CHAPTER II.

BIOLOGY OF

AQUATIC HEMIPTERA-HETEROPTERA.
INTRODUCTION.

This chapter embodies the results on the biological studies of aquatic bugs carried out during the period 1962-1965 in the laboratory of the Central Inland Fisheries Research Institute, Barrackpore, W. Bengal. The economic importance of the aquatic bugs in relation to the pond fisheries has been pointed out in the preface of the thesis. But it is distressing to note that a pisciculturist in India has very little knowledge on the biology of these important components of the pond community.

Aquatic Heteroptera are remarkable on account of their adaptation to the aquatic way of life. Thus, they afford an interesting study on the behaviour and life-histories. A perusal of the voluminous insect literature reveals that much work has been done on these aspects in other countries. Bueno in a series of papers (1901, 1903, 1906a, 1906b and 1916) added greatly to the knowledge of the biology of the American species. Hungerford (1919) published a comprehensive and monographic paper on the ecology and biology of aquatic Hemiptera. Hale (1923) dealt with, in detail, the biology of the Australian species. Brocher (1909), Poisson (1926, 1938, 1957), Macan (1954), Wroblewski (1958), Popham (1960) and Crisp (1962) studied the behaviour and life-histories of the European species. In India, aquatic Heteroptera have
drawn the attention of the taxonomists (Distant, 1906 and 1910; Paiva, 1918; Hutchinson, 1934 and 1940; Hafiz and Pradhan, 1947 and Brooks, 1951), but it is unfortunate that no detailed work on their biology is available in spite of the richness of the fauna. However, scattered accounts exist on a few species. Nowrojee (1912) traced out the life-histories of *Ranatra filiformis* (Fabricius) and *Eupithegma indicum*. Raghunatha Rao (1959 and 1962) studied the biology of *Laccotrepha griseus* (Guer). *Ranatra elongata* Fabricius and *Sphaerodema annulaturn*. Gorai (1963) and Gorai and Raychaudhury (1963) dealt in brief with the food and feeding habits of *Anisops bouvieri* Kirkaldy. Julka (1965), in his observations on the biology of aquatic bugs injurious to the pond fishes, gave a detailed account on the life-history of *Anisops bouvieri* Kirkaldy. In the present investigations, it has been possible to trace out the complete life-histories of nine species of aquatic bugs, viz., *Ranatra filiformis, R. elongata, Laccotrepha griseus, Diplonychus rusticum, Micronecta scutellaris scutellaris* (Stål), *M. halioloides* Horvath, *Nychia marshalli* (Scott), *Anisops waltairensis* Brooks and *Plea frontalis* (Fieber). Observations on the habitat, habits, predators and parasites, structure of the egg and nymphs of these and a few other species have also been included. The collections made for the study of seasonal fluctuations in the population of aquatic bugs, were utilized for the
A hymenopterous egg parasite, *Prestwichia* sp. (Fam. Trichogrammatidae) has been reared for the first time from the eggs of *Anisos bouvieri* and *Plea frontalis*. This is the first record of *Prestwichia* Lubbock from India.

A research paper on the biology of *Anisos bouvieri* Kirkaldy is appended to the thesis. This includes observations on the food and feeding, mating, ovipositions, fecundity, life-history and growth.

**MATERIAL AND METHODS**

The material for biological studies in the laboratory was collected with a hand net from ditches, and temporary and permanent ponds at Barrackpore. The adults of *Ranatra*, *Anisos*, *Nychia* and *Diplonychus* were kept in separate glass jars of 15 cm. diameter and 22.5 cm. height, about half-filled with tap water. They were provided with aquatic plants for support and for egg-laying. After the deposition of eggs, a shoot of aquatic plant containing the eggs was removed to a separate glass jar (7 x 10 cm.). The adults of *Laccotrachelus* were placed in the glass jars of above dimensions, containing a little of water and a layer of mud at the bottom. Upon hatching, the nymphs were isolated. Both the nymphs and adults were fed regularly on
planktonic Crustaceans and mosquito larvae.

The corixids were reared in small petri dishes of 5 cm. diameter containing water and a layer of pond ooze at the bottom. Daily change of the water was effected to obviate the formation of scum at the surface which might render their normal breathing difficult. The dead insects at the bottom of the jars were removed daily which otherwise would cause foulness in the water.

For the study of the sex ratio of the species, samples collected for the study of seasonal fluctuations of these insects were utilized. The significance of the preponderance of one sex over the other was tested by standard Chi-Square Method. The Chi-square method was not applied to the samples, where the total number of individuals was less than 40, as such samples were not considered adequate for the statistical treatment.

The logarithm of body dimensions were plotted against the number of instar for growth studies and the correlation of coefficient was calculated by the method of least squares.

The measurements were made with an ocular micrometer and the diagrams were drawn with a graph oculo-meter and camera lucida.
FAMILY NEPIDAE

The bugs belonging to this family are commonly referred to as 'Water Scorpions'. They are readily recognised by the strong anterior raptorial legs, short rostrum and a long respiratory siphon present at the tip of the abdomen. China (1955) considers this family to be primitive due to its breathing by means of a respiratory siphon and places it lower than the other air-breathing aquatic bugs in the evolutionary tree. Examples of Ranatra and Laccotrechus which are well represented in India were taken for the purpose of biological studies.

REVIEW OF LITERATURE

Enock (1900) observed the process of oviposition in Ranatra linearis and noted that the female laid eggs in half decayed stems and occasionally in green stems. Pettit (1902) described in some detail the structure of the egg of R. fusca Paliot de Beauvois and considered the function of the appendages to that of protection against predatory vertebrates. Bueno (1903) made observations on the stridulation of R. fusca. Bueno (1906) also made a rather thorough study on the hibernation, respiration, parasites and development of R. quadridentata Stål. Nowrojee (1912) studied the life-history of an Indian nepid and gave an account of the structure...
of the egg and nymphs of *R. filiformis* (Fabricius). Bueno (1916) discussed the food and feeding habits and respiration and in Nepidae. Hungerford (1919), while reviewing the work done on these insects added some notes on their biology. Hale (1923) worked out the biology of *Laccotrephes tristis*. He noted 8-10 filaments arranged in circular formation on one end of the eggs in this species. He also dealt with the biology and life-history of *R. auskialiensis*. Hoffman (1930, 1033) traced out the life-history of *R. filiformis* and a species of *Laccotrephes*. He briefly dealt with their food, respiration, oviposition, mating and immature stages. Hamilton (1931) made a thorough study of the morphology of *Nepa cinerea* Linnaeus. He also studied the habits, life-history and copulation of this insect. Fernando (1958) recorded heavy infestation of larval water-mites on *R. elongate* Fabricius. Wilson (1958) gave brief biological notes on Nepidae. Raghunatha Rao (1959) described the nymphal instars of *L. griseus* (Guér.). Davis (1961) published an illustrated account of the egg and the hatching act in *R. fusca*. He pointed out that the egg shell ruptures due to the increase of internal pressure caused by the swelling of an inner hyaline membrane surrounding the nymph. The swelling occurred due to an osmotic phenomenon. Hinton (1961) gave a comparative account on the respiratory system of the egg shells of 16 species of Nepidae. Hati and Ghosh (1961)
showed the importance of *L. maculatus* as a predator of mosquito larvae and pupae. Raghunatha Rao (1962) made some observations on the biology of *R. elongata*. Davis (1964) gave a comprehensive account on the hatching of *R. absoma* D. and Dec.

**GENUS RANATRA** Fabricius

*Ranatra* can be easily distinguished by its long and slender body provided with a long respiratory tube. It is a very sluggish swimmer and when out of water it crawls or walks in an awkward manner. It is seldom observed in flight. *Ranatra* is very common in muddy or stagnant water. Ponds, lakes and roadside puddles are typical habitats. The richest single find was from about a nine acre artificial lake, Raja Sahib Kanika's Lake (Photo. 4), about one kilometre from the Central Inland Fisheries Research Substation, Cuttack (Orissa). It contained a dense growth of aquatic vegetation. The following species were collected at a time:

- *Ranatra filiformis* (Fabricius)
- *R. digitata* Hafiz and Pradhan
- *R. titliensis* Hafiz and Pradhan
- *R. unicolor*
- *R. varipes* Stål

Four species of *Ranatra*, viz., *R. filiformis*, *R. elongata*, *R. digitata* and *R. varipes* were recorded from a fish pond at
Barrackpore (W. Bengal) during a period of two years. The complete life-histories of only the first two species were traced out in the laboratory. The eggs of *R. digitata* were obtained to study the structural differences. The species can be easily recognised by the shape of the parameres in the male genitalia.

**BIOLOGY OF *RANATRA FILIFORMIS* (Fabricius)**

**HABITAT**

*Ranatra filiformis* is generally found clinging to the aquatic vegetation and floating wooden logs or twigs both in temporary and permanent ponds. Hoffman (1930) recorded it from the rapidly moving streams. He further noticed that it spends the winter in the adult stage. It is quite common during the monsoon months, i.e., from June to September, though it is available during the rest of the year in very small numbers.

**FOOD-FEEDING**

*Ranatra filiformis* is a predator and preys upon a variety of organisms dwelling in the water, and is capable of capturing much bigger organisms than itself. It can survive for a number of days without feeding. It feeds upon notonectids, corixids, immature stages of ephemirids, odonates, dipterans, coleopterans and fish fry, but shows a preference for notonectids and mosquito larvae.
The young ones prey upon tiny mosquito larvae, first or second instar of notonectid nymphs and planktonic crustaceans.

The anterior raptorial legs are well adapted for capturing the prey. The coxae are mobile and elongate; the femora are furnished on the lower side with two teeth in the middle and grooved in the distal half; the tibiae and the one-jointed tarsi are strongly curved and fit into the femoral grooves. It waits motionless, resting on a twig, stone or any support available in the water. The powerful raptorial forelegs are raised together in front, their pincers being half opened to seize any suitable prey which comes within its range. The prey, when within range, is captured with a lightning pincer movements of their forelegs and the victim is brought back to the short and sharp beak. The sharp stylets probe the victim's body until they are inserted at a vulnerable point and body juices are slowly sucked out. Under the binocular microscope stylets could be seen playing about in the body of the victim, darting and sending around as if to ream out every available bit of nutrient. After impaling the victim at the beak, the forelegs are ready to strike at a new prey.

PREDATORS AND PARASITES

*Ranaatra filiformis* has very few predators. Its nymphs are attacked by *Laccotrecha*. Green algae grow quite often
on its appendages and wings. It is generally found to be
infested by the larval Hydrachnids. The mites are attached on
any soft part between the chitinous plates. The maximum number
of mites observed on a single individual was six. The mite
infestation does not in any way interfere in its normal life,
except that the individual so infested is slightly sluggish
than the normal ones. Fernando (1958b) discussed the importance
of the insects in the dispersal of mites from one body of
freshwater to another. Enock (1900) reared a number of
hymenopteran egg-parasite, Prestwichia aquatica Lubbock
(Family Trichogrammatidae) from the eggs of a Ranatra sp.
In the present studies no such parasites were recorded from
the eggs of Ranatra spp.

DEATH-FEIGNING

*R. filiformis* shows a reaction of 'death-feigning'
or thanatosis (Wigglesworth, 1953), which is most readily
induced by taking the insect out of water either by hand
or forceps and dropping again in the water. In 'death-
feigning', the middle and hind legs are extended and closely
pressed against the body and the respiratory siphon is
almost straight. The insect remains in this position for
about five minutes. This reaction of 'death-feigning' has
also been observed by Hamilton (1931) in *Nepa cinerea* Linnaeus.
Their aquatic way of life has led to the development of structural modifications to enable them to breathe atmospheric air. The main inspiration current takes place through the respiratory siphon. The respiratory siphon consists of two filaments fringed with hydrofuge hairs, and grooved on the inner surface. Miall (1895) claims that in Ranatra linearis the continuity of the tube is maintained by a multitude of hook like bristles, which project from the opposite edges. Bueno (1906b) contradicts these observations and states that the fringing hairs are simple and further he (1916) observes that when the insect is submerged then two half tubes are kept together by the pressure of the water, the hairs serving to prevent leakage of air at the junction of the two filaments. The present investigations on R. filiformis also show that the hairs on the filaments are simple. The groove of each filament leads into a well-developed last abdominal spiracle, which in turn opens into a well-developed trachea. The opening of the spiracle is heavily guarded by fine hairs.

During mating, the two halves of the respiratory siphon are forced apart to facilitate the union. This does not in any way interfere in the normal breathing of the insect.

The mode of respiration is quite different in the
nymph from that of the adult. The laterotergites are well-developed and extend downwards and inwards over the medially raised sternum, forming a canal over five pairs of spiracles on either side. The air is led to the canals by a short, ventrally grooved respiratory tube at the tip of the abdomen (Plate I, Fig.44). The gas store in the canals is held in position by the long hydrofuge hairs arising from the inner margins of the latero-tergites and the outer margins of the medially raised sternal ridge.

COPULATION

The male is smaller than the female and the latter can be distinguished by a narrow and pointed seventh abdominal sternum, which is serrated dorsally. The mating takes place inside the water.

The male is the active participant and seizes the female round her prothorax by his anterior raptorial legs and climbs on her back. If the female is non-receptive she tries to dislodge him by her hind legs, but once he has taken a firm grip, it becomes difficult for her to do so. To effect union, he bends his body to one side (either right or left) and pushes the tip of the abdomen beneath that of female. The male keeps the female in position with his three legs of one side, while the legs of the
other side rest on some vegetation for support. The respira-
tory tube is split open into two halves and the penis is
extruded, turned upwards and thrust into the female genital
opening. The hook-shaped parameres at the base of phallus
clap the second valvulae of the female ovipositor. The
union lasts for about twenty to thirty minutes and during
this period the male withdraws and inserts his phallus for
about twelve to fifteen times. While in copula the female
rubs behind her fore legs against her head. The female is
copulated for a number of times before she oviposits.

