



Handbook on Major Hemipteran Predators of India

ANIMESH BAL and B. BISWAS



Zoological Survey of India



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ANIMESH BAL and B. BISWAS

Zoological Survey of India, M-Block, New Alipore, Kolkata-700 053

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INTRODUCTION

In Animal Kingdom the functional role of predators is to attack, kill and eat their prey in the process of transferring of energy through different trophic levels, which, in turn, may be referred to a part of food web of secondary consumers in an ecosystem.

Predatory nature is found in some of the insect orders, as it is seen in the Hemipteran bugs. Among Hemiptera some species which belong to different families are predators, such as Assassin-bugs (Reduviidae), Pirate-bugs (Anthocoridae), Damsel-bugs (Nabidae), all the members of water bug families and a few Pentatomids, Lygaeids and Mirids. Of these a listed 35 species which are more predominant predators reported in India have been discussed in the present study for their predatory habits and morphological characteristic for easy identification along with their photographs.

The reduviids are generally known as Assassin bugs and they are entomophagous, feeding on different insects of suitable sizes. Pirate-bugs are belonging to the family Anthocoridae and are of minute in sizes but they have the potentiality to reduce the population of mites, aphids, psyllids, thrips, sugar cane, mealy bugs, white flies and also lepidopteran eggs. Mirids also do in same way to mites and thrips.

Aquatic heteropterans are commonly known as water-bugs, and because of their exclusively predatory nature they are the most important component in the food web of aquatic communities. It is also observed that in starvation they show cannibalism, stronger individuals feed upon the weaker one.

Predatory hemipterans have various morphological adaptations particularly the appendages for holding the prey as well as the number, shape and direction of style dentition for biting and killing the captured prey. It is not true that the hemipteran predators only ingest the body fluid (haemolymph) of other prey. But they use a solid-to-liquid feeding method by attacking nutrient solid or semi solid body parts of their prey.

Predatory insects have dual role, harmful as well as beneficial. They are harmful in the sense that they kill indiscriminately huge number of preys-insects, fishes or other aquatic organisms which have high commercial value and in turn, they also perform beneficial role when they destroy the harmful insects or their larvae, which are vectors of different diseases of man and domestic animals. Predatory hemipteran insects can be used as bio-controlling agents for harmful organisms and insects. The present Handbook will be helpful for better understanding the predatory bugs of India.

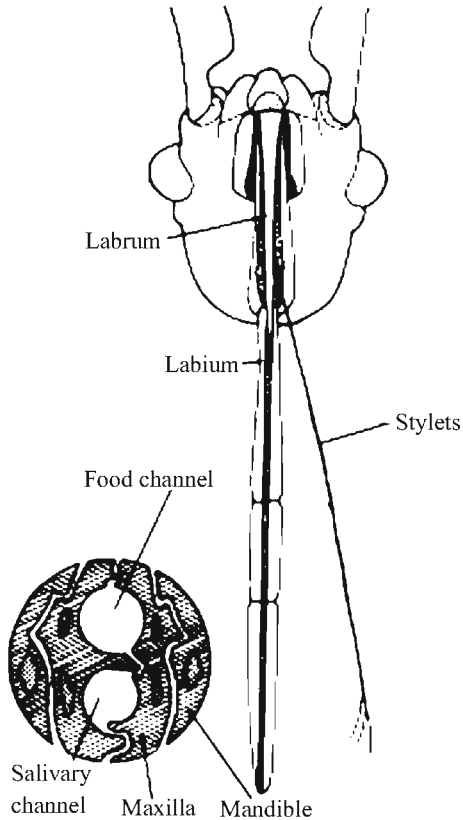
MODIFICATION OF MOUTH PARTS IN DIFFERENT PREDACEOUS HETEROPTERA

Insects of the Order-Hemiptera are having piercing-sucking type of mouth parts for sucking the body fluid of their prey or the sap of their host plant. In general, the labrum, upper lip has no function so as to become reduced and remain as a small remnant to the base on the upper side of the mouth parts, while the labium, the lower lip has been modified greatly and becomes a 3-4 segmented piercing tool called "Rostrum", with a mid-longitudinal groove all through its length to hold the highly modified and sophisticated maxilla and mandibles in the form of maxillary and mandibular stylets. These maxillary and mandibular stylets actually perform the function of cutting and sucking mechanism in the prey body. These stylets have been greatly modified through course of evolution to achieve a unique sucking apparatus among the predatorial hemipteran insects.

In most of the predatory Heteroptera the rostrum is shorter, stouter, and angular, holds in a horizontal plane to the body while feeding. Predatory bugs all have some types of mandibular stylet teeth that are curved back away from the prey body allowing the predator to hold the struggling prey. Predation in the hemipteran insects is particularly related with the number, shape and direction of stylet teeth.

Pentatomid predator *Eeocanthecona furcellata* (Wolff.) possesses

mandibular stylets with blunt tips and sharp hooks for anchorage to the prey tissue. In general, the stylets of pentatomids are harpoon-like, whereas reduviids have knife-like stylets. There is a variation among the mandibular teeth of different predaceous Heteroptera. In Pentatomid predators the mandibular hooks are recurved and pointed backward. These hooks aid in holding the prey while sucking. Cohen (1990) investigated the mouth part structures of five species of predaceous heteroptera and concluded that in reduviids the stylet teeth ranges from 16-17 down to a few in Pentatomids and Lygaeids.



Mouth parts of a Hemipteran insect

Maxilla : One of the major adaptations of predaceous heteroptera is the sharpened spoon shaped maxillary stylet tip. These stylet bundles when not in use are housed by the rostrum which is tipped with sensillae. Only one of the mandibular stylets in *Geocoris punctipes* of the family Lygaeidae is modified into a rasp whereas the others are toothed and knife shaped.

Mandible : Cobben (1979) observed that salivary fluid is being injected into the prey body, especially into the legs and antennae and mixed with prey tissue through the movement of the mandibular stylets and then being sucked out the body fluid. Miles (1972) described this behaviour as flush feeding and opined that as a result of such feeding activity, predator remove large amount of digestible prey materials leaving the non-digestible matters such as sclerotin and chitin.

