Entomon, 1976, *Vol.* **1**, *No.* 2, *pp.* 123 *to* 132.

BIOECOLOGICAL STUDIES ON SOME AQUATIC HEMIPTERA – NEPIDAE

T. K. RAGHUNATHA RAO
Department of Zoology, Loyola College, Madras, India 600 034

(*Received 11 October 1976*)

A study of the biological and ecological aspects of four species of aquatic Hemiptera belonging to the family Nepidae with details on oviposition preferences, duration of postembryonic development, growth rates of body parts during postembryonic development, and population periodicity are presented.

INTRODUCTION

Information relating to the bioecological aspects of aquatic Hemiptera in India appears meagre, being limited to the species *Ranatra filiformis* FAB. (NOWROJEE, 1911), *Sphaerodema rusticum* FAB. (PRESSWALA & GEORGE, 1936) and *Ranatra elongata* (RAO, 1962). An understanding of the modes and preferences of oviposition, growth rates of different structures during postembryonic development, structural adaptations as well as population periodicities appear essential in bio-ecological studies. An attempt is made here to study on comparative basis species of two genera *Ranatra* and *Laccotrephes* (Nepidea). *Ranatra* is cosmopolitan, while *Laccotrephes* is confined to the old world.

MATERIAL AND METHODS

Aquaic Hemiptera collected from different habitats were reared in the laboratory in small glass jars or aquaria provided with natural vegetation. Nymphs were isolated and reared separately in small containers. Adults were fed with *Anispos bouvieri* and nymphs of dragonflies and mayflies.

For the study of seasonal fluctuations, insects were collected weekly from different localities, with a pond net wielded for about 30 minutes, and the sampling areas were chosen in transects so as to cover the entire pond. The insects collected were calculated per metre sq. area.

Measurements of nymphal instars were made 48 hours after moulting, with an eye piece micrometer. For microscopic mounts, material preserved in 70% alcohol was treated with 5% KOH, washed in distilled water, passed through alcoholic series, cleared in clove oil and mounted in Canada balsam.

OBSERVATIONS

Habitat

The permanent pond is about 1.3 hectares, oval and about 1.8 metres deep. The temperature ranges between 21.8° C and 37.6° C. During October and November, water is turbid due to rains. The pH varied from 7.8 to 9.2. Blue green algae grew in the water, the dominant forms being *Microcystis* sp., *Oscillatoria* and *Nostoc*. Fairly abundant zooplankton and submerged vegetation also occur in the ponds.

R. filiformis mostly occurs amongst vegetation fringing the shallower parts of the pond at depths of 30–60 cm clinging to submerged vegetation, and is scarce in deeper areas of pond. *R. elongata* inhabits temporary water puddles existing from October to March. Adults of *R. elongata* prefer deeper parts of pools. *Laccotrephes robustus* inhabits among decaying vegetation along the edges of the temporary pools, while *L. griseus* commonly occurs in habitat with dark soil matching its body colour, in permanent pond near the edges.

Feeding habits

Under natural conditions, adult *R. filiformis* feeds on live nymphs of dragonflies and mosquito pupae caught between the raptorial forelegs. *Anisops bouvieri* and nymphs of dragonflies and may flies were provided in the laboratory to the adults. With a view to evaluate the degree of food preference two different prey species were offered at the same time in equal numbers; the preferred prey were once again offered in equal numbers along with a third species of food prey. Ten replicates were made during this experiment and it was found that the species of *Anisops*, tadpoles, nymphs of Odonates and mayflies come in order of preference. The nymphs of *R. filiformis* on the other hand were observed to prefer the larvae of mosquitoes.

In the field *R. elongata* is seen to feed on tadpoles, species of *Anisops*, nymphs of Odonates, mayflies and other species of aquatic Hemiptera. In the laboratory, the adults seem to prefer larger prey such as big tadpoles, adult notonectids, corixids and *Anisops*. The nymphs prefer larvae of mosquitoes and nymphs of *Anisops*.