**OVIPOSITION**

*Ranatra filiformis* inserts its eggs into the stems or
leaves of a variety of aquatic plants, *viz.*, *Hydrilla
Verticillata*, *Hygrophila polysperma* and *Vallisneria
spiralis*. The female grasps the stem or leaf with her
middle and hind legs and raising her anterior half high up
makes an oblique slit by the downward and backward movements
of her pointed and serrated seventh abdominal sternum for
twenty to thirty seconds. The egg is completely embedded
in the plant tissue with its long filaments free in the
water. After depositing the egg the female moves forward
a little distance to deposit another egg. The eggs are
laid in an irregular manner and the oviposition takes
place mostly during the night.
Photo. 4. Raja Sahib Kanika's Lake, Cuttack, Orissa.

Photo. 5. Eggs of *Ranatra filiformis* in situ.
LIFE-HISTORY

Under laboratory conditions with water temperature ranging from 26.5°C - 32.5°C, Ranatra filiformis takes averagely 31.64 days to complete its life-history. The nymph after hatching casts off its skin five times to reach the imago stage. The incubation period and the duration of each instar are given in Table VII.
### TABLE - VII.

**INCUBATION PERIOD AND THE DURATION OF EACH INSTAR.**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>First instar</td>
<td>3.5-4.0</td>
<td>3.66</td>
</tr>
<tr>
<td>Second instar</td>
<td>2.0-3.0</td>
<td>2.50</td>
</tr>
<tr>
<td>Third instar</td>
<td>3.5-4.0</td>
<td>3.90</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>4.0-5.0</td>
<td>4.25</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>9.0-11.5</td>
<td>10.33</td>
</tr>
</tbody>
</table>

Total period of development = 31.64 days.
DESCRIPTION OF THE EGG AND NYMPHS

EGG (Photo 5; Plate I, Fig. 45)

Size - Length: 1.96-2.15 mm. (mean: 2.05 mm.)
Width: 0.44-0.52 mm. (mean: 0.5 mm.)
Length of respiratory horn:
5.93-6.44 mm. (mean: 6.31 mm.)

Colour - Pale yellow, turning to yellowish-brown before hatching; respiratory horns pale yellow.

Shape and structure - Elongate-oval, with the distal end subtruncate. If viewed from the side, the ventral side is almost straight while the dorsal one is distinctly convex. At the distal end on the ventral side, there is a small circular depression from which arise two long filaments, the respiratory horns (after Hinton, 1961). Hinton (1961) gave a detailed structure and discussed the respiratory function of these horns. Pettit (1902) described these filaments as the organs of protection against predators.

Each respiratory horn is about three times as long as the egg and tapers gradually to a point near its apex where it enlarges into a knob. The respiratory horn, if examined under the high magnification, consists of an internal opaque, yellowish, spongy core and an outer transparent, pale-yellow sheath. The sheath or plastron extends from a little beyond the base to the apex of the horn. It shows a pattern of
irregular hexagonal markings. The surface of the egg shell is finely granulated, with irregularly scattered large and round punctate elevations (Plate II, Fig.60). On the dorsal side, near the distal and basal ends, are present two areas of irregular hexagonal reticulations.

HATCHING (Photo 6,7)

The opacity of the egg shell prevented observations on the development of the embryo, except on the third day when crimson-coloured eye spots could be marked easily towards the distal end. The egg shell just before hatching is dirty-brown in colour, eye spots prominent and the rhythmic movements of the embryo can be observed inside the egg shell. A semi-circular split appears towards the distal end on the dorsal side just at the base of the respiratory horns and the nymph is enclosed in a transparent membrane (post-natal molt of Hungerford, 1919). The nymph remains in this position for three to five minutes, after which the nymph, by the upward movement of its head, breaks open the 'post-natal molt' and wriggles out by pushing away the cap bearing the respiratory horns. The head is first to come out followed by the legs and the rest of the body. The 'post-natal molt' comes out along with the nymph. The newly emerged nymph is greenish-yellow in colour, eyes crimson-coloured and the appendages pale-yellow.

Photo 7. Hatched egg of *Ranatra filiformis*, showing the 'postnatal molt'.
Davis (1961) gives an illustrated account of hatching in *Eunatra fusca*. According to him the nymph is enclosed in two inner thin membranes and the split in the egg shell occurs due to the pressure exerted by the osmotic swelling of the outer hyaline membrane.

**NYMPHAL INSTARS**

**First instar** (Plate I, Fig. 46; Plate II, Fig. 61)

Body yellowish-brown, ventral side greenish-yellow; eyes dark above and crimson-coloured below; rostrum dark brown; appendages pale-yellow. Head with a well-developed median spine and broader than prothorax; rostrum short, 4-jointed; inter-ocular space distinctly more than the width of eye. Prothorax widest and sinuate anteriorly to accommodate head; sternum widely grooved. Wing pads absent. Prothoracic legs raptorial with long coxae; femoral teeth in the form of two ridges, bearing a few long setae; tarsi 1-jointed. Middle and hind legs long and slender; tarsi 1-jointed; claws 2, well-developed. Abdomen six segmented, provided with a short, ventrally grooved respiratory siphon.
SECOND INSTAR

General colour and structure as in the previous instar. Median spine on head well-developed. Wing pads indistinct. Anterior raptorial legs with femoral teeth distinct, furnished with a few setae. Respiratory tube short and one-third of abdomen length.

THIRD INSTAR

Wing pads rudimentary; anterior wing pads extend upto the middle of metanotum; posterior wing pads not extending beyond posterior margin of first abdominal segment. Respiratory tube about half of abdomen length.

FOURTH INSTAR

General colour dark brown. Antennae with prominences on the second and third segments. Wing pads well developed; anterior ones extending beyond posterior margin of metanotum and posterior ones reach beyond first abdominal segment.

FIFTH INSTAR

General colour and form as in the previous instar. Wing pads very well-developed; anterior wing pads overlapping the posterior ones and extend to the middle of first abdominal segment. Respiratory tube about three fourth of abdomen length.
---

**TABLE - VIII**

MEASUREMENTS OF NYMPHS AND ADULT IN MILLIMETERS OF *R. FULIGINEUS*.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>HEAD WIDTH</th>
<th>BODY WIDTH</th>
<th>BODY LENGTH</th>
<th>RESPIRATORY LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
<td>Range Mean</td>
</tr>
<tr>
<td>First instar</td>
<td>0.65-0.69</td>
<td>0.67</td>
<td>0.61-0.65</td>
<td>0.63</td>
</tr>
<tr>
<td>Second instar</td>
<td>0.83-0.91</td>
<td>0.87</td>
<td>0.74-0.78</td>
<td>0.76</td>
</tr>
<tr>
<td>Third instar</td>
<td>1.09-1.14</td>
<td>1.12</td>
<td>0.89-0.93</td>
<td>0.91</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>1.45-1.54</td>
<td>1.48</td>
<td>0.99-1.10</td>
<td>1.08</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>1.90-1.96</td>
<td>1.94</td>
<td>1.28-1.35</td>
<td>1.30</td>
</tr>
<tr>
<td>Adult</td>
<td>2.20-2.50</td>
<td>2.35</td>
<td>1.56-1.70</td>
<td>1.60</td>
</tr>
</tbody>
</table>

---
Biology of Ranatra elongata Fabricius

Ranatra elongata can be distinguished from Ranatra filiformis by its large size, absence of a median tubercle on the head, eyes broader than the interocular space, anterior femur with one tooth and the seventh abdominal sternite which in the female is unserrated.

It inhabits both temporary and permanent ponds, clinging to the aquatic plants with its respiratory siphon touching to the water surface. It is a fierce and voracious predator and is capable of attacking much bigger organisms like tadpoles. When unfed, the adults show cannibalistic tendencies and attack their own young ones. The feeding mechanism, mode of respiration, mite infestation (Photo. 8) and death feigning is similar to that of Ranatra filiformis.

Copulation (Photo. 9)

The female is bigger than the male and its seventh abdominal sternite is narrow, pointed and unserrated. The mating starts from June and continues up to September. It occurs at any time during the day or night. The male seizes the female with his anterior raptorial legs and mounts on her back from the side. The union is effected more or less in the same manner as in
Photo 8. Hydrachnid larvae attached to the respiratory tube of the female *Ranatra elongata*.

R. filiformis. They remain in cocula for about half an hour.

OVIPOSITION

In the field, the eggs of Ranatra elongata are found embedded in the decaying aquatic plants. In the laboratory, a female was kept in a jar containing a variety of aquatic plants. She failed to deposit the eggs into the plant tissue but simply dropped them to the bottom of the jar. The eggs were always dropped during the night. These eggs, except a few, failed to hatch out.

LIFE-HISTORY

Ranatra elongata takes about six days more than that of R. filiformis to complete its life-cycle. Total period of development in this species is about 37 days. There are five nymphal instars from the egg to the imago stage. The incubation period and the duration of each instar is given in Table IX.

DESCRIPTION OF THE EGG AND NYMPH

EGG (Photo. 10, 11; Plate I, Fig. 47; Plate II, Fig. 59)

Size - Length: 2.33-2.44 mm. (mean: 2.38 mm.)
Width: 0.83-0.87 mm. (mean: 0.84 mm.)
Length of the respiratory horn: 2.75-2.83 mm. (mean: 2.81 mm.)

Colour - Pearly-white, becoming pale-yellow before hatching; respiratory horn also pearly-white except towards the apex which is light brownish.

Shape and structure - Elongate-oval, distally depressed, ventral side straight while the dorsal one is convex. Respiratory horns differ considerably, both in length and structure, from those of the eggs of *R. filiformis*. Each respiratory horn is a little longer than the egg. It tapers up to two thirds of its length and gradually dilates towards the extremity. The tip of the respiratory horn is more or less like a knob, bearing very small papillae. The plastron extends beyond two thirds the length of the horn. As in *R. filiformis*, the surface of the egg shell is finely granulated with round punctate elevations. The egg shell in the regions at the base of the horns and hydropyle, shows a pattern of somewhat hexagonal marking, which, except a few peripheral ones, are devoid of punctate elevations.

NYMPHAL INSTARS

First instar (Plate I, Fig. 48)

Body dark brown with pale margins; eyes dark; anterior
Photo. 10. Egg of *Ranatra elongata*, dorsal view.

Photo. 11. Egg of *Ranatra elongata*, lateral view.
legs brownish-yellow; middle and hind legs pale with indistinct light brownish bands on the femur, coxae ashy and tarsi dark distally. Head without median spine on the vertex; rostrum 4-jointed with a tuft of setae at the tip; antennae white, club-shaped, 1-jointed; eyes large. Prothorax narrower than head, one and a half as long as pterothorax. Wing pads absent. Anterior leg with coxa long; femur flattened, furnished ventrally with short setae; femoral tooth in the form of a ridge bearing a few long setae; tibia curved, about half the length of femur; tarsus 1-jointed without any claw. Middle and hind legs with coxae short; tibia longer than femur; tarsus 1-jointed bearing two claws. Total body length about four and a half times as long as respiratory tube. Respiratory tube grooved ventrally.

Second instar.

General colour and shape as in the previous instar. Antennae pale, 2-jointed. Wing pads indistinct. Femoral tooth quite distinct; all tarsi 1-jointed; tibiae and tarsi of second and third legs bear sparsely arranged short black setae.

Third instar.

Antennae as in the second instar. Wing pads rudimentary;
## TABLE - IX

**INCUBATION PERIOD AND THE DURATION OF EACH INSTAR.**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>8.00-2.00</td>
<td>8.50</td>
</tr>
<tr>
<td>First instar</td>
<td>3.00-6.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Second instar</td>
<td>5.00-6.00</td>
<td>5.20</td>
</tr>
<tr>
<td>Third instar</td>
<td>2.00-6.00</td>
<td>4.20</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>4.00-7.00</td>
<td>5.20</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>8.00-10.00</td>
<td>9.20</td>
</tr>
</tbody>
</table>

*Total period of development = 37.30 days.*
anterior ones do not reach the posterior margin of metanotum; posterior ones reaching the middle of first abdominal segment. Femoral tooth well-developed. Total body length about three times as long as respiratory tube.

Fourth instar.

General form not much different from the previous instars except for some variations in proportions. Antennae 3-jointed; second and third each with a prominence internally at the distal end. Eyes much enlarged, distinctly broader than interocular space. Wing pads well-developed; anterior ones reach beyond metathorax while posterior ones reach beyond the first abdominal segment. Total body length about two and a half times as long as respiratory tube.

Fifth instar.

General form as in the fourth instar. Antennae 3-jointed; second and third segments with prominences well-developed and elongated. Eyes broader than the interocular space. Median tubercle on head absent (Photo II, Fig. 63). Wing pads very well developed, long and narrow; anterior wing pads overlap the posterior ones and reach the middle of second abdominal segment. Anterior femur with a single, triangular, well developed tooth.
Total body length about twice as long as respiratory tube.

Table X gives the measurements of the head, body and respiratory tube of the nymphal instars and the imago.

MOULTING (Photo 11*)

Before moulting, the nymph is dark in colour, sluggish and stops feeding. It rests on a support with its respiratory tube touching the water surface. The cuticle splits along the mid-dorsal line on the thorax and the split extends forward on the head between the eyes. The head is first to come out followed by the fore legs, thorax and abdomen. The newly moulted nymph is yellow in colour; eyes are red and appendages pale.

