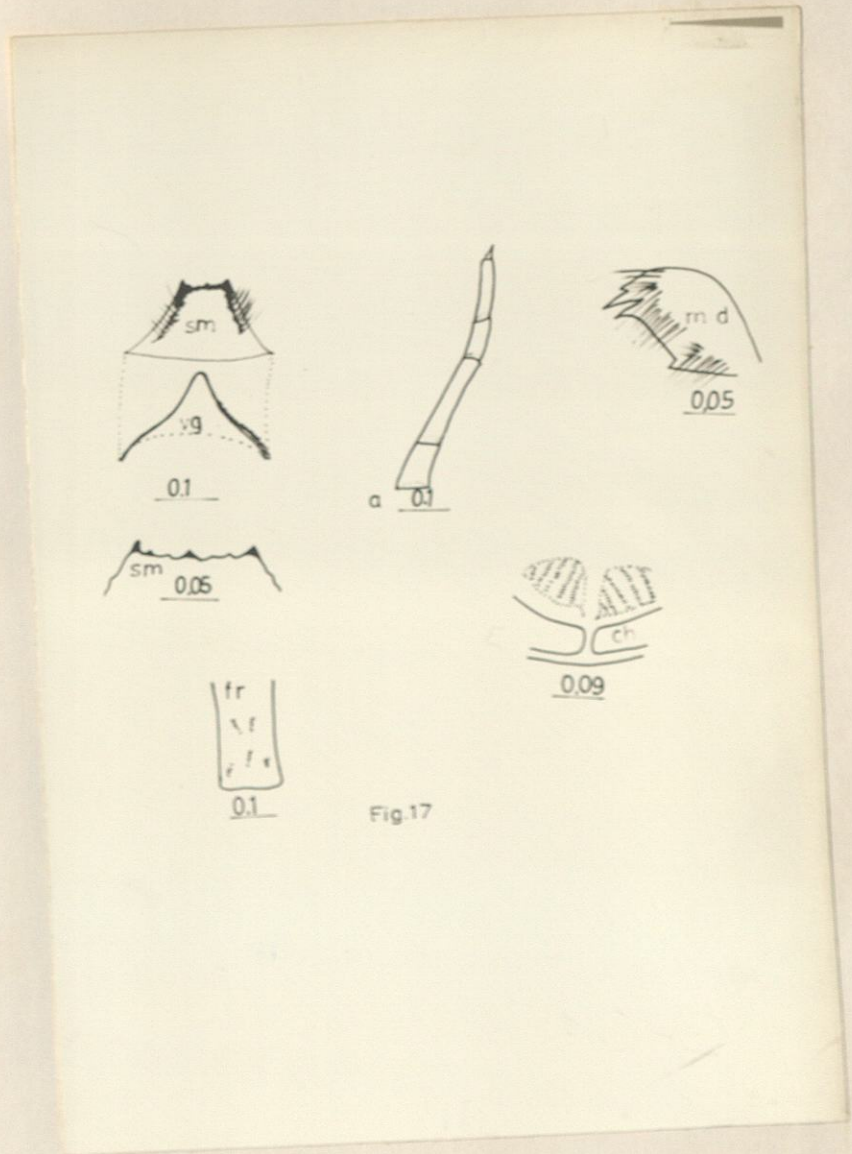


Fig.17

Figure # 17

O. chitraliense sp.n.

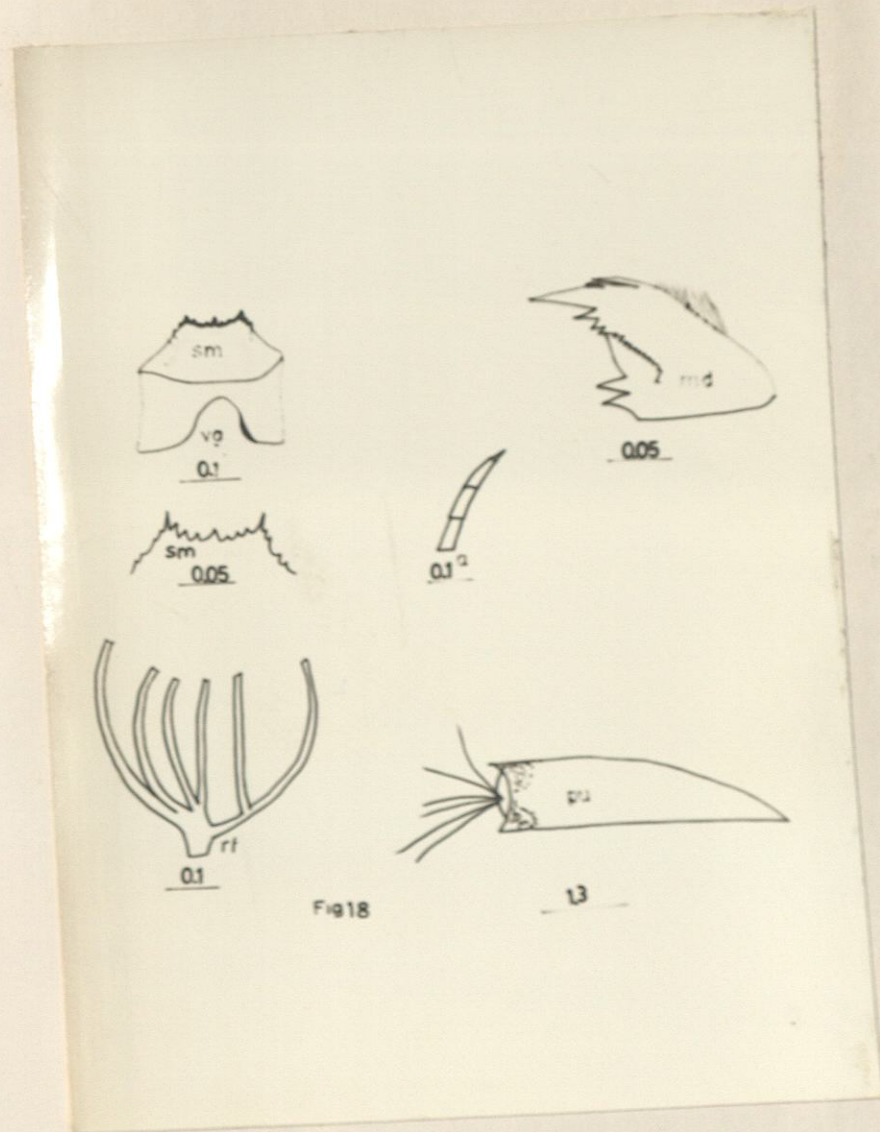


Figure # 18

Simulium aureohirtum

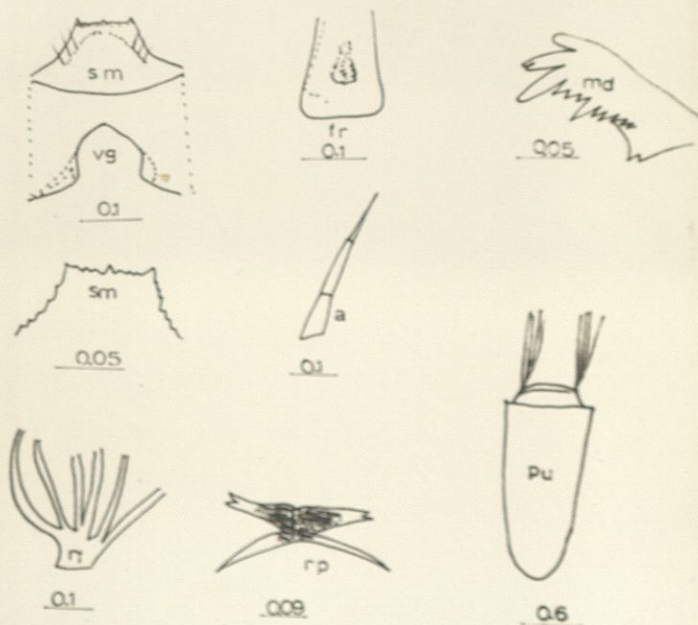


Fig. 19

Figure # 19

S. austeni

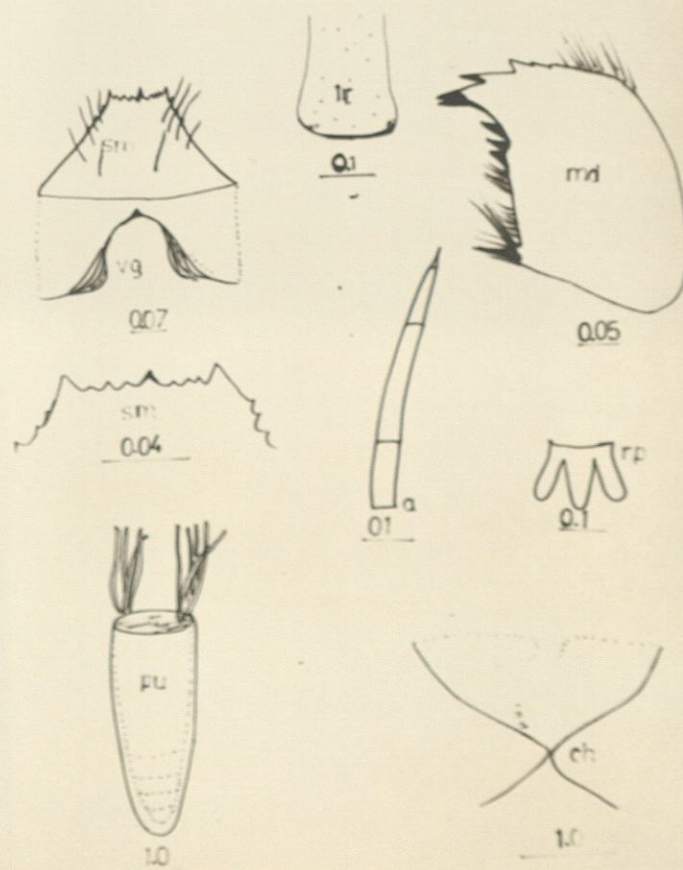


Fig-20

Figure # 20

S. kohatiense sp.n.

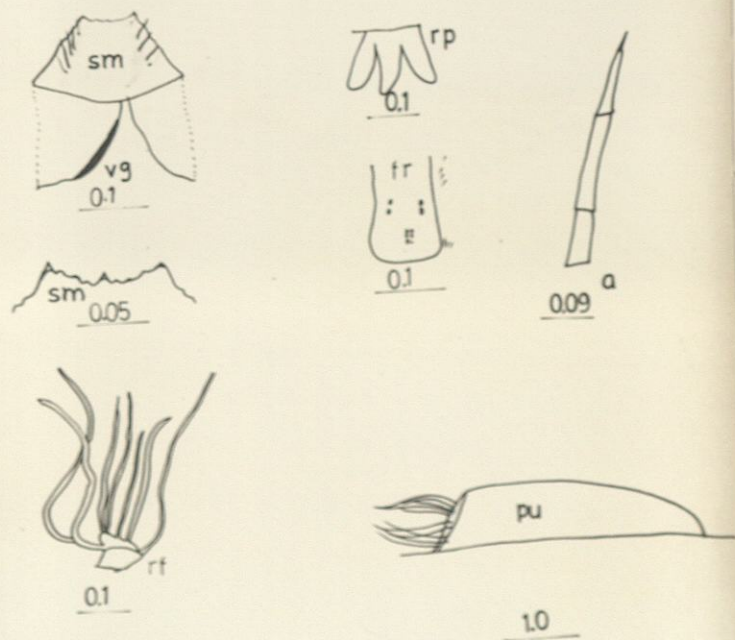


Fig. 21

Figure # 21

S. kurense

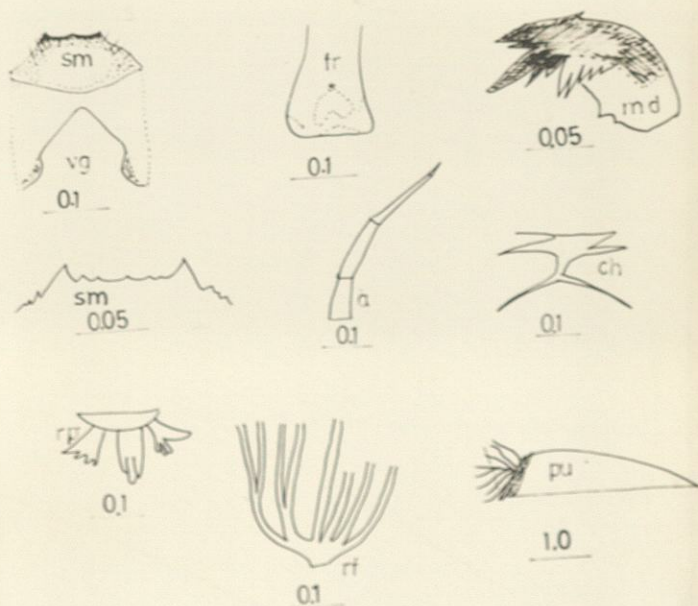


Fig.22

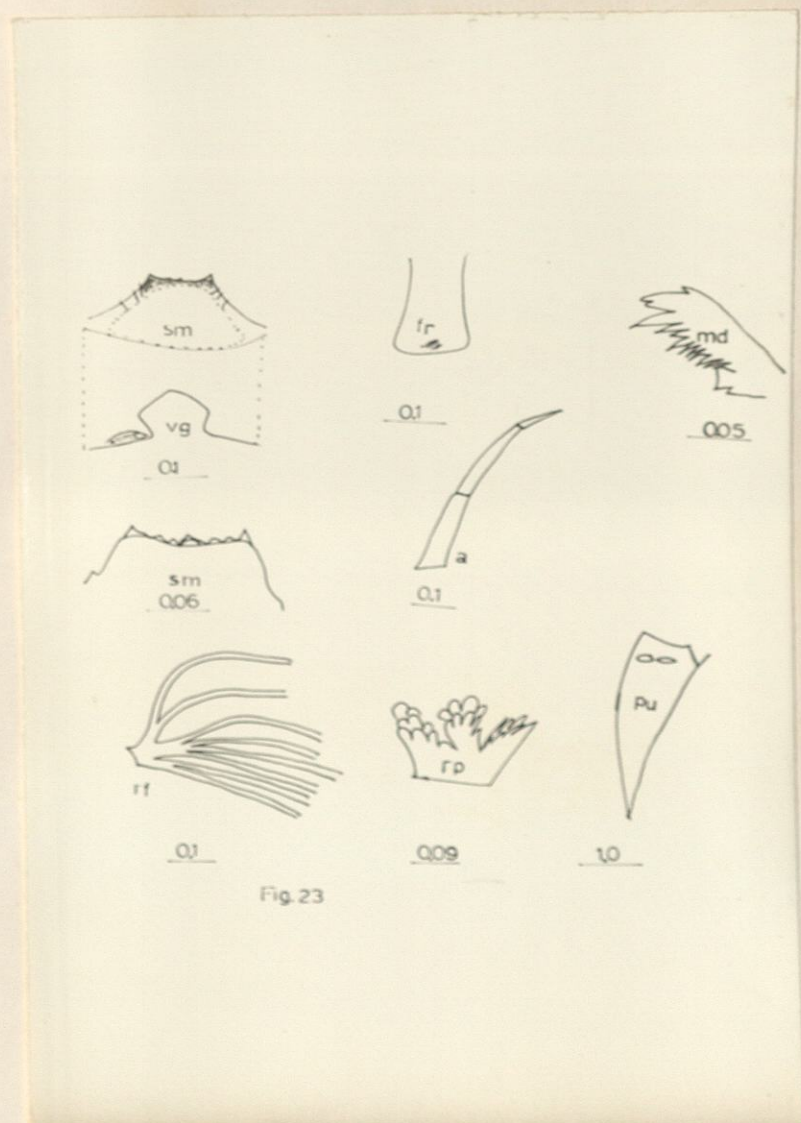


Figure # 23

S. multistriatum

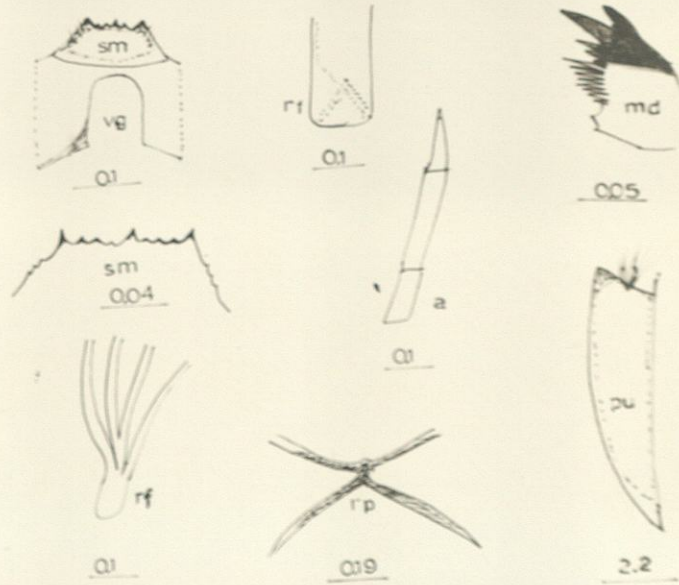


Fig.24

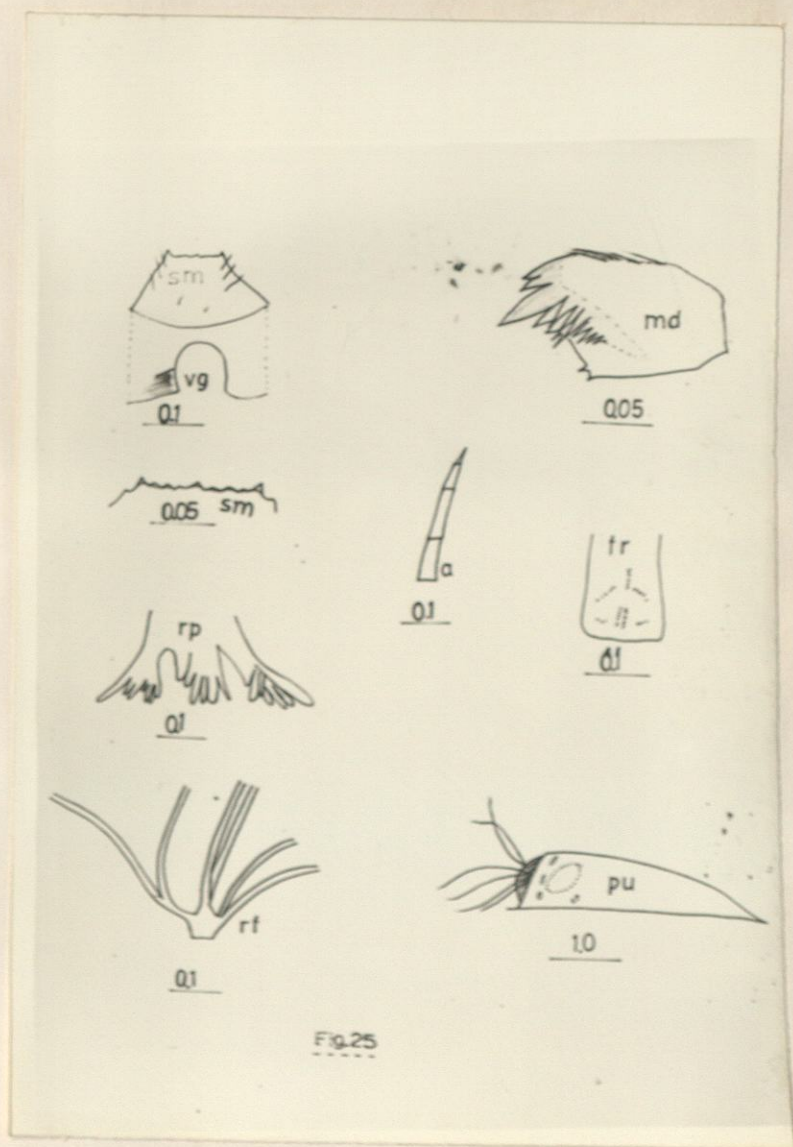


Figure # 25

S. remotum

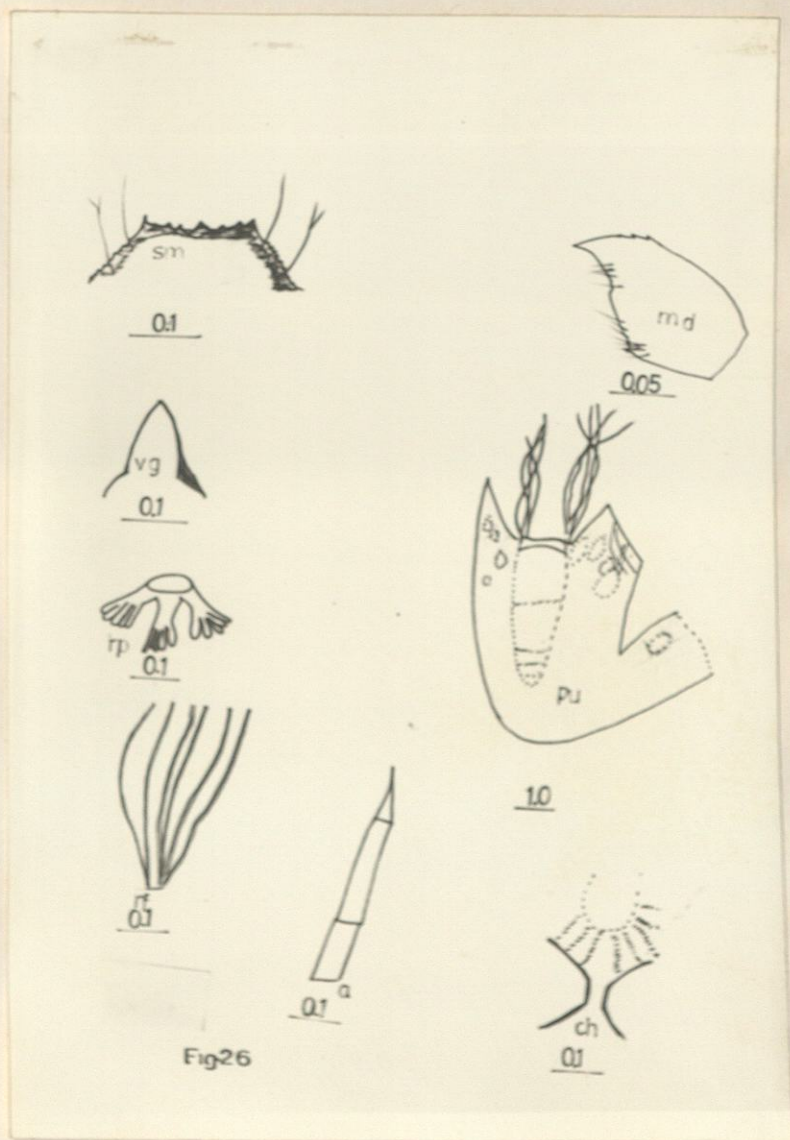


Figure # 26

S. swatiense sp.n.

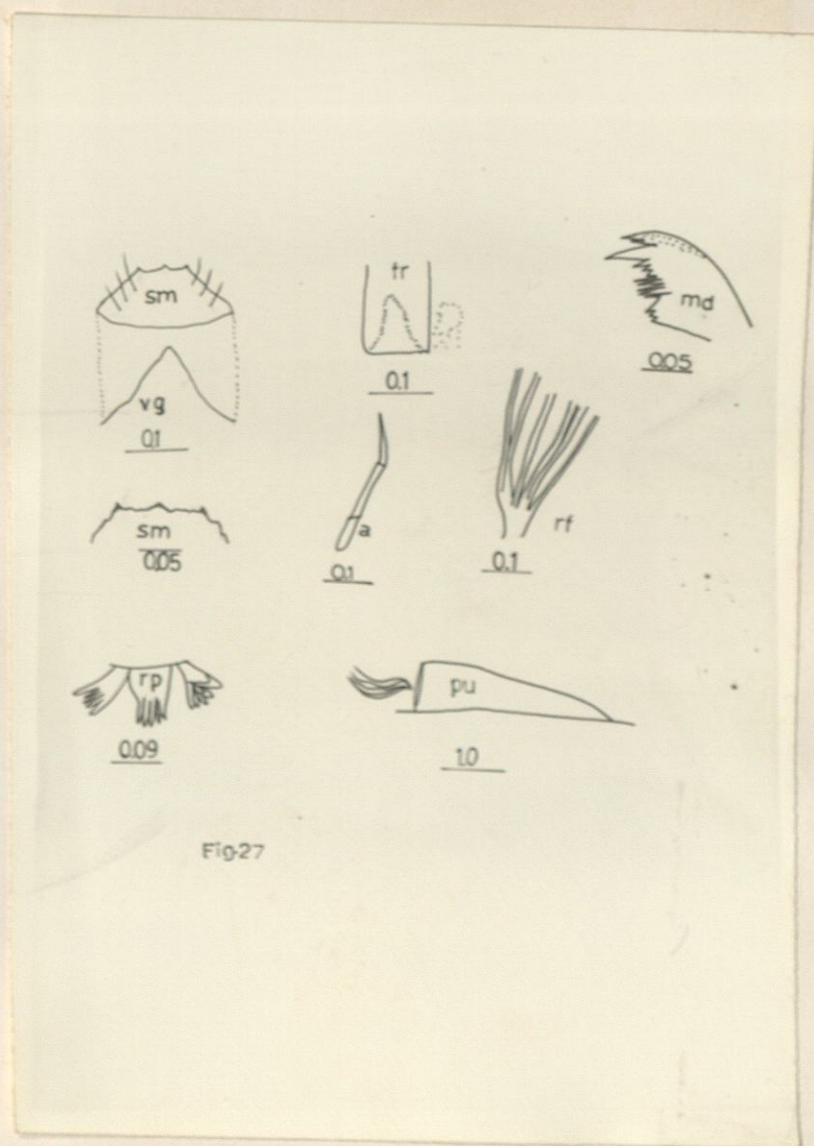


Fig27

Figure # 27

S. tumolusum