Oviposition

R. filiformis lays eggs inside the tissues of aquatic plants while *R. elongata* lays eggs on the substratum. The eggs of *R. filiformis* are laid in rows along the length of stem, with the anterior part of the eggs hidden from the view of predators. Though *Hydrilla*, *Ceratophyllum*, *Elodea* and *Marsilea* were used for oviposition in the aquarium, *Marsilea* is preferred for oviposition followed by *Elodea*, *Hydrilla*, *Vallisnaria* and *Ceratophyllum*. The sharp ovipositor with serrated edges is well adapted to pierce the soft tissues of plants.

In *L. robustus* an average of eighteen eggs are laid in groups of five to six on loose soil or in decaying vegetation, during November–December. The eggs are not covered by soil or mud. In *L. griseus*, the eggs are laid along the edge of the pond glued in a mass to sand grains, the distal ends of the filaments being free. The period of incubation varies. During the monsoon the eggs take 9 days to hatch, while in March they hatch in 6 days.

The nature and number of filaments on the egg appears species specific, with *R. filiformis* bearing a pair of long filaments, while the more elongate eggs of *R. elongata* bear two shorter filaments. Similarly, the eggs of *L. griseus* have ten short filaments, while those of *L. robustus* bear six filaments. Details pertaining to the nature of the eggs of the four species discussed are summarised in Table I.

TABLE 1. Measurements of eggs of different species in Nepidae.

Species	Colour	Shape	Filaments	Length in mm	(Width in mm)
R. filiformis	Pale yellow when laid; white in 24 hrs.	Oval	2	2.0–2.25	(0.75-0.78)
R. elongata	White	Oval	2	2.8–3.1	(0.84–0.86)
L. griseus	Pale white	Oval	6	1.5–1.7	(0.5–0.70)
L. robustus	White	Oblong	10	2.5–2.8	(1.45–1.65)

