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REDESCRIPTION, BIOLOGY AND BEHAVIOUR OF THE HARPACTORINE ASSASSIN BUG *IRANTHA ARMIPES* (STÅL) (HEMIPTERA: REDUVIIDAE)

S. Sam Manohar DAS[1], Dunston P. AMBROSE[2*]

[1]Present Address: Department of Zoology, Scott Christian College,
Nagercoil - 629 003, Tamil Nadu, India.
[2]Entomology Research Unit, St. Xavier's College (Autonomous)
Palayankottai 627 002. Tamil Nadu - India.
e.mail: eruxavier@sancharnet.in
*Corresponding author

Abstract - A redescription of *Irantha armipes* (Stål) is given and its behaviour in the laboratory is described. *Irantha armipes* eggs have brown chorion and white rim-collar veil covering a brown convex, finely sculptured operculum. A female on average laid 97.28 ± 3.2 eggs in 12.9 ± 0.86 clusters with 1 to 15 eggs per cluster. The eggs hatched after 9.1 ± 0.77 days. The developmental durations of the I, II, III and IV nymphal instars and V nymphal instar to adult male and adult female were 8.2 ± 0.67, 9.4 ± 0.78, 10.1 ± 0.91, 9.8 ± 0.82, 9.8 ± 0.68 and 11.2 ± 0.91 days respectively. Measurements and illustration of life stages are given with a key to identify the nymphal stages. The sex ratio of male and female was 1 : 0.94. The preoviposition, oviposition and postoviposition periods were 9.8 ± 0.62, 72 ± 4.5 and 4.5 ± 0.29 days respectively. The adult males and females lived for 76.9 ± 6.1 and 86.4 ± 4.6 days. Sequential acts of predatory behaviour such as arousal, approach, capturing, paralysing, sucking and postpredatory behaviour were observed. The sequential acts of mating behaviour were excitation, approach, nuptial clasp including riding over, genitalia extension, connection achievement and postcopulatory behaviour.

KEY WORDS: *Irantha armipes*, assassin bugs, redescription, biology, nymphal morphology, predation, mating.

Izvleček – PONOVNI OPIS, BIOLOGIJA IN VEDENJE ROPARSKE STENICE VRSTE *IRANTHA ARMIPES* (STÅL) (HEMIPTERA: REDUVIIDAE: HARPACTORINAE)

Podan je ponoven opis vrste *Irantha armipes* (Stål) in opisano je njeno vedenje v ujetništvu. Jajčeca imajo rjav horion in belo ovratno tančico, ki pokriva rjav izbočen, drobno strukturiran operkulum. Samica je v povprečju izlegla 97,28 ± 3,2 jajčec v 12,9 ± 0,86 gručah z 1 do 15 jajčeci na gručo. Ličinke so se izlegle po 9,1 ± 0,77 dneh. Dolžine razvoja ličink I., II., III. in IV. stadija ter V. stadija do odraslih samcev in samic je bila 8,2 ± 0,67, 9,4 ± 0,78, 10,1 ± 0,91, 9,8 ± 0,82, 9,8 ± 0,68 in 11,2 ± 0,91 dni. Podane so meritve in risbe razvojnih stadijev s ključem za njihovo določitev. Spolno razmerje je bilo 1 : 0,94 v korist samcev. Obdobja pred, med in po odlaganju jajčec so bila dolga 9,8 ± 0,62, 72 ± 4,5 in 4,5 ± 0,29 dni. Odrasli samci in samice so živeli 76,9 ± 6,1 in 86,4 ± 4,6 dni. Opazovali smo zaporedna dejanja plenilskega vedenja, kot so pozornost, približevanje, ulov, ohromitev in sesanje plena ter vedenje po lovu. Zaporedna dejanja spolnega vedenja so bila vzburjenje, približevanje, svatbeni objem vključujoč jahanje na hrbtu, iztegnitev genitalij, opravljena povezava in vedenje po kopulaciji.

KLJUČNE BESEDE: *Irantha armipes*, roparske stenice, ponovni opis, biologija, morfologija ličink, plenilstvo, parjenje.

Introduction

Reduviidae are speciose, abundant, occur worldwide, are highly successful predators, and play a vital role in the biocontrol of insect pests (Ambrose, 1999). Moreover, they exploit diverse microhabitats of terrestrial ecosystems and prey on a wide variety of insect pests. Since many of them are polyphagous predators they are valuable predators in situations where a variety of insect pests occur. However, life stages of some harpactorine species exhibit a certain amount of host as well as stage preferences (Ambrose, 1999). Hence, they should be conserved in their natural habitats and/or augmented to effectively utilize them in the Integrated Pest Management Programmes (IPM) (Ambrose, 1999, 2000, 2003; Ambrose et al., 2003, 2006, 2007). For instance, augmentative release of a harpactorine assassin bug *Pristhesancus plagipennis* (Walker) in Australia effectively suppressed the larvae of *Helicoverpa* spp. in cotton and green mirid *Creontiades diluton* (Stål) and looper caterpillars *Chrysodeixis* spp. in soya bean (Grundy and Maelezer, 2000a, b; Grundy et al. 2000a,b). In India, augmentative release of another harpactorine assassin bug *Rhynocoris kumarii* Ambrose and Livingstone significantly reduced the population level of red cotton bug *Dysdercus cingulatus* (Fabricius) (Claver and Ambrose, 2001a, b). Use of any biological control agent relies upon comprehensive knowledge on its ecology, physiology and behaviour.