GROWTH (Figs. 35, 36 and 37)

According to Dyar's law (1890), the larval instars of Lepidoptera follow a regular geometrical progression in growth. To ascertain the validity of this law in relation to Ranatra elongata, the relationships between the number of instar and head width as well as body width and body length were calculated. These relationships were found to be linear in the semi-logarithmic form and are adequately expressed by the following equations:
**TABLE - X**
MEASUREMENTS OF NYMPHS AND ADULT IN MATURE FORM OF R. ELONGATA

<table>
<thead>
<tr>
<th>Stage</th>
<th>Head Width</th>
<th></th>
<th>Body Width</th>
<th></th>
<th>Body Length</th>
<th></th>
<th>Resp. Tube Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>First instar</td>
<td>0.61-1.00</td>
<td>0.86</td>
<td>0.65-0.74</td>
<td>0.68</td>
<td>6.30-7.04</td>
<td>6.62</td>
<td>1.37</td>
</tr>
<tr>
<td>Second instar</td>
<td>1.24-1.30</td>
<td>1.27</td>
<td>0.82-0.96</td>
<td>0.82</td>
<td>10.42-11.33</td>
<td>10.75</td>
<td>2.25</td>
</tr>
<tr>
<td>Third instar</td>
<td>1.61-1.74</td>
<td>1.70</td>
<td>1.00-1.33</td>
<td>1.22</td>
<td>15.00-17.50</td>
<td>16.51</td>
<td>4.56</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>2.17-2.28</td>
<td>2.22</td>
<td>1.52-1.61</td>
<td>1.56</td>
<td>21.02-22.32</td>
<td>23.03</td>
<td>8.75</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>2.88-3.15</td>
<td>3.04</td>
<td>2.04-2.17</td>
<td>2.12</td>
<td>37.00-41.00</td>
<td>38.55</td>
<td>17.50</td>
</tr>
<tr>
<td>Adult</td>
<td>3.22-3.52</td>
<td>3.42</td>
<td>2.42-2.59</td>
<td>2.48</td>
<td>47.00-49.00</td>
<td>48.16</td>
<td>50.50</td>
</tr>
</tbody>
</table>

PHS AND ADULT IN MILLIMETERS OF R. ELONGATA
(1) Number of instar and head width

\[ \log Hw = -0.1428 + 0.1242 \, n \]

(Coefficient of correlation, \( r = 0.9988 \))

(2) Number of instar and body width

\[ \log Bw = -0.2916 + 0.1227 \, n \]

(Coefficient of correlation, \( r = 0.9912 \))

(3) Number of instar and body length.

\[ \log Bl = .6403 + .1876 \, n \]

(Coefficient of correlation, \( r = 0.9743 \))

Where, \( Hw \) = Head width; \( Bw \) = Body width; \( Bl \) = Body length; \( n \) = Number of instar.

The high values of \( r \) show that the correlation is highly significant.

**DESCRIPTION OF THE EGG OF RANATRA DIGITATA**

HAFIZ & PRADHAN.

*(Plate I, Fig. 49)*.

Size - Length : - (mean : 1.75 mm.)

Width : - 0.46 - 0.50 mm (mean: 0.49 mm.)

Length of respiratory horn : -

6.33 - 6.92 mm (mean: 6.60 mm.)

Colour - Yellow; respiratory horns pale yellow.
Fig. 35. Relationship between number of instar and head width of *Ranatra elongata* Fabricius.

Fig. 36. Relationship between number of instar and body length of *Ranatra elongata* Fabricius.

Fig. 37. Relationship between number of instar and body width of *Ranatra elongata* Fabricius.
RANATRA ELONGATA

FIG. 37

LOG BODY WIDTH IN MM.

NUMBER OF INSTAR
Shape and structure - The eggs of *Banatra digitata* are very similar to those of *B. filiformis*, except that the respiratory horns are about four times as long as egg.

The egg is elongate-oval, with the distal end subtruncate and narrowly invaginated. The pleuron on the respiratory horn, extends from a little beyond its base to its apex. The egg shell is finely granulated with scattered round punctuate elevations except in the regions at the base of the horns and hydropyle, where it shows a pattern of somewhat hexagonal markings.

**Biology of Laccotrephes griseus** (Guér)

Habitat

*Laccotrephes griseus* is generally found hiding below the stones, clinging to the vegetation or half buried in the mud near the shallow littoral region of the ponds with its long respiratory siphon touching the water surface. It buries itself by raking mud or sand over its back with the hind legs. Owing to its form and colour, it is not easily located against the background of the decayed vegetation. The anterior legs are raptorial and the second and third pairs of legs are ill adapted for swimming. When out of the water, it crawls in an awkward manner.
FOOD AND FEEDING (Photo 12 and 13)

It is a fierce and voracious predator. It preys upon all types of aquatic insects and fish fry, and is capable of attacking much bigger organisms like tadpoles. However, first to third instar nymphs prefer tiny mosquito larvae and mayfly nymphs. It is not uncommon to observe two to three adults of *L. priscus* feeding upon a single prey (Photo 14). When unfed, the adults attack their own young ones.

The anterior raptorial legs are well adapted for capturing the prey. The prey is seized with lightning speed by the raptorial legs and brought back to the short beak and the sharp stylets probe the victim's body until a suitable spot is located for their insertion. The body juices are slowly sucked out and the crumpled body of the victim is thrown away and the insect is ready again to strike at the next prey.

PREDATORS AND PARASITES

At no time during the period of observations in the laboratory, it was preyed upon by other insect predators, i.e. *Ranatra* and *Diplonychus*, although, it was kept in their association. However, Hoffman (1932) observed that *Laccotrephes* may fall prey to the ducks and amphibians. Green algae grow on its body and respiratory tube, and is often infested by the larval water mites.

Photo 12. *Laccotrephes griseus* preying upon a dragonfly nymph.
Photo. 13. *Laccotrephes griseus* feeding on a dragonfly nymph.

Photo. 14. Three *Laccotrephes griseus* preying upon a dragonfly nymph.
DEATH-FEIGNING (Photo 15)

Like *Banatra*, *L. griseus* also shows a reaction of 'death-feigning' which can be induced by holding it with the forceps or fingers. The anterior legs are folded back and the middle and hind legs are pressed against the body and the respiratory tube is straight. The feigning lasts for about 3-5 minutes.

RESPIRATION:

The air is taken in through the long respiratory siphon, which consists of two filaments. Each filament is grooved and furnished with fine setae on the inner side. The filaments open into well-developed abdominal tracheae through the last pair of spiracles. In the nymphs, the latero-tergites are flap-like and extend downwards and inwards, enclosing a canal on either side of the medially raised sternum (Plate II, Fig. 72). The siphon is composed of a single filament which is ventrally grooved and fringed with hydrofuge hairs. The air is taken through the respiratory siphon and held in the canals. There are five pairs of abdominal spiracles located in the latero-tergites.

COPULATION (Photo 16)

The male is smaller than the female. Mating starts in March and may continue till August. They copulate at any time of the day. The male seizes the female round her thorax and mounts on her back. If the female is disinclined,
Photo. 15. Death-feigning in Laccotrephes griseus.

Photo. 16. *Laccotrephes griseus in Copula.*
she dislodges him by pushing him away with her hind legs but once he has taken a firm grip, it becomes difficult for her to dislodge him. The male may mount from the anterior. He holds the anterior legs of the female with his raptorial legs and climbs on her back. He immediately reorients himself so that he lies over her back and faces the same direction. To effect union, he takes a position either to her right or left and bends his abdomen beneath that of the female. The phallus is extruded, bent upwards between the respiratory filaments and is inserted into the female genital opening. They may remain in copula for several hours. With the male attached in this position, the female may feed or walk over the bottom of the aquarium as if nothing is happening. After mating, on a few instances, the male was observed holding the anterior legs of the female and pricking them with his beak.

OVIPOSITION

In the laboratory Laccotrephes griseus was always observed laying eggs during the night. The eggs are deposited in batches at the bottom of the glass jars, containing mud and held together by a transparent mucilaginous substance. The number of the eggs vary from six to ten per batch.

LIFE-HISTORY

Under the laboratory conditions with the water
temperature ranging from 26.4°C - 34.3°C, L. priscus takes about 35 days to complete its life-history. There are five nymphal instars before the adult stage is reached. The time taken by the eggs to hatch and the duration of each instar is given in Table XI.

**DESCRIPTION OF DIFFERENT STAGES.**

**Egg (Photo 17)**

- **Size** - Length: 1.70 - 1.85 mm. (mean: 1.75 mm).
- **Width**: 0.75 - 0.78 mm. (mean: 0.77 mm).
- **Length of respiratory horn**: 0.85 - 0.90 mm. (mean: 0.87 mm).

- **Colour** - Pearly-white, turning to yellow before hatching; respiratory horns white with their extremities light brown.

- **Shape and structure** - Oval, with one end subtruncate and less curved on one side. The truncated end bears ten respiratory horns arranged in a circle, each of which is about half the length of egg. The plastron extends beyond two thirds of its length. The egg shell is finely granulated with irregularly scattered round punctate elevations, except in the regions at the base of the horn which show a pattern of somewhat hexagonal reticulations.
Photo. 17. Egg of *Laccotrephes griseus*.

Photo. 18. *Diplonychus rusticum* Fabricius. Male carrying the eggs which the female has glued to his back.
TABLE - XI.

INCUBATION PERIOD AND THE DURATION OF EACH INSTAR.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>8.00 - 10.00</td>
<td>9.16</td>
</tr>
<tr>
<td>First instar</td>
<td>4.00 - 5.00</td>
<td>4.33</td>
</tr>
<tr>
<td>Second instar</td>
<td>3.00 - 4.00</td>
<td>3.66</td>
</tr>
<tr>
<td>Third instar</td>
<td>3.00 - 5.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>5.00 - 8.00</td>
<td>6.20</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>7.00 - 9.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Total period of development = 35.35 days
FIRST INSTAR (Plate II, Fig. 73)

Colour light brown; eye dark; legs pale with inconspicuous dark grey bands. Head about half the width of pronotum; antenna 2-segmented. Pronotum broadly emarginated anteriorly. Prosternum without any tubercle. Wing pads absent. Fore legs with femur broad and slightly constricted at the base; tarsus 1-segmented. Middle and hind legs with femora and tibiae subequal, tarsi 1-segmented bearing two claws. Respiratory tube short.

SECOND INSTAR (Plate II, Figs. 68, 74)

General colour as in the previous instar except that abdomen in the middle is dark brown. Antennae 2-segmented with a faint division of the second segment. Wing pads rudimentary. Tarsi all 1-segmented. Middle and hind legs with tibia and tarsi furnished with sparsely arranged long setae.

THIRD INSTAR (Plate II, Figs. 69, 75)

General structure and colour as in the previous instars. Pronotum slightly depressed in the middle. Wing pads well-developed; anterior wing pads not extending beyond posterior margin of metanotum; posterior wing pads reaching posterior margin of first abdominal segment.
FOURTH INSTAR (Plate II, Figs. 70, 76)

Colour dark brown, with the margins of thorax and abdomen and appendages pale. Antenna distinctly 3-segmented; second and third segments with mesial prominences. Anterior wing pads extending beyond metanotum and posterior ones reaching the middle of second abdominal segment.

FIFTH INSTAR (Plate II, Figs. 71, 72, 77)

Colour as in the previous instar. Antenna with prominences on second and third segments well developed. Prosternum with a median tubercle. Wing pads well-developed and elongated; anterior ones completely covering posterior ones and extend to the middle of third abdominal segment.

Table XII gives the measurements of the nymphs and adults.

FAMILY BELOSTOMATIDAE

Family Belostomatidae comprise large and flat bugs with the hind legs flattened and ciliated for swimming. The fore legs are raptorial and a pair of short, flat and retractile filaments are present at the tip of the abdomen.

REVIEW OF LITERATURE:

Very little work has been done on the biology of this
<table>
<thead>
<tr>
<th>STAGE</th>
<th>HEAD WIDTH</th>
<th>BODY WIDTH</th>
<th>BODY LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>First Instar</td>
<td>.69-.78</td>
<td>.72</td>
<td>1.09-1.12</td>
</tr>
<tr>
<td>Second Instar</td>
<td>.87-.91</td>
<td>.90</td>
<td>1.48-1.61</td>
</tr>
<tr>
<td>Third Instar</td>
<td>1.09-1.13</td>
<td>1.11</td>
<td>2.09-2.17</td>
</tr>
<tr>
<td>Fourth Instar</td>
<td>1.39-1.42</td>
<td>1.40</td>
<td>2.89-2.96</td>
</tr>
<tr>
<td>Fifth Instar</td>
<td>1.78-1.83</td>
<td>1.80</td>
<td>3.98-4.06</td>
</tr>
<tr>
<td>Adult</td>
<td>-</td>
<td>2.00</td>
<td>4.92-5.08</td>
</tr>
</tbody>
</table>
family and only a few references are available on the biology of *Diplonychus*, a species of which was studied during the present investigations. There are a few papers on the food-feeding, breeding and life-histories of other genera. Bueno (1906a) studied the life-history of *Belostoma fluminea* Jay. Needham (1907) described the eggs and their hatching in *Benacus Stål*. Bueno (1916) gave notes on the flight and respiration of belostomatids. Hungerford (1919) dealt with the biology of this family. Hoffman (1924) gave biological notes on *Lethocerus americanus* (Leidy). Hungerford (1925) studied the flight and process of hatching in *Lethocerus* and *Benacus*. Hoffman (1933) observed the life-history of *Lethocerus indicus* Lep. and Serv. Henkin (1935) studied in detail the life-history of *Lethocerus americanus* (Leidy). Lauck (1959) gave an account on the mechanism of locomotion in *Lethocerus*. The biology of *Sphaerodema annulatum* Fabricius was studied by Radhunetha Rao (1962).

**BIOLOGY OF *DIPLONYCHUS RUSTICUM* (Fabricius)**

*Diplonychus rusticum* inhabits ponds with muddy bottoms and rich in aquatic vegetation. It is generally found hiding among the aquatic plants and at times surfaces to exchange the gas stores. It swims by the rapid movements of the hind legs.
Their predatory propensities are well known and in the laboratory they fed upon a variety of organisms, viz., Anisos, mosquito larvae, mayfly and odonate nymphs and fish fry. The prey is captured by the anterior reuptorial legs and the body juices of the victim sucked up through the beak. Bueno (1906a) observed that the helcostomatids inject some paralyzing poisons into the victim’s body.

In the fish hatcheries, it feeds voraciously on fish fry and in order to substantiate this view some experiments were performed to find out its predatory capacity in relation to other predatory aquatic insects, viz., Danetra elongata, Anisos bouvleri and dragonfly nymph. The experiments were performed in glass jars (22 x 30 cms.) containing 2.5 litres of tap water and a few shoots of aquatic plants. Fifty fish fry of 10-12 mm. length were placed in each jar containing _D. elongata, A. bouvleri, D. rusticum_ and dragonfly nymph respectively. Total number of fish fry destroyed per hour by each insect was determined and the results (Table XIII) show that on an average _D. rusticum_ destroys large numbers of fish fry next to dragonfly nymph.