Stylets : The stylets of predaceous bugs have fine teeth and sharp serration well suited for penetration and lacerating the tissues. The maxillary stylets are grooved and interlocking, the larger groove forming a food canal and the smaller groove as salivary canal. Cobben (1979) demonstrated a system of bristles in the food canal of several aquatic species of predaceous heteropterans. The reduviids also have bristles, which filter larger solid food from the digestive tract. Cohen (1990) observed that the stylets help in cutting, rasping and spreading solid structures within the preys body cavity, which can go upto the legs and antennae mechanically reducing intact structures to semi-liquid pulp. He also narrated that the splaying of stylets is an important component of the mechanical ability of these helps predators to “chew” their prey within the body itself.

MODE OF ATTACK IN DIFFERENT PREDACEOUS HETEROPTERAN INSECTS

The method of attack in a predaceous stinkbug, *E. farcellata* differ from that of other, like Reduviidae, which does not use its forelegs for prey capturing but directly inserts the stylets into any part of the

prey body. It is observed that feeding stink-bugs when disturbed can drag a prey which is at least five times heavier than its body (Usha Rani *et al.*, 1994), where as it is also observed that maxillae are blunt and the mandibular tips consist of three recurved hooks to hold the prey while sucking on it. The maxillae are attached to the inner side of the mandibular stylets and difficult to separate from the mandible. Interlocking ridges between teeth the mandibles are absent. The tip of each mandibular hook is sharply pointed.

Cohen (1996) observed the positioning and posture of the labium during predatory feeding in Pentatomorpha and Cimicomorpha. The labium at the joint between the 1st and 2nd labial segment forming an angle, controlled by stylet muscle which help in deep penetration of labium into the prey tissue is unique among predatory Heteroptera. The flexible stylets are armed with knife and rasps, together with a system of potent digestive salivary enzymes predisposes, by which the Heteropterans are able to use large amount of prey body mass and inject only the most nutritious and biologically useful materials (Cohen, 1990). The piercing and sucking mechanism lends itself remarkably well to predation, enabling them to larger prey.

Most of the herpctorine reduviids on sighting the prey, approach in slow gait, extend their long straight or slightly curved rostrum, jab the prey and instantaneously inject toxic saliva and usually keep their rostrum inserted into the wriggling prey. They use their fore legs only when they fail to manage their prey with rostrum inserted into the prey. These predators rely mainly on the rostral strength rather than their tibial strength. They seldom actively chase the prey.

The aquatic bugs are not fast swimmers rather than slow movers in water but they are the ambush attackers of their prey. Quietly they wait among the vegetation for the chance of any prey of suitable size come close. They attack first to hold the prey with the help of their raptorial anterior pair of legs and pierce the rostrum into the victim's body and inject the saliva to immobilize it.

FACTORS INDUCE THE PREY SEEKING BEHAVIOUR

The presence of receptors at the labial tip helps to discriminate and select the food to be consumed and all these adaptations to heteropterans have led to an enormous success in predation. The labial tip of all the predaceous heteroptera consists of different types of sensilla, and neural canal in the mandibular and maxillary stylet tips. The role of labial tip sensilla is crucial and participates in important decision making about where to direct feeding activities and are located possibly within the oral cavity. The rostrum in Heteroptera also consists of sensory structures and participates in prey searching. The two symmetrically located sensory fields on each side of stylet groove consist of several long sharply pointed sensilla trichodea which perceive the mechanical stimuli in predatory stink bug *E. furcellata*.

MAJOR HEMIPTERAN PREDATORS

Total 35 species of hemipteran insects under 25 genera which are belonging to 9 families have been described here. Pictures of each species also have been provided to have a first look on them. Diagnostic characters definitely will help anyone to identify these predatory insects for various purposes.

Series GEOCORISAE (Terrestrial bugs)

Family ANTHOCORIDAE

1. *Orius tantillus* (Motschulsky)

Diagnosis : Length of the body is 1.48 mm. Head, pronotum, last two segments of antennae, scutellum, base of clavus, sternum and abdomen brown to dark brown; pronotal disc containing shallow callosities separated by a few punctures; anterior tibiae in male with a row of peg-like teeth; long setae on pronotal angles absent; lateral margins of pronotum wide.

Habit and Habitat : The species is known as predator of insects like thrips, aphids and mites which are infesting the cultivated plants. This species can be located along with these insects in the field. This species has been recorded from Coimbatore sugar breeding institute.

Distribution : India : Tamil Nadu. *Elsewhere* : Australia, Micronesia, Pakistan, Sri Lanka.

Remarks : The similarity in external appearance of *Orius tantillus* (Mats.), *Orius indicus* (Reuter) and *Orius ianthe* (Dish) might be due to their overlapping distribution. The only isolation between them apparently being sexual. Hence their only differentiating feature is in the shape of aedeagus.



Orius tantillus

Family LYGAEIDAE

2. *Geocoris ochropterus* (Fieber)

Diagnosis : This species grows up to 3.5 to 4 mm in length; head brownish yellow, pronotum, scutellum and body black, membrane transparent; abdomen, corium, coxae, legs, lateral margins of sternum, pronotum and rostrum yellow with slight brownish tinge; first joint of rostrum a little longer than second.

Habit and Habitat : *Geocoris ochropterus* (Fieber) is the most widely occurring species from Myanmar to Pakistan across North Indian foothills and plains up to Coimbatore district of Tamil Nadu, stretching through the Peninsular India (Mukhopadhyaya and Das, 2004).

Distribution : India : Karnataka, North Indian States, Tamil Nadu, West Bengal. *Elsewhere* : Myanmar, Sri Lanka.

Remarks : *G. ochropterus* has the capability of attacking sedentary pests like jassids, flies, thrips and also small moving caterpillars. They also hunt by actively chasing as well as wait and capture method. The partial phytophagic and narcophagic habits give this species a special characteristic to survive at the time of living prey shortage. The stance raising and suspending a living prey at the tip of labium (rostrum) till the salivary toxins immobilize it which enables the geocorid bugs to handle quite large active prey.

Geocoris ochropterus (Fieber) is predaceous on weevil, *Mylloceous viridanus*, the mired bugs, *Calocoris angustatus* and *Ragmus importunitus*, pentatomid bugs, *Coptosoma crubarria*, the aphids, *Aphid gossypii*, *Aphis nerii*, the Coccids, *Pseudococcus* sp. and *Dachylopius nipae*.



Geocoris ochropterus

3. *Geocoris jucundus* (Fieber)

Diagnosis : This species has been recorded as 3 mm in length; head black, having a spot on each side in front of eyes; pronotum black with lateral angular area yellow with slight brownish tinge, scutellum and corium pale yellowish brown with a brown spot at a nial margin, ntrtrum yellowish brown with base of first, third joint and the apex black.