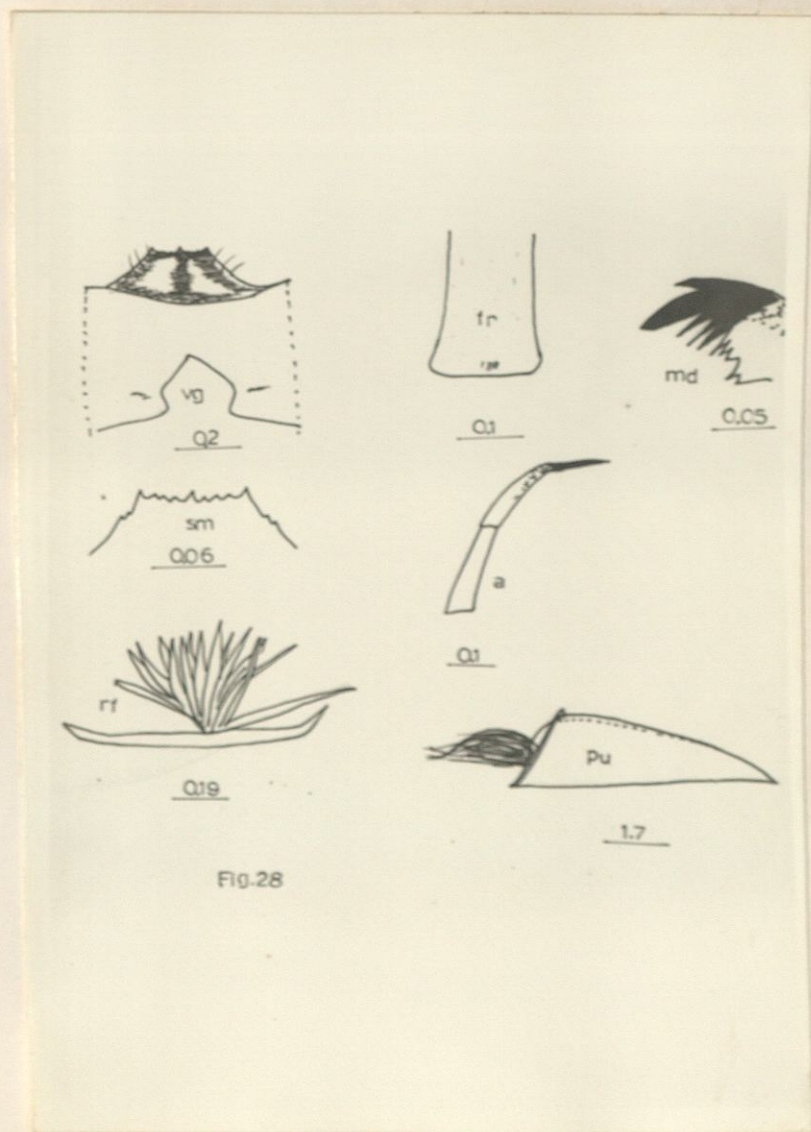


FIG.28

Figure # 28

S. worsakiense sp.n.

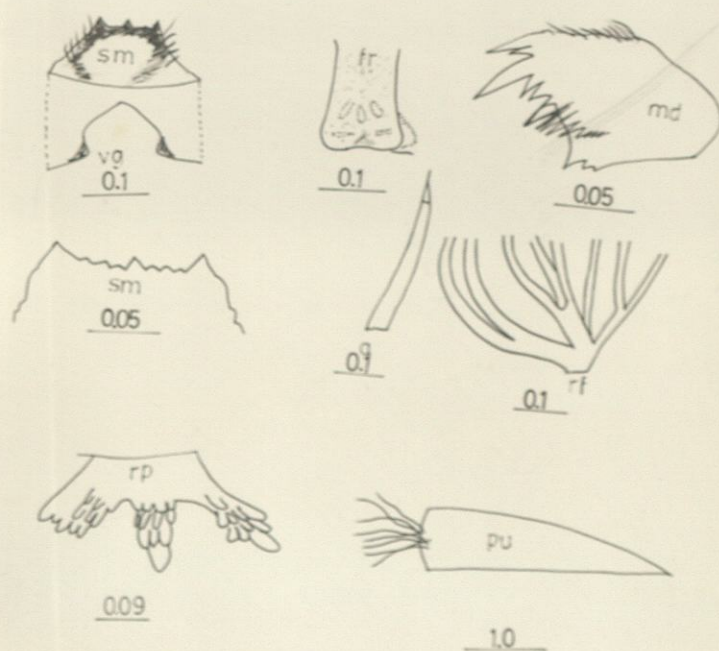


Fig.29

Figure # 29 S. xanthogastrum

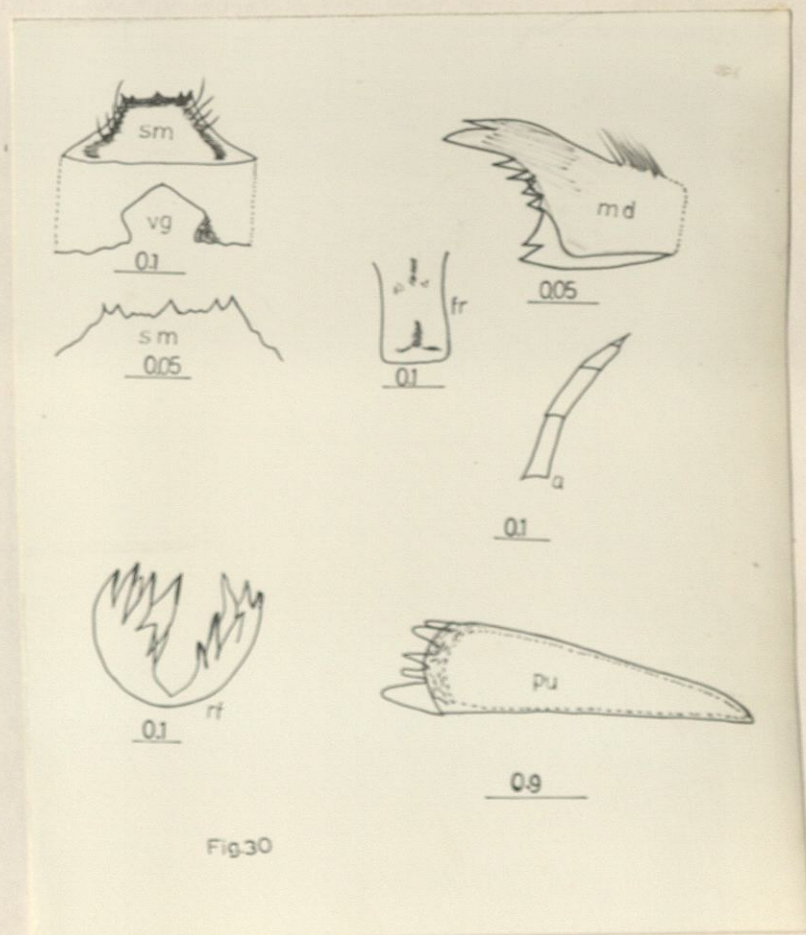


Figure # 30

Wilhelmia e. equina

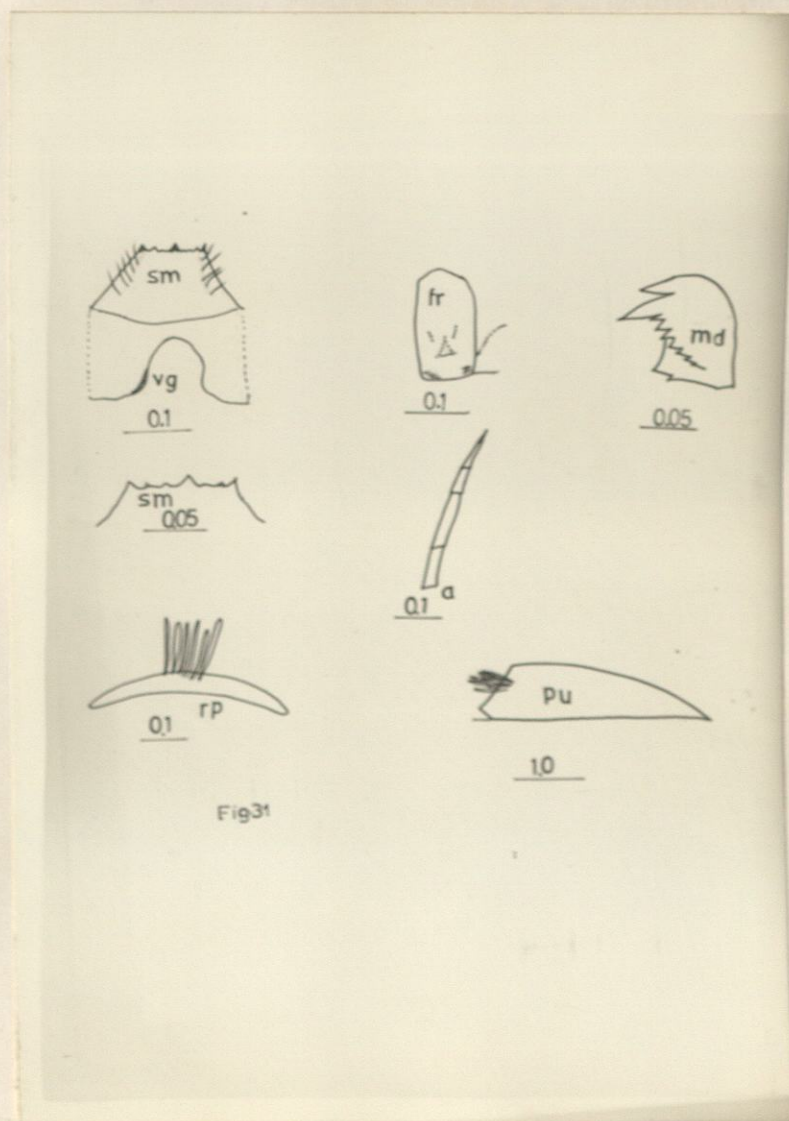


Figure # 31

W. lineata

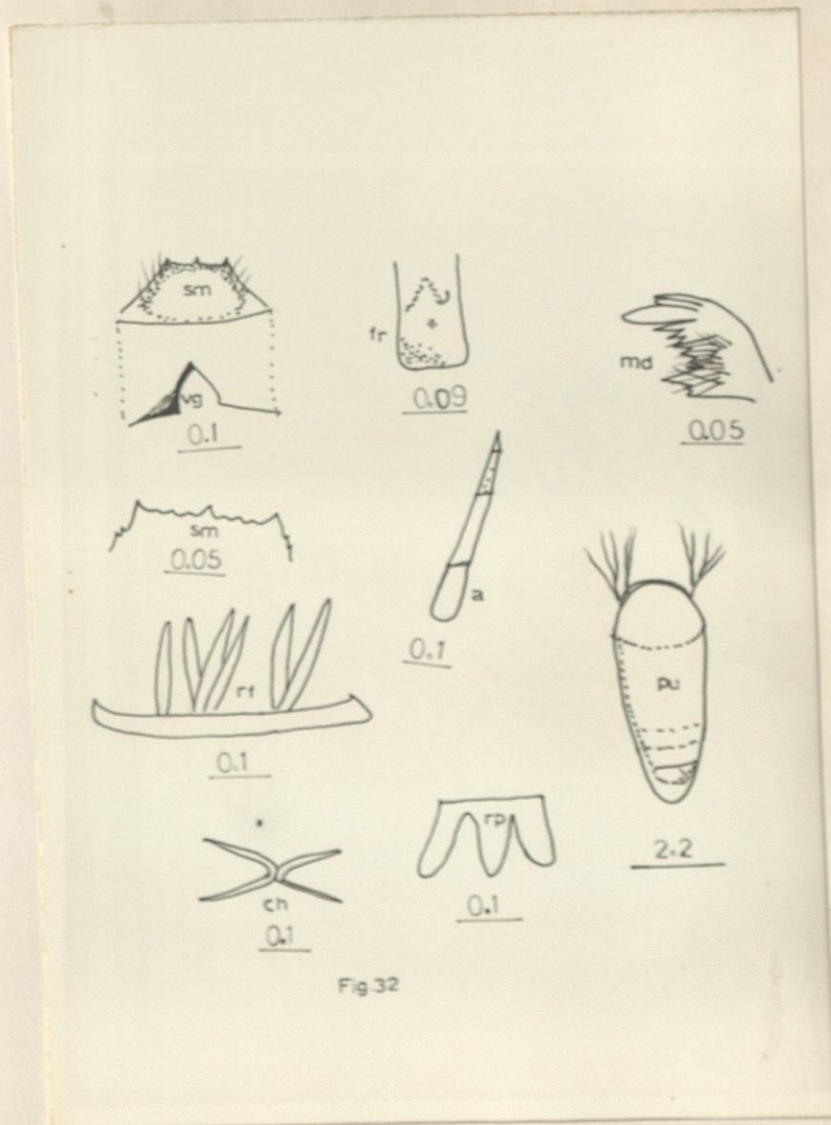


Figure # 32

W. mayariense sp.n.

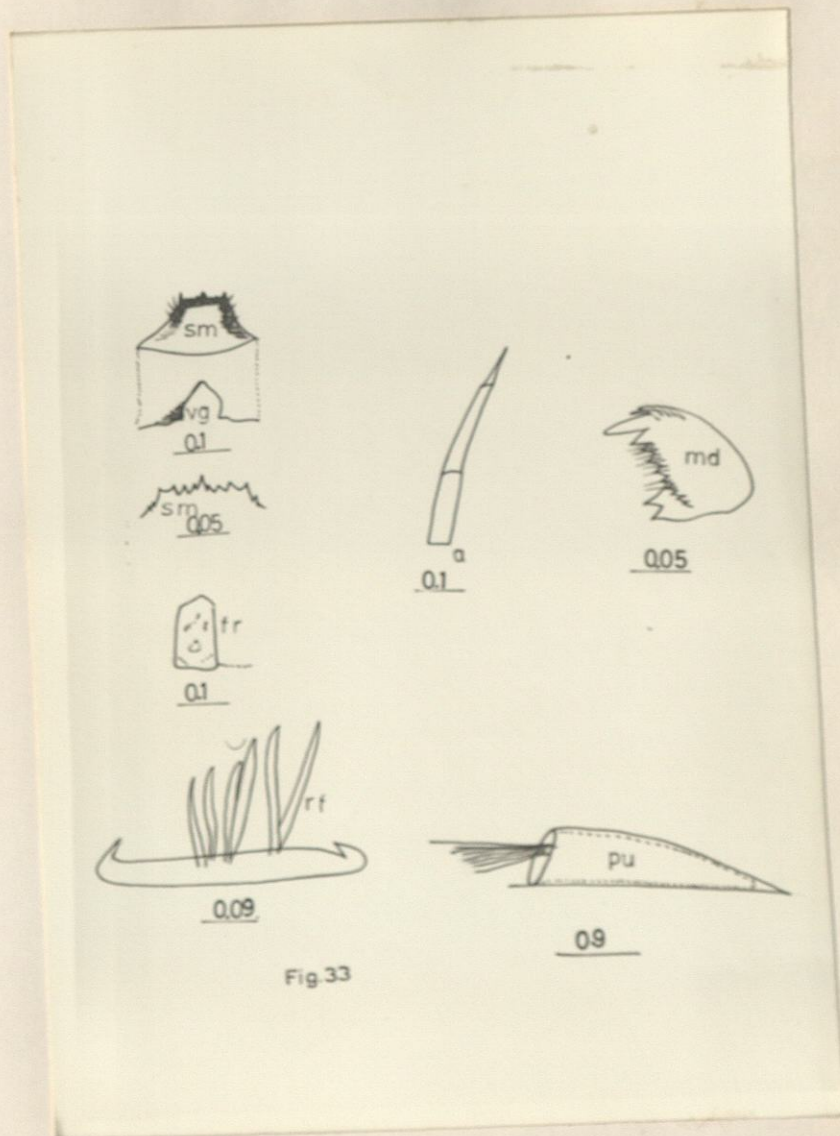


Figure # 33

W. mediterranea

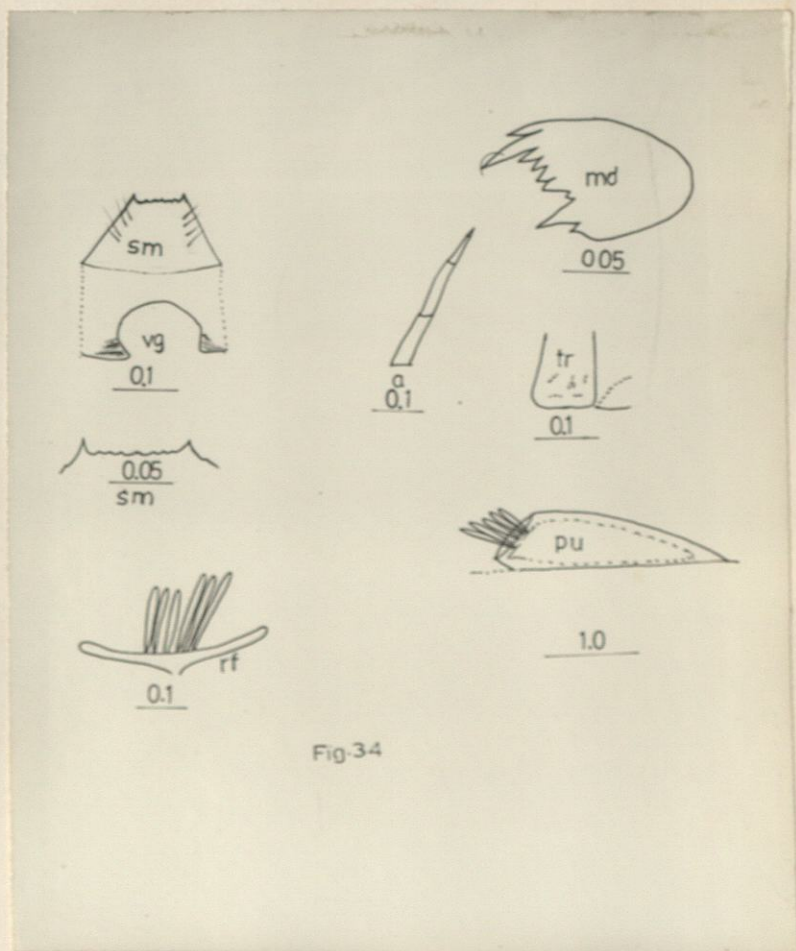


Figure # 34

W. paraequina

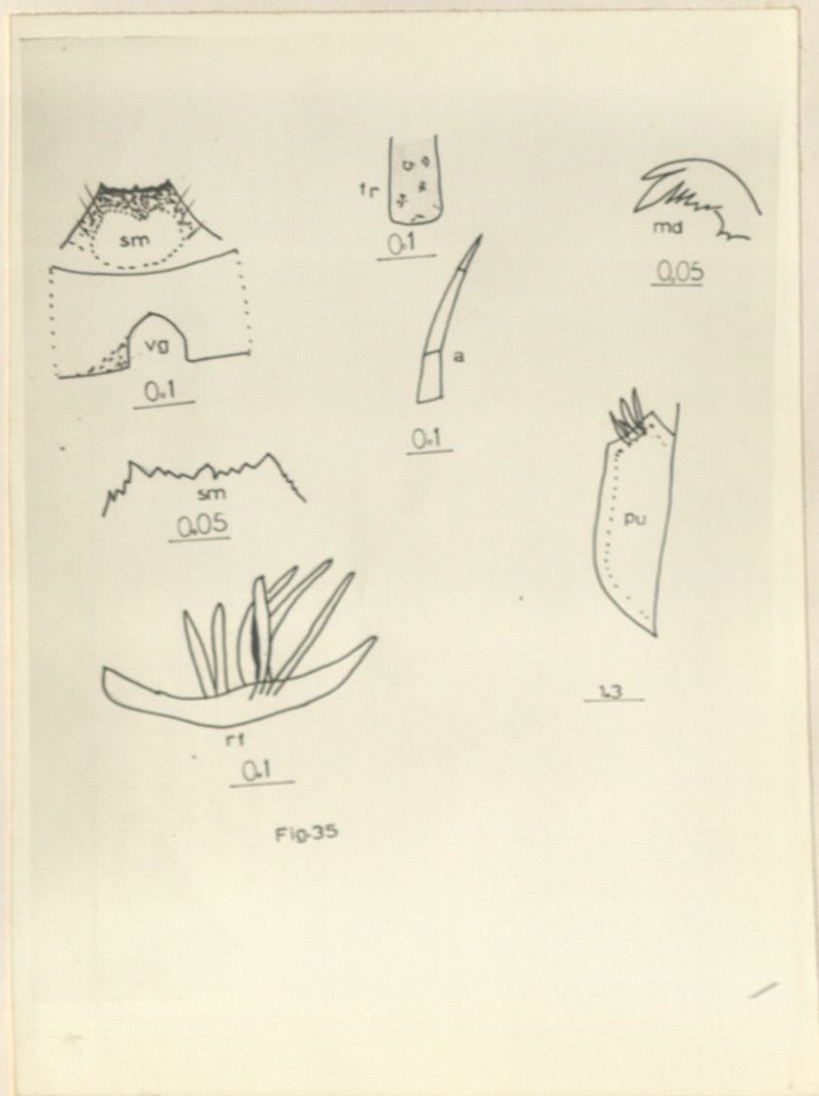


Figure # 35

W. salopiensis

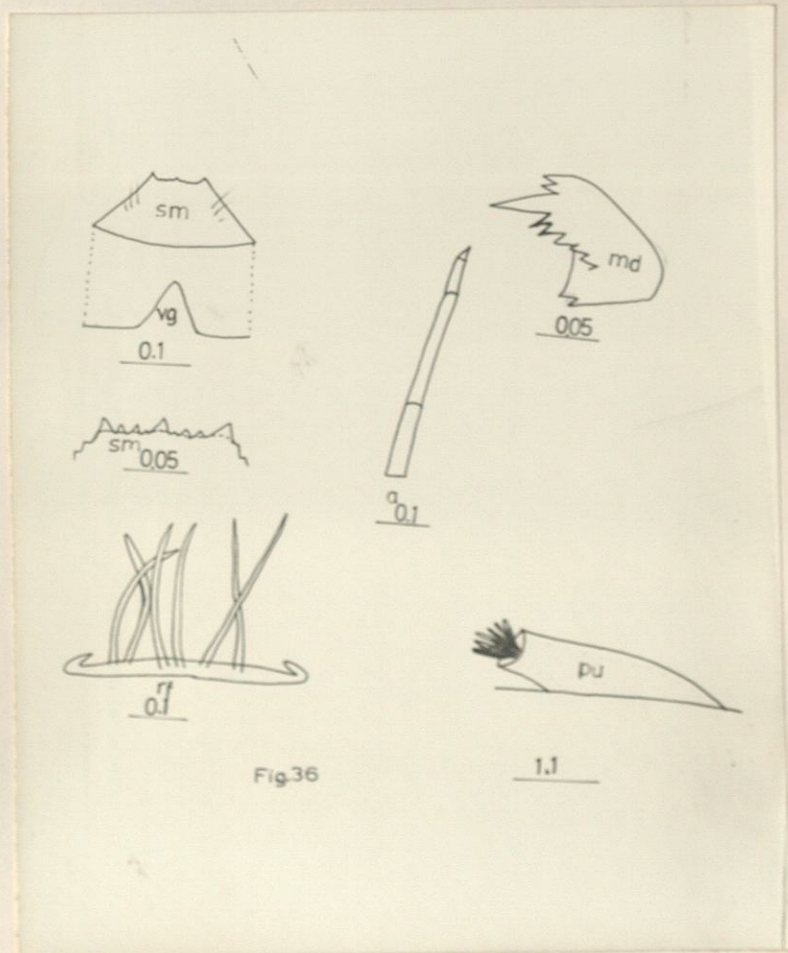


Figure # 36

W. turgaica

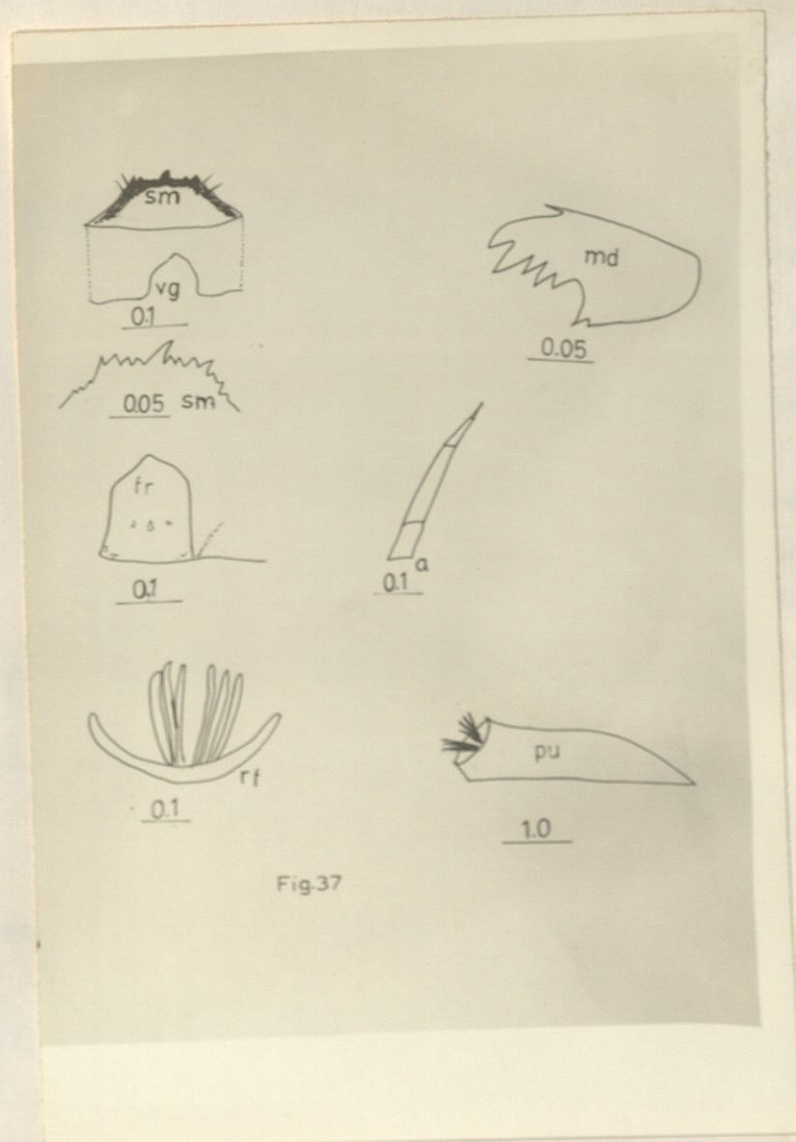


Fig.37

Figure # 37

W. veltistshevi.

Simuliid larval distribution from SWat & Malakand.