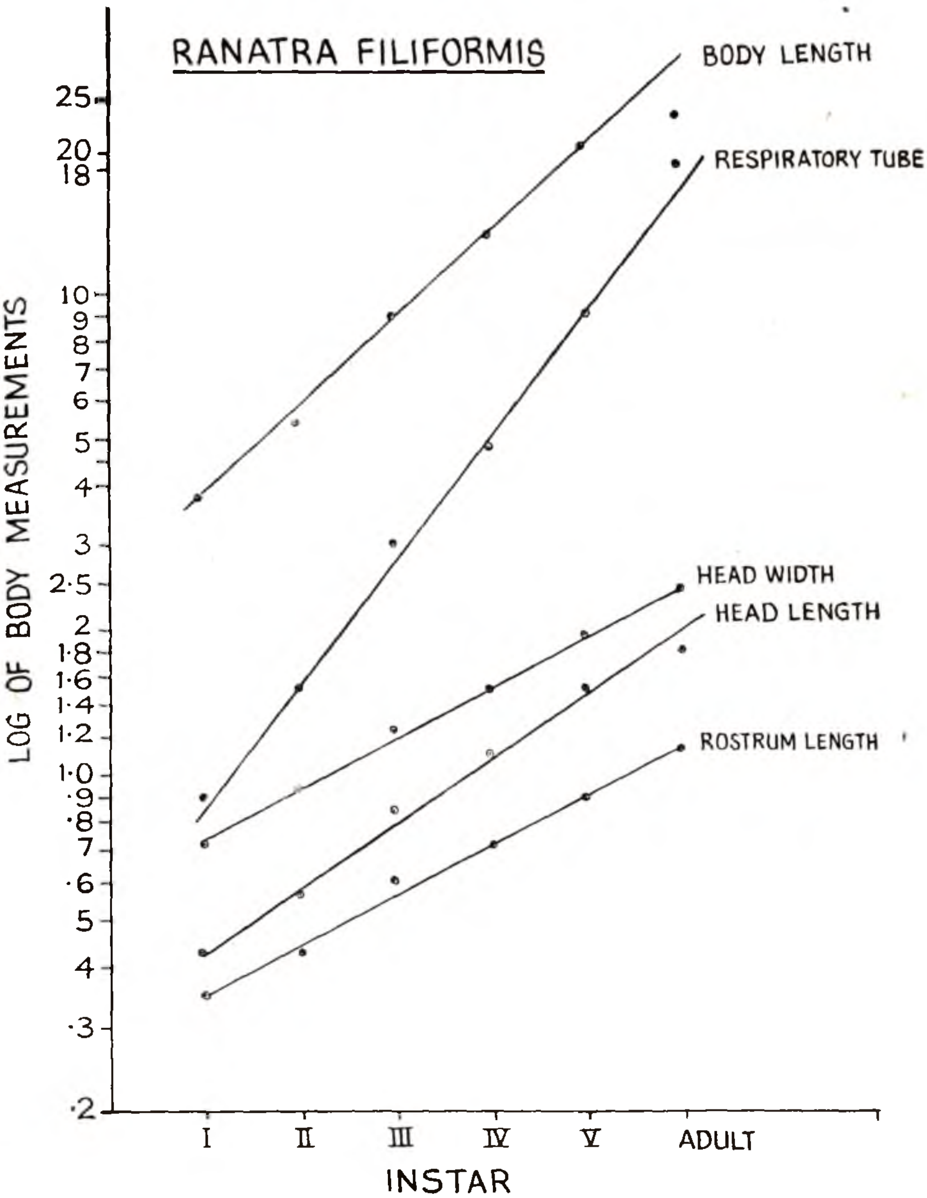


Fig. 1. Measurements of various organs plotted semilogarithmically against instars (Average of six individuals).