Habit and Habitat : This species is abundant and widely distributed and is known to occur in agroclimatically diverse region of India.

Distribution : India : Bihar, West Bengal. *Elsewhere* : Myanmar.

Remarks : This species has been found to be effective component as predator in the natural enemy complexes of crop pest.



Geocoris jucundus

Family REDUVIIDAE

4. *Acanthaspis siva* Distant

Diagnosis : A moderate to large size about 18 mm in length. Generally black or dark species with an angular creamy white spot on basal and an irregular rounded spot on subapical area of corium; apex of the membrane is also creamy white enclosing a smoky brown spot, anterior lobe of pronotum sculptured, lateral angle dentate and recurved, disc unarmed, scuteller spine obliquely ascendant.

Habit and Habitat : Both nymphs and adults freely lurk around the hives, in crevices or in cracks, in tree trunks near the locations of the nests of the Indian bees. The adult bugs are active during September to November. Generally this species is found in the entire three major ecosystem i.e. tropical rain forests, scrub jungles and semi-arid zones as well as agro-ecosystems

Distribution : South India and North-Central provinces of India.

Remarks : The brownish spherical eggs are laid single in crevices on hive stand or decaying leaf moulds accumulated in the vicinity of the hive.

Incubation period : 17-28 days. Nymph passes through five nymphal instars to become adult.

Total nymphal period : 107-186 days. The longevity of male and female is 202 days and 115 days, respectively. Frequent cleaning of base boards and surrounding of the hives help in keeping away these bugs from attacking the honey bees.



Acanthaspis siva

5. *Acanthaspis pedestries* Stål

Diagnosis : A pitchy black species which grows up to 13.5 mm in length, with a basal angular and an irregular shaped creamy white spot on corium, another creamy white spot at the apex of the membrane; anterior lobe of pronotum sculptured, posterior lobe finely wrinkled with a central and two narrow lateral spots, blackish red.

Habit and Habitat : It is found predominantly in the semi-arid zones, scrub jungles and on the foot hills of forests and their bordering agro-ecosystems.

Distribution : India : South India, Tamil Nadu and West Bengal

Remarks : This species kills higher number of prey with the increasing prey density. The prey includes *Pectinophora gossypiella* and *Odontotermes assumthi*.



Acanthaspis pedestris

6. *Cydnocoris gilvus* (Burmester)

Diagnosis : Moderate to large size 16-18 mm. Body blood reddish in colour; anterior spine to head curved; antennae, eyes, legs, membrane, coxae, trochanters black; lateral area of abdomen, posterior area of pro, meso and metasternum black.

Habit and Habitat : Although the Harpactorines prefer the rainforests followed by semi-arid zones and scrub jungles ecosystem. This species is recorded from the agro-ecosystem. They are found on vegetation especially on foliage. They also occupy a variety of microhabitats such as underneath bark, in litter under boulders and in termitaria.

Distribution : India : Tamil Nadu. *Elsewhere* : Java, Sumatra, Sri Lanka and Myanmar.

Remarks : This species is known to attack *S. litura*, *Okya nitidula*, *Odontotermis obesus*.



Euagorus plagiatus

7. *Euagorus plagiatus* (Burm.)

Diagnosis : Total length of the species is 13 to 14 mm. Head, pronotum, scutellum reddish yellow with slight brownish tinge, hemelytron pronotum, a broad central spot to pronotum black; posterior spines to the pronotum curved and reflexed; first joint of antennae about as long as anterior femora or head, pronotum and scutellum together, rostrum reddish with its apex black.

Habit and Habitat : This species prefer the vegetation especially on foliage or they may also occur underneath bark, in litter, under boulders and in termitaria, it can be located in and around the vicinity of its prey, banana lace-wing bugs near the banana tree.

Distribution : India : Assam, Andaman and Nicobar Islands, Meghalaya, South India. *Elsewhere* : Myanmar.

Remarks : This species attack the banana lace-wing bug.

Stephanitis typical (Fletcher), (David and Ananthkrishnan, 2006) and is known to be a potential predator of this Tingidae species.



Endochus inornatus

8. *Endochus inornatus* Stål

Diagnosis : This species attain a length of 20-21 mm. Body dark cinnamon brown; legs pale reddish except base of the posterior tibiae and apex of the posterior femora; head about the same length of the pronotum with a short spine behind each antenna; anterior pronotal lobe longitudinally impressed and the posterior lobe finely wrinkled; lateral spines to the pronotum horizontally produced, pronotum between the lateral spines transversely ridged.

Habit and Habitat : This species prefers the scrub jungles, semi arid zones and adjacent agroecosystem upon vegetation especially on foliage. They may occur under the bark, in litter, under boulders.

Distribution : Almost all over India.

Remarks : B.V. David and T.N. Ananthkrishnan (2006) have reported this species as a potential predator of banana lacewith bug *Stephanitis typica* (Fletcher).



Ectomocoris tibialis

9. *Ectomocoris tibialis* Distant

Diagnosis : The male of this species grows up to 17 mm in length. Body black, the first joint and the base of the second joint of antennae, tibiae, tarsi yellowish brown; hemelytra rudimentary only reaching up to base of the 1st abdominal segment; head as long as anterior lobe of pronotum; the spongy furrows occupy about three fourth of the under surface of the anterior tibiae.

Habit and Habitat : This species is known to inhabit under boulders or in litter, but comes out and visit the agroecosystem in search of its prey.

Distribution : India : Maharashtra and South India.

Remarks : Ambrose reported that *E. tibialis* can suppress 84 and 80% of nymphs and adults of *D. cingulatus* (Koenigii), respectively.



Occamus typicus

10. *Occamus typicus* Distant

Diagnosis : Total length of the body is 12 mm; antennae, pronotum head are brownish yellow; a short tuberculous spine on the dorsal surface of the base of antennae; pronotum with anterior lobe shorter than the posterior, sculptured with a suberect spine at each anterior angle, posterior lobe with a much longer straight slender spine at each lateral angle, and two short erect spines on disk a little before base; scutellum with two spines, one straight near base, the other at apex, long and strongly curved; membrane not reaching the abdominal apex.

Habit and Habitat : This Harpactorian species may be found on vegetation especially on foliage. They may occupy a variety of microhabitats such as underneath bark, in litter, under boulders etc.