**OVIPOSITION (Photo 12)**

The eggs are laid in clusters, firmly glued on the back
### Table XIII

<table>
<thead>
<tr>
<th>No. of Expt.</th>
<th>A. elongata</th>
<th>A. bouvieri</th>
<th>D. rusticum</th>
<th>Dragonfly</th>
<th>Nymph</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

**Average** = 3.8 5 6.3 18.2
of the males. The female climbs on his back from the rear and deposits a number of eggs, held together by a light yellowish coloured mucilaginous substance. The number of eggs per cluster varies from 75-95. Once two berried females were kept together in a glass jar containing water, aquatic plants and a few brownish-coloured stones. On subsequent observations, it was found that both the females had laid eggs on each other's back and on the stones. After a few days, both dislodged their burden and the eggs failed to hatch out.

LIFE-HISTORY

There are five nympha1 instars and it takes on an average 31 - 58 days to complete its life-history at a temperature ranging from 28°C to 32°C. Table XIV gives the incubation period and duration of each instar.

DESCRIPTION OF EGG (Plate I, Fig. 50).

Size:

- Length: 1.22 - 1.48 mm. (mean: 1.30 mm.)
- Width: 0.78 - 1.22 mm. (mean: 0.84 mm.)
- Colour: When freshly laid greenish-yellow; can or operculum light brown.

SHAPE AND STRUCTURE

Oval, one end broadly rounded and the other narrow; from
lateral view, one side slightly concave and other considerably convex; cap or operculum, under high magnification, shows a pattern of somewhat hexagonal markings.

HATCHING

Just before hatching, the egg is light brown and operculum dark brown colour. The position of the eyes can be located towards the free end. The operculum is half-opened by the pressure exerted from within and the eyes of the emerging nymph can be easily seen. By further pressure, the head is pushed through and the young nymph slowly wriggles out. The operculum remains hinged to the empty egg shell.
### TABLE - XIV

**INCUBATION PERIOD AND DURATION OF EACH INSTAR IN DAYS.**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>7.50 - 8.50</td>
<td>8.00</td>
</tr>
<tr>
<td>First instar</td>
<td>4.00 - 6.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Second instar</td>
<td>-</td>
<td>4.00</td>
</tr>
<tr>
<td>Third instar</td>
<td>2.00 - 3.00</td>
<td>2.50</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>4.00 - 6.00</td>
<td>4.75</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>7.00 - 8.00</td>
<td>7.33</td>
</tr>
</tbody>
</table>

**Total period of development** = 31.58 days.
FAMILY CORIXIDAE.

The corixids commonly known as the 'water boatmen', may be easily recognised by their somewhat flattened body, short and blunt rostrum and enlarged fore tarsi called as palae. Three genera, viz., Micronecta, Corixa and Agraotocorixa were encountered in the fish ponds at Barrackpore, W. Bengal, during a period of two year survey, i.e., 1963-65. Micronecta is the commonest and most predominant of the corixids.

REVIEW OF LITERATURE.

Kirkaldy (1898) gave an account of the corixid eggs as a food for man and birds in Mexico. Lange (1904) observed the flight of Corixa. The life-history of Ramphocorixa balanodis Abbot was traced out by Abbot (1912). Bueno (1916), in his studies on aquatic Hemiptera in the relation of structure to environment, referred briefly to the mode of respiration and locomotion in Corixidae. Hungerford (1919) dealt in detail with the biology of Corixidae. He performed experiments to indicate the existence of selection in their foraging. McAtee (1922) gave a short note on a shower of Corixidae. Poisson (1938) made observations on the biology of Micronecta species, viz., M. meridionalis (Costa), M. minutissima (Linné) and M. noveri (Douglas & Scott). He dealt with the habitat, oviposition and structure of the egg of these species.
Griffith (1945) traced out the complete life-history of
_Ramphocorixa acuminata_ (Uhler) and discussed its association
with the crayfish. The life-history of _Corixes canzeri_ Fieb.
was worked out by Sutton (1947). Hungerford (1948), in his
monographic work on the corixidae of Western Hemisphere, gave
brief notes on their habitat, flight, food, stridulation,
mating and oviposition. He (1948b) further described the eggs
of Corixidae. Frost and Macan (1948) observed the importance
of Corixidae as food of fish. Banks (1949) studied the absorption
of water by the eggs of _Corixa punctata_. Sutton (1951) gave a
good account on the food and feeding mechanism of Corixidae.
Popham (1959) carried out experiments on the influence of
temperature and illumination on the phototactic response of
Corixidae. Hynes (1955) gave some biological notes on _Micro-
necta scutellaria_ Stål and _M. dimidiata_ Poisson. Poisson (1957)
briefly dealt with the biology of Corixidae. Wroblewski (1958)
presented data on larval development and ecology of _Micro-
necta_ species. Popham (1960) dealt with in detail the respiration
and tracheal system of Corixidae, and also discussed the
locomotion and mating habits of these bugs. Fernando (1961)
made observations on the phenomenon of flight at night among
the corixids and other aquatic bugs. Popham's (1961) note
referred to the function of the paleal legs of Corixids.
Crisp (1962), in his paper on the biology of *Corixa germari* (Fieb.) dealt with the nymphal instar, growth, sex ratio, copulation, oviposition and feeding.

**GENUS MICRONECTA** KIRKALDY.

Since the habitat, food and feeding and the mode of respiration of its different species are apparently similar, they will be discussed here.

*Micronecta* chooses a wide range of habitat although it prefers small bodies of water with muddy bottoms. Habitats frequented include ditches, fish hatcheries, nurseries, temporary and permanent ponds. It is most abundantly found in the shallows of ponds, resting on the aquatic plants, stones or any other submerged object.

**FOOD AND FEEDING.**

It feeds mainly on the flocculent ooze deposited at the bottom of the pond. The fore legs, with their tarsi well-flattened and fringed with bristles, are well-adapted for gathering the ooze which is swept in through the beak by the scooping movements of the fore legs. The ingested ooze can be seen in the alimentary canal through the transparent body. The adults of *Micronecta scutellaris scutellaris* (Stål) occasionally attack
the copepods, cladocerans, tiny mosquito larvae and chironomid pupae. The prey is captured by the fore legs and the contents sucked out.

**PREDATORS AND PARASITES**

Other carnivorous bugs, *viz.*, *Anisops*, *Ranatra*, *Laccotrephes*, *Diplonychus*, and dragonfly nymphs are its fierce predators. Adults of *Micronecta* are often infested by the larval hydraclid mites (Photo.19). These parasites are globular in shape with their sharp beaks piercing the host's body. However, no mites were found on the immature stages of *Micronecta*.

**RESPIRATION**

Generally, *Micronecta* remains at the bottom, holding fast submerged objects by the long middle legs furnished with long claws. It swims in a quick darting manner by its oar-like hind legs fringed with fine hairs. At intervals, *Micronecta* surfaces to breathe atmospheric air. The air is stored in a space beneath hemelytra and on the ventral surface of abdomen. Exchange of gases takes place by the momentary contact of the region between the head and pronotum with the atmospheric air. In the first and second nymphal instars the respiration is cutaneous and they were never observed to come to the surface to
breathe atmospheric air. The third, fourth and fifth instars like the adults visited the water surface to replenish air. In these instars the air is stored on the ventral surface of the abdomen, under the wing pads and on the lateral edges of the pterothorax.

An experiment was performed to find out the average interval between surface visits for *Micronecta scutellaris* (Stal) and *Micronecta quadrirstrigata* Horvath. It was determined by setting up two jars (30 x 20 cm.), about half filled with water, one containing four adults of *M. scutellaris scutellaris* and the other containing four adults of *M. quadrirstrigata*, together with the detritus at the bottom and a few twigs of aquatic plants. The total number of surface visits per 30-minute period for each species was counted and the observations showed (Table XV) that *M. scutellaris scutellaris* visited the surface more often than *M. quadrirstrigata*. 
### TABLE XV.

**NUMBER OF SURFACE VISITS PER HALF AN HOUR.**

<table>
<thead>
<tr>
<th>NO. OF EXPT.</th>
<th>SPECIES</th>
<th>M. scutellaris</th>
<th>M. quadristriata</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>9.6</strong></td>
<td><strong>3.4</strong></td>
</tr>
</tbody>
</table>
BIOLOGY OF MICRONECTA SCUTELLARIS SCUTELLARIS (STAL)

Micronecta scutellaris scutellaris is one of the commonest bugs found in the fish ponds. Extensive collecting for a period of two years has shown this to be the most abundant Micronecta in the fish ponds at Barrackpore, West Bengal. It has a preference for the shallows of the pond with muddy bottoms. During the monsoons, it is attracted towards light at night in large numbers. It can be easily distinguished by the large size, greyish-brown colour and somewhat obscured pronotal and hemelytral pattern.

SEX RATIO

In determining the sex ratio, 6470 and 25451 specimens were examined in 1963-64 and 1964-65 respectively. Tables XVI and XVII show the monthly sex ratio between the males and females. A glance at the tables would reveal that in most of the months there was a preponderance of the females. The data, where the number of the individuals was more than 40, were subjected to statistical treatment by means of 'Chi-square Test', under the hypothesis that a 1:1 ratio exists between the males and the females. The chi-square values in most of the cases were highly significant against this ratio and indicated that the population did normally have more females than
males in these months. Only in July, '64, the males were significantly more than the females.

COPULATION (Photo. 20)

There is some difference in the size of the sexes of this bug, the male being smaller than the female. The abdomen of the female is symmetrical, while in the male the abdominal segments are irregular. The strigil is present on the right side of the 6th abdominal segment in the male. Copulation usually takes place from April to September and is more prevalent from June to August. In mating, the male suddenly mounts the female and holds closely to her back, clasping her between the head and prothorax with his anterior legs. The copulatory organ of the male is long and curves around the side of tip of the female's body to come into contact with the female genital opening. They remain in copula for several minutes. Since, while joined in this way, they are unable to replenish their gas stores in the normal way (i.e. between the head and prothorax), the pair rolls over on one side and the exchange of gases takes place on the other side. During the breeding season, the male is quite often observed producing a chirping sound of 'trr - trr - trr', which could be listened in the laboratory from a distance of about four meters.
### Table XVI

**Sex Ratio of Micronecta Scutellaris Scutellaris (Stal)**

1962-64

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NUMBER OF SPECIMENS EXAMINED</th>
<th>SEX RATIO</th>
<th>Chi-square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb.'63</td>
<td>44</td>
<td>1 : 3</td>
<td>11.00</td>
<td>0.001</td>
</tr>
<tr>
<td>March</td>
<td>336</td>
<td>1 : 2.4</td>
<td>58.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>April</td>
<td>165</td>
<td>1 : 1.6</td>
<td>8.29</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>May</td>
<td>4974</td>
<td>1 : 1.3</td>
<td>105.96</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>June</td>
<td>95</td>
<td>1 : 1.2</td>
<td>0.54</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>July</td>
<td>304</td>
<td>1 : 2.7</td>
<td>66.35</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>* August</td>
<td>3</td>
<td>1 : 1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* Sept.</td>
<td>13</td>
<td>All females</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>* October</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>November</td>
<td>116</td>
<td>1 : 2</td>
<td>13.79</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>December</td>
<td>228</td>
<td>1 : 1.1</td>
<td>0.35</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>January’64</td>
<td>127</td>
<td>1 : 1.1</td>
<td>0.20</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

* Chi-square not applied due to inadequate data.
### TABLE - XVII

**SEX RATIO OF M. S. SCUTELLARIS (STAL)**

1964-65

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NUMBER OF SPECIMENS EXAMINED</th>
<th>SEX RATIO</th>
<th>Chi-square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male : Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February '64</td>
<td>1597</td>
<td>1 : 1.4</td>
<td>43.97</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>March</td>
<td>1248</td>
<td>1 : 1.5</td>
<td>58.41</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>April</td>
<td>106</td>
<td>1 : 1.5</td>
<td>3.77</td>
<td>0.05</td>
</tr>
<tr>
<td>May</td>
<td>1778</td>
<td>1 : 3.3</td>
<td>50.76</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>June</td>
<td>1410</td>
<td>1 : 1.6</td>
<td>69.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>July</td>
<td>4520</td>
<td>1 : 0.8</td>
<td>42.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>August</td>
<td>12458</td>
<td>1 : 1.1</td>
<td>10.99</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>September</td>
<td>246</td>
<td>1 : 2.2</td>
<td>32.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>October</td>
<td>278</td>
<td>1 : 2</td>
<td>31.78</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>November</td>
<td>286</td>
<td>1 : 2.4</td>
<td>47.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>December</td>
<td>1256</td>
<td>1 : 1.7</td>
<td>95.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>January '65</td>
<td>248</td>
<td>1 : 1.1</td>
<td>0.26</td>
<td>&gt;0.317</td>
</tr>
</tbody>
</table>

* Males are significantly more than females.
Photo. 19. *Micronecta scutellaris scutellaris* (Stal) in copula.

Photo. 20. Hydrachnid larva infesting *Micronecta scutellaris scutellaris* (Stal)
OVIPOSITION (Photo 21)

The oviposition takes place at night. The eggs are deposited singly on any available support in the water. They are found on the stems and leaves of a variety of aquatic plants, stones, sticks and molluscan shells. In the laboratory, they also laid eggs on the vertical sides of the glass jars in which they were reared. Each egg is firmly affixed to the substratum by a whitish translucent and mucilaginous substance.

LIFE-HISTORY

Under the laboratory conditions with water temperature ranging from 27.2°C - 28.9°C, Micronecta scutellaris scutellaris takes about 23 days to complete its life-history. Table XVIII shows the time taken by the eggs to hatch and the duration of each instar.

DESCRIPTION OF THE EGG AND NYMPH

EGG (Plate I, Fig. 51)

Size - Length: 0.52-0.55 mm. (mean: 0.53 mm.)
Width: 0.202-0.211 mm. (mean: 0.209 mm.)