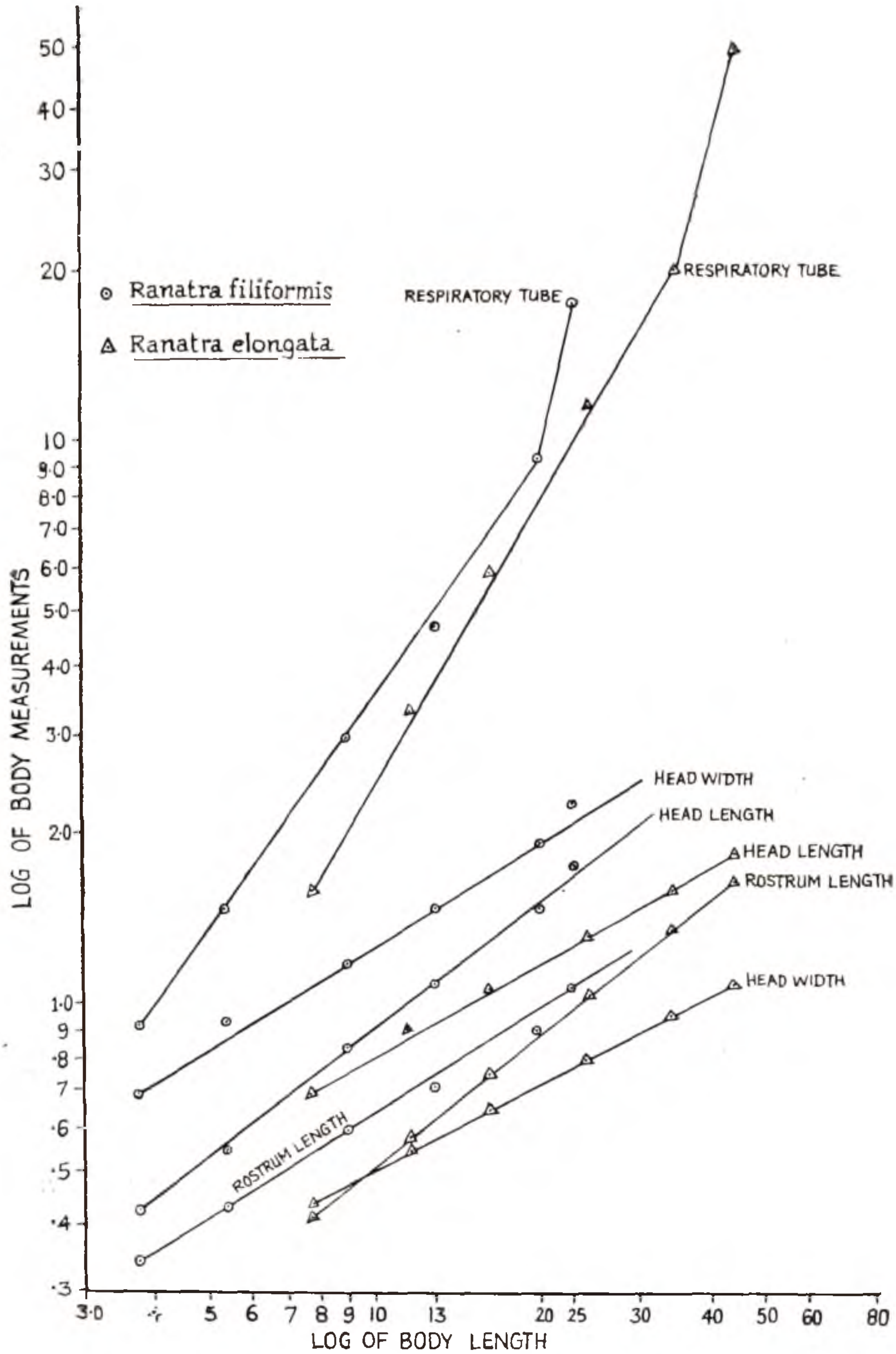


Fig. 2. Body measurements of *R. filiformis* and *R. elongata* plotted logarithmically against total body length (average of six individuals).