Distribution : India : Kerala, Karnataka, Tamil Nadu. *Elsewhere* : Sri Lanka.

Remarks : David and Ananthakrishnan (2006) have reported that this species as an important predator upon a tinged banana lace wing bug *Stephanitis typica* (Fletcher).



Rhinocoris costalis

11. *Rhinocoris costalis* (Stål)

Diagnosis : Length of the body is between 12 to 14 mm. Body black, lateral margin and basal area of posterior pronotal lobe, lateral areas of corium, coxae, trochanters abdomen beneath, apex of scutellum coral red; anterior lobe of pronotum sculptured, centrally impressed posterior lobe not impressed; a spot between and a lateral spot behind eyes, coral red; head ventrally and spots to femora beneath brownish yellow.

Habit and Habitat : Although this species occur in the vegetable gardens and other agricultural fields on vegetation especially on foliage, they may be seen in the cotton fields predated upon cotton bugs *Dysdercus koenigii*.

Distribution : India : Andhra Pradesh, Assam, Meghalaya, West Bengal. *Elsewhere* : Malayan Peninsula, Myanmar.

Remarks : David and Ananthkrishan (2006) observed that in India *Rhinocoris costalis* (Stål) is predaceous on red cotton bug *Dysdercus koenigii*.



Rhinocoris fuscipes

12. *Rhynocoris fuscipes* (Fabricius)

Diagnosis : Length of the body is 14 to 16 mm. Body coral red; rostrum, antennae, anterior area of the posterior lobe of pronotum, disk of scutellum, an oblong spot between antennae, upper surface of post ocular area, legs, two spots to pronotum, black; pronotum with the anterior lobe distinctly sculptured, posteriorly centrally a little impressed; membrane passing abdominal apex with its posterior margin pale fuliginous.

Habit and Habitat : This Harpactorines bugs occurs on vegetation especially on foliage. They may occupy a variety of microhabitats such as underneath bark, in litter, under boulders.

Distribution : India : Assam, Maharashtra, South India. *Elsewhere* : Sri lanka.

Remarks : It is predaceous on larvae of *Helicoverpa ormigera*, *Sodoptera litura*, *Semiorthisa pervolgata*, *Eurema hecabae*, and *Cotopcila pyranthe* and beetles *Henosepilachana vigintioctopum* and *Rapidopalpa foveicollis*.



Rhynocoris marginatus

13. *Rhynocoris marginatus* (Fabricius)

Diagnosis : Large to moderate in size, 19.5 mm to 20 mm; body base of the antennae and the lateral margins of abdomen blood reddish; membrane, scutellum, abdomen ventrally, apical portion of tibiae black; anterior lobe of pronotum sculptured; corium and posterior lobe minutely wrinkled; head as long as pronotum; ante and posterior area are equal in length.

Habit and Habitat : This species can be located on vegetation particularly on the foliage. They also occupy some other microhabitat such as underneath bark, in litters, under boulders.

Distribution : India : Andhra Pradesh (Visakhapatnam), North India, South India. *Elsewhere* : Sri Lanka.

Remarks : The male and female *R.marginatus* consume 1:7 and 1:9 prey/predator, respectively at two prey density but consume more number of *D. koenigii* at the density of 32 red cotton bugs during the 24 hours of observation (Ambrose & Kumarswamy 1990).



Irantha armipes

14. *Irantha armipes* (Stål)

Diagnosis : This species is recorded as 10 mm in length. Body pale yellow with slight brownish tinge; connexivum broadly spotted with black more on fourth and fifth segments; femora of anterior legs spinous; abdomen in female dilated lateral spines of posterior pronotal lobe shorter and broader in female whereas in male it is finely and spinously produced, first joint of antennae annulated.

Habit and Habitat : This species also can be found on vegetation especially on foliage and may also occupy variety of microhabitats such as underneath bark, in litter, under boulders and in termitaria.

Distribution : India : South India, Uttar Pradesh. *Elsewhere* : Sri Lanka.

Remarks : This species has been located in the rice field predated upon rice pest *Leptocorisa acuta* (Thunb.).



Andrallus spinidens

Family PENTATOMIDAE

15. *Andrallus spinidens* (Fabricius)

Diagnosis : Moderate in size 13 mm to 16 mm in length and width between pronotal angles form 8.5 mm; a band of blackish punctures in the form of band on each side of the central lobe of head and a pale central smooth shiny line between the pronotal angles; pronotal lateral angles with two spines, posterior spine being very small.

Habit and Habitat : This species occurs on vegetation especially on foliage.

Distribution : India : Assam, Bihar, Karnataka, Meghalaya, Sikkim, West Bengal. *Elsewhere* : East Africa, Fiji, Malay Archipelago, Mexico, Tahiti.

Remarks : This species predate upon “Yellow Stem Borer”, “Whit Backed Plant hopper”, *Pamara mathias* (Fabr.), *Sesamia inferens* (Walk.), *Spodoptera litura* (Fabr.), *Melanitis leda ismene*. This species was earlier under the genus *Audinetia*.



Amyotea malabaricus

16. *Amyotea malabaricus* (Fabricius)

Diagnosis : Length of the body may varies from 12 to 14 mm; antennae, eyes, a basal spot to head, two to three spots on pronotum and two spots one on each basal angle of scutellum and membrane black, abdomen, rostrum, coxae femora, pale reddish.

Habit and Habitat : This species can be located in and around the rice fields. Although this species are basically phytophagous they are also known to be a potential predator on rice bug *Leptocorisa acuta* (Thumb.) of the family Alydidae.

Distribution : India : Assam, Karnataka, Maharashtra, West Bengal.
Elsewhere : Borneo, Java, Mayanmar, Philippines, Sumatra.

Remarks : In the state of Orissa this species are known to predate upon *Melanitis leda ismene* (Cramer).



Eocanthecona furcellata

17. *Eocanthecona furcellata* (Wolff.)

Diagnosis : The body may attain 15 to 16 mm in length. Body grayish yellow with dark bronzy punctures; pronotum with a broken transverse fascia on anterior area, some more or less distinct longitudinal fasciae on anterior half and the lateral angles bronzy black.

Habit and Habitat : This species are known to occur on vegetation, especially on foliage.

Distribution : India : Bihar, Maharashtra, Tamil Nadu, West Bengal.
Elsewhere : Mayanmar and also found throughout Oriental and Nearctic regions.