(Total No. of larvae collected).

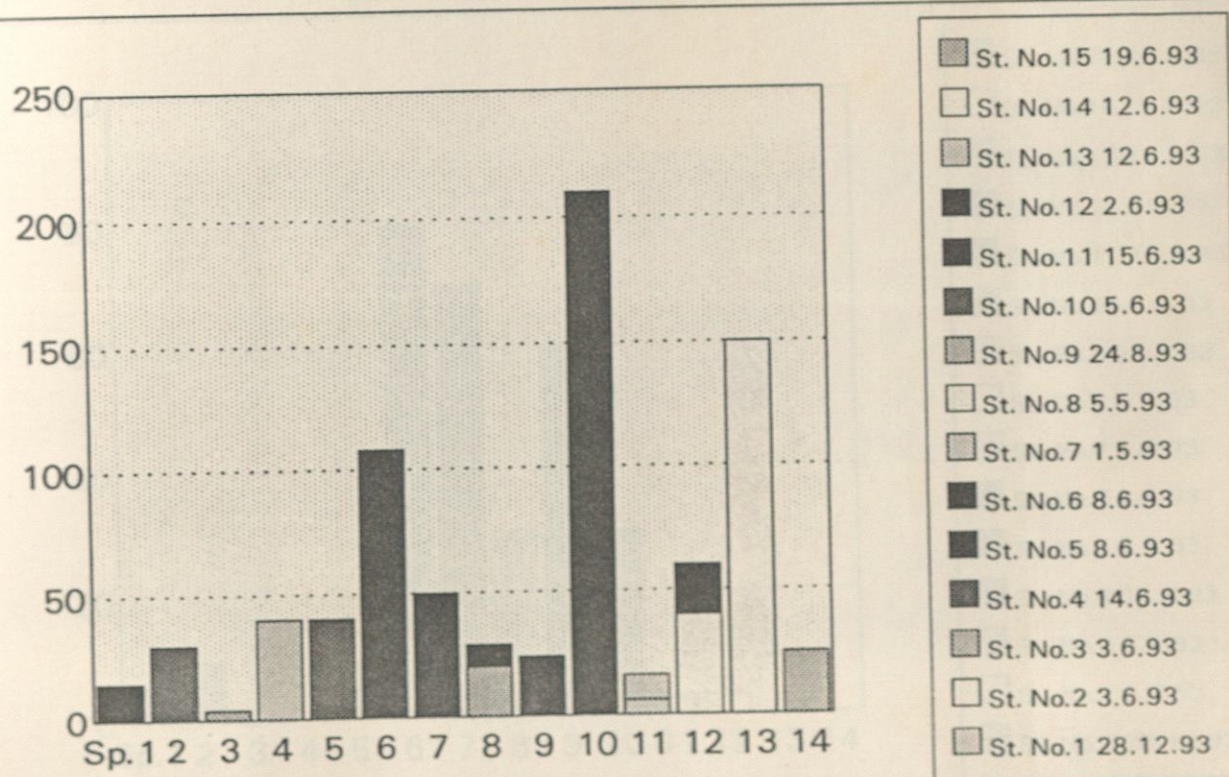


Figure No.38

Whereas:

1 is E. bicorn 2. E. fontinale 3. E. malakandiense sp.n.
 4. E. planiparum 5. E. pygmaeum 6. S. austeni 7. S. moristan 8. S. remotum 9. S. swatiense sp.n. 10. S. tumolusum 11. W. e. equina 12. W. mediterranea 13. W. salopiensis 14. W. turgaica

Simuliid pupal distribution from Swat & Malakand. (Total numbers of pupae collected).

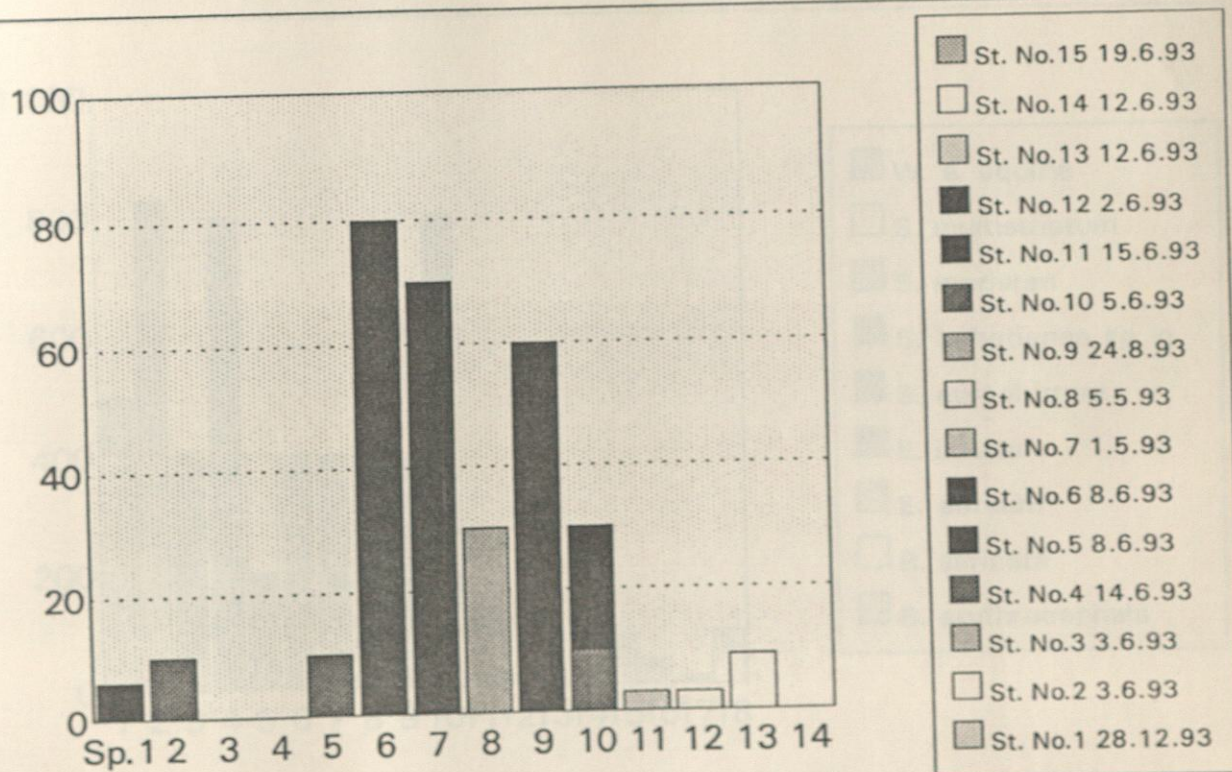


Figure No.39

Whereas:

- 1 is E. bicorn 2. E. fontinale 3. E. malakandiense sp.n.
 4. E. planiparum 5. E. pygmaeum 6. S. austeni 7. S. moristan
 8. S. remotum 9. S. swatiense sp.n. 10. S. tumolusum
 11. W. e. equina 12. W. mediterranea 13. W. salopiensis
 14. W. turgaica

Simuliid larval distribution from Kohat.

(Total numbers of larvae collected).

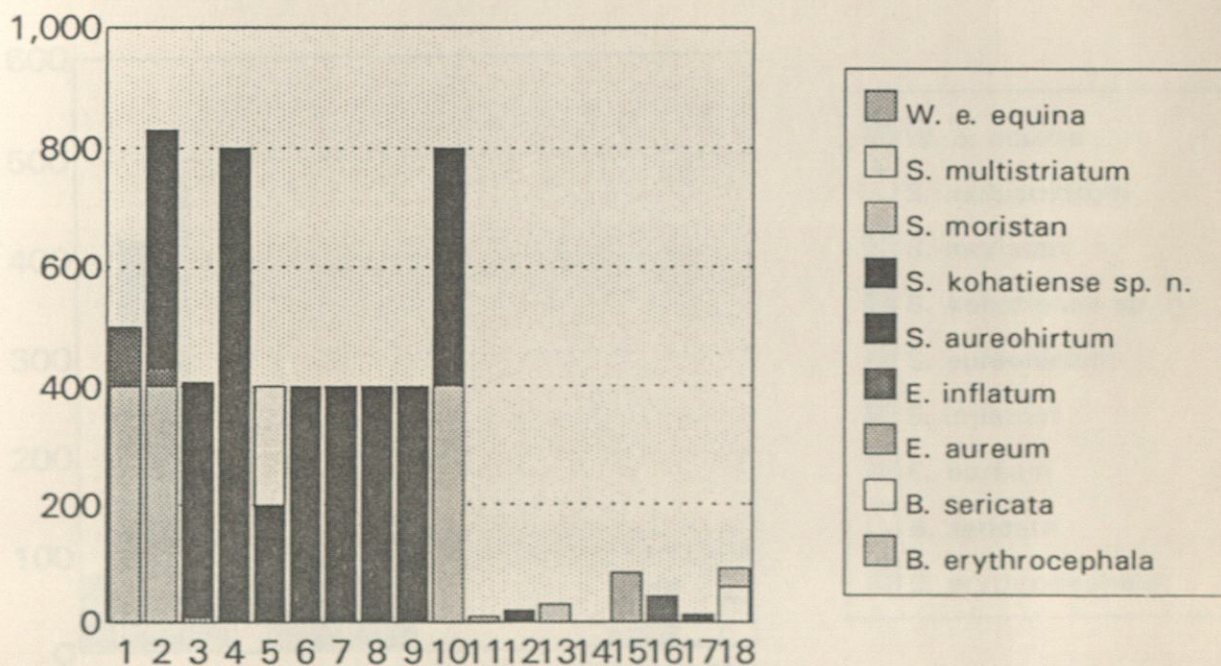


Figure No.40

Where as 1 to 3 is station 16, 4 to 10 is station 17, 11 to 14 is station 18, 15 is station 19, 16 to 17 is station 20 and 18 is station 21 (Refer to Table No.11).

Simuliid pupal distribution from Kohat.

(Total numbers of pupae collected).

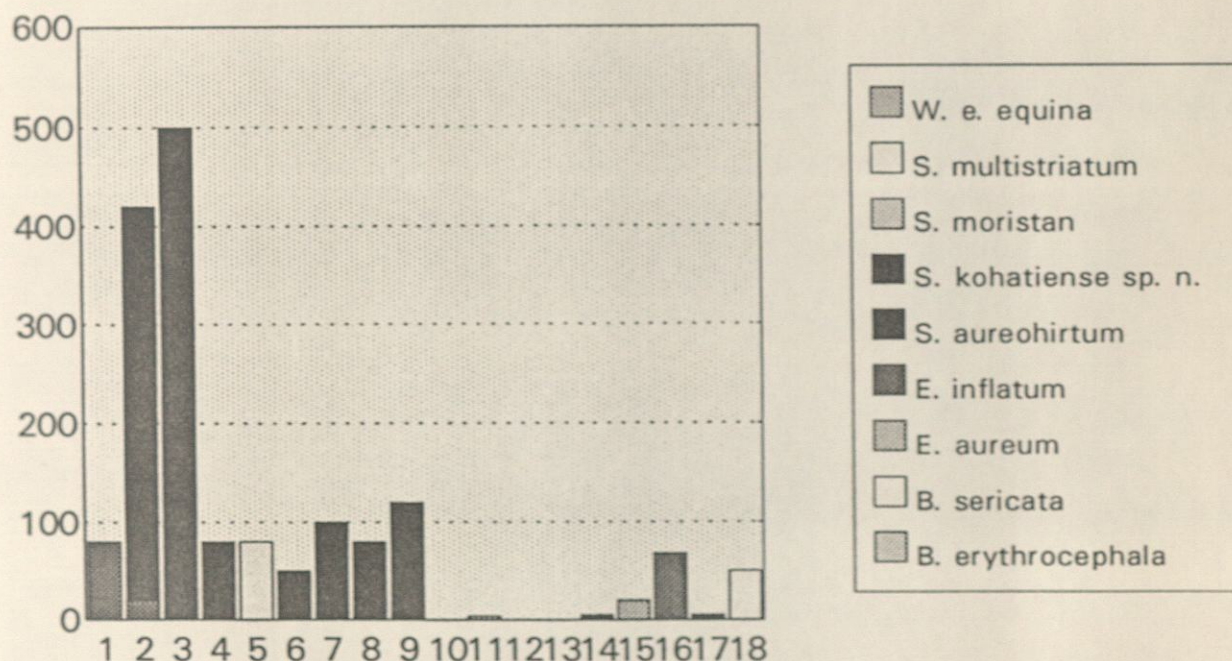


Figure No.41

Where as 1 to 3 is station 16, 4 to 10 is station 17, 11 to 14 is station 18, 15 is station 19, 16 to 17 is station 20 and 18 is station 21 (Refer to Table No.11).

Simuliid larval distribution from Dir.

(Total numbers of larvae collected).

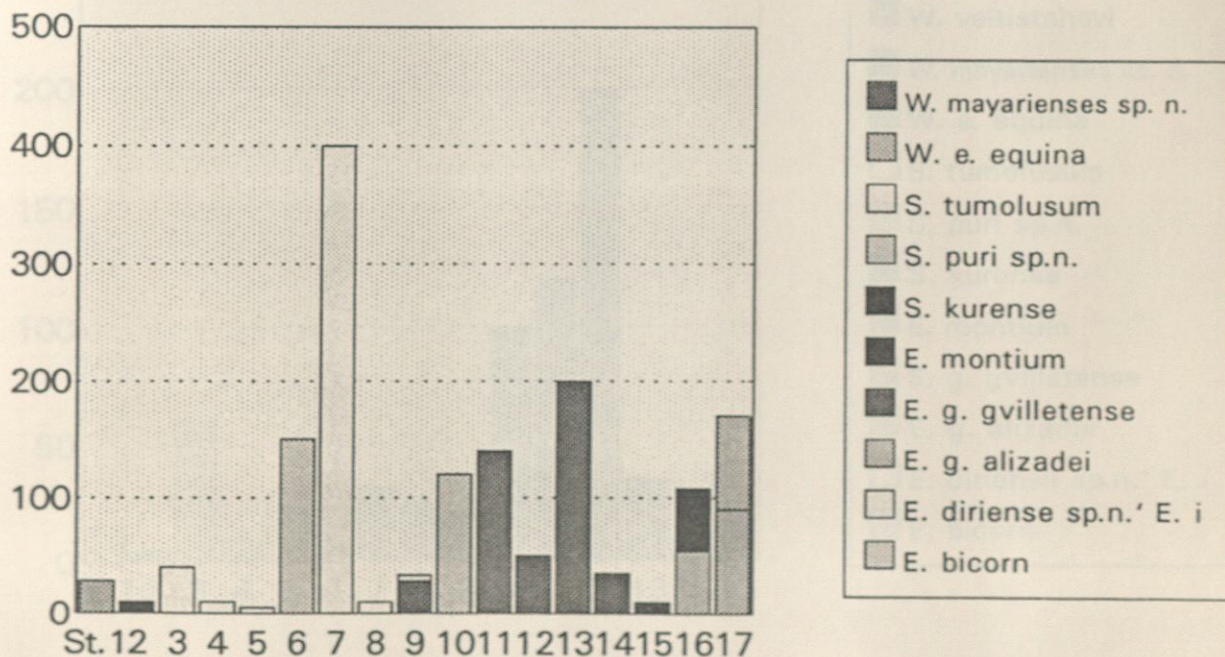


Figure No.42

Where as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 is station No. 22, 23, 24, 25, 25, 26, 27, 27, 28, 29, 30, 30, 30, 30, 31 and 32 respectively (Refer to Table No.12).

Simuliid pupal distribution from Dir.

(Total numbers of pupae collected).

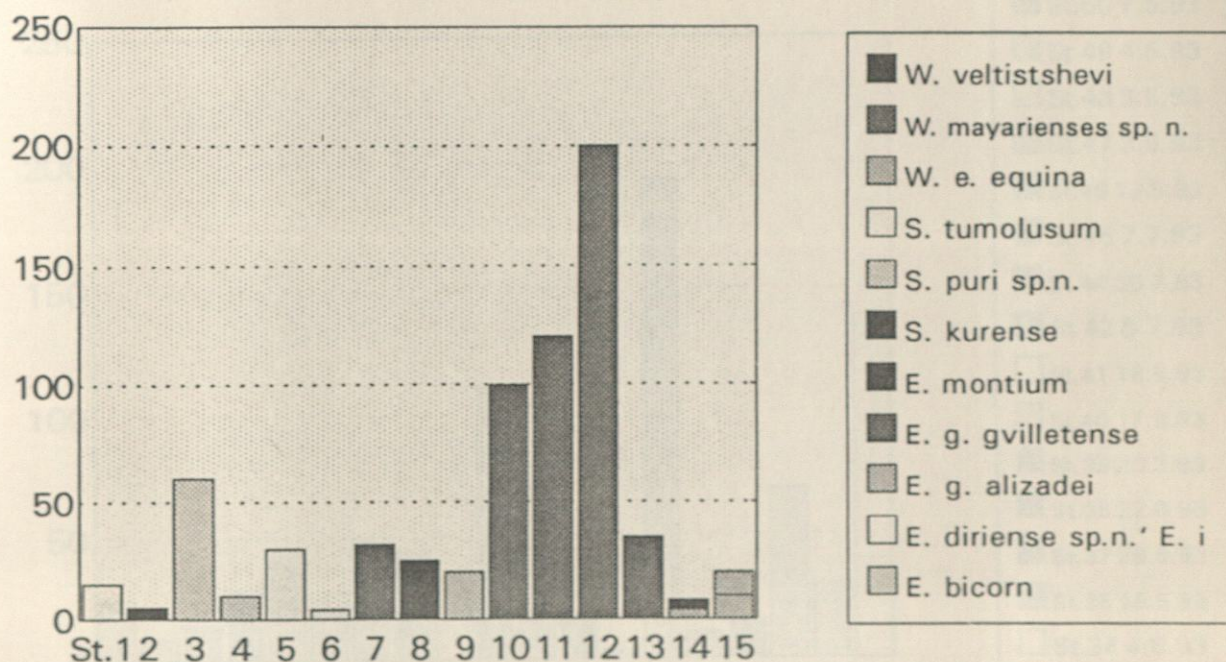


Figure No.43

Where as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 is station No. 22, 23, 24, 25, 25, 26, 27, 27, 28, 29, 30, 30, 30, 30, 31 and 32 respectively (Refer to Table No.12).

Simuliid larval distribution from different Districts.

(Total numbers of larvae collected).

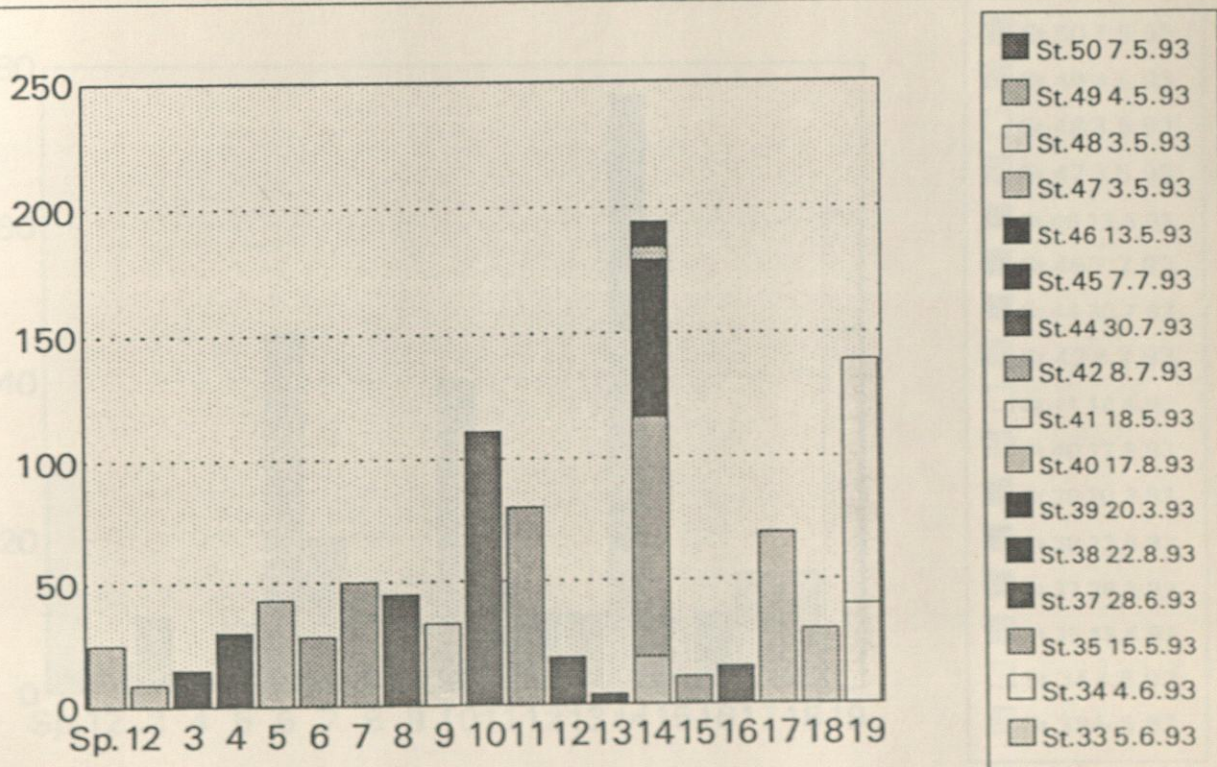


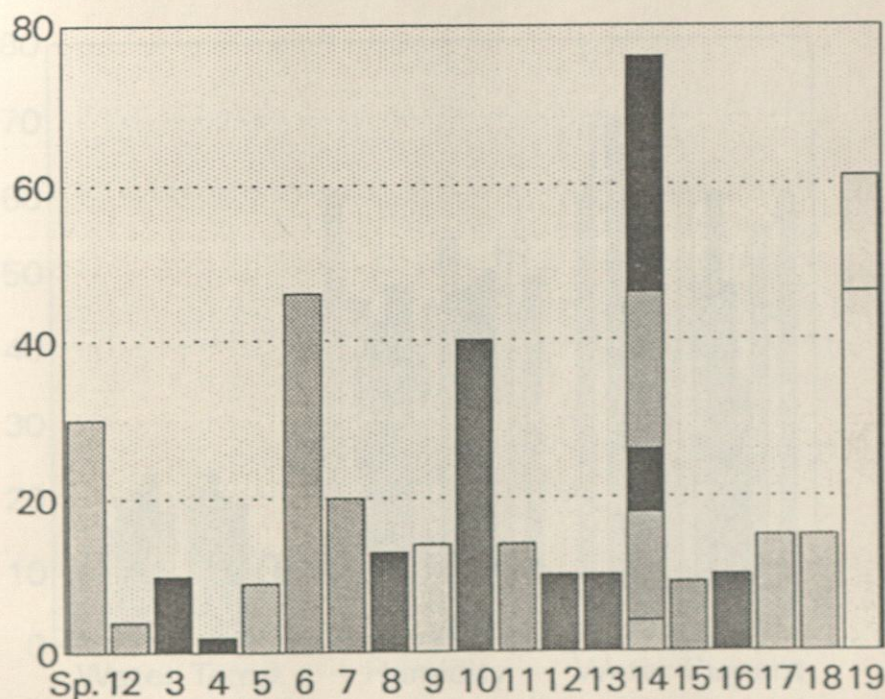
Figure No.44

Whereas:

1 is Boophthora erythrocephala, 2 is Eusimulium aureum, 3 is E. fontinale, 4 is E. lepnevae, 5 is E. planiparum, 6 is Obuchovia albella, 7 is O. Chitraliense sp.n., 8 is S. Kurense, 9 is S. moristan, 10 is S. puri sp.n., 11 is S. remotum, 12 is S. worsakiense sp.n., 13 is S. xanthogastrum, 14 is Wilhelmia e. equina, 15 is W. lineata, 16 is W. mediterranea, 17 is W. paraequina, 18 is w. turgaica, 19 is W. veltistshevi.