The genus *Irantha* was originally described by Stål (1861) with the type species *Harpactor armipes* from Sri Lanka, transferred to the genus *Irantha* as *I. armipes* (Stål, 1855). Distant (1902) also recorded it from Nepal (Maldonado, 1990). *Sinea hoplites* (Dohrn, 1860) and *Sthinerea armipes* (Walker, 1873) were synonymized with *Irantha armipes*. In addition, two original descriptions under *Irantha*, viz. *I. hoplites* (Stål 1866) and *I. germana* (Breddin, 1909), were synonymized with *I. armipes* by Distant (1902). Later, additional four species of the genus, viz. *I. bramarbas* Breddin (1903) from North West Sumatra, Indonesia; *I. consobrina* Distant (1904) from India; *I. pepparai*

Livingstone and Ravichandran (1988) from South India (Ambrose 2006) and *I. nigrina* Chen et al. (2005) from China, were described. As the available superficial morphological descriptions of *I. armipes* without illustrations (like that by Stål) do not allow an accurate diagnosis, a redescription is included in this work. Even though information on biology and behaviour of many reduviids is available, no such information is documented for any of the *Irantha* species. Hence, an attempt was made to study the biology and predatory and mating behaviour of *I. armipes*. Better understanding will enable one to have baseline information used for conservation and augmentation of the predator and thereby realizing its biocontrol potential against insect pests.

Materials and Methods

Adults and immatures of *Irantha armipes* (Stål) were collected from Kodayar tropical rainforests, Kanyakumari District, Tamil Nadu (77° 20' 17" E and 8° 28' 9" N). They were reared on larvae of rice meal moth *Corcyra cephalonica* (Stainton) (Pyralidae) in plastic containers (5.5 x 6.5 cm) under laboratory conditions (temp. 30 ± 2°C, 75 ± 5% rh, 12 ± 1 hr photoperiod). The virgin adult males and females emerged in the laboratory were allowed to mate. Only adults reared in the laboratory were used for the experimental studies.

The number of batches of eggs and the total number of eggs laid were recorded for each female. Batches of eggs were allowed to hatch separately in 15 ml plastic containers covered with netted lids. The newly hatched nymphs were isolated soon after eclosion and reared in individual plastic containers (50 ml) on the fifth instar (1.5 cm long) larvae of rice meal moth *C. cephalonica*. The containers were examined at regular intervals for spermatophore capsules ejected after successful copulation as well as for eggs. Observation on eclosion, fecundity, hatchability, ecdysis, nymphal mortality, emergence, sex ratio and adult longevity for those adults that emerged in the laboratory were made.

Predatory behaviour was observed in 24 hr prey deprived *I. armipes* on two prey, viz. *C. cephalonica* larvae (1.5 cm long) and the termite *Microtermes obesi* Holmgren (Kalotermitidae). The mating behaviour of sex starved virgin predators was recorded. Camera lucida illustrations and measurements of life stages under microscope with micrometers were made with specimens preserved in 70 % ethanol. Measurements (no = 6) of life stages from the laboratory culture are given in Tables 1 & 2 and compared among instars to formulate the nymphal key.

Results

Microhabitat. *Irantha armipes* was found to inhabit shrubs in Kodayar tropical evergreen forest, Kanyakumari District, Tamil Nadu, South India. Specimens were found under the large leaves of *Macaranga indica* Wight. Mating pairs were encountered occasionally. During heavy monsoon rains and winds, specimens were found to take shelter on the lower side of large leaves of plants like *Jadropa glandulifera* Roxb., *Solanum torvum* SW. and *Lantana camara* L. They were found feeding mainly on caterpillars, grasshoppers *Poekilocerus* sp. (Acrididae) and *Colemania* sp. (Acrididae), and ant *Camponotus compressus* Fabricius (Formicidae) in the field. We found certain plant bugs and seven other reduviid predators with *I. armipes* such as its congener *Irantha consobrina* (Distant), *Sphedanolestes himalayensis* Distant, *S. pubinotum* Reuter, *Macracanthopsis nodipes* Reuter, *Euagoras plagiatus* (Burmeister), *Cydnocoris gilvus* (Burmeister), *Rhynocoris fuscipes* (Fabricius), *R. kumarii* Ambrose and Livingstone, *R. marginatus* (Fabricius) and an unidentified species of *Coranus* sp.

Redescription. The superficial morphological description of *Irantha armipes* (Stål 1861) without illustrations does not allow accurate diagnosis of the species and hence, it necessitates a redescription with measurements, illustrations and additional diagnostic features based on observations on specimens and holotype images from Stockholm Museum (www2.nrm.se/en/het_nrm/a/irantha_armipes.html) as follows (Tab. 1 & 2, Fig. 1 to 11).