Remarks : The early instar nymphs feed on host plant and later become predaceous on other insects. Both nymphs and adults approach insect caterpillars from behind, place the rostrum in between the two anal prolegs and thrust the stylets into the body of the larvae and suck the body fluid. The larvae thus get killed hang head downwards. The bugs are predaceous on larvae of *Amsacta albistriga*, *Spodoptera exigua*, *Spodoptera litura*, *Athalia lugens proxima*, *Thosea cervina*, *Utethesia pulchella*, *Hyblaea puera*, *Semiothesia pervolgata*, *Eurema hecabe*, *Catopsilia pyranthe*, *Helicoverpa armigera* and *Thiacidas postica*.

Cannibalistic tendency is also noticed in this species.



Zicrona caerulea

18. *Zicrona caerulea* (Linnaeus)

Diagnosis : Medium size 9 mm to 10 mm in length; body violaceous blue; membrane and antennae black; scutellum a little elevated at base; body above very finely and sparingly punctate.

Habit and Habitat : This species are known to occur upon the foliage in the agro ecosystem.

Distribution : India : Jammu and Kashmir, Nagaland and West Bengal. *Elsewhere* : China, Japan, Myanmar, Mexico, Pakistan, a widely distributed species throughout palaeartic region.

Remarks : Both adults and late inster nymphs are predaceous on larvae of *Sdoptera litura*, *Semiothesa pervolgata*, *Catopsilia pyranthe*, *Eurema hecabae*, *Anticarsia irrorata*, *Helicoverpa armigera* and *Pelopidas mathias*.



Cyrtorhynus lividipennis

Family MIRIDAE

19. *Cyrtorhynus lividipennis* (Reuter)

Diagnosis : This species has been measured as 2.75 to 3.50 mm in length; body black; base of head and a large spot on inner side of each eye, rostrum, apex of first joint of antennae, anterior callosities, a broad central area to posterior area of pronotum, a large lateral spot on each side of scutellum, body beneath and legs flavescent; a lateral spot to sternum, black.

Habit and Habitat : This species has been recorded from the rice agro ecosystem.

Distribution : India : Andaman and Nicobar Island, Andhra Pradesh, Bihar, Madhya Pradesh, Karnataka. *Elsewhere* : Myanmar, Sri Lanka.

Remarks : Prey of this species is known to be White backed plant hoppers and leaf hoppers, Brown plant hoppers.



Anisops bouvieri

Series HYDROCORISAE (Truly aquatic bugs)

Family NOTONECTIDAE

20. *Anisops bouvieri* Kirkaldy

Diagnosis : Males are 6.0-6.3 mm in body length while females are a little small, ranging from 5.7-6.0 mm in their length. The males have the horn like cephalic projection more or less acuminate and larger, which may be one fifth of its ventral length and extends beyond the anterior margin of eyes. Tufts of hairs are present on the labrum.

Habit and Habitat : This species is found in freshwater pools, lakes, ponds, forest stream etc. and attracted to light also. It is a very common insect predator available in fish ponds all over the country. This particular species of insect feeds voraciously on fish fry, nymphs and larvae of other aquatic insects like mosquitoes, chironomids, mayflies and also different types of planktonic forms of animals. It is also observed that during period of starvation they show cannibalism.

Distribution : India : Andhra Pradesh, Andaman & Nicobar Islands, Assam, Madhya Pradesh, Orissa, Tamil Nadu, West Bengal. *Elsewhere* : Bangladesh, China, Malayasia, Myanmar, New Guinea, Thailand.

Remarks : Julka (1965), Nishi & Venkatesan (1989) reported on the predation of this species, David & Ananthkrishnan (2004) also recorded the high predations behaviour of this species.



Anisops sardeus

21. *Anisops sardeus* Herrich-Shaffer

Diagnosis : Adult males attain 7.5-8.4 mm in body length while females are a little smaller 7.2-7.5 mm in length and in general the greatest body width is about midway the length of the body. General body colour is pale yellow or brownish yellow. Males are provided with much prominent cephalic horn, a median projection of head, with frons excavate of its entire length and bordered laterally by two carinae. Anterior tibia of male is provided with stridulatory comb which is gradually narrow towards the apex. The comb is composed of about 18 teeth. In male the left paramere is deeply excavate. In females the ovipositor is provided with longitudinal teeth and lateral tooth-like setae.

Habits and Habitat : This species are very common in slow moving mountain streams. They are also available in streams and running water in plains as well as in freshwater ponds and lakes. The members of this species prey upon varieties of small animals like aquatic larvae and nymphs of different insects and other zooplanktons. By killing mosquito larvae they are performing in the role of beneficial insects as well.

Distribution : India : Bihar, Chandigarh, Delhi, Himachal Pradesh, Karnatka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : Afghanistan, Africa, Albanie, Canary Islands, Myanmar, Syria, Turkey.



Enithares ciliate

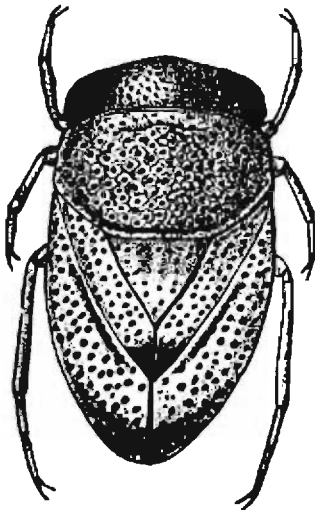
22. *Enithares ciliata* (Fabricius)

Diagnosis : General body length of this species varies from 8.5-10.0 mm. in both the sexes, males may be considered a little smaller in size than the females. The mesotrochanter is rounded and provided with a patch of black spicules along the ventral margin, covering a much larger area.

Habit and Habitat : This species is found in the water very close to the surface and swim like other notonectids in an upside down position which commonly labeled them as “back swimmers”. They feed on preys of suitable sizes which comprise of aquatic larvae and nymphs of insects and other small animals and by holding with the help of their raptorial fore legs. They also feed voraciously on mosquito larvae.

Distribution : India : Andhra Pradesh, Bihar, Goa, Kerala, Maharashtra, Tamil Nadu, West Bengal. *Elsewhere* : Bhutan, Indonesia, Malaysia, Mauritius, Sri Lanka, Vietnam.

Remarks : This species has been found as a potential killer of mosquito larvae in nature.