Simuliid pupae distribution from different Districts.

(Total numbers of pupae collecte).



St.50 7.5.93
St.49 4.5.93
St.48 3.5.93
St.47 3.5.93
St.46 13.5.93
St.45 7.7.93
St.44 30.7.93
St.42 8.7.93
St.41 18.5.93
St.40 17.8.93
St.39 20.3.93
St.38 22.8.93
St.37 28.6.93
St.35 15.5.93
St.34 4.6.93
St.33 5.6.93

Figure No.45

Whereas:

1 is Boophthora erythrocephala, 2 is Eusimulium aureum, 3 is E. fontinale, 4 is E. lepnevae, 5 is E. planiparum, 6 is Obuchovia albella, 7 is O. Chitralsense sp.n., 8 is S. Kurense, 9 is S. moristan, 10 is S. puri sp.n., 11 is S. remotum, 12 is S. worsakiense sp.n., 13 is S. xanthogastrum, 14 is Wilhelmia e. equina, 15 is W. lineata, 16 is W. mediterranea, 17 is W. paraequina, 18 is w. turgaica, 19 is W. veltistshevi.

Physical Data For Different Water Bodies

From District Swat and Malakand.

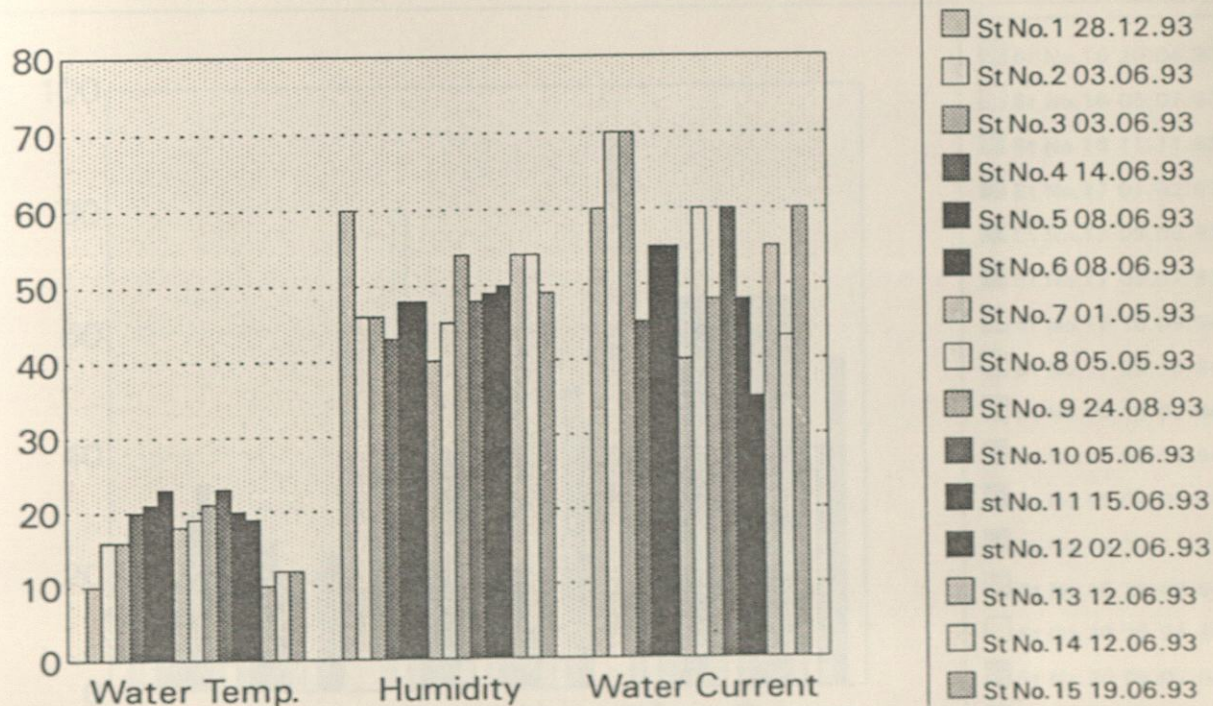


Figure No.46

Physical Data For Different Water Bodies

From District Kohat

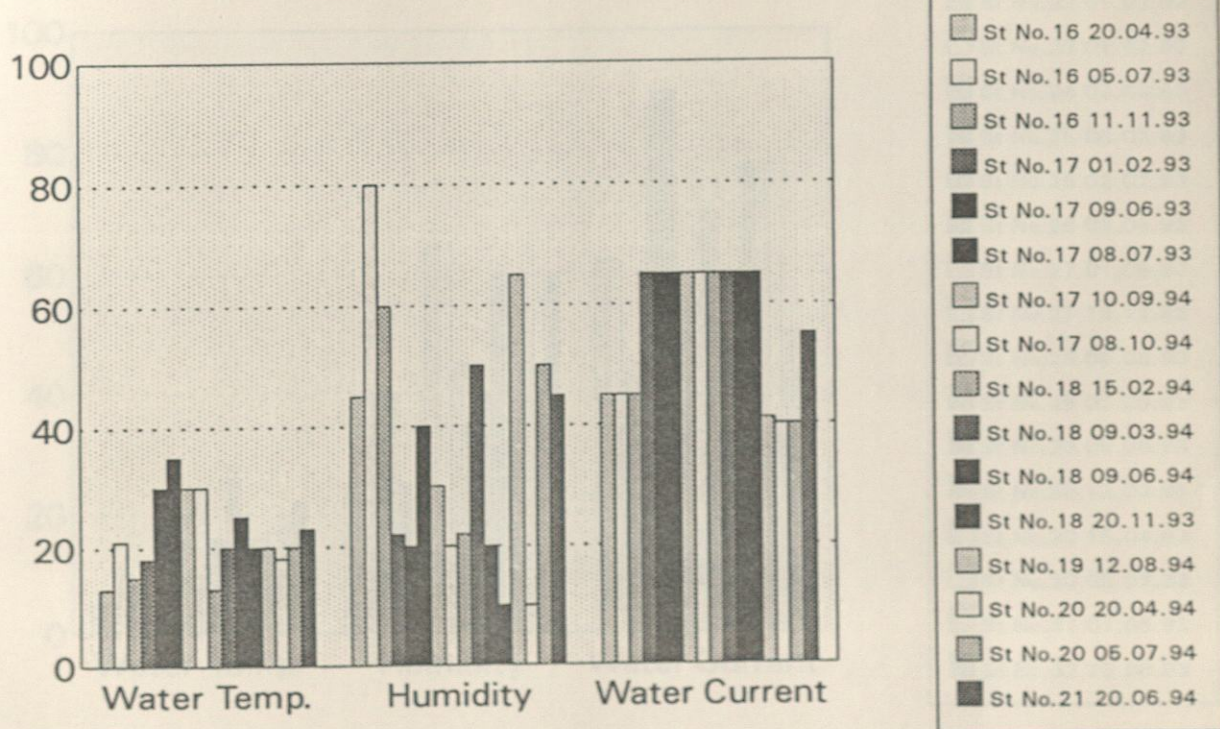


Figure 47

Physical Data For Different Water Bodies

From District Dir

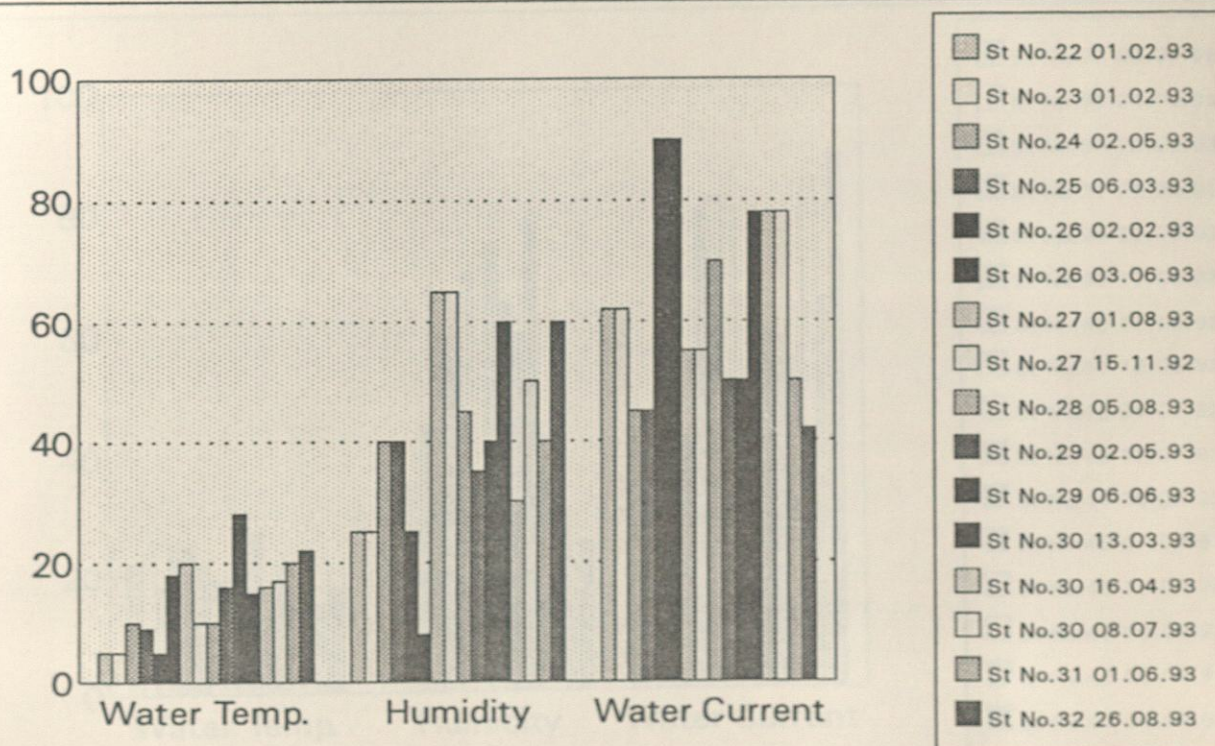


Figure No.48

Physical Data For Different Water Bodies

From Different Districts

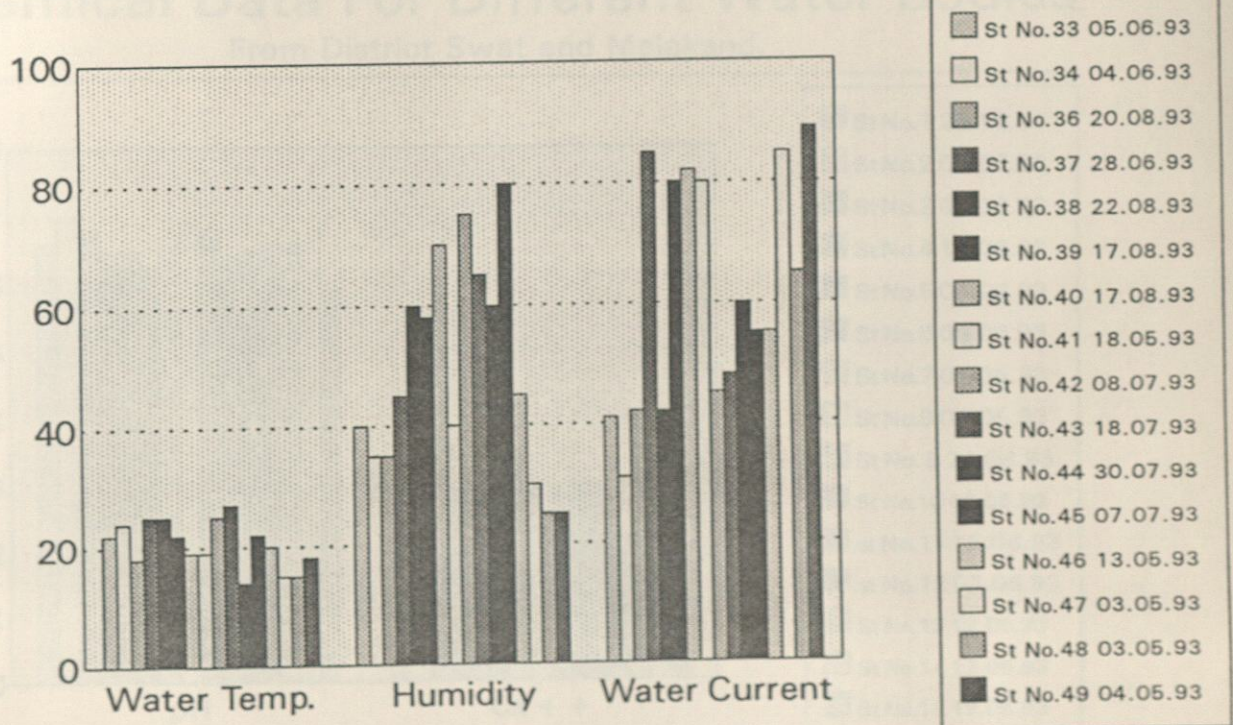


Figure No.49

Chemical Data For Different Water Bodies

From District Swat and Malakand.

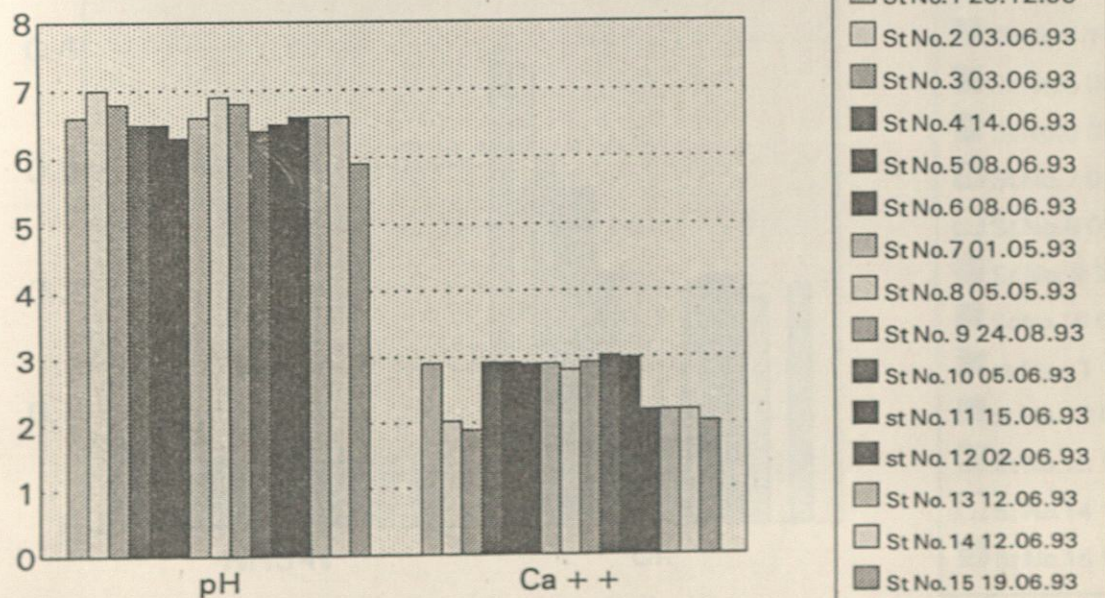


Figure No: 50

Chemical Data For Different Water Bodies

From District Swat and Malakand.

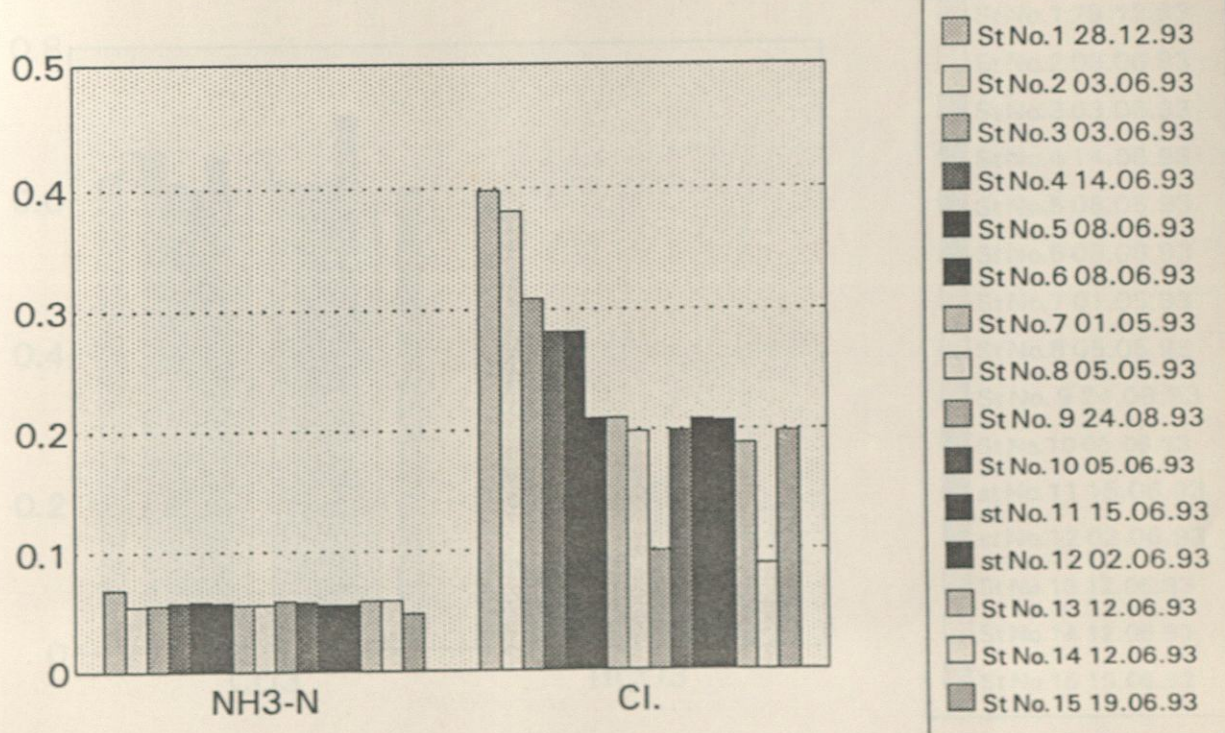


Figure No.51

Chemical Data For Different Water Bodies

From District Swat and Malakand.

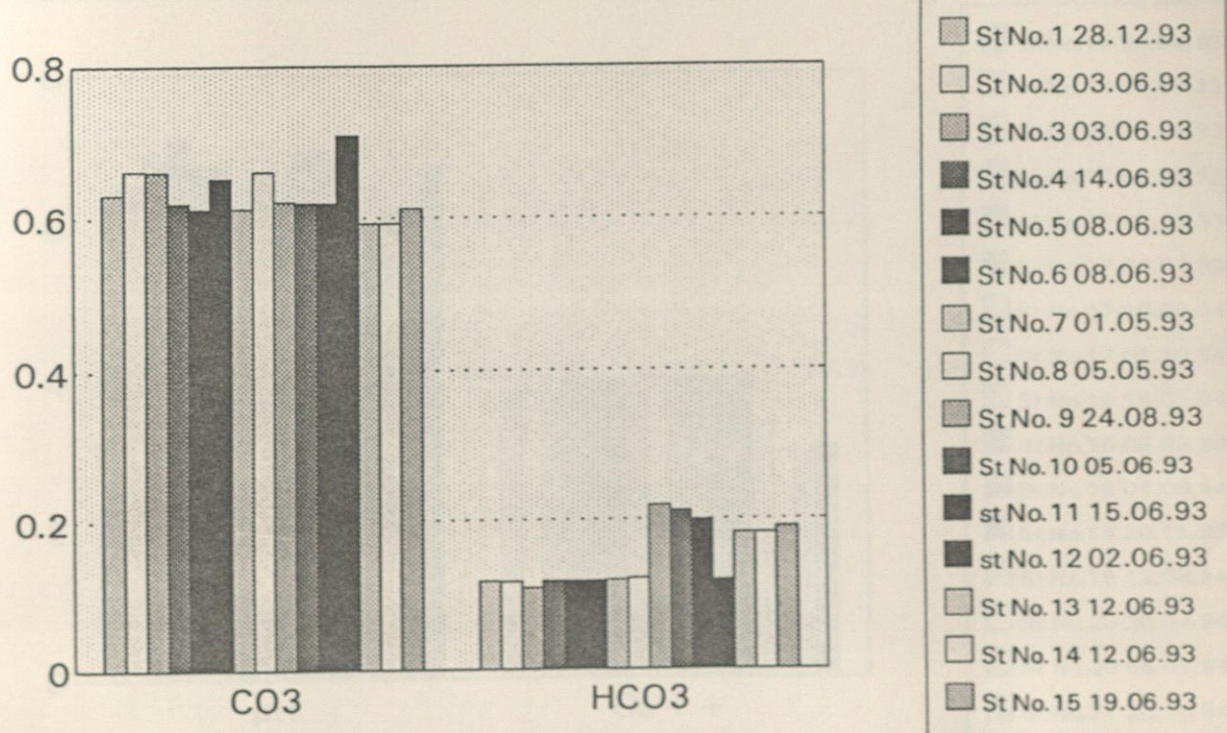
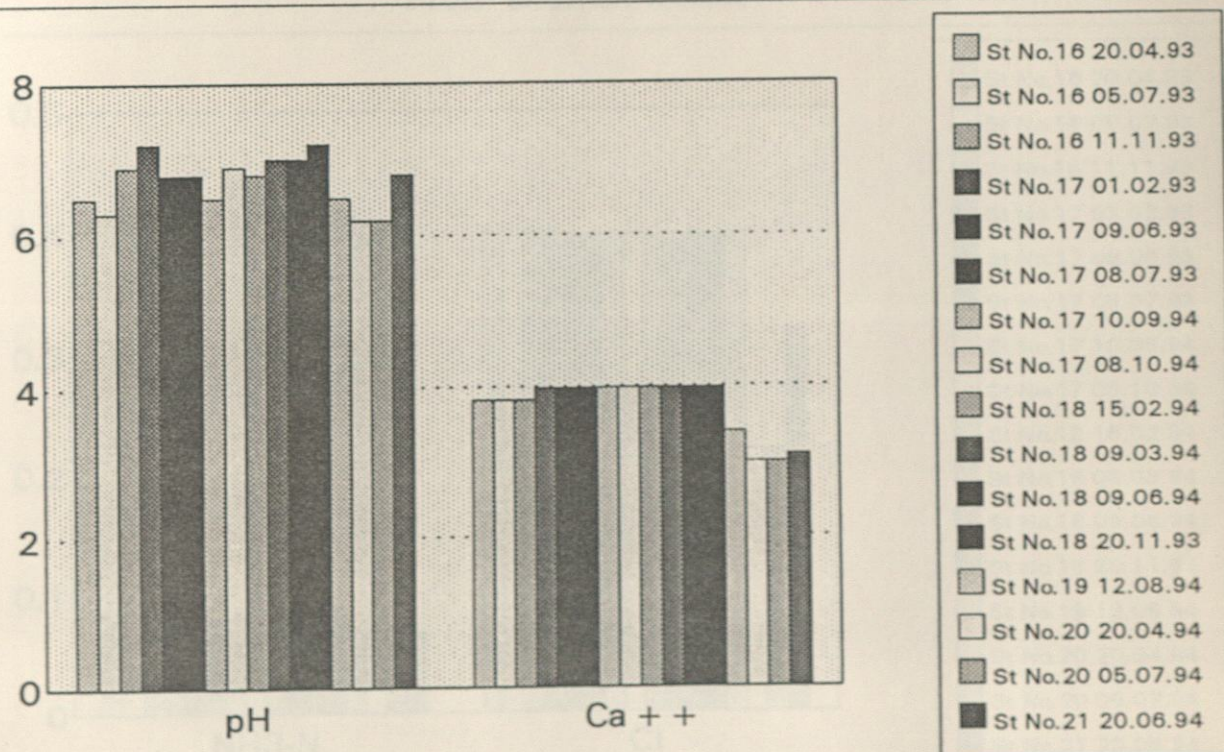