Colour: Pearly-white when freshly laid, darkens to yellow as the embryo develops within.
### TABLE - XVIII

**INCUBATION PERIOD AND DURATION OF EACH INSTAR.**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>3.21 - 3.45</td>
<td>3.34</td>
</tr>
<tr>
<td>First instar</td>
<td>2.00 - 5.00</td>
<td>3.12</td>
</tr>
<tr>
<td>Second instar</td>
<td>2.00 - 5.00</td>
<td>2.86</td>
</tr>
<tr>
<td>Third instar</td>
<td>2.00 - 4.00</td>
<td>2.70</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>3.00 - 7.00</td>
<td>5.83</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>5.00 - 6.00</td>
<td>5.50</td>
</tr>
</tbody>
</table>

Total period of development = 23.35 days.
Shape and structure - Oval; affixed side almost straight and the opposite strongly curved. The egg shell is opaque and prevents observations on the internal developmental changes. It is finely granulated. The affixed surface is smooth and shining, while the non-adherent surface is strongly curved bearing a number of short filaments.

HATCHING

The opacity of the egg shell prevented observations on the internal development. On the third day of development a pair of crimson-coloured eyes, and a mass of large cells are visible inside the egg shell. Before hatching, the egg is light brownish in colour and slightly increases in length and width. Inside the chorion, the movements of the embryo can be seen. The egg shell breaks longitudinally and the nymph comes out with its head first followed by the thorax and the abdomen. The time required for emergence from the egg ranges from three to six minutes. The freshly emerged nymph is more or less translucent and white in colour. The eyes are red and the dorsal abdominal scent glands are light brown. As soon as the nymph emerges, it is capable of swimming rapidly. It begins feeding immediately on the detritus which can be seen in its digestive tract.
NYMPHAL INSTARS

First instar (Plate I, Fig. 52)

General body translucent and white; eyes red. Head about one and a half times as wide as the width of synthelipsis; eyes prominent and deeply pigmented; antennae 2-jointed, inserted far down towards the beak. Thorax slightly broader than the head. Wing pads absent. Middle legs long; all tarsi 1-jointed, long; hind tarsus sparsely bristled; intermediate claws curved, as long as tarsi. Abdomen transparent, with three pairs of scent glands in the middle of the third, fourth, and fifth abdominal segments; scent glands brownish in colour and visible through the transparent abdomen; abdominal segments indistinct; tip of the abdomen truncated.

Second instar

Colouration as in the previous instar. Head about twice as wide as the width of synthelipsis. Thorax a little broader than the head. Wing pads indistinct. First tarsus broad, fringed with moderately long, pale-yellow setae. Hind legs with femora slightly flattened. Abdomen as in the first instar.

Third instar

General colour and structure as in the previous instar. Wing pads noticeable, but not reaching the posterior margin of metathorax. First tarsus as broad as femur, fringed with long bristles; third tarsus with a narrow light brown band.
at its distal end. Abdomen distinctly segmented; abdominal scent glands dark brown.

Fourth instar  (Plate I, Fig. 53).

General surface of body ale-brown; eyes dark red; head with a faint brown line between the eyes. Antennae 2-segmented. Throax broader than head. Wing pads well-developed, extending to the posterior margin of the metathorax. All tarsi 1-jointed. First leg with femur about as long as tibia and tarsus together. Second leg with femur flattened, a little longer than the combined length of tibia and tarsus; tibia shorter than tarsus; claws two, long, about as long as tarsus. Third leg with femur two and a half times broader than tibia, tarsus one and a half times longer than tibia; tarsal band dark.

Fifth instar.  (Plate I, Fig. 54).

More pigmented and less transparent than the previous instar; posterior margins of head and thorax fuscous; eyes dark brown; head with three brown lines between the eyes; antennae white, 2-jointed; thorax and abdomen with smoky brown blotches; legs pale-yellow. Wing pads with outer margins pale-yellow, extending to the posterior
margin of the first abdominal segment. Legs as in the previous instar.

Table XIX gives the measurements of the nymphal instars and the adult.

MOULTING

A fifth instar nymph was observed beginning to moult. Before moulting, the nymph stops feeding and holds a support with the middle legs. Eyes, wing pads and tips of the metathoracic legs were dark. Abdomen was very much enlarged. In moulting, the anterior wing pads were raised up, head bent downwards, mesothoracic legs moved back and forth and a slit appeared on the head between the eyes which extended behind to the metathorax. The head comes out first followed by the thorax, legs and abdomen. It is not uncommon to find dead nymphs while in the process of moulting. The whole process took about thirty minutes. The newly moulted imago was quite active and started swimming immediately. It is greenish-white in colour with the elytra greenish-grey and a median pink line between the eyes and the legs pale. Wings were unexpanded.
<table>
<thead>
<tr>
<th></th>
<th>HEAD WIDTH</th>
<th>SYNTH. WIDTH</th>
<th>BODY LENGTH</th>
<th>BODY WIDTH</th>
<th>ABOMEN WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>First instar</td>
<td>0.28-0.33</td>
<td>0.31</td>
<td>.16-.22</td>
<td>.19</td>
<td>.79-.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.30-.38</td>
<td>.34</td>
<td>.32-.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second instar</td>
<td>.39-.44</td>
<td>.42</td>
<td>.19-.25</td>
<td>.21</td>
<td>.06-.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.06</td>
<td>.109</td>
<td>.42-.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.47</td>
<td></td>
<td>.52-.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third instar</td>
<td>.56-.60</td>
<td>.59</td>
<td>.29-.33</td>
<td>.31</td>
<td>.44-.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-1.56</td>
<td>1.51</td>
<td>.65-.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.70</td>
<td></td>
<td>.79-.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth instar</td>
<td>.76-.85</td>
<td>.81</td>
<td>.33-.43</td>
<td>.38</td>
<td>2.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-2.22</td>
<td>2.16</td>
<td>.87-1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>.97</td>
<td></td>
<td>1.09-1.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth instar</td>
<td>1.04-1.11</td>
<td>1.07</td>
<td>.42-.48</td>
<td>.46</td>
<td>.78-3.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.92</td>
<td>1.26-1.39</td>
<td>1.38-1.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.59</td>
<td></td>
<td>1.49</td>
</tr>
<tr>
<td>Adult</td>
<td>1.13-1.26</td>
<td>1.19</td>
<td>.47-.56</td>
<td>.52</td>
<td>.48-3.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.61</td>
<td>1.13-1.26</td>
<td>1.52-1.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GROWTH (Figs. 38, 39, 40).

The relationships between the number of instar and head width as well as body width and body length are linear in the semi-logarithmic forms, which can be expressed as:

1. **Number of instar and head width.**
   
   \[ \text{Log } Hw = -0.6445 + 0.1363 \text{ n} \]
   
   (Coefficient of correlation, \( r = 0.9898 \))

2. **Number of instar and body width.**
   
   \[ \text{Log } Bw = -0.6192 + 0.1502 \text{ n} \]
   
   (\( r = 0.9848 \))

3. **Number of instar and body length.**
   
   \[ \text{Log } Bl = -0.2417 + 0.1418 \text{ n} \]
   
   (\( r = 0.9983 \))

Where, \( Hw = \text{Head width} \); \( Bw = \text{Body width} \);

\( Bl = \text{Body length} \); \( n = \text{Number of instar} \).

The high values of \( r \) show a high level of significance of correlation.
Fig. 38. Relationship between number of instar and head width of *Micronecta scutellaris scutellaris* (Stal)

Fig. 39. Relationship between number of instar and body width of *Micronecta scutellaris scutellaris* (Stal)

Fig. 40. Relationship between number of instar and body length of *Micronecta scutellaris scutellaris* (Stal)
MICRONECTA SCUTELLARIS SCUTELLARIS

FIG. 40

LOG BODY LENGTH IN MM.

NUMBER OF INSTAR
It can be easily recognised by its hemelytra olivaceous-brown with scattered black spots. *Micronecta haliploides* is most commonly found among the submerged vegetation and on the bottom in the shallows of the ponds. It was collected in large numbers from a fish pond full of *Hydrilla* and *Vallisneria* near Neelganz, W. Bengal.

It feeds on the algae and the detritus material deposited at the bottom of the pond. Unlike *Micronecta scutellaris scutellaris*, it was never observed feeding upon the tiny mosquito larvae and chironomid pupae. The ovipository habits and the structure of the egg are quite different from that of *Micronecta scutellaris scutellaris*.

OVIPosition (Photos, 22, 23; Plate I, Fig. 51).

The female lays eggs in batches fastened to the support by an abundance of transparent gelatinous material. The eggs are deposited on the upper or lower surface of the leaves of *Hydrilla verticillata* and *Vallisneria spiralis*. In the laboratory, however, it also laid eggs on the bottom and sides of the glass jars. The number of eggs per batch varies from five to fourteen.

Photo 22. Eggs of *Micromecta haliploides* Horváth *in situ*.
Photo. 23. Eggs of *Micronecta holiploides* showing the development of eyes.
LIFE-HISTORY

Under the laboratory conditions with water temperature ranging from 26.4°C - 32.8°C, Micronecta helioleides takes about 19 days to complete its life-history. Table XX shows the incubation period and the duration of each instar.

DESCRIPTION OF DIFFERENT STAGES

EGG - (Plate I, Fig. 51)

Size - Length : 0.46-0.51 mm. (mean: 0.49 mm.)
Width : 0.19-0.21 mm. (mean: 0.20 mm.)
Colour: Pearly-white, changing to yellow before hatching.

Shape and structure - Oval; affixed side almost straight and the non-adherent side slightly curved. The egg shell is transparent, shining and smooth. The filaments present on the eggs of Micronecta scutellaris are lacking.

HATCHING

On the second day of development, eyes can be seen in the form of tiny crimson-coloured spots. The embryo is fully differentiated into head, thorax and abdomen on the third day. Before hatching the egg is yellowish in colour, embryo is completely developed with its ventral side upwards and shows movements of the legs and abdomen. The egg shell splits longitudinally on the cephalic end and the nymph wriggles
# Table XX

**Incubation Period and the Duration of Each Instar**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Range (in days)</th>
<th>Average (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>-</td>
<td>4.00</td>
</tr>
<tr>
<td>First instar</td>
<td>-</td>
<td>3.00</td>
</tr>
<tr>
<td>Second instar</td>
<td>2.00-3.00</td>
<td>2.80</td>
</tr>
<tr>
<td>Third instar</td>
<td>-</td>
<td>1.00</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>-</td>
<td>3.00</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>-</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Total period of development = 18.80 days.
out with its head first followed by the rest of the body. The time taken in hatching varies from two to five minutes and all the eggs of a batch hatch out within one hour after the first one has hatched out. The newly emerged nymph is transparent with reddish eyes.

**NYMPHAL INSTARS**

**First instar** (Plate I, Fig.56)

General body white and transparent; eyes red; abdominal scent glands brownish. Head narrower than thorax; antennae 2-jointed. Wing pads absent. Tarsi all 1-jointed. Middle leg with claws well-developed. Abdomen truncate, segmentation obscure; segments 3-7 furnished with small setae on the margins. Abdominal scent glands well-developed, third one smaller than the first two.

**Second instar**

General colour and form of body as in the previous instar. Wing pads indistinct. First tarsus broadened bearing a few setae. Middle leg with femur twice as long as tibia and claws a little shorter than tarsi; hind leg with femur broader than tibia but subequal in length, tarsus one and a half times the length of tibia.

**Third instar**

Colour yellowish-white; eyes dark brown; pronotum smoky
brown; scent glands narrow and light brown. General structure as in the previous instars. Wing pads rudimentary. Tarsi 1-jointed. Middle leg pale, tarsus a little longer than tibia. Hind legs with the outer margins of tibia and tarsus light brown.

**Fourth instar** (Plate I, Fig. 57)

Head yellowish, raised in the middle and with a longitudinal ashy-coloured band and three ashy-coloured spots in front of each eye; eyes dark brown. Prothorax, inner margins of mesothorax and dorsal margins of wing pads ashy. Abdominal scent glands dark brown; abdominal segments with their posterior margins dark. Anterior wing pads well-developed, but not reaching beyond the posterior margin of metathorax. Middle legs transparent with anterior margins of femora dark; claws long and equal. Hind legs with margins of femur, tibia, tarsus and claws dark.

**Fifth instar** (Plate I, Fig. 58)

General colour yellow; eyes dark; head light brown, posteriorly with a pale line in the middle; three dark spots in front of each eye; posterior margin of pronotum, mesonotum, metanotum and wing pads smoky brown; abdomen with irregular blotches; scent glands dark brown. Wing pads well-developed extending beyond metanotum. First tarsus
broadened into palea, bearing long setae. Second femur a little longer than tibia and tarsus together; tarsus longer than tibia and twice the length of the claws. Third leg with femur flattened; tarsus long and one and a half times the length of tibia, fringed with long setae; claws dark.

Table XXI indicates the measurements of the nymphs and adult.

GROWTH (Figs. 41, 42, 43)

The relationships plotted in the semi-logarithmic form between the number of instar and head width, body width and body length are linear. The high values of the coefficient of correlation indicate a high level of significance of correlation. The relationships can be expressed as -

1. **Number of instar and head width**
   
   \[ \log Hw = -0.6930 + 0.1308 n \]
   
   \[ (r = 0.9937) \]

2. **Number of instar and body width**
   
   \[ \log Bw = -0.6551 + 0.1458 n \]
   
   \[ (r = 0.9832) \]

3. **Number of instar and body length**
   
   \[ \log Bl = -0.2939 + 0.1228 n \]
   
   \[ (r = 0.9982) \]
Fig. 41. Relationship between number of instar and head width of *Micronecta haliploides* Horvath.

Fig. 42. Relationship between number of instar and body width of *Micronecta haliploides* Horvath.

Fig. 43. Relationship between number of instar and body length of *Micronecta haliploides* Horvath.
MICROPECTA HALIPOIDES

**Fig. 41**

Log head width in mm. vs. number of instar.
FIG. 42

NUMBER OF INSTAR

FIG. 43

LOG BODY LENGTH IN MM.