Paraplea frontalis

Family PLEIDAE

23. *Plea frontalis* (Fieber)

Diagnosis : Body length may be upto 2.5 mm; a small brown mid-longitudinal streak is present on the front of the head and two pairs of small irregular brownish patches are placed just above the streak on the vertex. Pronotum is covered with coarse punctures. Elytra are covered with fine hairs, and are coarsely and reticulately punctate. Abdominal sternites are keeled which are very prominent and provided with backwardly directed prominent spine. Right ovipositor is having 14 to 17 spines while left one is having 16 to 20 spines. Males are a little smaller in size than females.

Habit and Habitat : The individuals of this species generally occur in large number in stagnant freshwater pools amongst the aquatic vegetation. They voraciously feed on the larvae of mosquitoes and other zooplanktons. In the Fish pond food webs this species becomes a strong competitor of the fish fry which may lead the later to a detrimental condition for their survival (Jhingran, 1975).

Distribution : India : Andaman & Nicobar Islands, Bihar, Orissa, Pondicherry, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : China, Formosa, Indonesia, Malayasia.



Laccotrephes ruber

Family NEPIDAE

24. *Laccotrephes ruber* (Linnaeus)

Diagnosis : Body elongated and dorso-ventrally flattened. Length of the adult insects may be 30-35 mm while abdominal appendages are slightly longer than the body length. Abdomen above is yellowish red in colour. Anterior area of prosternum is having with a small indistinct tubercle. The prosternum is convex along the middle and slightly raised medially near the posterior end. The male parameres are curved and hook shaped. Because of their similarity in body form with scorpions they are commonly known as “Water-scorpions”.

Habit and Habitat : This larger species is reported from a wide variety of habitats of both lentic and lotic water bodies like ponds, lakes, swamps, streams, rivers. It is predatory on small aquatic organisms like fish fry, larvae or nymphs of other insects in shallow waters at the edge of the water bodies.

Distribution : India : Bihar, Gujarat, Jammu & Kashmir, Kerala, Maharashtra, Meghalaya, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : China, Formosa, Japan, Nepal, Pakistan.

Remarks : This species is having good flying capabilities and are light attractants.



Laccotrephes griseus

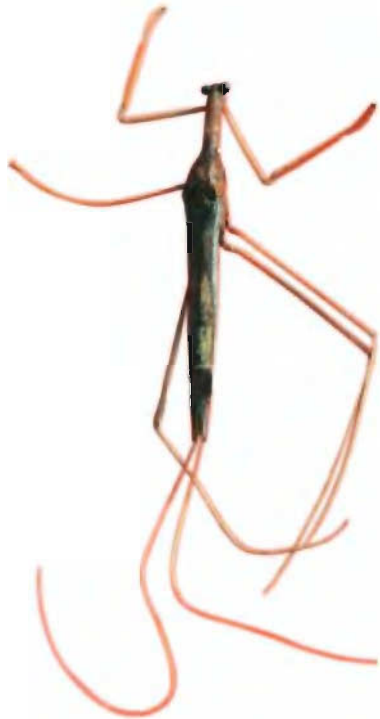
25. *Laccotrephes griseus* (Guerin)

Diagnosis : This species is relatively small in size than that of *L. ruber*. Body length is 15-20 mm while abdominal appendages are directly shorter than the body length. Prosternum is armed with a strongly acute tubercle at the anterior area. Abdomen above with light bluish tinge. The base of the anterior femur is provided with a obtusely rounded tooth. Male parameres are symmetrical and slightly hook shaped.

Habit and Habitat : This species is very sluggish in movement and often found in stagnant or slow running pools at the edge amongst the aquatic weeds or at the bottom of water with dark soil matching its body colour. They feed on small aquatic animalcules like fish fry, or nymphs larvae of aquatic insects.

Distribution : India : Andhra Pradesh, Bihar, Kerala, Maharashtra, Orissa, Pondicherry, Punjab, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : Myanmar, Malacca, Seychelles, Sri Lanka, Thailand.

Remarks : This species attacks carp spawn and fry, and cause considerable damages (Jhingran, 1975). In addition to causing direct mortality, these bugs also actively compete with the carp fry for food to the detriment of the fish (Bal & Basu, 1992).



Ranatra elongate

26. *Ranatra elongata* Fabricius

Diagnosis : Adult of this species may be 40-45 mm in body length while abdominal appendages are about 50-55 mm., which justifies the name of the species as *elongata*. The species can be recognized by the structure of the anterior femur which is provided with a triangular tooth beyond the middle of its length. The metasternal process is subtriangular and mid-longitudinally foveately sulcate. The anterior coxae are two-thirds of the length of prothorax. Anterior lobe of prothorax is less than twice the length of posterior lobe.

Habit and Habitat : This species prefers to dwell in the deeper parts of ponds and lakes, and feeds on tadpoles, nymphs of mayflies and other aquatic bugs of suitable sizes. During dry season it migrates in search of suitable habitat (Rao 1962, 1976).

Distribution : India : Andhra Pradesh, Bihar, Chandigarh, Delhi, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Pondicherry, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere :* Australia, Nepal, Sri Lanka.



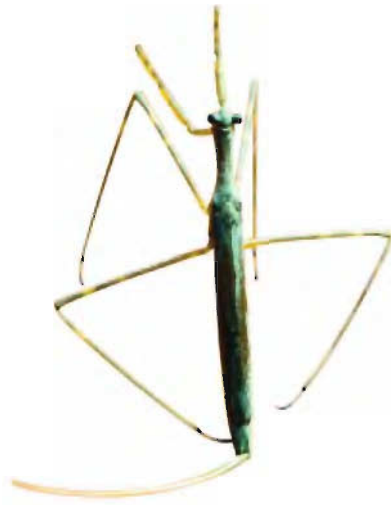
Ranatra filiformis

27. *Ranatra filiformis* Fabricius

Diagnosis : Adult insect may attain a length of about 27-28 mm and abdominal appendages is about 23 mm. Both the teeth on anterior femur are spinulose. Head is provided with distinct tubercle on the vertex. The males of this species can easily be identified by the absence of a tooth and presence of several small spines on the inner margins of distally hook-shaped paramere. Interocular space is wide.

Habit and Habitat : This species is found both in lentic and lotic waters among vegetation, fringing the shallower parts of water bodies by clinging to the submerged aquatic plants. It feeds on nymphs of odonates and mosquito pupae. The paired filamentary caudal appendages united to form a respiratory siphon and it is protruded out of the surface of water when insect is completely submerged and clinging to the aquatic vegetation.