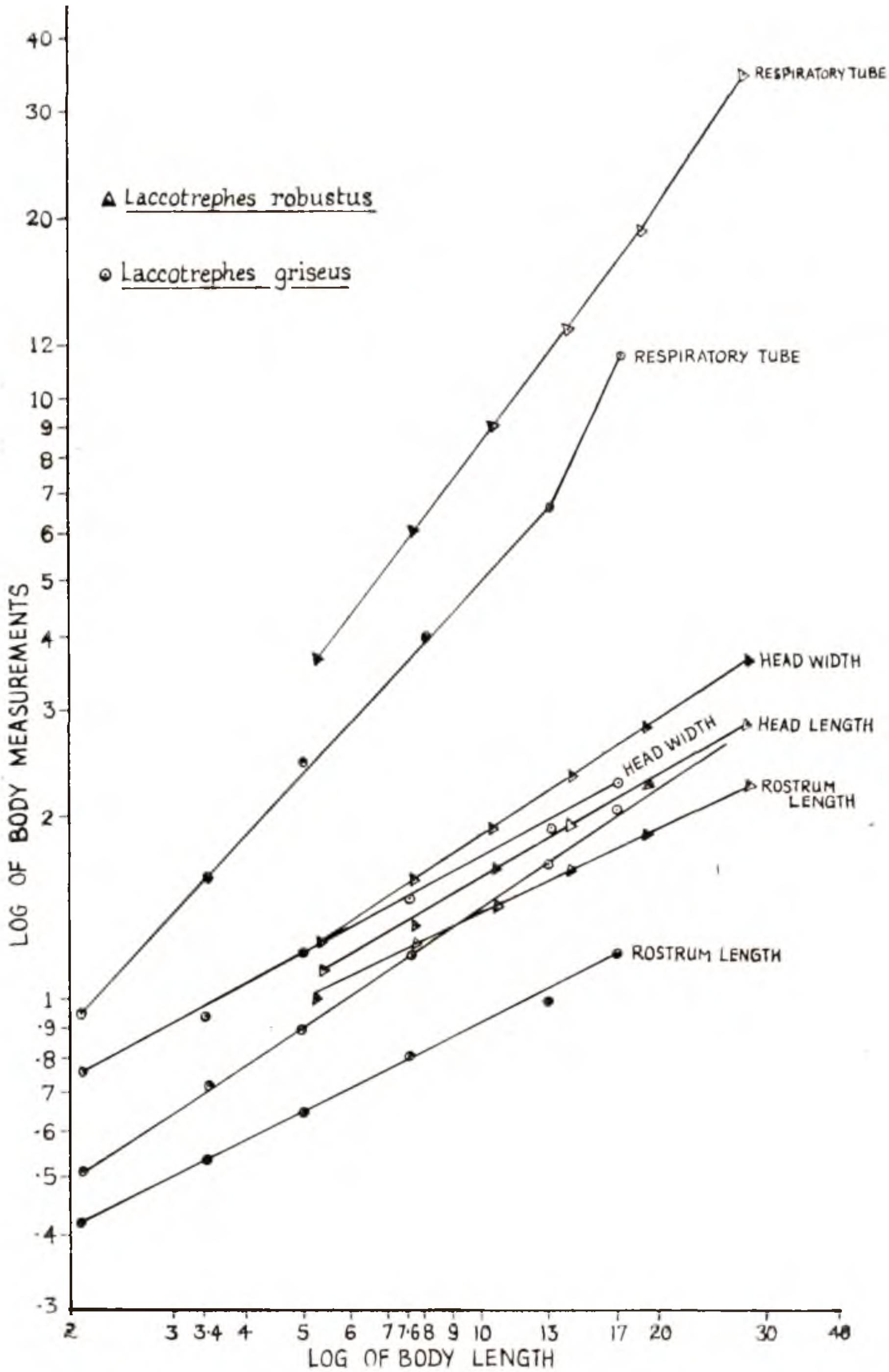
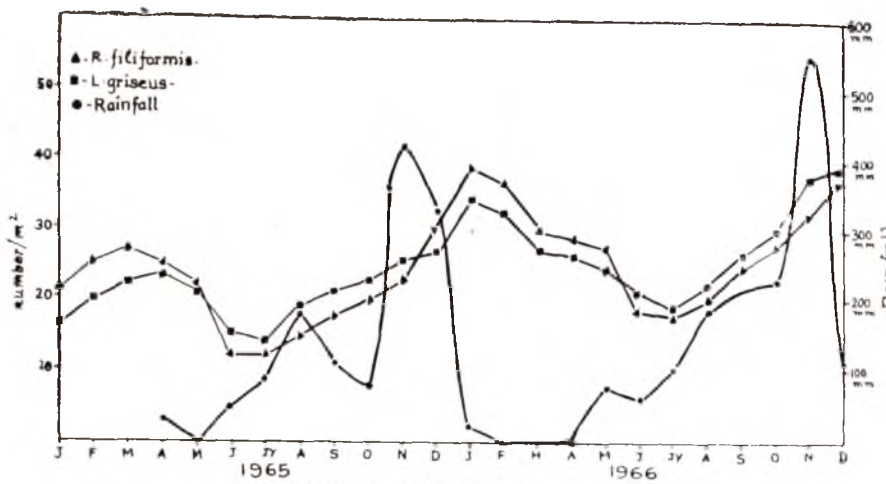
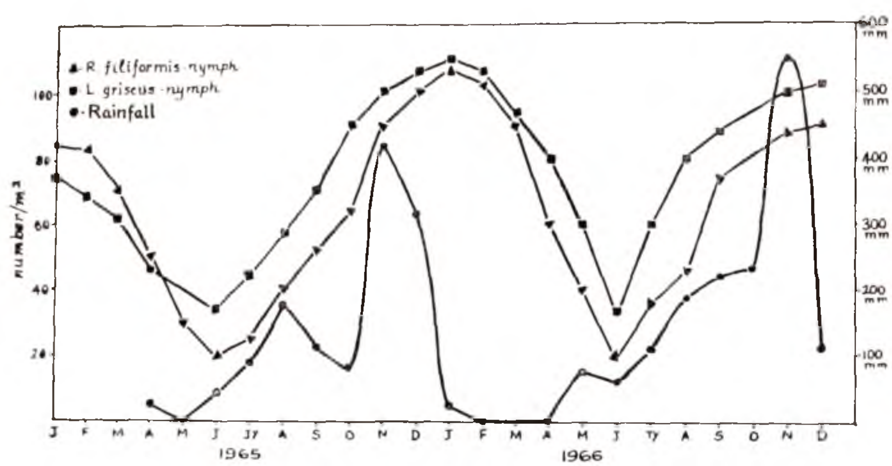


Fig. 3. Body measurements of *L. robustus* and *L. griseus* plotted logarithmically against total body length (average of six individuals).