Figure No.52

Chemical Data For Different Water Bodies

From District Kohat



Graph 53

Chemical Data For Different Water Bodies

From District Kohat

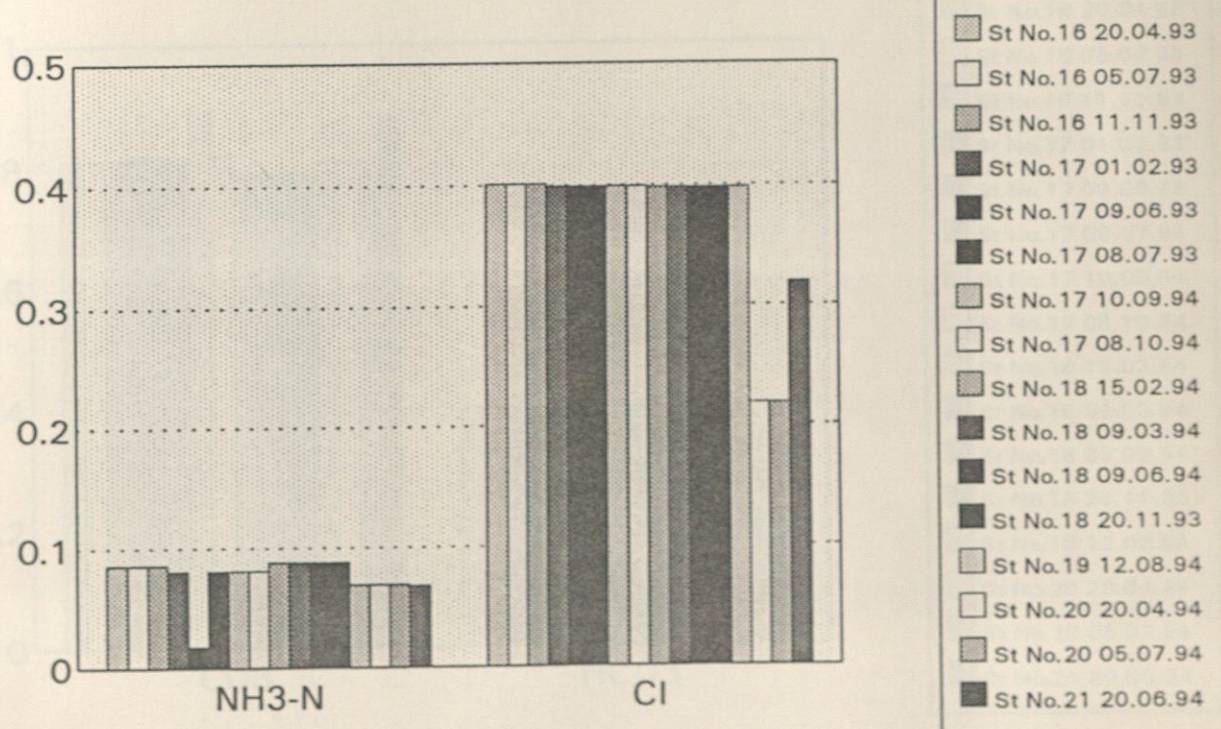
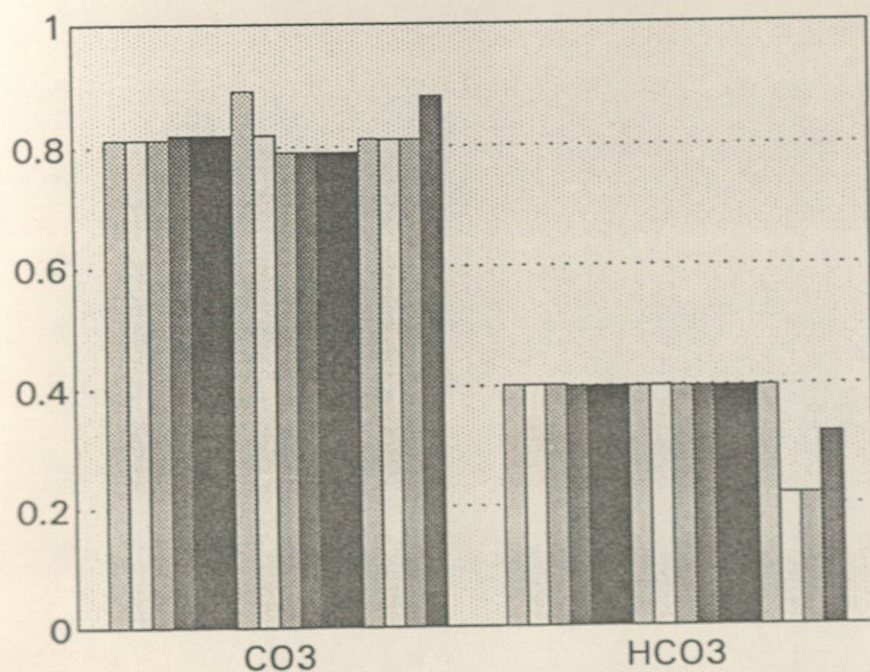


Figure No. 54

Chemical Data For Different Water Bodies

From District Kohat

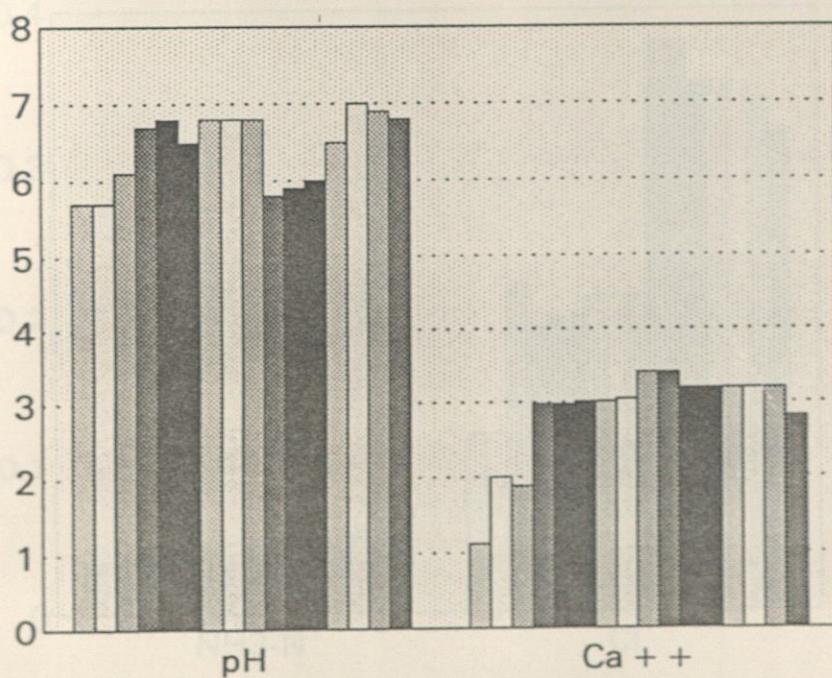


- St No.16 20.04.93
- St No.16 05.07.93
- St No.16 11.11.93
- St No.17 01.02.93
- St No.17 09.06.93
- St No.17 08.07.93
- St No.17 10.09.94
- St No.17 08.10.94
- St No.18 15.02.94
- St No.18 09.03.94
- St No.18 09.06.94
- St No.18 20.11.93
- St No.19 12.08.94
- St No.20 20.04.94
- St No.20 05.07.94
- St No.21 20.06.94

Figure No. 55

Chemical Data For Different Water Bodies

From District Dir



- St No.22 01.02.93
- St No.23 01.02.93
- St No.24 02.05.93
- St No.25 06.03.93
- St No.26 02.02.93
- St No.26 03.06.93
- St No.27 01.08.93
- St No.27 15.11.92
- St No.28 05.08.93
- St No.29 02.05.93
- St No.29 06.06.93
- St No.30 13.03.93
- St No.30 16.04.93
- St No.30 08.07.93
- St No.31 01.06.93
- St No.32 26.08.93

Figure No.56

Chemical Data For Different Water Bodies

From District Dir

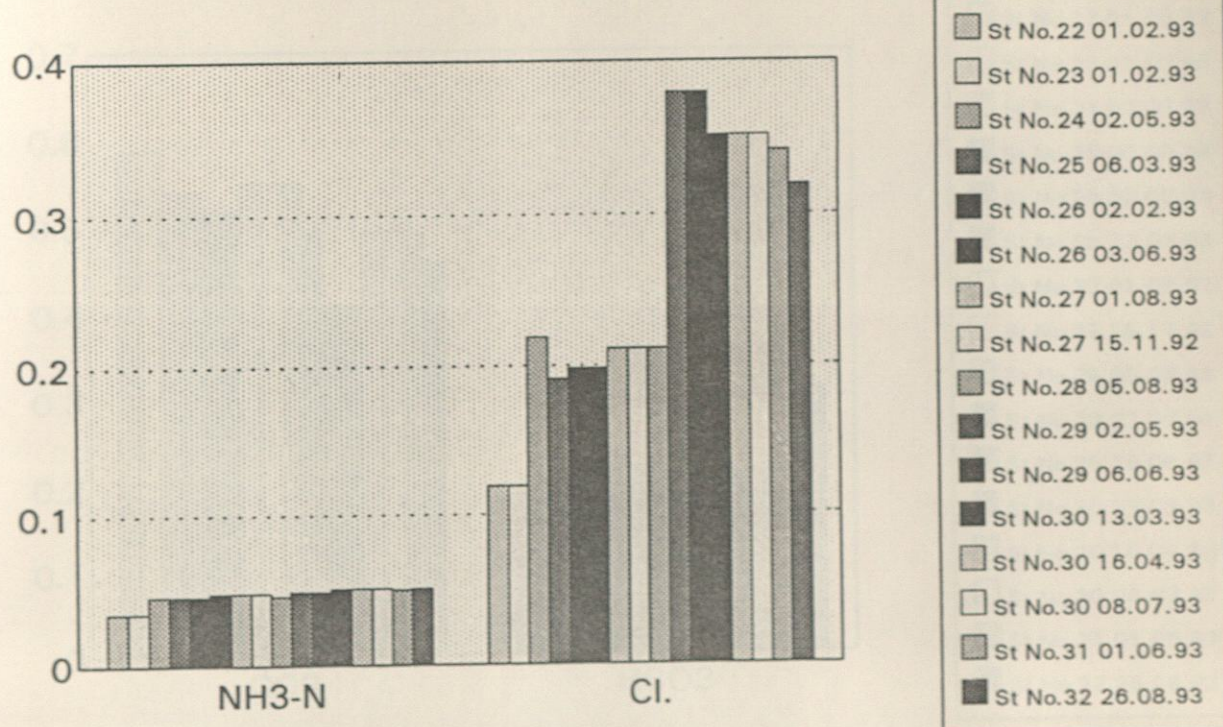


Figure No.57

Chemical Data For Different Water Bodies

From District Dir

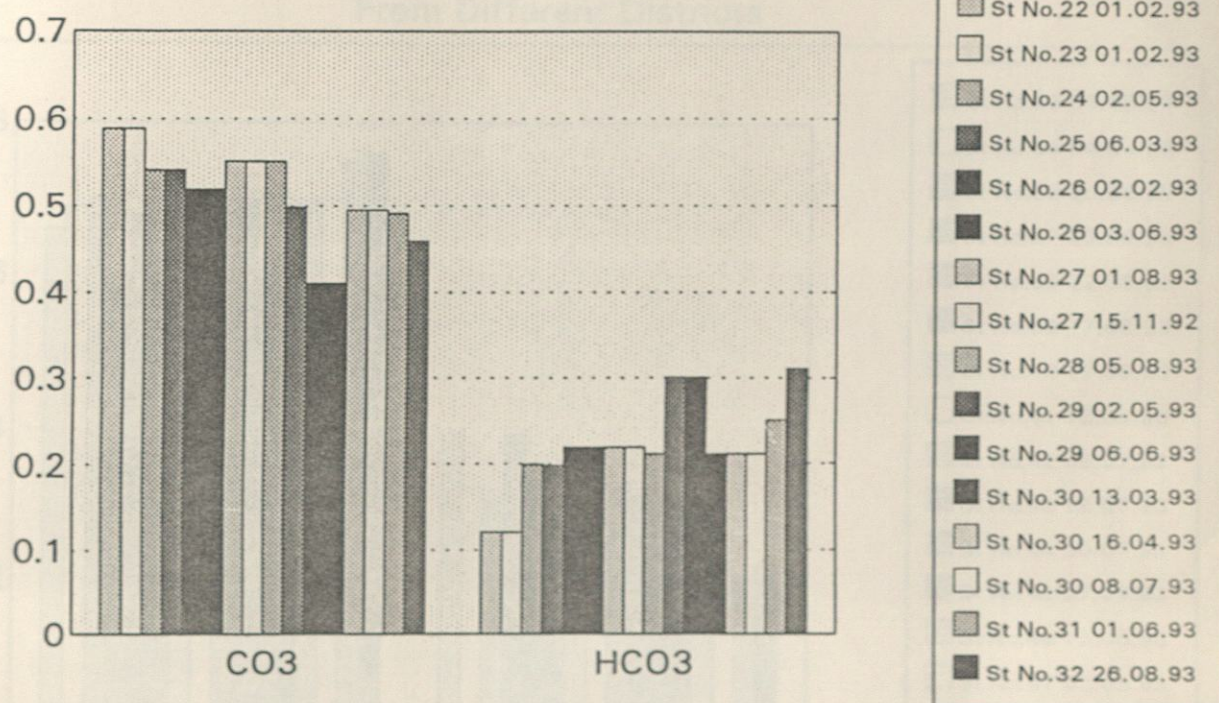


Figure No.58

Chemical Data For Different Water Bodies

From Different Districts

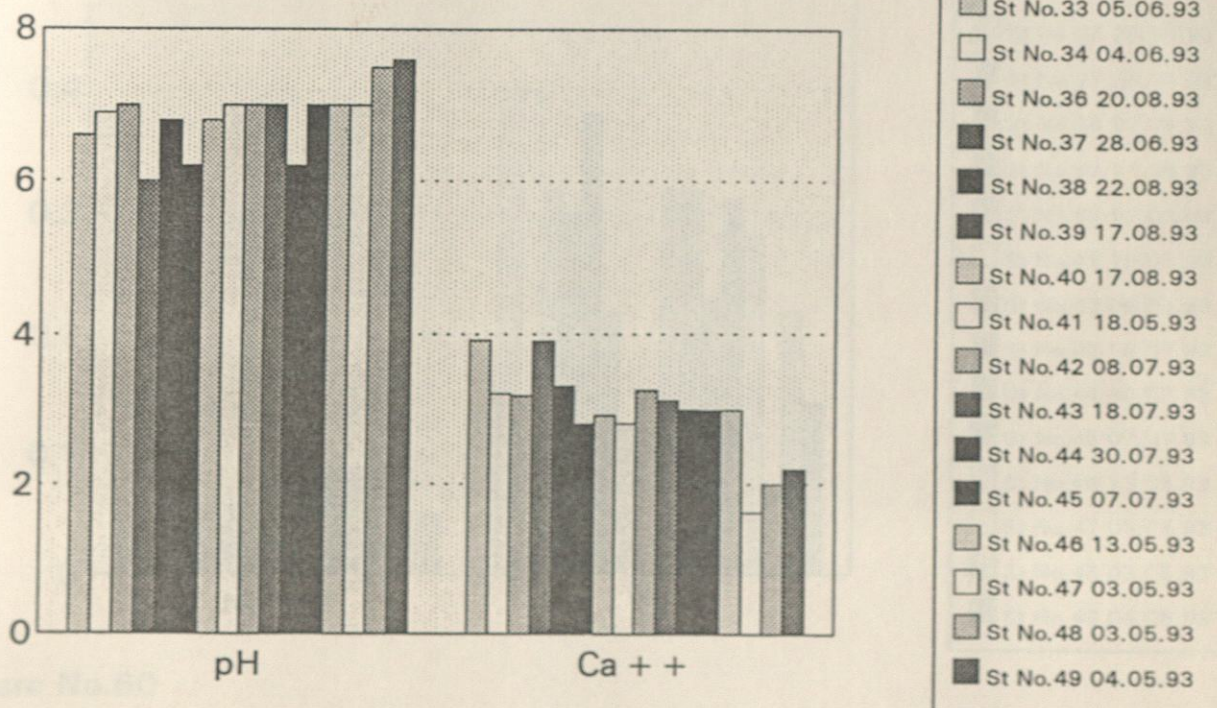


Figure No.59

Chemical Data For Different Water Bodies

From Different Districts

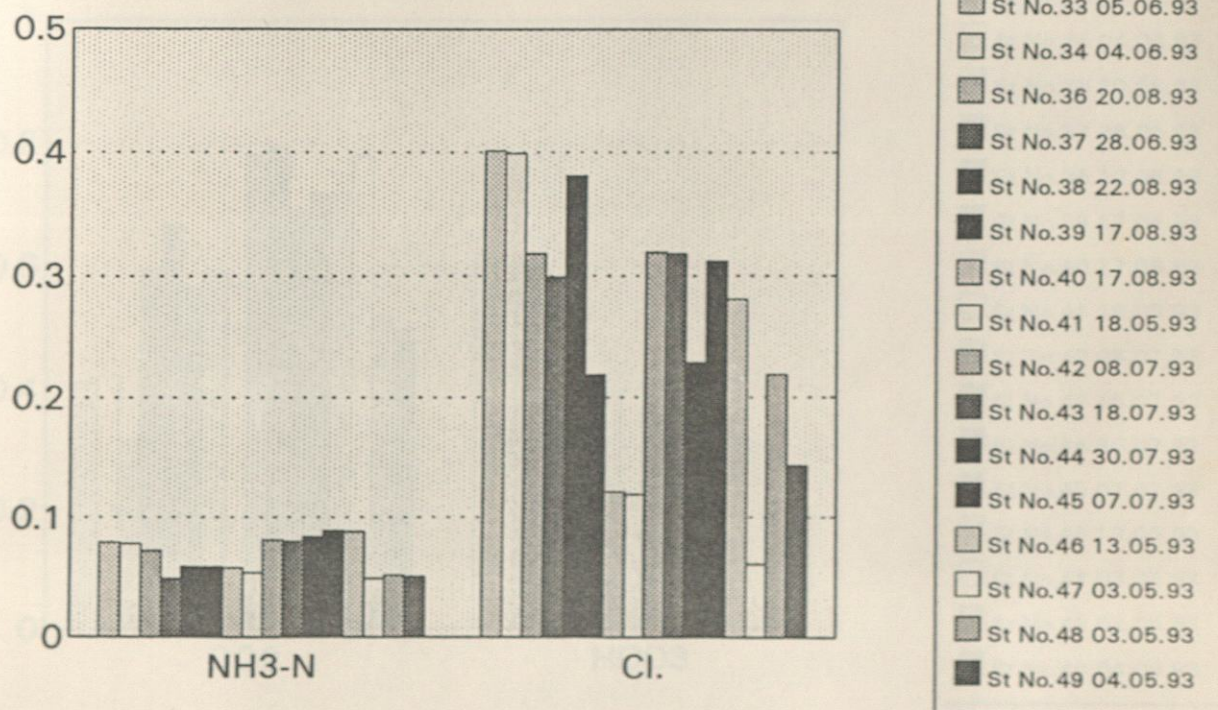


Figure No.60

Chemical Data For Different Water Bodies

From Different Districts

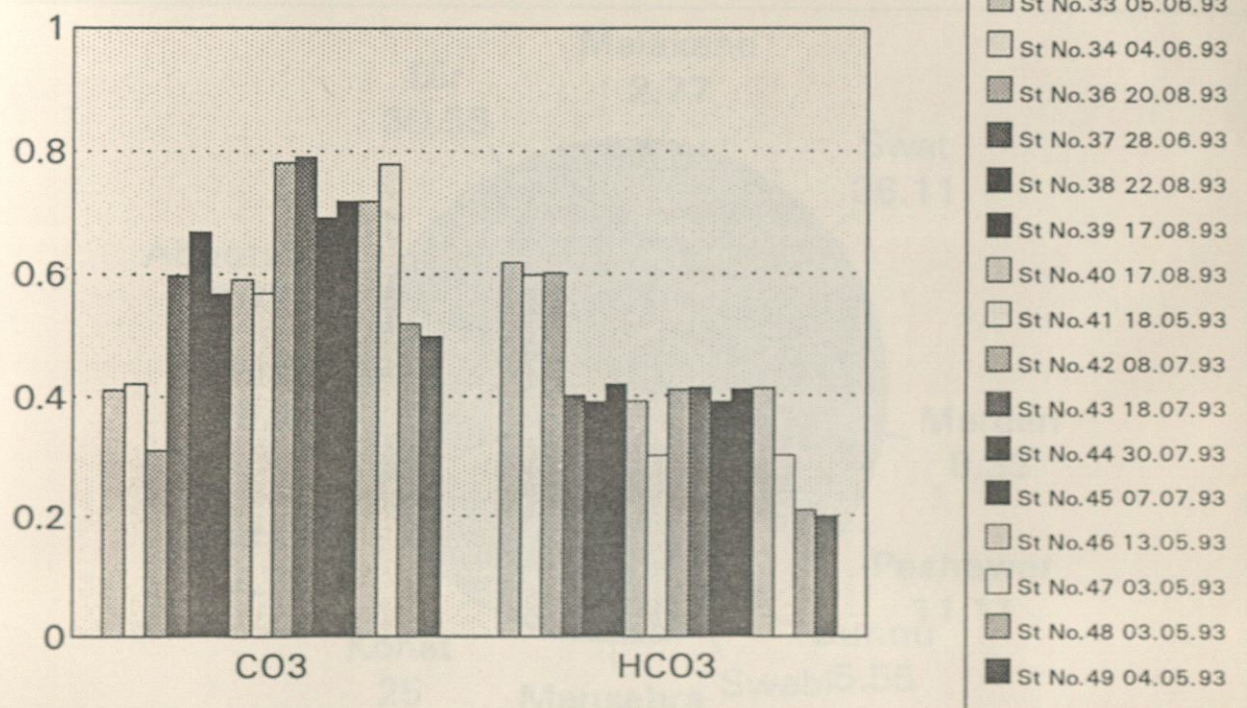


Figure No.61

District Wise Percentage of Simuliidae

No of Species in a Distt./Total No of Species Found.