MICRONECITA HALIPOI'DES

LOG BODY WIDTH IN MM.
### TABLE XXI

MEASUREMENTS OF NYMPHS AND ADULT IN MILLIMETRES.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>HEAD WIDTH</th>
<th>SYNTH WIDTH</th>
<th>BODY LENGTH</th>
<th>BODY WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>First instar</td>
<td>0.25-0.29</td>
<td>0.27</td>
<td>0.15-0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Second instar</td>
<td>0.35-0.38</td>
<td>0.37</td>
<td>0.21-0.24</td>
<td>0.22</td>
</tr>
<tr>
<td>Third instar</td>
<td>0.42-0.55</td>
<td>0.51</td>
<td>0.23-0.30</td>
<td>0.26</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>0.65-0.72</td>
<td>0.69</td>
<td>0.31-0.38</td>
<td>0.35</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>0.83-0.92</td>
<td>0.89</td>
<td>0.39-0.52</td>
<td>0.46</td>
</tr>
<tr>
<td>Adult</td>
<td>0.89-1.00</td>
<td>0.92</td>
<td>0.39-0.49</td>
<td>0.46</td>
</tr>
</tbody>
</table>
Fig. 44. Ventral view of the abdomen of fifth nymphal instar of *Ranatra filiformis* (Fabricius).

Fig. 45. Egg of *Ranatra filiformis* (Fabricius), dorsal view.

Fig. 46. Fore leg of first nymphal instar of *R. filiformis* (Fab.).

Fig. 47. Egg of *R. elongata* Fab., dorsal view.

Fig. 48. Fore leg of first nymphal instar of *R. elongata* Fab.

Fig. 49. Egg of *R. digitata* Hafiz and Pradhan.

Fig. 50. Egg of *Diplonychus rusticum* (Fab.).

Fig. 51. Egg-shell of *Micronecta scutellaris scutellaris* (Stål).

Fig. 52. First nymphal instar of *M. scutellaris scutellaris* (Stål).

Fig. 53. Fourth nymphal instar of *M. scutellaris scutellaris* (Stål).

Fig. 54. Fifth nymphal instar of *M. scutellaris scutellaris* (Stål).

Fig. 55. Eggs of *M. haliploides* Horvath laid on a leaf of aquatic plant.

Fig. 56. First nymphal instar of *M. haliploides* Horvath.

Fig. 57. Fourth nymphal instar of *M. Haliploides* Horvath.

Fig. 58. Fifth nymphal instar of *M. haliploides* Horvath.
PLATE II

Fig. 59. Cephalic end of the egg of *Ranatra elongata* Fab. showing hexagonal markings.

Fig. 60. Egg-shell of *Ranatra filiformis* (Fab.) showing punctate tubercles.

Fig. 61. First nymphal instar of *R. filiformis* (Fab.).

Fig. 62. Head of *R. filiformis* (Fabr.), lateral view.

Fig. 63. Head of *R. elongata* Fabr., lateral view.

Fig. 64. Antenna, second nymphal instar of *R. elongata* Fabr.

Fig. 65. Antenna, third nymphal instar of *R. elongata* Fabr.

Fig. 66. Antenna, fourth nymphal instar of *R. elongata* Fabr.

Fig. 67. Antenna, fifth nymphal instar of *R. elongata* Fabr.

Fig. 68. Antenna, second nymphal instar of Laccotrephes *griseus*.

Fig. 69. Antenna, third nymphal instar of L. *griseus*.

Fig. 70. Antenna, fourth nymphal instar of L. *griseus*.

Fig. 71. Antenna, fifth nymphal instar of L. *griseus*.

Fig. 72. L. *griseus*, fifth nymphal instar, ventral view.

Fig. 73. L. *griseus*, first nymphal instar.

Fig. 74. L. *griseus*, second nymphal instar.

Fig. 75. L. *griseus*, third nymphal instar.

Fig. 76. L. *griseus*, fourth nymphal instar.

Fig. 77. L. *griseus*, fifth nymphal instar.

Fig. 78. Hydrachnid larva.

Fig. 79. Hydrachnid larva.
FAMILY NOTONECTIDAE

The members of this family are commonly known as the 'backswimmers' due to the habit of swimming on their backs, a character by which they are easily recognised in the field. The other distinguishing characters are, - antenna 4-jointed; rostrum 4-segmented; hind legs long, flattened and densely fringed with fine hairs. Examples of Nychia (N. marshalli (Scott)) and Anisops (A. bouvieri Kirkaldy and A. waltairensis Brooks) were taken up for biological studies.

REVIEW OF LITERATURE

Esseenbery (1915) gave an account on the egg-laying, phototactic habits and natural history of the 'backswimmers'. Bueno (1916) discussed the mode of respiration in notonectids. Hungerford (1917, 1918 and 1919) in a series of papers added greatly to our knowledge on the oviposition, feeding habits and parasitism of these bugs. He (1922) observed the presence of oxyhaemoglobin in Bueno margaritacea Bueno. Hale (1923) gave a detailed account of the biology of Anisops hyperion Kirkaldy in his studies on Australian aquatic hemiptera. Bare (1926) tracing the life-histories of some Kansas 'backswimmers'. Poisson's (1926) account on Anisops producta Fieber related to its flight, food, oviposition, development and parasites. The seasonal distribution and life-history of Montonecta undulata Say was studied by Clark (1928). He
reared _Eustrichia aquatic_ Lubbock (a hemipteron egg-parasite) from its eggs. In a revision of Notonectidae and Corixidae, Hutchinson (1929) gave a brief account on the egg and nymphs of _Nychia limoida_ (Stål). Rice (1954) observed the biology of ten notonectid species. DeAbate (1960) studied the food and feeding, oviposition and growth of the 'backswimmers. In his observations on the respiration of aquatic hemiptera, Popham (1960) dealt with the evolution of the notonectid type from the generalized one. Leong (1962) traced out the life-history of _Anisos breddini_ Kirkaldy and discussed the effect of temperature on the development. Gorai (1963) and Gorai and Raychavdhary (1963) discussed briefly the oviposition and food feeding habits of _Anisos bouvieri_ Kirkaldy. The hatching process in _Notonecta malaena_ Kirkaldy was studied by Davis (1964). Miller (1964) published a note on the function of haemoglobin in _Anisos_. Julka (1965) studied the food-feeding, copulation, oviposition, fecundity, certain aspects of behaviour during hatching and moulting and growth of _Anisos bouvieri_ Kirkaldy. McPherson (1965) gave notes on the life-history of _Notonecta hoffmanni_ Hungerford.

**Biology of _Nychia marshalli_ (Scott)**

_Nychia marshalli_ (Scott) has a wide range of distribution and has been recorded from Africa, Australia, Burma, China
and Ceylon. *Nychia limicola* (Stål) described by Hutchinson (1929) is a synonym of *Nychia marshalli* (Scott) (Potting, 1957). It can be recognised by its transverse pronotum and holoptic eyes, which if seen from the side are Z-shaped. The first two pairs of legs are prehensile and third ones are long and fringed.

*Nychia marshalli* inhabits both temporary and permanent ponds. It is generally found swimming on its back with the abdominal tip touching the water surface. At times, it clings to the submerged shoots of aquatic plants or any other support available in the water. The air is stored in a space below the hemelytra and on the ventral surface of the abdomen, guarded by long hydrofuge hairs.

**FOOD AND FEEDING.**

*Nychia marshalli* is a predator and responds immediately to the floundering insect that has fallen into the water or to the dissecting needle touching the water surface. It preys upon the planktonic crustaceans, mosquito and chironomid larvae. The prey is captured by the first and second pairs of legs, which are well-armed with spines and strong claws. The victim's body is pierced by the short rostrum and the juices sucked up.
The female lays eggs on the leaves or stems of aquatic plants, stones or any other available support in the water. In the laboratory, she also laid eggs on the bottom and walls of the glass jars. The eggs are laid singly and fastened to the support with a mucilaginous secretion without any regular pattern. In oviposition, she clings to the support and slightly raises up her body. By the backward and forward movements of the abdomen, an egg is deposited. The egg-laying takes from 2-3 minutes.

LIFE-HISTORY.

Under laboratory conditions with the temperature ranging from 27.7°C - 35.0°C, *Nychia marshalli* takes about 33 days to complete its life-history. The nymph after hatching casts off its skin five times to reach the imago stage. Table XXII gives the incubation period and duration of each instar.
## TABLE - XXII

INCUBATION PERIOD AND THE DURATION OF EACH INSTAR

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>7.0 - 9.0</td>
<td>8.26</td>
</tr>
<tr>
<td>First instar</td>
<td>3.0 - 5.0</td>
<td>4.00</td>
</tr>
<tr>
<td>Second instar</td>
<td>2.0 - 4.0</td>
<td>3.37</td>
</tr>
<tr>
<td>Third instar</td>
<td>2.0 - 4.0</td>
<td>3.20</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>7.0 - 7.0</td>
<td>7.00</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>7.0 - 8.0</td>
<td>7.20</td>
</tr>
</tbody>
</table>

Total period of development = 33.06 days.
DESCRIPTION OF DIFFERENT STAGES.

Egg (Photo. 24)

Size - Length: 0.85-0.97 mm. (mean: 0.9 mm.)
Width: 0.35-0.39 mm. (mean: 0.36 mm.)

Colour - White when freshly laid, changing to light brown before hatching.

Shape and Structure - Oval; if seen from side, the lower affixed surface is almost straight and the upper one is strongly curved. The egg shell is finely granulated and presents a pattern of hexagonal markings. The nymph emerges through a longitudinal slit on the upper side.

NYPHAL INSTARS.

First instar. (Plate III, Figs. 84, 85).

General colour light brown; eyes dark brown; legs pale with coxae brownish. Head broader than pronotum; eyes not holoptic, if viewed from side, comma-shaped. Wing pads absent. Hind legs sparsely fringed on the tarsi.

Second instar.

Colour as in the previous instar; rostrum dark brown. Eyes not holoptic. Wing pads indistinct. Hind legs with tarsi more densely fringed.
Third instar.

Colour and structure as the previous instars. Eyes still not holoptic. Wing pads rudimentary.

Fourth instar.

Colour brown. Eyes still comma-shaped from the sides and not holoptic. Wing pads well-developed, but do not extend up to posterior margin of metanotum.

Fifth instar.

Colour brown; eyes and rostrum dark; ventral margin of wing pads dark brown. Eyes holoptic, slightly E-shaped from the sides. Wing pads well-developed and extend up to the posterior margin of metanotum. Hind legs with apex of tibia and tarsus densely fringed.

Table XXIII gives the measurements of the nymphs and imago.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>BODY LENGTH</th>
<th>BODY WIDTH</th>
<th>HEAD WIDTH</th>
<th>SYNF. WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>First instar</td>
<td>1.09-1.22</td>
<td>1.12</td>
<td>0.35-0.43</td>
<td>0.39</td>
</tr>
<tr>
<td>Second instar</td>
<td>1.43-1.56</td>
<td>1.50</td>
<td>0.48-0.54</td>
<td>0.50</td>
</tr>
<tr>
<td>Third instar</td>
<td>1.51-1.96</td>
<td>1.79</td>
<td>0.56-0.65</td>
<td>0.60</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>2.35-2.61</td>
<td>2.48</td>
<td>0.74-0.83</td>
<td>0.77</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>3.04-3.65</td>
<td>3.31</td>
<td>0.78-1.09</td>
<td>0.96</td>
</tr>
<tr>
<td>Adult</td>
<td>3.91-5.17</td>
<td>4.65</td>
<td>0.91-1.22</td>
<td>1.12</td>
</tr>
</tbody>
</table>
The relationships between the number of instar and head width, body width, body length and length of hind leg are ascertained. These relationships which are linear in the semi-logarithmic form can be expressed by the following equations:

1. **Number of instar and head width**
   \[
   \log Hw = -0.5051 + 0.0826 n \\
   (r = 0.9749)
   \]

2. **Number of instar and body width**
   \[
   \log Bw = -0.5028 + 0.0975 n \\
   (r = 0.9988)
   \]

3. **Number of instar and body length**
   \[
   \log Bl = -0.0657 + 0.1154 n \\
   (r = 0.9111)
   \]

4. **Number of instar and length of hind leg**
   \[
   \log Hl = 0.0390 + 0.1229 n \\
   (r = 0.9822)
   \]

The high values of \( r \) indicate the high level of significance of the correlations.

Where, \( Hw = \) Head width; \( Bw = \) Body width; \( Bl = \) Body length; \( Hl = \) Length of hind leg; \( n = \) Number of instar.
Fig. 80. Relationship between number of instar and head width of *Nychma marshalli* (Scott).

Fig. 81. Relationship between number of instar and body width of *Nychia marshalli* (Scott).

Fig. 82. Relationship between number of instar and body length of *Nychia marshalli* (Scott).

Fig. 83. Relationship between number of instar and hind leg length of *Nychia marshalli* (Scott).
A detailed account on the biology of this species has been published by the candidate in the *Proc. Indian Acad. Sci.*, Vol. LXI, 1965 (reprint appended). In this paper, observations on food-feeding, copulation, oviposition, fecundity, life-history and growth were dealt with. The following account relates to the additional notes on the biology of this species, which were not included in the paper.

*A. bouvieri* is most commonly found swimming in the ditches, temporary and permanent ponds. It is also attracted towards light at night. It swims on its back with the help of long oar-like hind legs and at intervals surfaces to change the gas stores. The air is stored in a space beneath the hemelytra and on the ventral abdominal surface, guarded by long hydrofuge hairs.

**PARASITISM** (Plate III, Figs. 89, 90, 91 & 92).

Parasitism by the hymenopterous egg-parasites has been observed in few cases of aquatic insects. Ganin (1869) bred these parasites from the odonate eggs. Enock (1898, 1900) reared *Prestwichia aquatica* Lubbock from the eggs of *Notonecta* sp., *Dytiscus marginalis* L. and *Ranatra* sp. Brocher (1910) recorded hymenopterous parasites from the eggs of semi-aquatic and aquatic bugs and dragonflies. Ussing (1910) found *Prestwichia aquatica* from the eggs of *Aphelocheirus montandoni*. Matheson and Crosby (1912) recorded *Caraphractus cinctus* from the eggs of *Notonecta*. Ruschka and Thiemann (1913) and Kosakov (1916) obtained a number of hymenopterous parasites from the odonate eggs. Henrikson (1922) reviewed the work on the parasites and carried out investigations on their biology. Clark (1926) reared *Prestwichia aquatica* from
the eggs of Notonecta undulata Say. Recently Jackson (1956, 1958a, 1958b and 1961) dealt with in detail the biology of the hymenopterous egg-parasites and bred them in the eggs of different species of beetles.