Distribution : India : Ahdhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Delhi, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Manipur, Meghalaya, Orissa, Pondicherry, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : China, Nepal, Pakistan, Philippines, Sri Lanka.



Ranatra varipes

28. *Ranatra varipes* Stål

Diagnosis : Body length is about 19-20 mm and length of the caudal appendages is upto 12 mm. Pronotum is provided with a distinct ridge at the posterior angle of each side. Metasternal process is blunt at the posterior end and a bit rounded without any lateral concavity. Anterior tibia is longer and clearly touching the inner tooth on the anterior femur which is brood with irregular brown markings. Male with a hatched shaped paramere at the distal end.

Habit and Habitat : Though the individual of this species are relatively small in size than other *Ranatra* species, but they are no less in their preying capability on different aquatic larvae of insects along with other small aquatic organisms. They are found in the stagnant freshwater water bodies at the edge in the aquatic vegetation.

Distribution : India : Orissa, Tamil Nadu, Uttar Pradesh, West Bengal.
Elsewhere : Australia, Indonesia, Malaysia, Myanmar, Taiwan.



Cercotmetus fumosus

29. *Cercotmetus fumosus* Distant

Diagnosis : Body length of adult insect is about 48 mm while the paired caudal appendages are relatively stout and short in length which may be upto 14 mm. Head is provided with a pointed distinct tubercle in between the eyes. Hemelytra are a little short and do not reach the apex of the 5th abdominal segment. Abdomen on the ventral side is strongly keeled. Anterior femur is stout and considerably shorter than the length of pronotum. Caudal appendages are short, and two and a half times longer than the operculum which is narrow and consinate.

Habit and Habitat : This species is sluggish and awkward swimmer like *Ranatra* species. Commonly the individuals of this species are found at the edge of stagnant freshwater pools among aquatic plants. Very often they are seen to protrude the tip of the respiratory siphon above the surface of water for respiration while resting them by holding the aquatic plants. They are preying upon larvae as well as other small aquatic animalcules.

Distribution : India : Bihar, Himachal Pradesh, Orissa, Tamil Nadu, Uttar Pradesh. *Elsewhere* : Sri Lanka.



Diplonychus annulatus

Family BELOSTOMATIDAE

30. *Diplonychus annulatus* (Fabricius)

Diagnosis : This species may attain a body length of 21-22 mm and breadth is a little less than its length which gives it a more or less oval rounded shape of the dorsoventrally flattened body. Head is as long as the interocular space. Anterior tarsus is two segmented and hemelytra are not having any shining rounded spot beyond the middle of the inner margin.

Habit and Habitat : This aquatic bug occurs in lentic freshwater bodies like ponds, lakes and swamps amongst rich submerged vegetation. They rest at the surface in fresh aquatic vegetation by extending their body obliquely downwards and proceeding tip of the abdomen slightly above the surface film. Males of *Diplonychus* carry eggs on their back on the elytra, which are forcibly placed and attached by the females. This is a remarkable adaptation presumably serving as protection for the eggs. They are feeding upon larvae of mosquitoes, chironomids, tadpoles, fish fry and other aquatic insects of suitable sizes.

Distribution : India : Assam, Bihar, Orissa, Tamil Nadu, West Bengal.
Elsewhere : Bangladesh, Pakistan, Taiwan.



Diplonychus rusticus

31. *Diplonychus rusticus* (Fabricius)

Diagnosis : Body length may be 15-17 mm and shape of the body is suboval. Lateral basal margins of pronotum and enbolium pale in colour. Anterior tarsi single segmented and armed with a smaller claw. Ventro-lateral stripe of fine hairs on the venter of abdomen is narrower. A rounded shining spot beyond the middle of the inner margin of the elytron is present distinctly.

Habit and Habitat : This moderate size belostomatid is commonly occurs in fish ponds and is a voracious feeder on fish fry. It is also known to feed on a wide variety of aquatic organisms including mosquito and chironomid larvae.

Distribution : India : Bihar, Jammu & Kashmir, Kerala, Maharashtra, Orissa, Tamil Nadu, West Bengal. *Elsewhere* : Australia, China, Myanmar, New Guinea, New Zealand, Sri Lanka, Thailand.

Remarks : Besides killing fish fry they are also destroying the larvae of vector insects.



Lethocerus indicus

32. *Lethocerus indicus* (Lep. & Serv)

Diagnosis : Adults may attain a length of about 62-85 mm. Body large, elongate and dorso-ventrally flattened. Eyes are elongate and dorso-ventrally flattened. Eyes are elongate and large, twice as long as wide. Middle and hind legs are provided with thick set of swimming hairs on the ventral side, while fore legs are raptorial and strong enough to hold larger prey animals. A pair of retractable, strap like caudal appendages at the tip of abdomen as and when required.

Habit and Habitat : This species in true sense is known as “Giant water-bugs” because of its size. This water-bugs prefer to live in deeper water of big ponds, lakes and swamps, streams, or rivers, with or without aquatic vegetation, by clinging to some support and tip of its abdomen in contact with the surface film. It is a good flier and can fly from one place of water to another covering a considerable distances. This insect is phototropic and is attracted to light frequently at night.

This bug occurs in ponds, lakes and other freshwater water-bodies and are predaceous on other insects, fishes, tadpoles of frogs, snails *etc.* It can attack and kill a fish three or four times larger its own size.

Distribution : India : Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Delhi, Karnataka, Kerala, Meghalaya, Madhya Pradesh, Maharashtra, Mizoram, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere :* China, Indonesia, Malaysia, Myanmar, Pakistan, Sri Lanka.

Remarks : By destroying the larvae of mosquitoes and snails—the potential vectors of the disease like Malaria and Schistosomiasis respectively this species is performing an excellent role in biological control of the concerned disease for the mankind.



Aquarius adelaidis

Family GERRIDAE (Semi-aquatic bugs)

33. *Aquarius adelaidis* (Dohrn)

Diagnosis : Macropterous and Brachypterous males of this species may be upto 11.2-12.2 mm and 10.4-10.9 mm in body respectively while females of both forms may be a bit larger in size like 14.6-15.2 mm. First antennal segment is longest while second and fourth segments are smaller than first and third is smallest. Head, rostrum, pronotum and legs are black in colour. A semilunar pale marking is at the base of the head. Anterior femur of male is almost straight with a little constriction before apex which is terminated by the presence of two distinct spines. Males are also provided with stout and long connexival spines which are almost reaching the abdominal end (proctiger). Females are also provided with stout end surpassing the abdominal end. In males parameres are conical and setose, the proctiger is elongate, ovate with pointed apex.