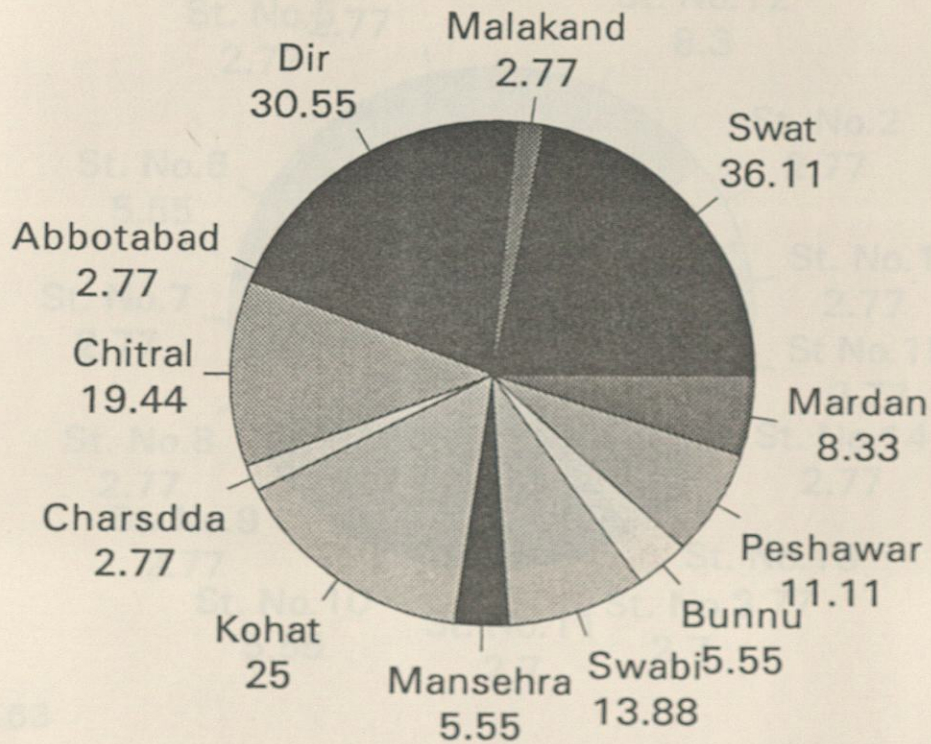


Figure No.62

Locality wise percentage of Simuliidae

from Swat and Malakand

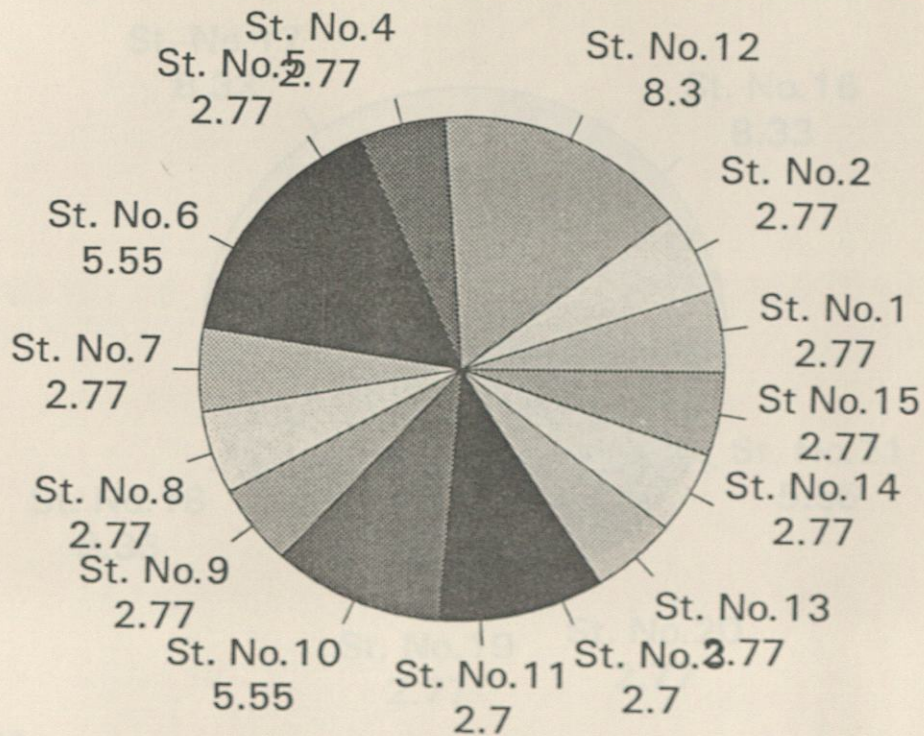


Figure No.63

Locality wise percentage of Simuliidae from Kohat

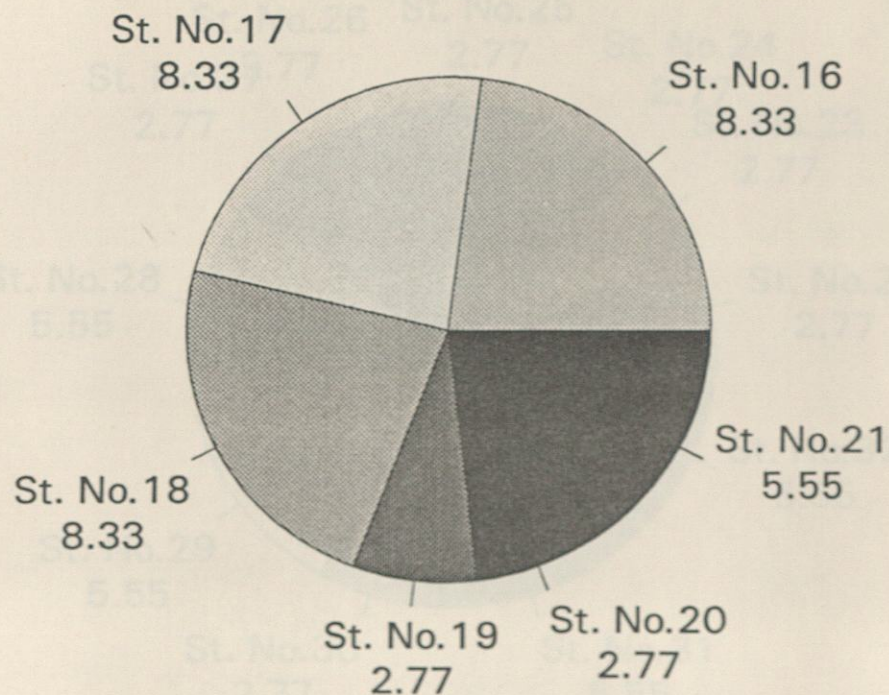


Figure No.64

Locality wise percentage of Simuliidae from Dir.

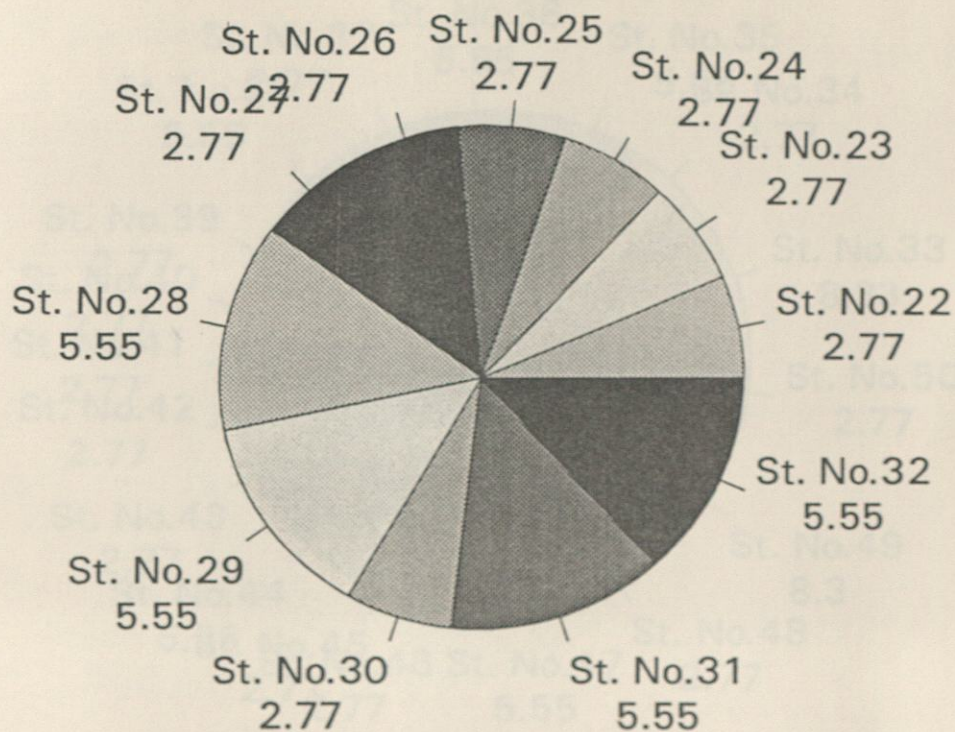


Figure No.65

Locality wise percentage of Simuliidae from different districts

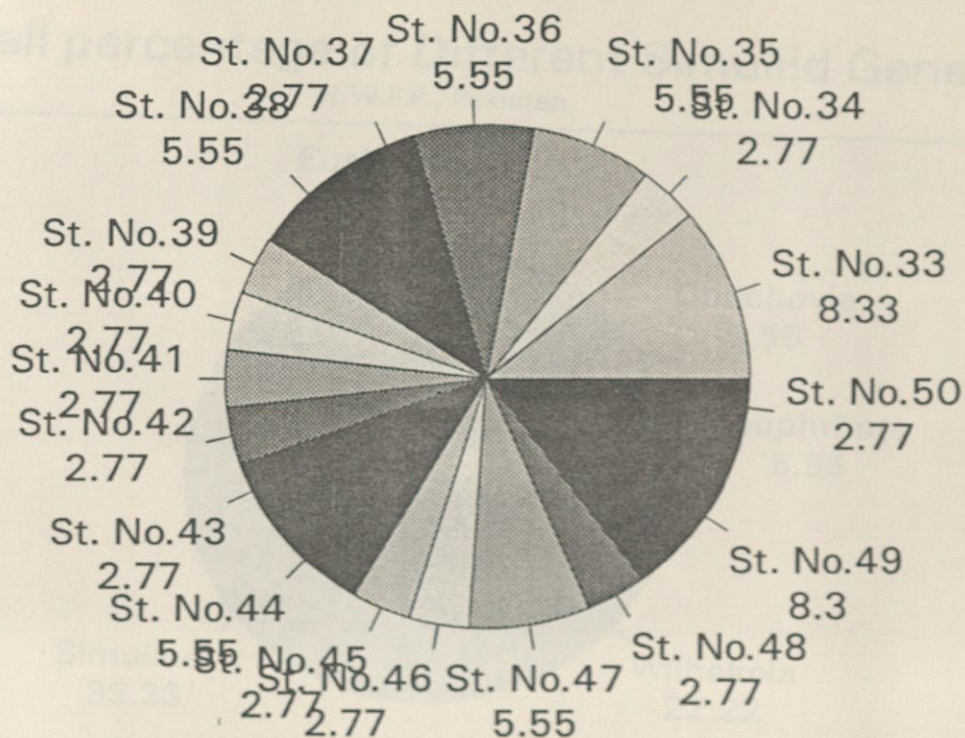


Figure No.66

District Wise Percentage of Simuliidae

No. of infected districts = 10 No. of districts examined = 30

Overall percentage of Different Simuliid Genera

N.W.F.P., Pakistan.

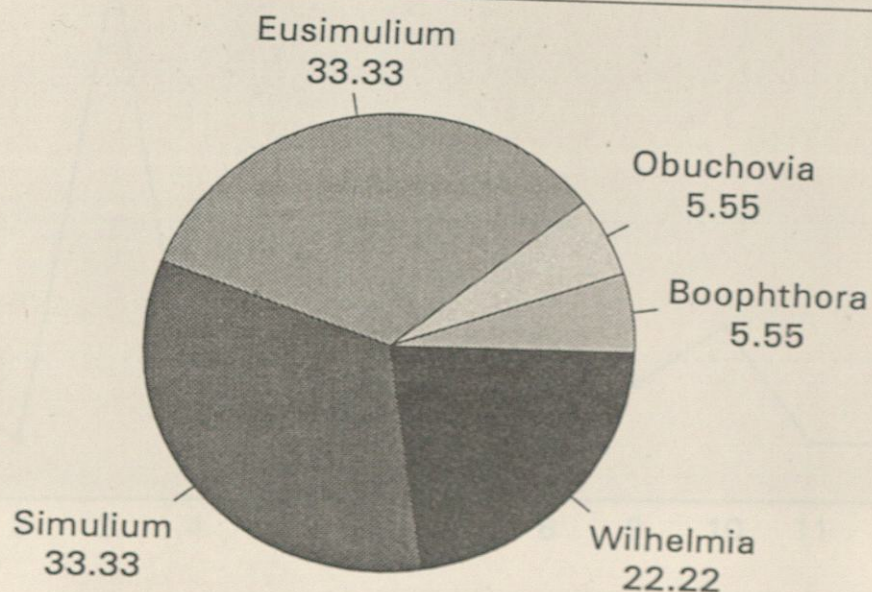


Figure No.67

District Wise Percentage of Simuliidae

No of infested districts/total No. of districts examined.

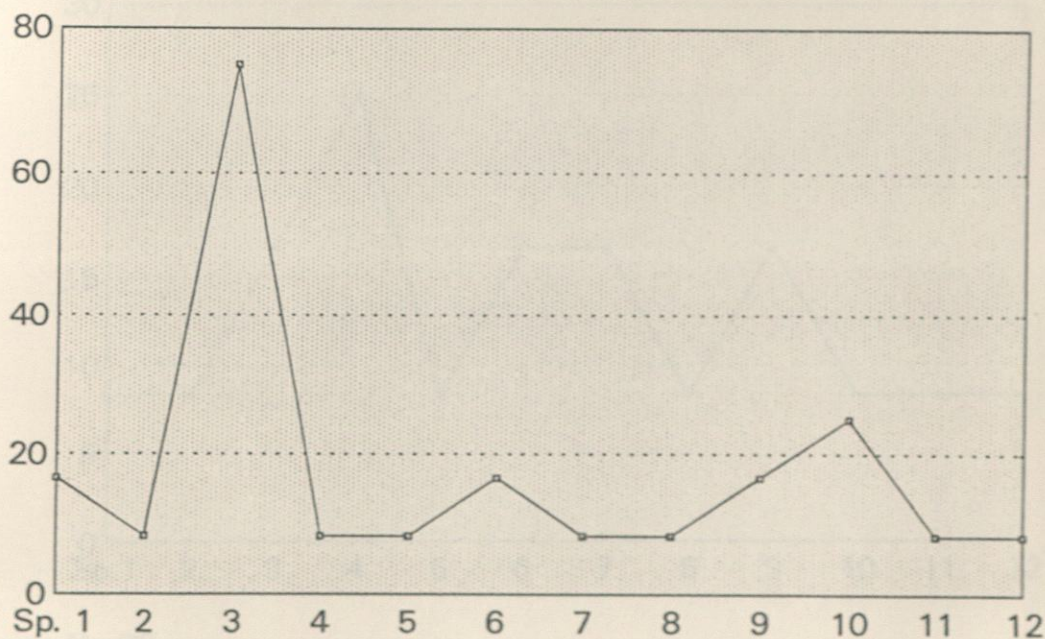


Figure No.68

Whereas

1. B. sericata, 2. Boophthora erythrocephala, 3. Wilhelmia e. equina, 4. W. lineata, 5. W. mayariense sp.n., 6. W. mediterranea, 7. W. paraequina, 8. W. salopiensis, 9. W. turgaica, 10. W. veltistshevi, 11. Obuchovia albella, 12. O. Chitraliense sp.n.

District Wise Percentage of Simuliidae

No of districts infested/Total No. of district examined.

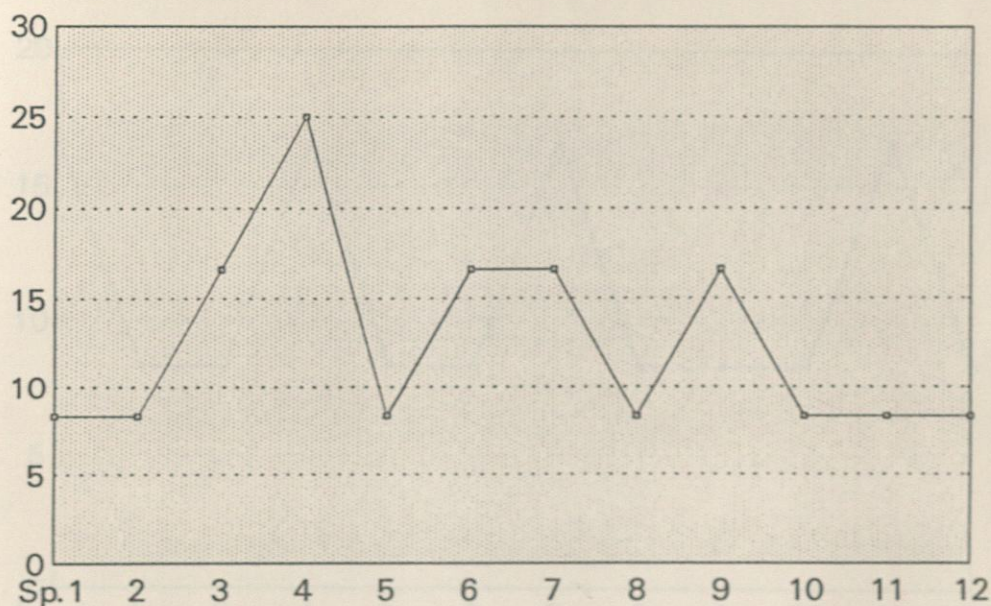


Figure No.69

Whereas

1. Simulium aureohirtum, 2. S. austeni, 3. S. Kurense, 4. S. moristan, 5. S. Kohatiense sp.n.,
6. S. puri sp.n., 7. S. remotum, 8. S. multistriatum, 9. S. tumolusum, 10. S. swatiense sp.n.,
11. S. worsakiense sp.n., 12. S. xanthogastrum,

District Wise Percentage of Simuliidae

No of infested districts/total No. of districts examined.

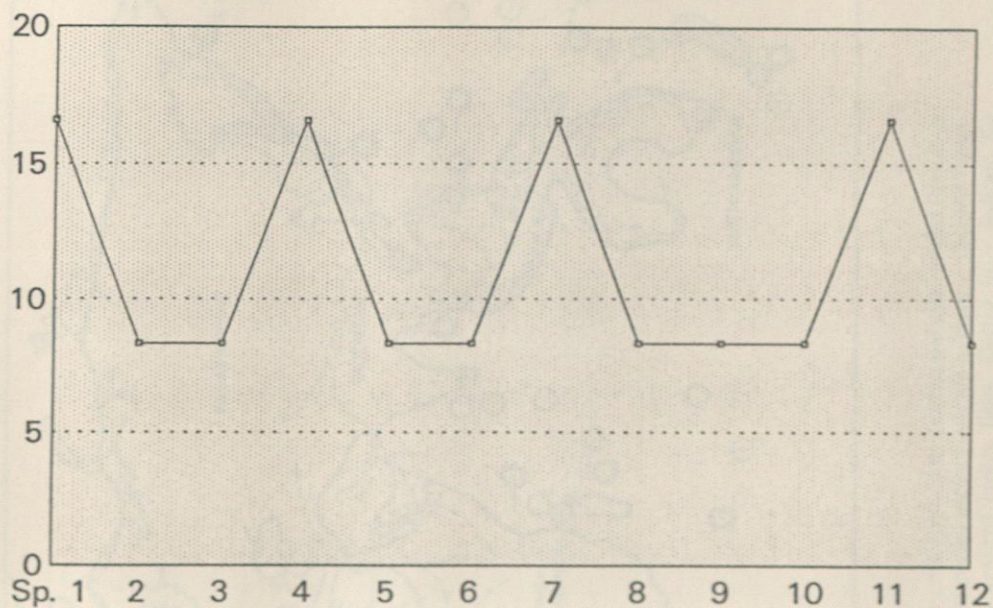
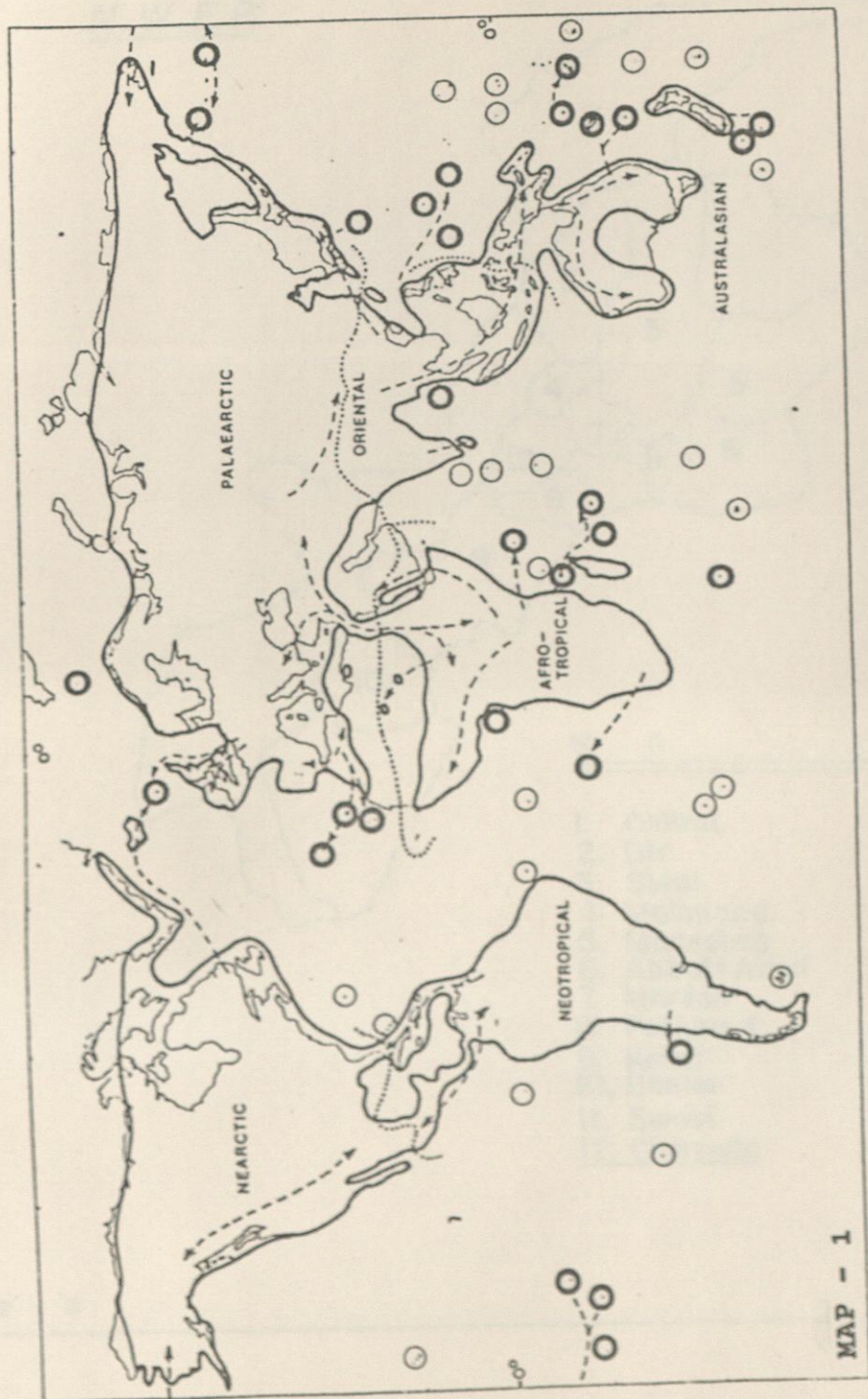


Figure No.70

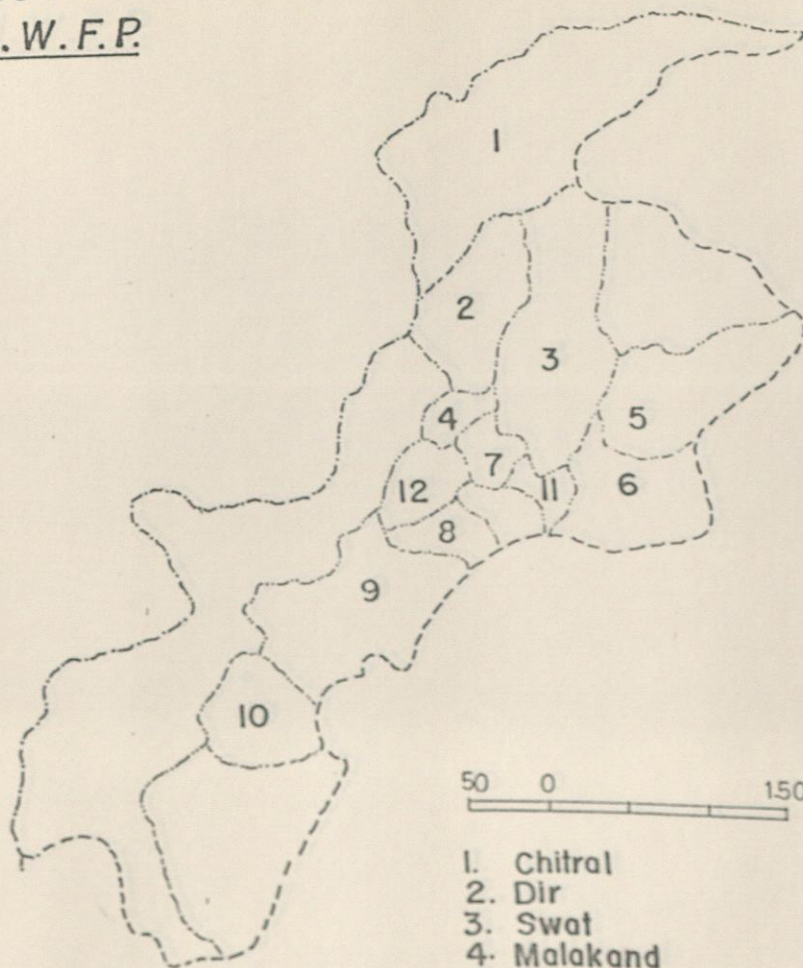
Whereas

1. Eusimulium aureum, 2. E. diriense sp.n., 3. E. gvilletense alizadei, 4. E. bicorn, 5. E. g. gvilletense, 6. E. inflatum, 7. E. fontinale, 8. E. lepnevae, 9. E. malakandiense sp.n., 10. E. montium, 11. E. planiparum, 12. E. pygmaeum,



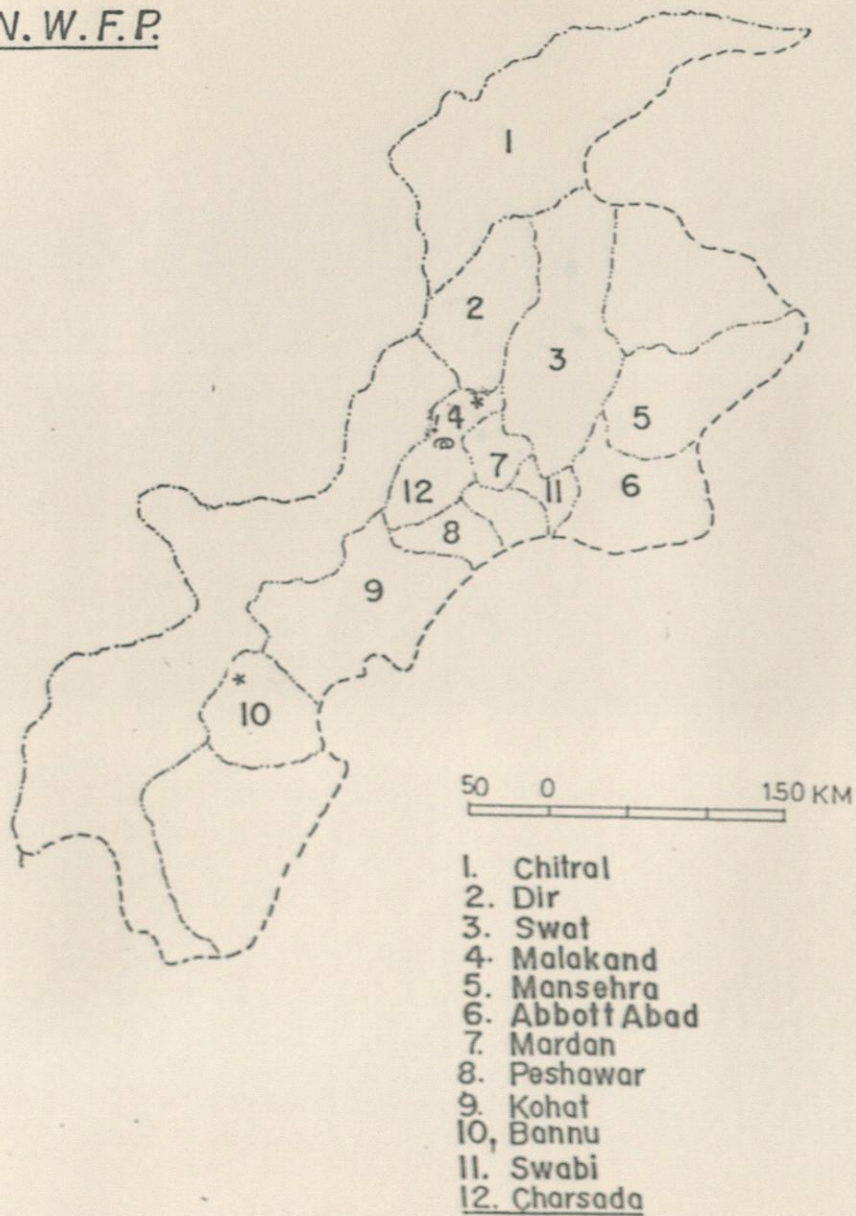
The world distribution of the family Simuliidae (theory outlines). Heavy circles indicate isolated islands or island groups where at least one species occurs; light circles indicate islands without a simuliid fauna. Some presumed routes of dispersal are shown by arrowed broken lines. Dotted lines indicate the approximate boundaries between the zoogeographical regions named.