(Adult population in relation to rainfall)



(Nymphal population in relation to Rainfall)

Fig. 4. Relationship between rainfall and population density of the adults (above) and of the nymphs (below) of *R. filiformis* and *L. griseus*.

Postembryonic development and growth

The duration of development from first instar to adult is 35–52 days for *R. filiformis*, 33–40 days for *R. elongata*, 36–53 days for *L. griseus* and 30–46 days for *L. robustus*. An insight into the growth rate of siphon, head and rostrum etc. clearly indicated the nature of their variation in the different species. HUXLEY (1924) proposed the formula $y = bx^k$, where y is the organ growing allometrically in relation to body size or to any other organ whose growth is taken as standard x. Taking the total body length as the standard x, using the lengths of various organs for growing parts y at each developmental stage, the data was fitted into the formula $\log y = \text{Log } b + k \log x$ derived from $y = b^k$. When plotted semilogarithmically against instars, the average measurements for lengths of body, head and rostrum fall nearly on straight line indicating constant rates of growth. Growth gradients of different organs of the Nepidae studied are shown in Figs. 1–3.

Population periodicities

The rate of oviposition of *R. filiformis* is highest in the rainy season, the total number of eggs laid by a female during a period of 70 days being 182. The population density in the permanent pond was recorded throughout the year to ascertain the fluctuation of population and the factors affecting it. It was expressed as number/sq. metre (Fig. 4) which shows a tendency for increase during the monsoon and decrease in summer. As a result of heavy rainfall, favourable temperature, and increase in food prey such as mayflies, odonates and mosquitoes *R. filiformis* breed at a rapid rate. *R. filiformis* eggs appear to suffer little mortality as they are laid inside tissues of aquatic plants, hidden from predators. Moreover the filaments projecting from the eggs give a deceptive appearance. A remarkable similarity in the mode of oviposition exists between *R. filiformis* and *Anisops* the latter exhibiting the same trait as the predator, choosing *Ceratophyllum* and the leaf of *Hydrilla* for oviposition. *R. elongata* lays an average number of 7.3 eggs per day.

Laccotrephes increases in numbers in the rainy months. The fecundity of the species is also very high during this period. Following the monsoon period, the number of eggs laid is on the decrease, so that the population in summer is low (Table 2).

Food chain

R. filiformis being predatory in habit, preys upon the immature stages of the above mentioned insects besides species of *Anisops* which is the most favoured prey. In the field *Anisops bouvieri* is found in great numbers in monsoon season. An increase of *Anisops* population in these months coincides with the corresponding growth of population of *R. filiformis*. Adult *Anisops* and its nymphs feed on *Aedes* and *Culex* larvae. Thus, there appears to be a food chain at the end of which is the predator *R. filiformis*. The nymphs of the advanced stages prey on the younger stages.

Predation of *R. filiformis* by other insects in the pond is not known to occur except in rare cases when it is preyed by *Sphaerodema annulatum*. Various factors in summer reduce the number of this species as also its food prey. When there is a decrease in the food prey in summer there is a depletion in the population.

In the temporary habitat, there is plenty of food available in the rainy season. The temperature and the rainfall bring about the optimum conditions necessary for survival. In April when the pond dries

TABLE 2. Relationship between climatic conditions and duration of incubation of Nepids recorded (based on ten individuals) during the year 1966