Habit and Habitat : This is one of the most common species of semi-aquatic bugs which inhabit the permanent lentic waterbodies in India. They stride over the surface of water in considerable number and prey upon the considerable mosquito larvae and other small organisms which are swimming or moving just below the surface of water. They are seen to capture the prey with the help of their forelegs by pushing the anterior part of body down below the surface into the water and after catching is over they resurface to finish the feeding.

Distribution : India (very widely distributed in lentic waterbodies all over the country except on higher altitude). *Elsewhere* : Bangladesh, China, Indonesia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam.



Limnogonus nitidus

34. *Linnogonus (Linnogonus) nitidus* (Mayr)

Diagnosis : Body length of adult insects may be 6.0-8.0 mm. Head is with characteristic paired yellowish longitudinal lines within the eyes. First and fourth antennal segments are longest and subequal to each other while second and third segments are shortest and also subequal to each other in length. Posterior margin of dorsal vesicle plate of pronotum is remarkably angular. The 7th abdominal segments are provided with fairly prominent connexival spines in both the sexes.

Habit and Habitat : This species has been widely found from the temporary pools, rice fields flooded with water, ponds and lakes. It also has been recorded above 1000 metres sea level altitude from Nilgiri Hills, Southern India. This species is very much light attracted. It preys upon small aquatic organisms which fall on its way. It is also reported that this species is one of the predators of the Brown plant hopper of paddy-*Nilaparvata lugens* (Stål) of the family Delphacidae, which is a serious pest of paddy (Thirumalai, 2001).

Distribution : India : Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Chandigur, Delhi, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal. *Elsewhere* : Indonesia, Malaysia, Maldiva Islands, Myanmar, Nepal, Singapore, Sri Lanka, Thailand, Vietnam.

Remarks : A little bit biological control of Brown planthopper of paddy *Nilaparvata lugens* is performed by this species.



Neogerris parvula

35. *Neogerris parvula* (Stål)

Diagnosis : Body length of adult insect may be 6.0-6.5 mm. Presence of a large rounded yellowish spot on the pronotum makes this species separates from all other known species. Antennal first segment is longest and as long as a little longer than the second and third segments together, and the fourth segment is almost half the length of first segment. In male the hind margin of pygopore is straight while the hind margin of 7th ventral abdominal segment is bisinuate in females. The species is represented by both apterous and macropterous forms.

Habit and Habitat : This species is very common in both lentic and lotic waterbodies like reservoirs, ponds, rain-fed pools like flooded rice fields and slow running streams throughout Indian subcontinent. They prey upon small aquatic animalcules whatever they found on their way like *Limnogous* (L.) *nitidus* this species is also a notable predator of the Brown planthopper of paddy *Nilaparvata lugens* (Stål)—a serious pest of paddy.

Distribution : India : Arunachal Pradesh, Assam, Kerala, Orissa, Pondicherry, Tamil Nadu, Uttar Pradesh, West Bengal. *Elsewhere* : China, Indonesia, Iran, Japan, Malaysia, Myanmar, New Guinea, Oman, Philippines, Pakistan, Solomon Island, Sri Lanka, Taiwan, Thailand, Vietnam.



Giant water-bug (*Lethocerus* sp)

Remarks : Like *Linnogonus nitidus* this species also perform a natural controlling agent for the serious pest of paddy—*Nilaparvata lugens* (the Brown planthopper of paddy) of the family Delphacidae. (Sahayaraj 2004). Earlier this species was known as *Gerris tristan* as reported by Distant.

DISCUSSION

In the Handbook, authors have attempted to provide an account on the predatorial hemipteran insects which are most common in India and play a major role in different habitats. All together 35 species under 25 genera of 9 families have been chosen which are considered to be the major predators in the Order—Hemiptera in India. The pictures of all the species and their diagnostic characters, habit and habitats as well as their distribution in India and other countries have been provided in this Handbook. The authors are hopeful that this Handbook may be much helpful for those who are interested to know these predatorial insects for various purposes.

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REFERENCES

- Bal, Animesh and Basu, R.C. 1992. Water-bugs of Economic importance. *Proc. zool. Soc., Calcutta*, **45** (Suppl-A) : 324-329.
- Cobben, R.H. 1979. On the original feeding habits of Hemiptera (Insecta) : A reply to Merrill Sweet. *Ann. Entomol. Soc. Am.* **72** : 711-715.

- Cohen, A.C. 1990. Feeding adaptation of some of predaceous Hemiptera. *Annual Ent. Soc. Amer.*, **83** : 1215-1223.
- David and Ananthakrishnan, K.S. 2004. General and applied Entomology. Tata McGraw-Hill Publishing Company Limited : 345-422.
- Gorai, A.K. and Roychaudhuri, D.N. 1962. Food and feeding habits of *Anisops bouvieri* Krik. (Heteroptera : Notonectidae). *J. Asiat. Soc.*, **4** : 135-139.
- Jhingran, V.G. 1975. *Fish and fisheries in India*. Hindustan Publishing Corp., India, Delhi.
- Julka, J.M. 1965. Observation on Biology of aquatic bugs (Hemiptera) injurious to the pond fishes. I. *Anisops bouvieri* Krik. *Proc. Indian Acad. Sci.*, **61** : 49-61.
- Miles, P.W. 1972. The saliva of Hemiptera. *Adv. Insect Physiol.*, **9** : 183-256.
- Nishi, R. and Venkatesan P. 1989. Predation injection rate and its bearing on prey death rate in *Anisops bouvieri* Kirkady. *J. Entomol. Res.* (New Delhi), **13** : 140-145.
- Sathe and Bhosle. 2001. Insect pest predators. Daya Publishing House, Delhi.
- Singh, S.P. 1994. Fifteen years of AICRP on biological control. Project Directorate of Biological control, Banglore, p. 300.
- Sahayraj, K. 2004. Indian insect predators in Biological control. Daya publishing house : 1-336.
- Usha Rani, P. and Wakamura, S. and Asoka, K. 1994. Morphology of rostral tip appendages in carnivorous stink bug, *Eocanthecona furcellata* (Wolff) (Heteroptera : Pentatomidae). *J. Ent. Res.* **18**(3) : 1-4.