DISTRICT WISE MAP OF
N.W.F.P.



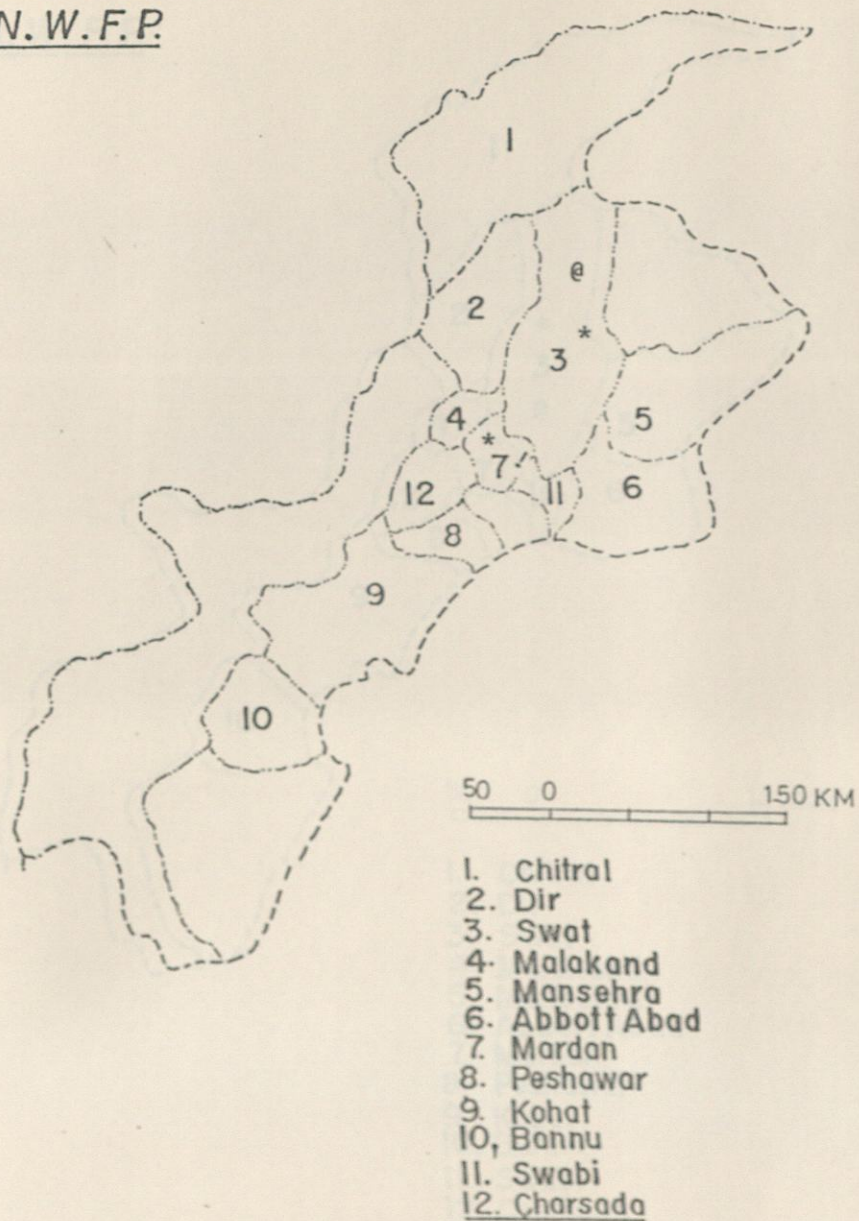
- 50 0 150 KM
1. Chitral
 2. Dir
 3. Swat
 4. Malakand
 5. Mansehra
 6. Abbottabad
 7. Mardan
 8. Peshawar
 9. Kohat
 10. Bannu
 11. Swabi
 12. Charsada

DISTRICT WISE MAP OF
N.W.F.P.



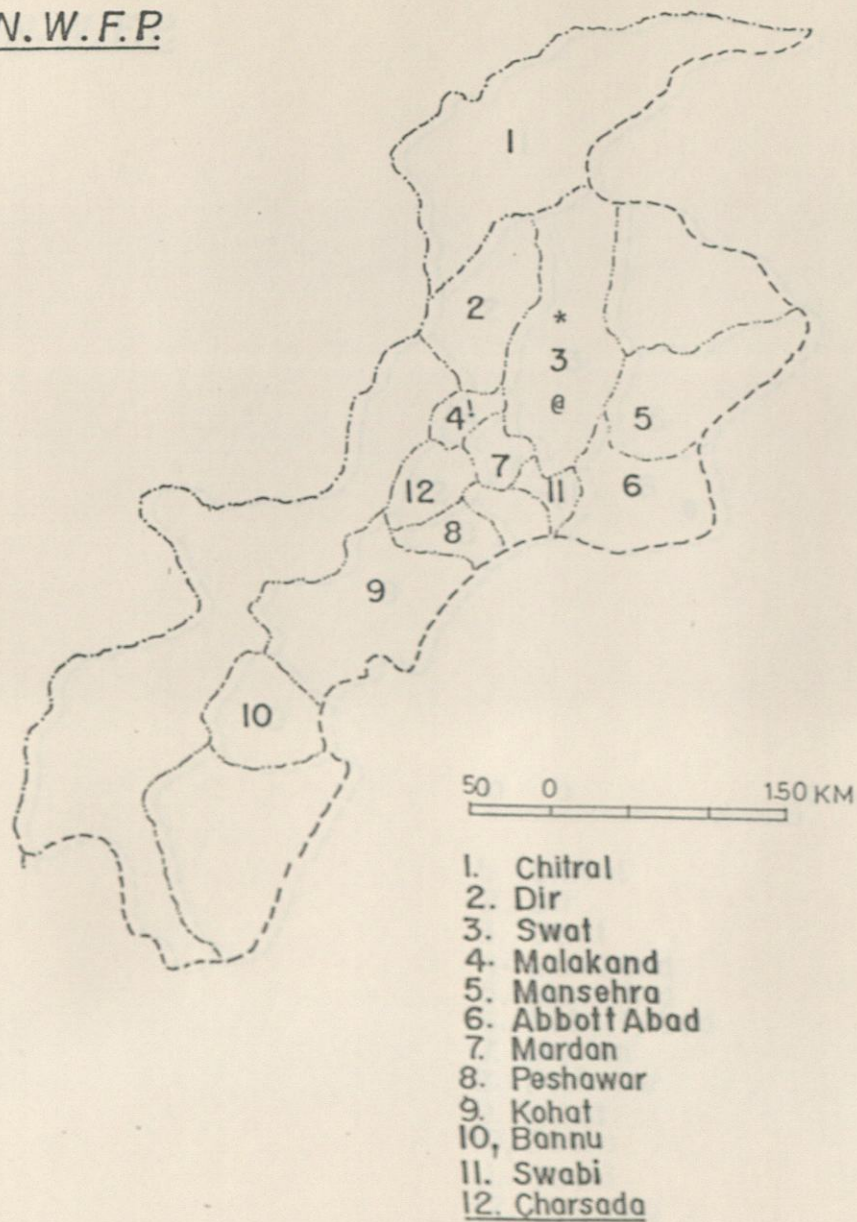
MAP - 3 Whereas B. erythrocephala is *, B. sericata is e and E. aureum is !.

DISTRICT WISE MAP OF
N.W.F.P.



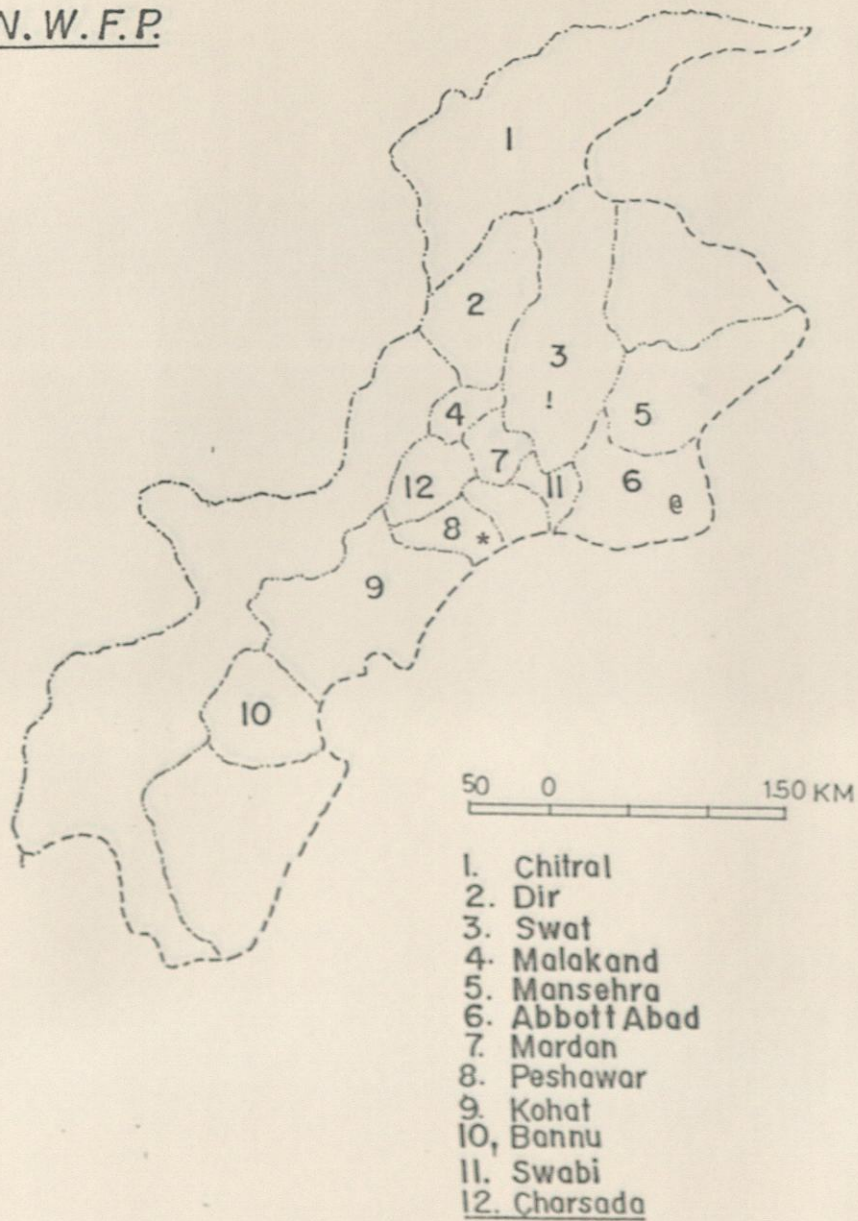
MAP - 4 Whereas E. bicorn is *, E. diriense sp.n. is @ and E. fontanile is !.

DISTRICT WISE MAP OF
N.W.F.P.



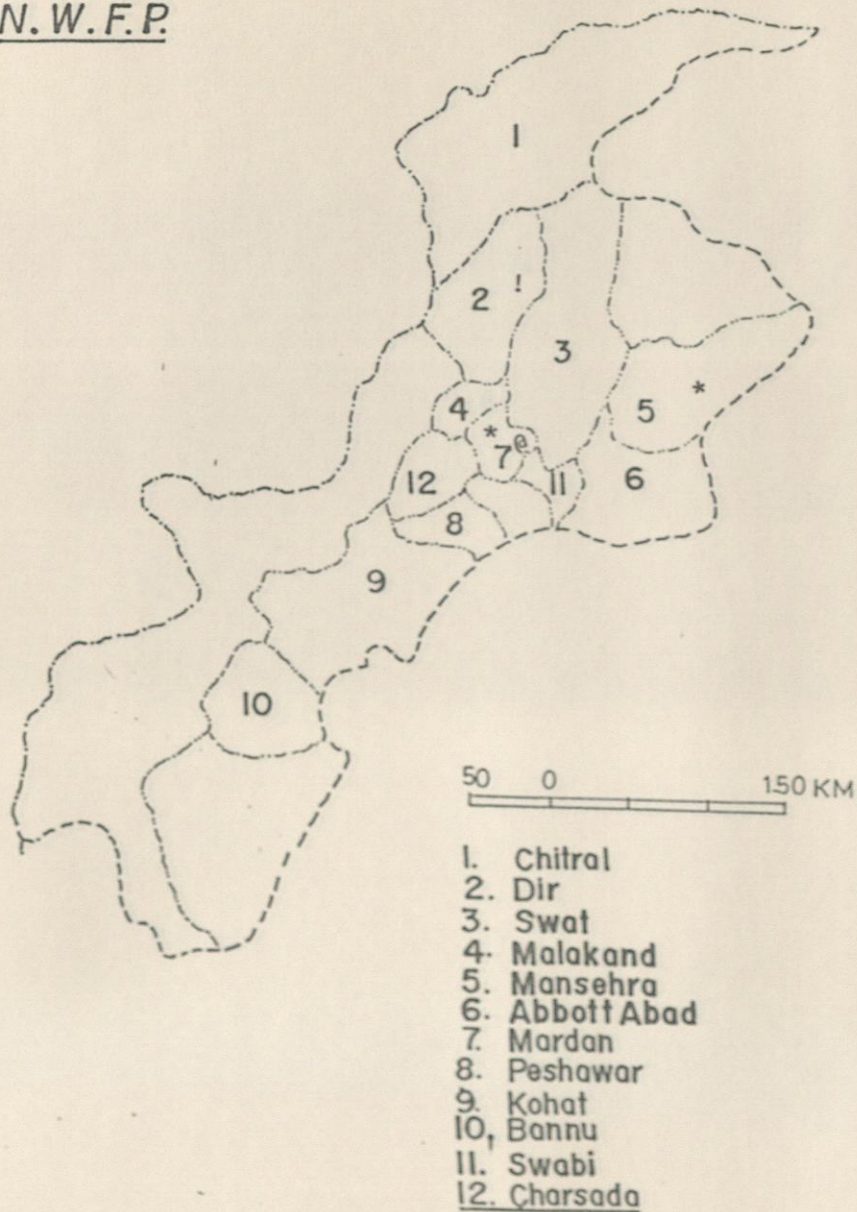
MAP - 5 Whereas E. gvilletense alizadei is *, E. g. gvilletense is @ and E. inflatum is !.

DISTRICT WISE MAP OF
N.W.F.P.



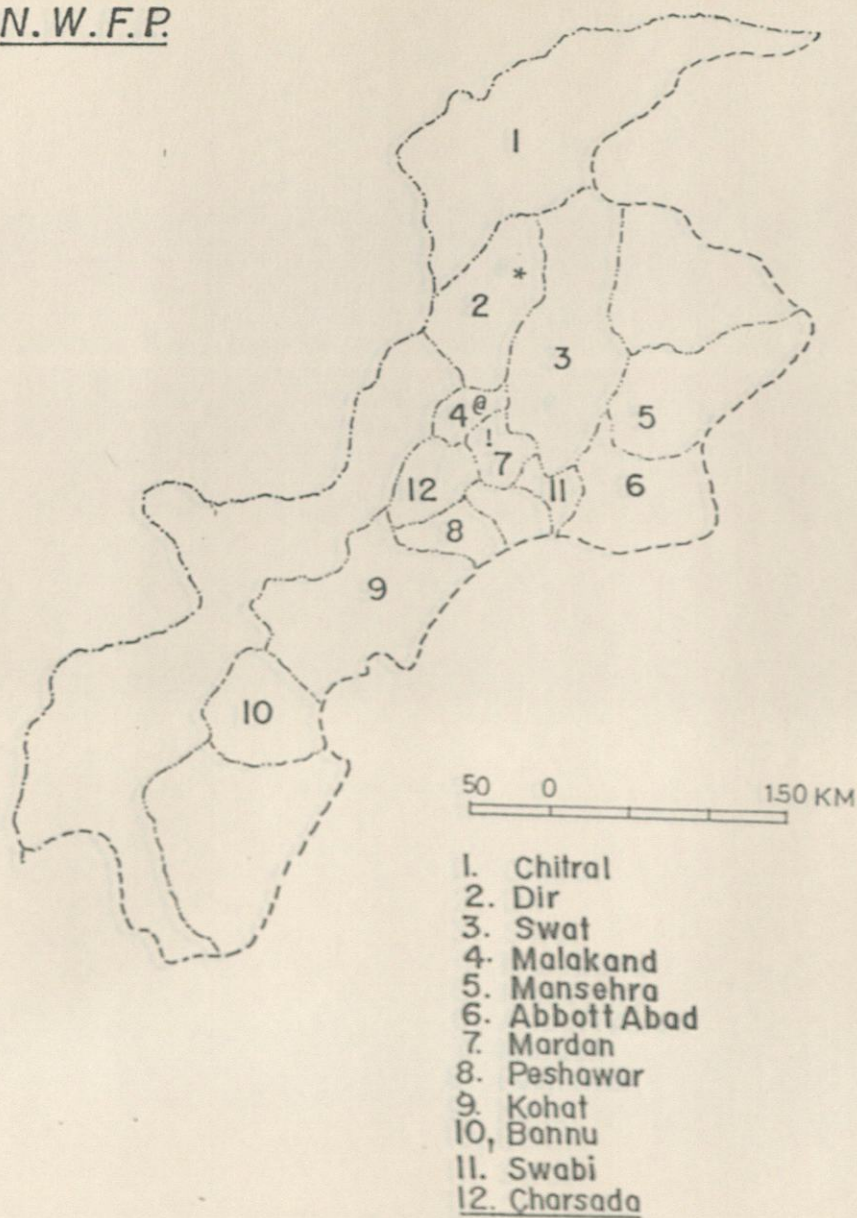
MAP - 6 Whereas E. lepnavae is *, E. malakandiense is @ and E. montium is !.

DISTRICT WISE MAP OF
N.W.F.P.



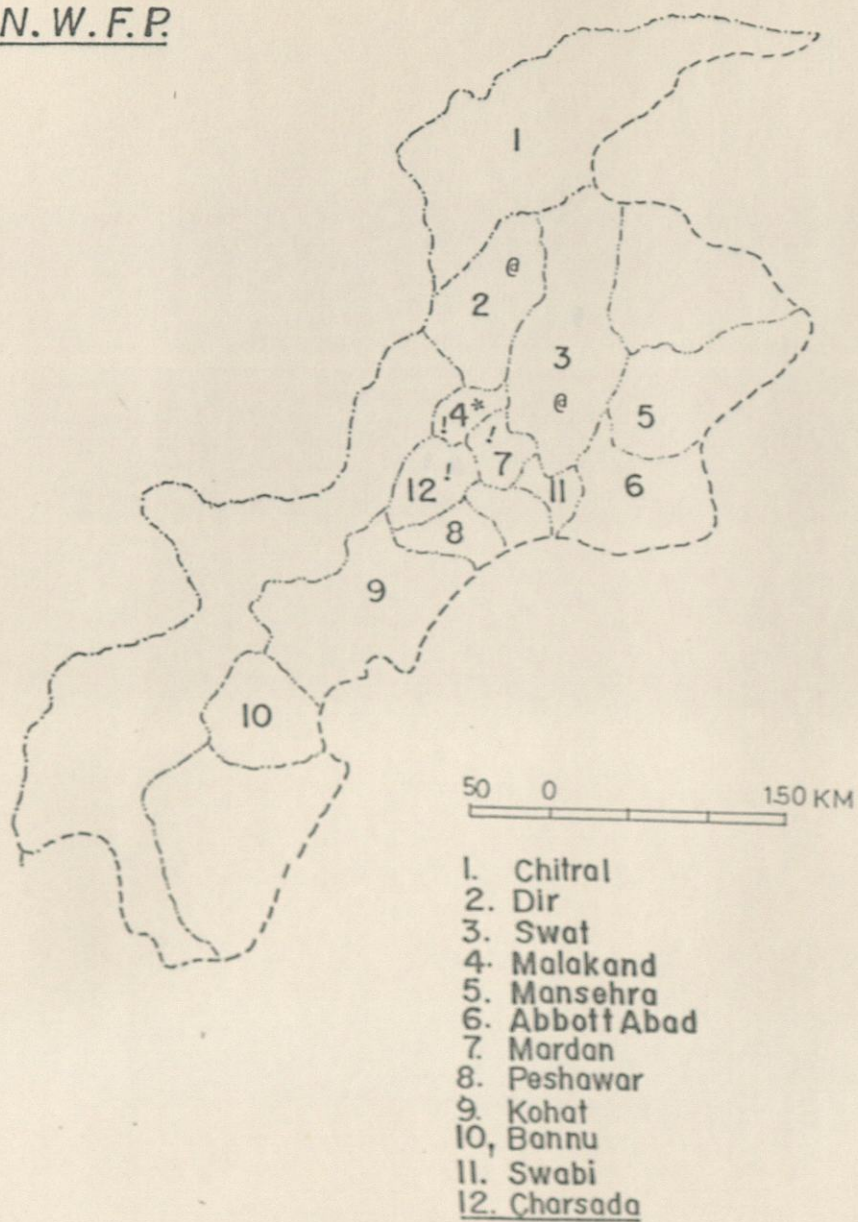
MAP - 7 Whereas E. planiparum is *, E. pygmaeum is e and O. albella is !.

DISTRICT WISE MAP OF
N.W.F.P.