During the present investigations, a number of eggs of Anisops bouvieri Kirkaldy collected in August 1964 from a temporary pond near Central Inland Fisheries Research Institute, Barrackpore were infested with a hymenopterous egg-parasite, Prestwichia sp. (Family Trichogrammatidae). A microscopic examination of these eggs showed that some of them were having holes in the egg shell through which the parasites had escaped. Such eggs were rejected for the determination of the number of parasites per host egg. Fifty parasitized eggs were dissected and the number of parasites in each egg were counted. Table XXIV gives the number of parasites per egg. The maximum number of parasites recorded from a single egg were 4, but majority of them contained only 2 parasites.

**TABLE - XXIV**

<table>
<thead>
<tr>
<th>Number of host eggs</th>
<th>Number of parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
Photo. 24. Eggs of *Nychia marshalli* (Scott) *in situ*.

Photo. 25. Temporary pond near central Inland Fisheries Research Institute, Barrackpore from where *Prestychia* sp. was collected.

Photo 27. *Prestwichia* sp. parasitizing the egg of *Knisops bouvieri*. 
In the laboratory the freshly laid eggs of *Anisops bouvieri*, deposited in the stems of aquatic plants, were exposed to the attacks of the female parasite. She walks over the plant twigs, touching them with their antennae until the egg is located. She raises up her body on the legs and the needle-shaped ovipositor is thrust into the host egg. While ovipositing, she quivers and scratches the plant tissue with her legs. The whole process of egg-laying takes from 4-6 minutes. The parasite takes about 11 days to complete its life-history with the temperature ranging from 26.6°C and 32.2°C. The adult emerges by biting a hole through the egg shell and plant tissue.

It is noteworthy to mention that the genus *Prestwichia* Lubbock is the first record from India and the eggs of *Anisops bouvieri kirkaldy*. The identification of these parasites belonging to the genus *Prestwichia* Lubbock have been confirmed by Dr. D.S. Hill of Commonwealth Institute of Entomology (personal communication).

**SEX RATIO**

The male can be distinguished from the female by the fore tarsi 1-segmented and by the presence of an acuminate cephalic projection between the eyes (Plate III, Figs. 86, 87) and a comb at the base of the fore tibia on the inner surface.
A total of 715 and 748 specimens were examined to determine the sex ratio. Tables XXV and XXVI give the sex ratio and the chi-square values. The 'chi-square test' has been applied to the samples of only those months, where the total number of specimens collected exceeded 40, as the other samples are not adequate for the statistical treatment. Tables XXV and XXVI indicate a preponderance of the females in most of the months except in December, '63 and March '64. The chi-square values are highly significant only in a few cases against the ratio 1:1 of the males and the females.
**TABLE - IXV**

**SEX RATIO OF ANTOPO COLUMBIAE IRIKALOV**

(1963-64)

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NUMBER OF SPECIMENS EXAMINED</th>
<th>SEX RATIO Male : Female</th>
<th>Chi-square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Feb. '63</td>
<td>4</td>
<td>1 : 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* March</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* April</td>
<td>6</td>
<td>1 : 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>66</td>
<td>1:12.2</td>
<td>47.51</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>* June</td>
<td>10</td>
<td>1 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>110</td>
<td>1 : 7.5</td>
<td>64.14</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>August</td>
<td>185</td>
<td>1 : 1.1</td>
<td>0.65</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Sept.</td>
<td>172</td>
<td>1 : 1.2</td>
<td>1.14</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Oct.</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td>102</td>
<td>1 : 2.9</td>
<td>26.47</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>* Dec.</td>
<td>37</td>
<td>1 : 0.7</td>
<td>1.32</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>* Jan. '64</td>
<td>23</td>
<td>1 : 4.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Chi-square not applied due to inadequate data.
TABLE - XXVI

SEX RATIO OF "SOUVIERI" KIRKALDY.
(1964-65)

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NO. OF SPECIMENS EXAMINED</th>
<th>SEX RATIO</th>
<th>CHI-SQUARE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male : Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chi-square</td>
<td>P</td>
</tr>
<tr>
<td>Feb.'64</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>11</td>
<td>1 : 0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>208</td>
<td>1 : 7.7</td>
<td>103.85</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>June</td>
<td>430</td>
<td>1 : 4.7</td>
<td>179.73</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>July</td>
<td>28</td>
<td>1 : 6</td>
<td>14.28</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>August</td>
<td>44</td>
<td>1 : 2.7</td>
<td>3.09</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>September</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>4</td>
<td>0 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>23</td>
<td>1 : 1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January '65</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Chi-square not applied due to inadequate data.
Anisops waltairensis Brooks is quite abundant in the ponds. It is generally found swimming on its back, using hind legs as the oars, near the littoral region. At times, it comes to surface to breathe and exchange gases. Like others of its kind, *A. waltairensis* is a fierce predator. The first two pairs of legs are prehensile and well-armed with spines and claws for capturing the prey. In the laboratory, it preyed upon mosquito larvae and planktonic crustaceans. It is less infested/larval water mites than *Anisops bouvieri*. Kirkaldy and the hymenopterous egg-parasite was not recorded from its eggs.

**SEX RATIO**

Tables XXVII and XXVIII show a preponderance of the females in most of the months. Only in February '63, the males were significantly more than females at less than 5% level, while the females were significantly more than males in May, September, November of 1963 and January, May, June and August of 1964.
OVIPOSITION

The eggs are inserted singly into the leaves or stems of aquatic plants. The female frequently explores the plant tissue with the tip of her beak and if the spot is unsuitable she moves away to find some other suitable place. In egg-laying, the female clings to a plant twig with her first two pairs of legs and a slit is cut by the backward and forward movements of her toothed ovipositor. The egg is fully embedded into the plant tissue except about 1/3rd of its upper surface.

LIFE-HISTORY

Under laboratory conditions with the temperature ranging from 26°C to 33°C, Anisops waltairensis takes about 27 days to complete its life-history. There are five nymphal instars. Table XXIX shows the incubation period and duration of each instar.
TABLE - XXVII

SEX RATIO OF ANISOPS WALTHERNSIS BROOKS
(1963-64)

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NO. OF SPECIMENS EXAMINED</th>
<th>SEX RATIO</th>
<th>Chi-square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male : Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February '63</td>
<td>72</td>
<td>1 : 0.6</td>
<td>5.55</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>March</td>
<td>41</td>
<td>1 : 0.9</td>
<td>0.024</td>
<td>&gt;0.07</td>
</tr>
<tr>
<td>* April</td>
<td>29</td>
<td>1 : 1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>112</td>
<td>1 : 2.6</td>
<td>22.32</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>* June</td>
<td>10</td>
<td>1 : 2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* July</td>
<td>14</td>
<td>1 : 3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* August</td>
<td>34</td>
<td>1 : 0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>195</td>
<td>1 : 1.5</td>
<td>7.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>October</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>97</td>
<td>1 : 3.6</td>
<td>31.18</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>December</td>
<td>85</td>
<td>1 : 1.4</td>
<td>1.99</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>January '64</td>
<td>206</td>
<td>1 : 6.6</td>
<td>112.15</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Chi-square not applied due to inadequate data.

# Males more than females.
TABLE - XXVIII

SEX RATIO OF A. WALTAIRENSIS BROOKS (1964-65)

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NO. OF SPECIMENS EXAMINED</th>
<th>SEX RATIO</th>
<th>Chi-square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb. '64</td>
<td>54</td>
<td>≠</td>
<td>1 : 0.8</td>
<td>0.67</td>
</tr>
<tr>
<td>March</td>
<td>39</td>
<td>1 : 1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>21</td>
<td>1 : 1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>60</td>
<td>1 : 9</td>
<td>38.40</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>June</td>
<td>152</td>
<td>1 : 5.3</td>
<td>71.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>July</td>
<td>20</td>
<td>1 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>46</td>
<td>1 : 2</td>
<td>5.56</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>September</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>4</td>
<td>0 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>2</td>
<td>≠</td>
<td>2 : 0</td>
<td></td>
</tr>
<tr>
<td>January '65</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* Chi-square not applied due to inadequate data
≠ Males more than females.
TABLE - XXIX

INCUBATION PERIOD AND THE DURATION OF EACH INSTAR

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>5.00 - 9.00</td>
<td>6.11</td>
</tr>
<tr>
<td>First instar</td>
<td>3.00 - 4.75</td>
<td>3.80</td>
</tr>
<tr>
<td>Second instar</td>
<td>3.00 - 3.79</td>
<td>3.45</td>
</tr>
<tr>
<td>Third instar</td>
<td>3.00 - 4.00</td>
<td>3.50</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>4.00 - 5.00</td>
<td>4.33</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>5.00 - 6-50</td>
<td>5.90</td>
</tr>
</tbody>
</table>

Total period of development = 27.09 days.
DESCRIPTION OF EGG

SIZE - Length: 1.04 - 1.25 mm (mean: 1.12 mm) 
Width: 0.35 - 0.37 mm (mean: 0.36 mm)

Colour - White, changing to light brown before hatching.

Shape and Structure - The shape and structure of the egg is oval, similar to that of A. bouvieri if viewed from side, upper surface is less curved than lower side. An oval-shaped operculum is present on the upper surface, extending from the cephalic end to the middle of the egg. Under the microscope, the operculum shows a pattern of hexagonal reticulations, the nymph emerges by pushing away the operculum. The egg shell is shiny and finely granulated.
FAMILY PLEIDAE

The members of this family can be recognised by their small, stout and punctate body, strongly convex dorsally; rostrum short and 3-jointed; hemetyltra coriaceous and strongly decurved behind. Hind legs not markedly flattened, but moderately more hairy than the other two pairs. Like the notonectids, these 'pygmy backswimmers' also swim on their backs.

REVIEW OF LITERATURE

This is the most neglected family of the aquatic bugs and the published work on their biology is very meagre. There is no complete published account on the life-histories of Indian species. Wefelscheid (1912) gave a detailed account on the hibernation, copulation, oviposition, larval development and longevity of *Plea minutissima* Leach. Hungerford (1919) published biological notes and structure of the egg of *Plea striola* Fieber. Bare (1926) observed the food and feeding, copulation, oviposition, incubation and nymphal development of *Plea striola*. Rice (1942), in her notes on the biology of notonectids, dealt with the food, incubation period, structure of the egg and nymphs of *Plea striola*. Ellis (1962) gave brief ecological notes on this species. Wilson (1963) published a brief review on the biological studies of Pleidae. Ellis (1965) gave an unusual habitat for *Plea striola*.
BIOLOGY OF PLEA FRONTALIS (FISHER).

Plea frontalis occurs in large numbers among the aquatic vegetation near the littoral region of both temporary and permanent ponds. During the night it is attracted towards light. It swims on its back by the quick movements of its hind legs and at intervals rises to the surface for the exchange of gases. The air is stored on the ventral side of the abdomen and between the coxae, held in position by very fine hydrofuge hairs. It is also capable of crawling on the stems of the aquatic plants and the bottom of the aquarium.

When handled, it secretes a milky fluid from the sides of the thorax and coxal joints.

PREDATORS AND PARASITES.

Plea frontalis enjoys immunity from the other bigger insect predators like Renatra, Laccotreches, Diplonychus and Anisops, due to its small size and coriaceous body. Unlike other aquatic bugs, it is not infested by larval water mites.

The eggs of Plea frontalis, collected from one of the temporary ponds of the Central Inland Fisheries Research Institute, Barrackpore in August 1964, were dark in colour. A few of these were dissected and were found to be infested by
the hymenopterous egg-parasite, *Prestwichia* sp. (Family Trichogrammatidae). Each egg contained a single parasite. In the laboratory, the female parasite deposited eggs into the freshly laid eggs of *Plea frontalis*. The eggs of *Plea frontalis* are the new hosts for *Prestwichia* Lubbock.

**COPULATION**

Copulation takes place when the female is resting on an object. The male mounts from behind and clasps the female around her pronotum with his first and second pair of legs. He takes a position either to her left or right, the phallus is protruded and inserted into the female genital opening from the side. They remain in *copula* for five to eight minutes, surfacing at intervals to replenish the gas stores.

**OVIPOSITION**

The eggs are deposited singly in the stems and leaves of the aquatic plants. The female clings to the plant tissue with her first and second pair of legs. A slit is excavated by the backward and forward movements of her serrated ovipositor. When the cut is completed there is a pause and the white egg is deposited in the slit below. After this,
the bug moves off to oviposit at a new spot or surfaces
to renew its air supply. The whole process of egg-laying is
accomplished within 2 to 4 minutes. Sometimes the female
may cut a slit without ovipositing. The egg is completely
embedded in the plant tissue, leaving the operculum exposed.

LIFE-HISTORY

Under the laboratory conditions with the temperature
ranging from 26.6°C - 32.7°C, *Plea frontalis* takes about
38 days to complete its life-history. There are five
nymphal instars from the egg to the imago stage. Table
XXX gives the incubation period and the duration of each
instar.

DESCRIPTION OF DIFFERENT STAGES

**Egg** - (Plate III, Fig. 94)

**Size** - Length : 0.52 - 0.58 mm. (mean: 0.54 mm.)
Width : 0.48 - 0.52 mm. (mean: 0.50 mm.)

**Shape** - Oval; if viewed laterally, the lower
surface (embedded into the plant tissue)
is more curved than the upper one (exposed)

**Colour and structure** - Pearly white, changing to
yellow before hatching. The egg shell is
smooth and shiny.
### TABLE - XXX

**INCUBATION PERIOD AND THE DURATION OF EACH INSTAR.***

*PLEA FRONTALIS*

<table>
<thead>
<tr>
<th>STAGE</th>
<th>RANGE (in days)</th>
<th>AVERAGE (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>8.00 - 9.00</td>
<td>8.44</td>
</tr>
<tr>
<td>First instar</td>
<td>3.00 - 5.00</td>
<td>4.22</td>
</tr>
<tr>
<td>Second instar</td>
<td>3.00 - 4.00</td>
<td>3.33</td>
</tr>
<tr>
<td>Third instar</td>
<td>6.00 - 8.00</td>
<td>6.61</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>8.00 - 8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>7.00 - 9.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

**Total period of development = 38.60 days**
NYMPHAL INSTARS

FIRST INSTAR (Plate III, Fig.95)

General colour light brown; eyes red; rostrum dark. Wing pads absent. Body convex dorsally. Thorax slightly wider than head. Fore and middle legs similar; femur $\frac{1}{2}$ times the length of tibia; tarsus and tibia subequal in length; claws short and equal. Hind leg with femur and tibia subequal in length; tarsus $\frac{1}{2}$ times as long as tibia; claws long and unequal.