Month	Total Rainfall in mm	Mean Max. Temp.°C	average number of eggs/individual				period of incubation (average) in days			
			R. filiformis	*R. elongata*	*L. robustus*	*L. griseus*	*R. filiformis*	*R. elongata*	*L. robustus*	*L. griseus*
January	24.2	28.4	11	19	10	17	11	8	8	9
February	—	29.9	8	4	10	9	9	8	7	8
March	—	34.1	15	8	8	6	8	5	6	7
April	0.8	33.7	14	3	4	5	7	5	5	6
May	81.7	37.9	6	—	—	4	7	—	—	6
June	65.5	35.5	4	—	—	6	9	—	—	7
July	102.7	34.3	5	—	—	—	9	—	—	—
August	190.2	33.8	18	—	11	5	8	—	8	9
September	223.6	31.8	10	—	8	8	10	—	9	8
October	230.3	30.6	16	15	16	28	9	7	7	9
November	556.3	30.0	11	16	14	12	11	8	9	9
December	112.6	28.3	17	18	18	15	12	9	10	12

some of the inhabitants migrate to other more permanent ponds. *R. elongata* and *L. robustus* are such migrants. Migration of these species takes place in summer to tide over unfavourable conditions and a similar behaviour was also observed in *R. filiformis*.

DISCUSSION

The habitat preferences appear well marked, with *R. filiformis* and *L. griseus* occurring only in permanent ponds, lakes, rivers and *R. elongata* and *L. robustus* inhabiting temporary ponds. The modes of oviposition of the species are correlated with the type of habitat. *R. filiformis* lays eggs inside the tissues of plant, while *R. elongata* drops the eggs loosely on the substratum. NOWROJEE (1911) and HOFFMANN (1930, 1933) have reported oviposition in aquatic vegetation by *R. filiformis*. The mode of oviposition in *R. elongata* also appears to be similar to that of *R. chinensis* (HOFFMANN, 1930).

As seen in the present study, from October to February there is a trend towards increase of population due to such physical factors as rainfall, temperature, abundance of food etc., while from April to August there is a decrease in population of aquatic Hemiptera. A heavy rainfall increases the population in monsoon seasons while poor rainfall has an adverse effect in the growth of population.

The egg of *Ranatra* has been the subject of investigation by many authors. PETIT (1902) attributed a protective function to the filaments against predators. BUENO (1906) described the mode of oviposition in plant tissues by *R. quadridentata*. BROCHER (1911) has reported similar mode of oviposition in *R. linearis* while HOLMES (1907) has made similar observation on *R. quadridentata*. HUNGERFORD (1919) indicated that eggs are laid in the stem of aquatic vegetation by *Ranatra* sp. and JORDAN (1925–27) has reported that eggs of *R. linearis*, about six to eight in number, on floating reeds, and rarely in leaves. Mention has not hitherto been made about the preference of the plant for oviposition though

JORDAN (1925–27) indicated that eggs were laid rarely in leaves. Present study shows a preference for the stem of *Marsilea* by *R. filiformis*.

The period of incubation varies from species to species and for the same species in different places. For the eggs of *R. filiformis* an incubation period of four days was reported by NOWROJEE (1911) in Delhi, while at Canton, HOFFMANN has given a period of nine to ten days for the same species. The present study reveals that in Madras the incubation period is six to twelve days. BUENO (1906) has given a period of fourteen days for the eggs of *R. quadridentata* to hatch, while JORDAN (1925–27) has reported thirty two to thirty nine days for *R. linearis* in Germany. An incubation period of eight days was reported in the case of the eggs of *R. chinensis* (HOFFMANN, 1930), while the eggs of *R. elongata* discussed here take five to nine days to hatch. The incubation period of eggs at different temperature in different places may be correlated with their ability to adjust to different climatic conditions. Around Madras eggs laid in rainy months take a longer time to hatch, while those laid in summer take shorter time.

The postembryonic duration varies from species to species and for the same species in different places. The short period of incubation and postembryonic duration of about thirtyfour days reported by NOWROJEE (1911) for *R. filiformis* at Delhi, may be due to the warm climate in April when his studies were made. HOFFMANN (1930) has reported a shorter postembryonic duration of thirtyfive days for the larger species *R. chinensis* and a comparatively longer duration of 42.5 days for the smaller species *R. filiformis*. Similar observations were made in the present studies. It is interesting to note that a larger species shows a shorter duration for nymphal development. It could be seen from the present study that the biology of this species is related to its habitat. Considering the fact that *R. elongata* is an inhabitant of temporary pool, a rapid development of the egg and nymphal stages would be of great survival value in such ephemeral habitats.