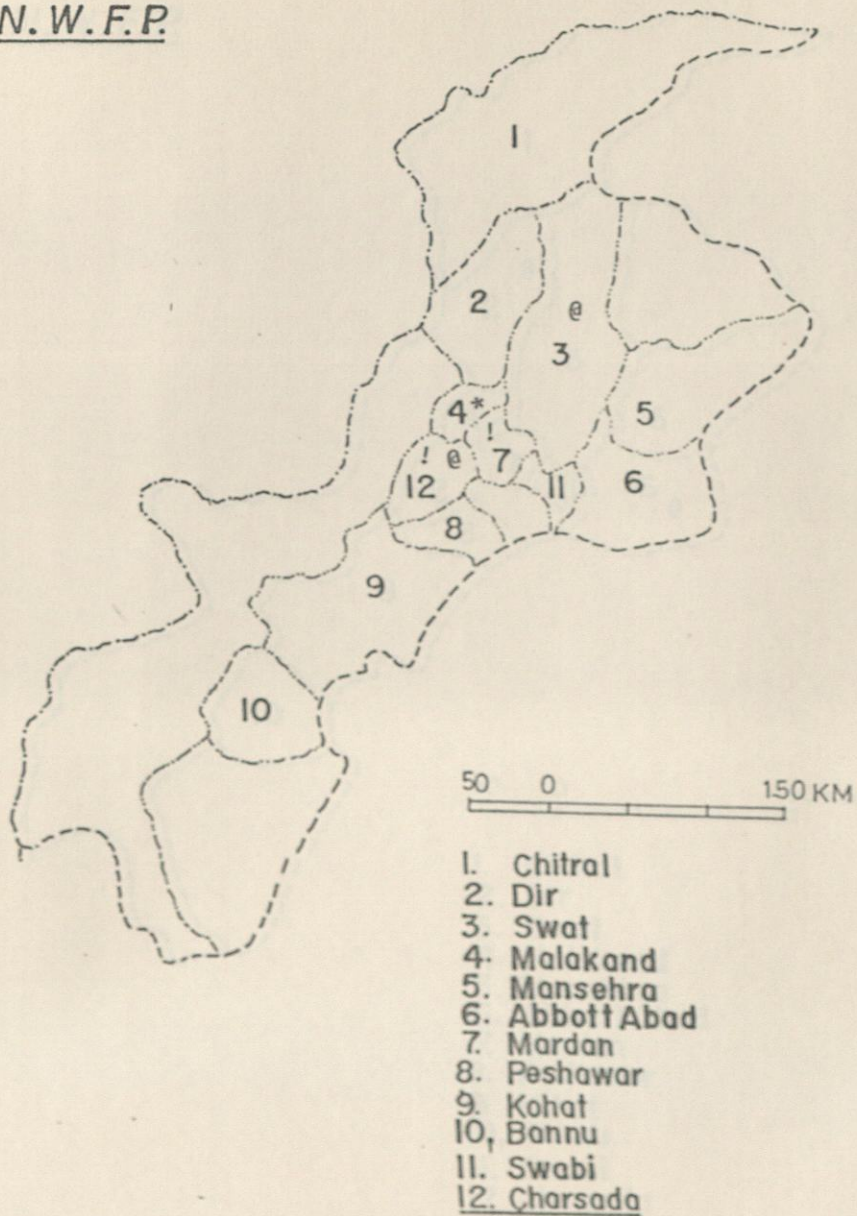
MAP - 8 Whereas O. chitraliense is *, S. ureohirtum is @ and S. austeni is !.

DISTRICT WISE MAP OF
N.W.F.P.



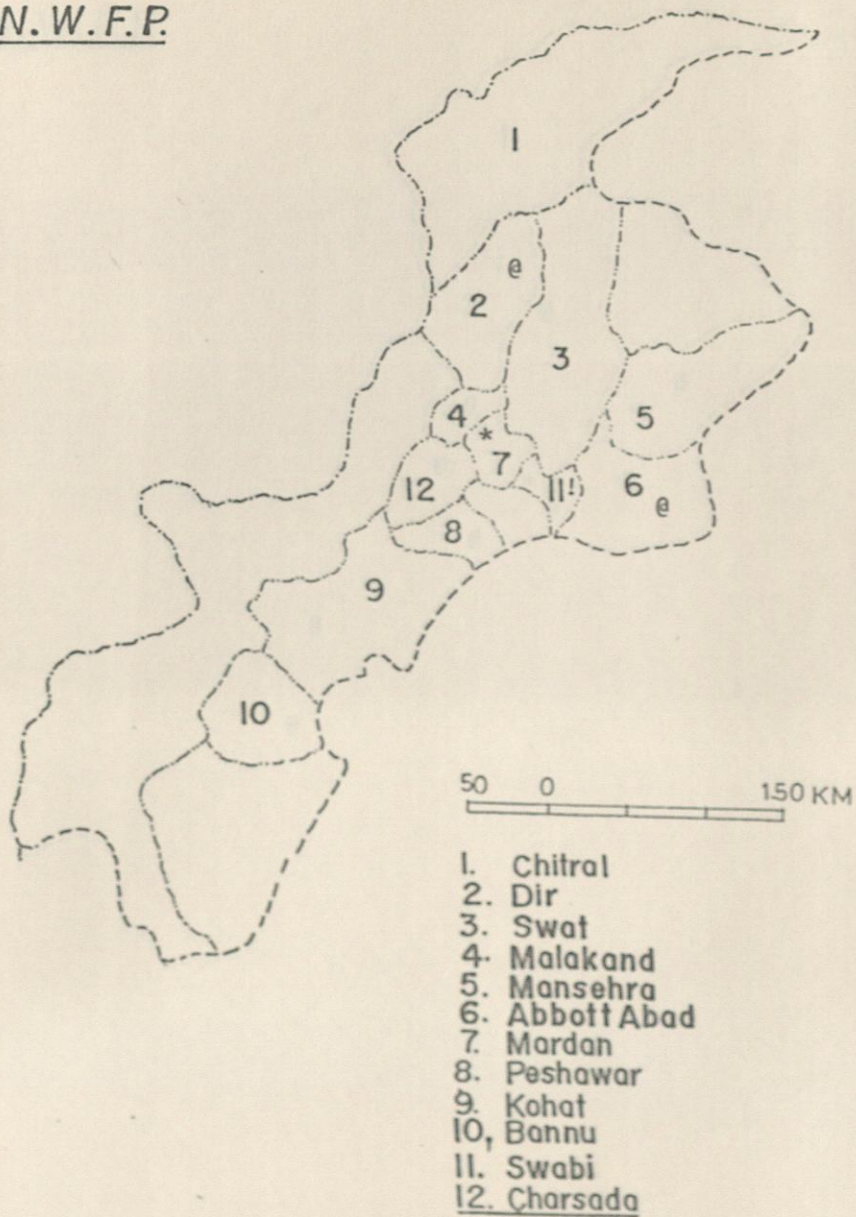
MAP - 9 Whereas S. kohatiense is *, S. kurense is e and S. moristan is !.

DISTRICT WISE MAP OF
N.W.F.P.



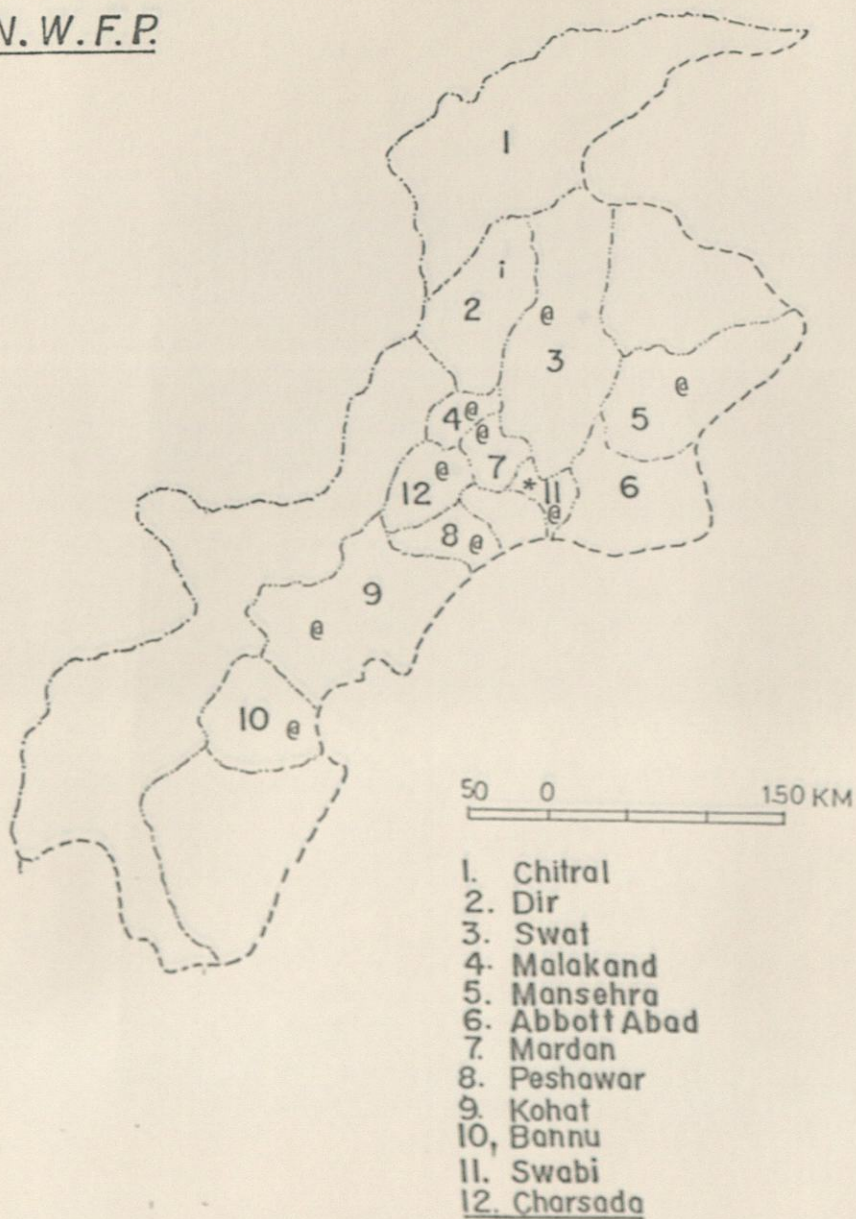
MAP - 10 Whereas S. multistriatum is *, S. puri sp.n. is @ and S. remotum is !.

DISTRICT WISE MAP OF
N.W.F.P.



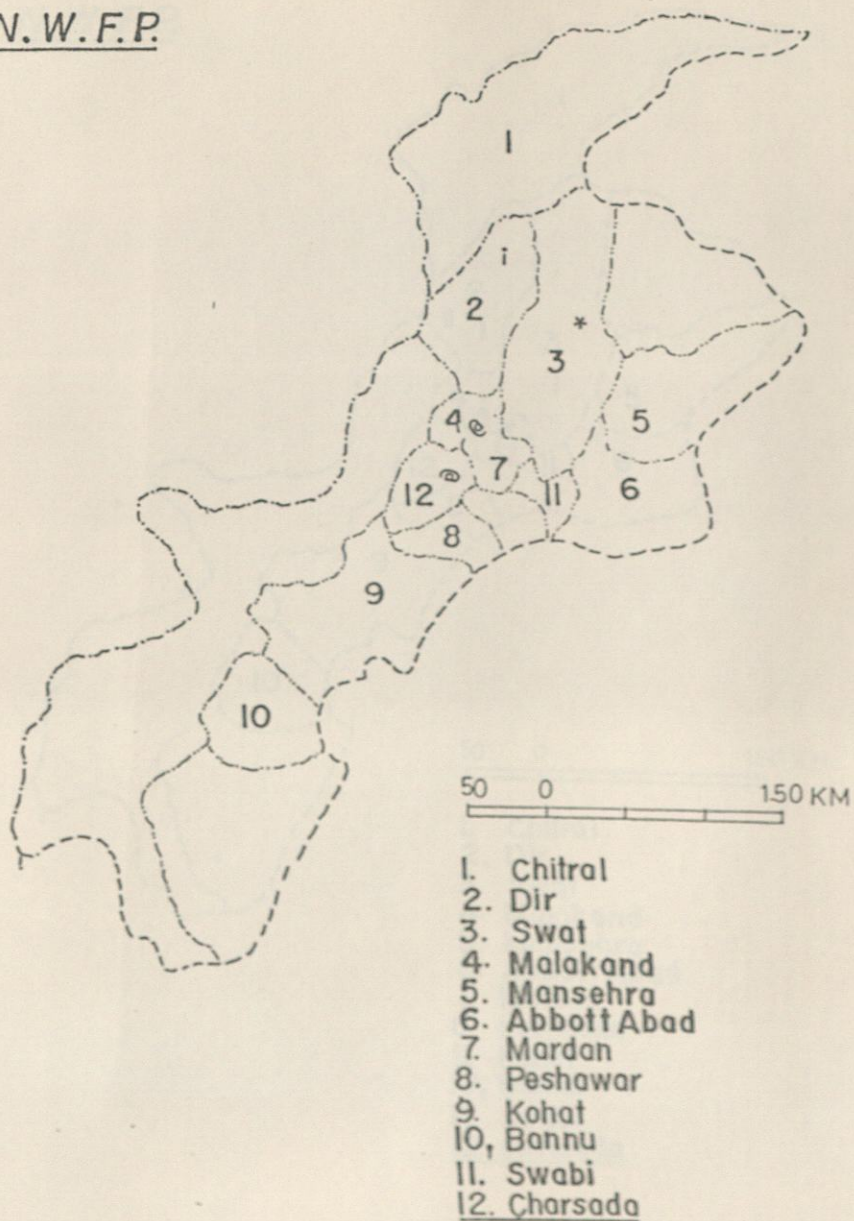
MAP - 11 Whereas S. swatiense is *, S. tumolusum is e and S. warsakiense sp.n. is !.

DISTRICT WISE MAP OF
N.W.F.P.



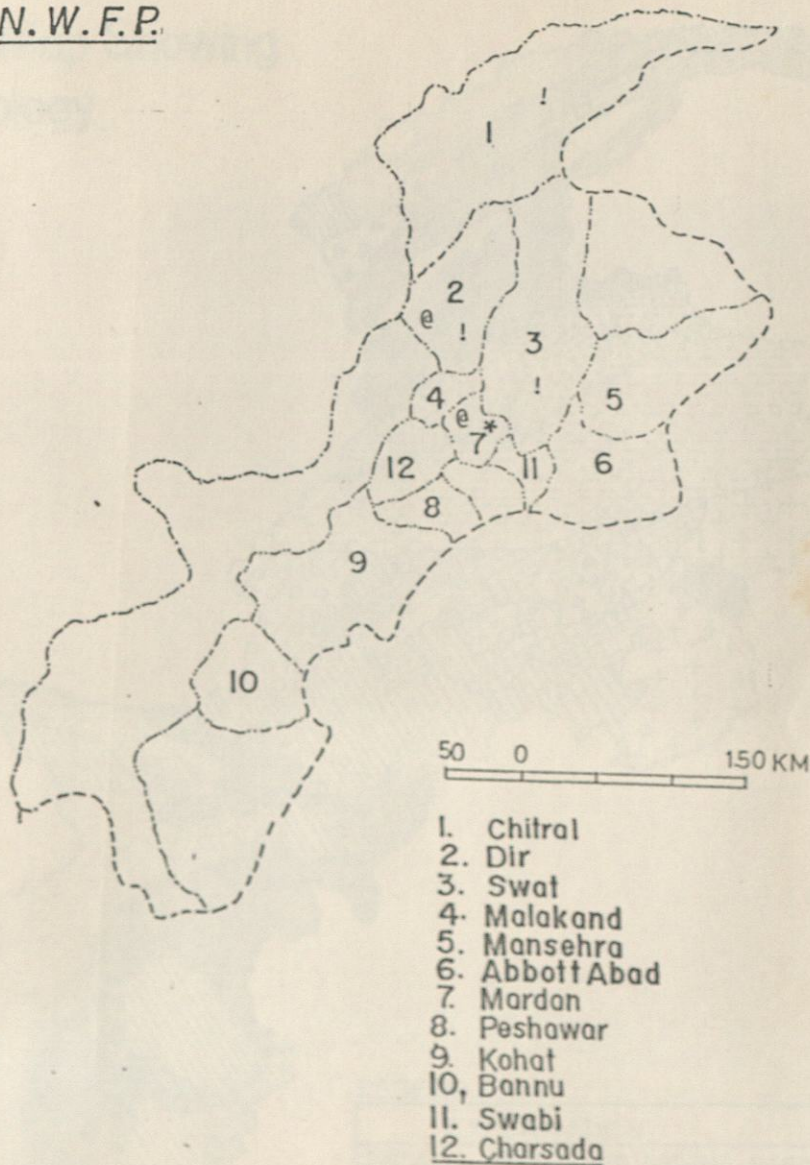
MAP - 12 Whereas S. xythogastrum is *, W. e. equina is @ and W. lineata is !.

DISTRICT WISE MAP OF
N.W.F.P.



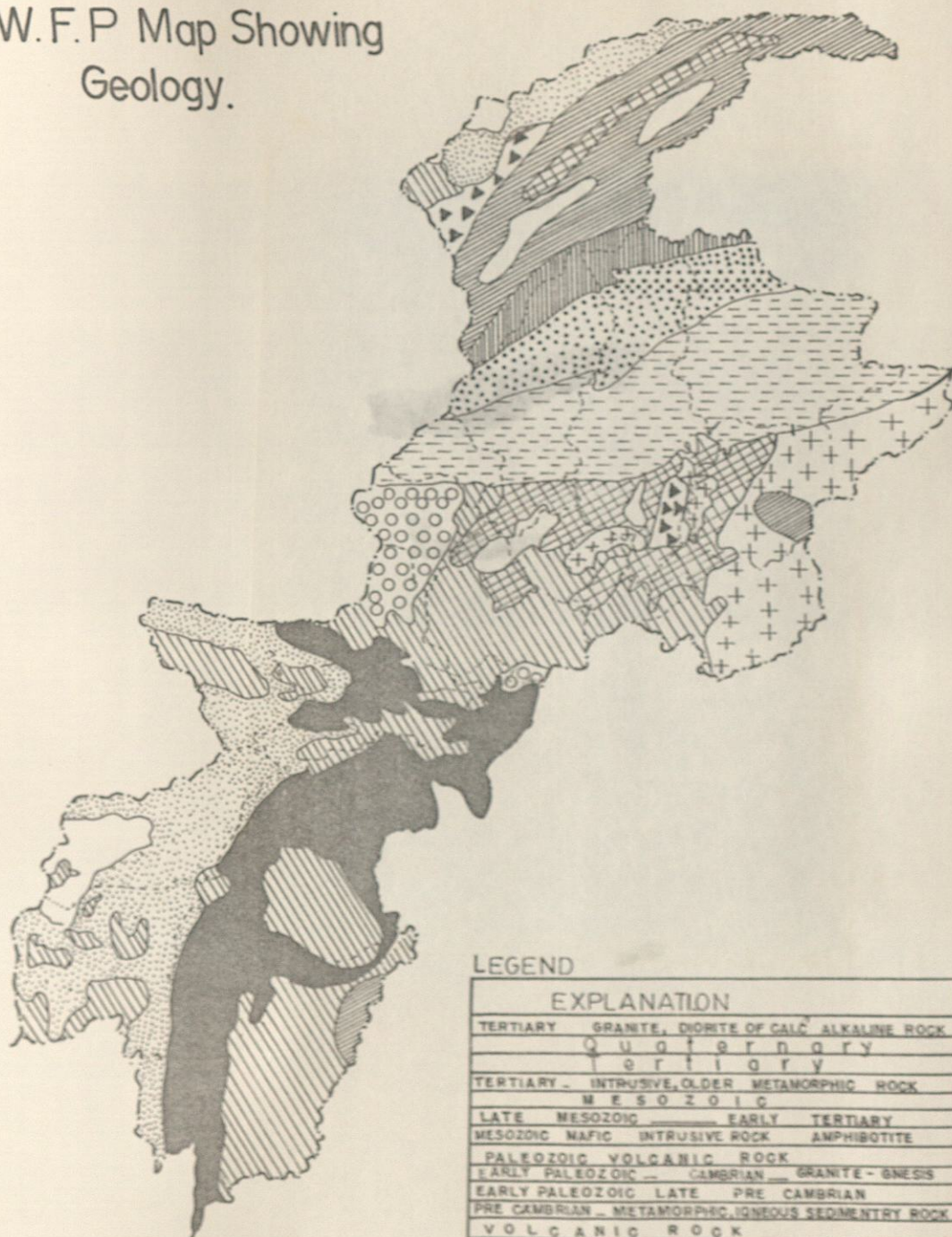
MAP - 13 Whereas W. mayariense is *, W. mediterranea is @ and W. paraequina is !.

DISTRICT WISE MAP OF
N.W.F.P.



MAP - 14 Wherea W. salopiensis is *, W. turgaica is @ and W. veltostshevi is !.

N.W.F.P Map Showing Geology.



LEGEND

EXPLANATION	
TERTIARY GRANITE, DIORITE OF CALC ² ALKALINE ROCK	▲▲▲
Quaternary	▨
Tertiary	▨
TERTIARY - INTRUSIVE, OLDER METAMORPHIC ROCK	•••••
MESOZOIC	▨
LATE MESOZOIC	▨
EARLY TERTIARY	▨
MESOZOIC MAFIC INTRUSIVE ROCK	▨
AMPHIBOTITE	▨
PALEOZOIC VOLCANIC ROCK	▨
EARLY PALEOZOIC - CAMBRIAN	▨
GRANITE - GNESS	▨
EARLY PALEOZOIC LATE PRE CAMBRIAN	▨
PRE CAMBRIAN - METAMORPHIC, IGNEOUS SEDIMENTARY ROCK	▨
VOLCANIC ROCK	+++
FAULTS	▨

Notem.



Fig. # 71. Simuliid larvae attached to plastic.



Fig. # 72. Simuliid larvae attached to plastic.



Fig. # 73. Simuliid larvae and pupae attached to potamogetan (grass) in bottle.



Fig. # 74. Simuliid larvae and pupae attached to potamogeton from Kohat.



Fig. # 75. Simuliid larvae and pupae attached to potamogeton from Kohat.



Fig. # 76. Simuliid larvae and pupae attached to potomogetan.



Fig. # 77. Simuliid pupae attached to potamogetan.



Figure # 78

Simuliid pupae attached to
Potamogetan



Fig. # 79. Simuliid larvae and pupae attached to typha leaves.

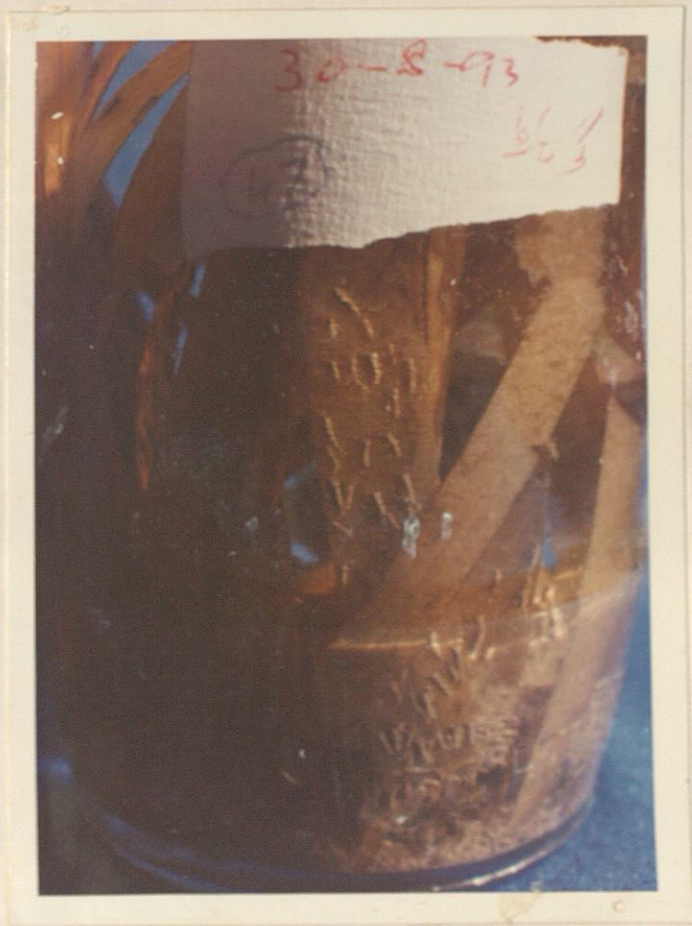


Fig. # 80. Simuliid larvae and pupae attached to typha leaves.



Fig. # 81. Simuliid pupae attached to typha.



Fig. # 82. Simuliid pupae attached to typha.



Fig. # 83. Simuliid larvae and pupae attached to hydrella and typha.



Fig. # 84. Simuliid pupae attached to Echinochloa.



Fig. # 85. Simuliid larvae and pupae attached to hydrilla and typha.



Fig. # 86. Simuliid pupae attached to roots of terrestrial tree.