SECOND INSTAR (Plate III, Fig.96)

General colour and structure as in the first instar. Wing pads indistinct. First two pairs of legs with femora broader than tibiae; tarsi little shorter than tibiae. Hind leg with tarsus a little longer than tibia; both tibia and tarsus sparingly fringed.

THIRD INSTAR (Plate III, Fig.97)

Anterior wing pads well-developed, extending to the middle of metanotum; posterior wing pads still not developed. Coxae dark, and the anterior surface of hind femur dark. Other structures and colour as the preceding instars.
PLATE III.

Fig. 84. *Nychia marshalli* (Scott), first nymphal instar.

Fig. 85. Head of first nymphal instar of *N. marshalli* (Scott), lateral view.

Fig. 86. Head of male *Anisos bouvieri* Kirkaldy, Lateral view.

Fig. 87. Head of female *A. bouvieri* Kirk., lateral view.

Fig. 88. Abdominal tip of female *A. bouvieri* Kirk., lateral view.

Fig. 89. Female *Prestwichia* sp., lateral view.

Fig. 90. *Prestwichia* sp. parasitizing an egg of *Anisos bouvieri* Kirk.

Fig. 91. Antenna of female *Prestwichia* sp.

Fig. 92. Pupa of *Prestwichia* sp.

Fig. 93. Abdominal tip of female *Plea frontalis*, lateral view.

Fig. 94. Egg of *Plea frontalis* (Fieb.), lateral view.

Fig. 95. *P. frontalis* (Fieb.), first nymphal instar.

Fig. 96. *P. frontalis* (Fieb.), second nymphal instar.

Fig. 97. *P. frontalis* (Fieb.), third nymphal instar.

Fig. 98. *P. frontalis* (Fieb.), fourth nymphal instar.

Fig. 99. *P. frontalis* (Fieb.), fifth nymphal instar.

Fig. 100. Abdominal tip of female *Ranatra elongata*, lateral view.

Fig. 101. Abdominal tip of female *R. filiformis*, lateral view.
FOURTH INSTAR (Plate III, Fig. 98).

General colour dark brown; eyes dark. Anterior wing pads extending beyond the middle of metathorax; posterior wing pads reaching the posterior margin of the first abdominal segment. Fore leg with femur 2½ times the width of tibia. Middle leg furnished with a few spines on the inner surface of femur.

FIFTH INSTAR (Plate III, Fig. 99).

Head with a dark spot in the middle; anterior wing pad with an oval-shaped darkened area. Wing pads very well-developed; anterior ones extending beyond the posterior margin of metathorax; posterior wing pads reaching up to the posterior margin of third abdominal segment. Legs as in the previous instar.

Table XXXI presents the measurements of the nymphs and adult of *Plea frontalis*.

GROWTH (Figs. 102, 103).

The relationships between the number of instar and head and body width are calculated and are found to be linear in semi-logarithmic form. The following equations adequately express the relationships.
TABLE - XXXI

MEASUREMENTS OF NYMPHS AND ADULT IN MILLIMETRES.
OF PLEA FRONTALIS.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>HEAD WIDTH</th>
<th>BODY LENGTH</th>
<th>BODY WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RANGE</td>
<td>MEAN</td>
<td>RANGE</td>
</tr>
<tr>
<td>I instar</td>
<td>.317-.356</td>
<td>.335</td>
<td>.711-.769</td>
</tr>
<tr>
<td>II &quot;</td>
<td>.404-.481</td>
<td>.444</td>
<td>.865-1.019</td>
</tr>
<tr>
<td>III &quot;</td>
<td>.538-.596</td>
<td>.565</td>
<td>1.096-1.231</td>
</tr>
<tr>
<td>IV &quot;</td>
<td>.673-.769</td>
<td>.723</td>
<td>1.404-1.519</td>
</tr>
<tr>
<td>V &quot;</td>
<td>.904-.980</td>
<td>.933</td>
<td>1.750-1.961</td>
</tr>
<tr>
<td>Adult</td>
<td>.957-1.087</td>
<td>1.032</td>
<td>2.000-2.500</td>
</tr>
</tbody>
</table>
(1) **Number of instar and head width**

Log $H_w = -0.5898 + 0.1127\, n$

($r = 0.9587$)

(2) **Number of instar and body width**

Log $B_w = -0.5708 + 0.1168\, n$

($r = 0.9866$)

Where, $H_w =$ Head width; $B_w =$ Body width; $n =$ Number of instar.

A definite relationship exists in both cases and the correlation is highly significant as can be seen from the high value of $r$. 
Fig. 102. Relationship between number of instar and head width of *Plea frontalis* (Fieber).

Fig. 103. Relationship between number of instar and body width of *Plea frontalis* (Fieber).
FIG. 102
PLEA FRONTALIS

FIG. 103
PLEA FRONTALIS

LOG HEAD WIDTH IN MM.

LOG BODY WIDTH IN MM.

NUMBER OF INSTAR
DISCUSSION

The present studies on the biology of aquatic bugs have revealed several interesting features in the adult behaviour and structure of the eggs. The aquatic bugs except Corixidae are predators, preying upon a variety of aquatic organisms and this predatory feeding has necessitated modifications of the forelegs which are raptorial and well-armed with spines for capturing the prey. The corixids are mainly detritus feeders, although Micronecta scutellaris scutellaris shows predatory tendencies by preying upon tiny mosquito larvae, chironomid pupae and planktonic crustaceans.

The air-bubbles are stored beneath the hemelytra or trapped on the ventral abdominal surface of almost all the aquatic bugs. Such bubbles are in contact with the spiracles and act not only as hydrostatic organs and stores of oxygen but also as 'physical gills' (Ege, 1915; Thorpe and Crisp, 1947, 1949; De Ruiter et al, 1952 and Popham, 1954). The renewal of the gas may be brought about by pushing the abdominal tip through the water surface or by the use of a specialized respiratory siphon (as in Ranatra and Laccotrephes). The relationships between the different types of respiration in aquatic Hemiptera have been discussed by Popham (1960).

Crisp (1962G) did not find any marked difference from 1:1 in the sex ratio of Corixa germari. The present studies on the sex ratios of the predominant species, viz., Micronecta
scutellaris scutellaris, Anisos bouvieri and A. waltairensis show a preponderance of the females in most of the months during a period of two years (1963-65). The chi-square values, calculated under the hypothesis that 1:1 ratio exists between the males and the females, are highly significant against this ratio.

A great diversity exists in the oviposition of the aquatic bugs. Ranatra elongata, R. filiformis, Anisos bouvieri, A. waltairensis and Plea frontalis insert their eggs singly into the aquatic plants. The ovipositors in these species are either serrated or pointed for cutting a hole into the plant tissue. Micronecta scutellaris scutellaris and Nychia marshalli affix their eggs singly on the stones or aquatic plants. The eggs in Micronecta halioloides and Laccotreihes griseus are laid in batches, the former affixing them on the plants and the latter on the mud at the bottom of the pond. The oviposition in Diplonychus rusticum is noteworthy. The female lays eggs on the back of the male. This type of oviposition has also been recorded in the other genera of Belostomatidae, viz., Abedus and Belostoma (Hungerford, 1913).

The total period of development in the laboratory ranges from 18.80 days in Micronecta halioloides to 38.08 days in Plea frontalis.

The eggs vary in structure and the differences involve
variations in the chorionic sculpturing and the presence or absence of filaments and operculum. In Nepidae, the chorion is finely granulated with scattered, rounded, punctate elevations. The eggs are characteristic in bearing respiratory horns at one end. The length of the respiratory horn and the extent of plastron on it varies in different species. Among the corixids, the eggs of Micronecta scutellaris scutellaris are covered with a number of short filaments on the upper surface while those of Micronecta halinloldes are smooth and shiny. Poirsson (1938) has also observed filaments on the eggs of Micronecta meridionalis. In Notonectidae, the egg-shell of the eggs of Nyphia marshalli are finely granulated and show a pattern of hexagonal markings. The egg of Anisops is also finely granulated, but provided with an oval-shaped operculum on the upper surface with a hexagonal pattern of markings.

The validity of Dyar's Law (1890) in relation to the aquatic bugs was tested by ascertaining the relationships between the number of nymphal instar and body dimensions of Ranatra elongata, Micronecta scutellaris scutellaris, M. halinloldes Nyphia marshalli and Plea frontalis. The relationships when plotted in semi-logarithmic forms are found to be linear, showing the growth in a regular geometrical progression. The values of different body dimensions of the adults of these species, however, fall below the line of best fit.
SUMMARY.
SUMMARY

The seasonal fluctuations in the physico-chemical conditions of a perennial fish pond and its insect fauna (especially Hemiptera-Heteroptera) are discussed in the first chapter.

The pond selected for the study is a typical Bengal fish pond. The water-level varies seasonally, being at the lowest level in summer before the onset of the monsoon. Maximum rainfall occurs from June to October. The surface temperature is the highest from the middle of May to the end of August.

Dissolved oxygen concentrations vary from traces to 4.412 ppm. Total alkalinity is of methyl orange indicator and the pH is in the alkaline range.

The pond is quite rich in its fauna, but the aquatic vegetation is very poor. The insects form the ubiquitous of the animal community.

The insect orders represented are Hemiptera (92.52%; 94.40%), Coleoptera (0.29%; 1.02%), Ephemeroptera (1.16%; 1.48%), Diptera (5.5%; 2.77%), Odonata (0.34%; 0.32%) and Lepidoptera (0.19%; - ) during the first and second years of the survey.

During the period of survey a total of nine genera and twenty-one species of Hemiptera and three genera and three species of Coleoptera, and immature stages of Diptera, Ephemeroptera, Odonata and Lepidoptera have been collected.
The frequency indices of the predominant genera (Micronecta and Anisops) of bugs are determined. Percentage compositions of Micronecta, Anisops and Ranatra species are also given.

Seasonal fluctuations in the populations of the aquatic bugs and other associated insects are also dealt with. The probable factors viz., temperature, rainfall and migration contributing to the sudden fluctuations of the aquatic bugs are discussed.

Of the 21 species of the bugs, Micronecta scutellaris scutellaris, M. quadristrigata, Anisops bouvieri, A. breddini, A. wulfairensis, Plea frontalis, Ranatra filiformis and R. elongata are well-represented; Micronecta thyesta, M. haliploides, Anisops barbata and Nychia marshalli are moderately represented, and the rest, viz., Micronecta albifrons albifrons, Corixa sp., Agraptocorixa sp., Anisops sardes, Plea sp., Ranatra digitata, R. varipes, Laccotrephes griseus and Diplonychus rusticum occur rarely.

Chapter II deals with the biology of ten species of aquatic bugs.

Ranatra filiformis is a predator and feeds upon a variety of organisms. It is often infested by the larval Hydrachnids. Certain aspects of behaviour during 'death-feigning', respiration, copulation and oviposition have been observed.
It takes on an average 31.64 days to complete its life-history under laboratory conditions. The egg is elongate-oval, bearing two respiratory horns at one end. Each respiratory horn is about three times as long as the egg. The structure of the respiratory horn and the chorion are dealt with in detail. The process of hatching and the structure of the nymphs are given. Habitat, copulation, oviposition and moulting of Ranatra elongata are discussed. Total period of development is about 37 days. Respiratory horn is a little longer than the egg. The growth of head width, body width and body length has been studied and relationships with the number of instar are established.

The egg of Ranatra digitata is also described. Respiratory horn is about four times as long as the egg.

Laccotrechus griseus is a predator and is found clinging to the vegetation or half buried in the mud. The copulation lasts for several hours. Eggs are deposited in batches at the bottom of the glass jars. Each egg is oval and bears a circle of ten respiratory horns at one end. Total period of development is about 35 days. Respiration and 'death-feigning' are also dealt with.

Diplonychus rusticum inhabits ponds rich in vegetation. Its fish fry destroying capacity in relation to other aquatic predatory insects is examined. The female lays eggs on the back of the male. The description of the egg and the process of
hatching are given.

**Micronecta scutellaris scutellaris** is commonly found in the shallow regions at the bottom of the pond. It feeds upon the pond ooze, planktonic crustaceans, tiny mosquito larvae and chironomid pupae. The females are normally more than the males in the population. Eggs are glued singly on any available support in the water. Each egg is oval and bears a number of short filaments on the upper surface. Total period of development is about 23 days. Respiration, copulation, hatching and molting of the species are discussed. Growth in a regular geometrical progression.

**Micronecta halinoides** feeds on the algae and detritus material deposited at the bottom of the pond. The female fastens eggs in batches on the aquatic vegetation by a transparent gelatinous material. Total period of development is about 19 days. Each egg is pearly-white, shiny and smooth. The process of hatching and descriptions of nymphal instars are also given. Growth in this species is also in a regular geometrical progression.

**Nychia marshalli** preys upon different types of planktonic crustaceans and aquatic insects. The female lays eggs singly on aquatic plants, stones or any other suitable available support in the water. Total period of development is about 33 days.
Descriptions of the egg and the nymphs are given. Relationships between the number of instar and different body dimensions have been calculated.

A hymenopterous parasite (Prestwichia sp.) has been reared from the eggs of Anisos bouvieri. Prestwichia is recorded for the first time from India and the eggs of Anisos bouvieri and Plea frontalis are a new host for the parasite.

The females are generally more than the males in the population of Anisos bouvieri.

Anisos waltairensis also preys upon mosquito larvae and planktonic crustaceans. The sex ratio is discussed. The female inserts eggs singly into the plant tissue. Total period of development is about 27 days.

Plea frontalis feeds on Ostracods. Prestwichia sp. (Hymenoptera) has been reared from its eggs. Copulation and nymphal growth are dealt with. Eggs are inserted singly into the plant tissue. Total period of development is about 38 days. The descriptions of the egg and nymphal instars have been given.