In the two species of *Laccotrephes*, habitat preferences are marked. *L. griseus* is seen in permanent ponds, lakes and rivers. In fact most of the records of collection are from rivers and tanks. *L. robustus* is seen in temporary bodies of water. The mode of oviposition differs in the two species studied. *L. griseus* lays eggs inside the moist soil covering the eggs with mud, while the latter is seen to drop the eggs on the substratum. In this habit, *L. robustus* resembles *R. elongata* in not concealing the eggs. A similar mode of oviposition was observed by HOFFMANN (1927) and by HALE (1924) in *L. tristis*.

Studies on the post-embryonic growth of the different parts of the body seem to follow the law of simple allometry in the case of species of Nepidae studied. The postembryonic growth of the respiratory siphon in all the four species studied shows that similar allometric growth patterns apper to exist for the respiratory siphon within the group. This is supported by MATSUDA (1963) who observed that in a group of related species, the growth pattern of segments with higher growth ratios are more similar than that of the other segments with lower growth ratios.

Acknowledgements:– I am very much indebted to Dr. T. N. ANANTHAKRISHNAN for his immense help, valuable guidance and encouragement throughout my studies. My sincere thanks are due to him.

REFERENCES

BROCHER, F. (1911) Observations biologiques sur quelques insectes aquatiques. *Ann. Soc. Biol. Lacustre*, **4** : 367–379.

BUENO, J. R. (1906) Ways of progression in water bugs. *Ent. News*, **17** : 1–4.

HALE, M. H. (1924) Studies on Australian aquatic Hemiptera. *Rec. South Australian Mus.*, **2** : 503–520.

HOFFMANN, W. E. (1927) Biological notes on *Laccotrephes* (Hemiptera – Nepidae) *Lingnam Agric. Rev.*, **4** : 73–93.

HOFFMANN, W. E. (1930) Notes on the biology of *Ranatra filiformis* F. (Hemiptera–Nepidae). *Lingnan Sci. J.*, **9** : 385–393.

HOFFMANN, W. E. (1933) Notes on the biology of second species of *Laccotrephes*. *Lingnan Sci. J*, **12** : 71–82.

HOLMES, S. J. (1907) Observations on the young one of *Ranatra quadridentata*. *Boil. Bull.*, **21** : 158–164.

HUNGERFORD, H. B. (1919) Biology and ecology of aquatic and semi-aquatic Hemiptera. *Kans. Univ. Sci. Bull.*, **2** : 1–328.

HUXLEY, J. (1924) Constant differential growth ratios and their significance. *Nature*, **114** : 895.

JORDAN, K. H. C. (1925–27) Sur biologie der aquatilen Rhynchoten. *Isis budiss.*, **11** : 142–167.

MATSUDA, R. (1963) A study of relative growth of leg and antennal segments in two species of *Orthotylus* (Heteroptera–Miridae). *Proc. Roy. Ent. Soc. Lond.*, **38** : 86–89.

NOWROJEE, D. (1911) Life History of Indian Insect. II. Some aquatic Rhynchota and Coleoptera. *Mem. Dept. Agric.*, Vol. 2.

PRESSWALLA, M.J. & C.J. GEORGE (1936) Morphology of *Sphaerodema rusticum* FABR. *J. Univ. Bombay*, **4** : 29–65.

PETIT (1902) The egg of water scorpin *Ranatra fusca*. *Canad. Ent.*, **34** : 213.

RAO, T. K. R. (1962) On the biology of *Ranatra elongata* Fabr. (Heteroptera : Nepidae) and *Sphaerodema annulatum* Fabr. (Heteroptera : Belostomatidae). *Proc. Roy. Ent. Soc. Lond.*, **37** : 61–64.

SOUTHWOOD, T. R. E. (1960) Flight activity of Heteroptera. *Tran. R. Ent. Soc. London.*, **112** (A) : 173–220.

SOUTHWOOD, T. R. E. (1962) Migration of terrestrial arthropod, in relation to habitat. *Biol. Rev.*, **37** : 171–214.