Measurements (n = 6): Total length from head to abdomen 8.82 ± 0.46 mm, width across eyes 0.585 ± 0.031 mm and maximum width across prothorax and abdomen 2.205 ± 0.14 and 4.5 ± 0.26 mm.

Colouration: Head, antennae, labium, pronotum, femora, tibiae and dorsum and venter of abdomen ochraceous, eyes bright reddish, scutellum ochroleucus, membrane bronzy, fourth and fifth segments of connexivum with testaceous markings.

Structure:

Head: Head elongate and distinctly spinose; a pair of spines on the vertex, a pair of spines at base of each antennifer and a pair of dorsal erect spines on the postocular; shorter anteocular separated by a deep sulcus from bulbous, longer and spinulose postocular; eyes laterally protruding; a pair of reddish middorsolateral ocelli just behind the eyes; neck long, prominent and devoid of spines (Figs. 2 & 3); antennae four segmented, distiflagellomere the longest and basiflagellomere the shortest segment, intercalary segments prominent in between scape, pedicel and proximal flagellar segments, scape moderately pilose, pedicel and flagellar segments densely pilose (Fig. 4); labium, robust and longer than head, first visible segment the longest and third the shortest, tip of labium reaches prosternal groove.

Thorax: Granulose pronotum with spines and minute tubercles, anterior lobe slightly shorter than posterior lobe with two pairs of middorsolateral erect spines, posterolateral angles of posterior lobe prominent, posterior margin truncated; collar obscure; unarmed, posteriorly attenuate but subspiniform (Figs. 2 & 3).

Legs: Hind leg the longest and midleg the shortest, femora incrassate and nodulose, anterior femora pilose with a long dorsal, distal spine, four pairs of short ventrolateral spines and three pairs of stumpy tubercles in between these two rows of spines, foretibia, mid- and hind femora densely pilose, tibial combs made up of dense setae, midtarsus the longest and foretarsus the shortest (Figs. 5 to 8).

Hemelytron: Corium spinulose, membrane transparent (Figs. 8 & 9).

Abdomen: Connexivum continuous, three dorsomedian intersegmental glandular openings in between third and sixth segments (Fig. 10).

Females are larger than males (Figs. 1 & 11).

Egg: The eggs are elongately oval (1.01 mm long, 0.42 mm wide) with brown chorion (Fig. 12). Both the chorion and the operculum are finely sculptured. The operculum is brown, convex and covering the mouth of the egg like a basket lid. It is completely covered by the snow white frills of the chorionic collar that are spread out like an umbrella and could be seen only after eclosion. In the laboratory eggs were laid in batches on the bottom of the rearing containers, each egg vertically glued to the substrate.

Biology: The preoviposition period was 9.8 ± 0.62 days. A female of *I. armipes* on average laid 12.9 ± 0.86 batches of eggs with a total number of 97.28 ± 3.2 eggs. Different batches of eggs contained 1 to 15 eggs with average minimum of 3.1 ± 1.2, average maximum of 8.82 ± 0.7 and average of 7.54 ± 0.62 eggs per batch (Tab. 3).

The oviposition period of *I. armipes* was about 72 ± 4.5 days and the index of oviposition period (percentage of egg laying days) was 4.5 ± 0.29 days. *I. armipes* lived only 4.5 ± 0.29 days (postoviposition days) after laying its last batch of eggs.

Hatching. The fertilized egg became swollen with pale reddish chorion and reddish eyespots prior to hatching whereas the unfertilized eggs become shrunken after a few days. The eggs hatched after 9.1 ± 0.77 days (Tab. 4). Both 0% (1.6 ± 0.11) and 100% (17.4 ± 0.39) hatchings were recorded among batches of eggs (Tab. 3). The newly hatched nymphs were fragile and they became tanned 3 to 6 hrs after emergence and thereafter start feeding, showing preference to small and sluggish prey.

Moulting and duration of instars. The developmental durations of the first to fourth immature instars and the fifth immature instar to adult male and adult female *I. armipes* were 8.2 ± 0.67, 9.4 ± 0.78, 10.1 ± 0.91, 9.8 ± 0.82, 9.8 ± 0.68 and 11.2 ± 0.91 days respectively. The duration of the entire immature development was 51.8 ± 2.0 days (Tab. 4).

Description of immatures. The following passages briefly describe the morphological characters in the five nymphal stages that are different from those in adults and distinguishing the nymphal stages (Fig. 13 to 17).

I instar

Total length from head to abdomen 1.845 ± 0.084 mm (Fig. 13).

Colour: Head, antennae, rostrum, pronotum and legs ochraceous and posterior abdominal segments blackish, eyes reddish, transverse annulation in between anteocular and postocular yellowish.

Structure:

Head: Head oval, dorsally swollen and sparsely pilose; compound eyes large, slightly laterally protruding; postocular not spinulose; intercalary segments in between scape and pedicel small and inconspicuous; neck prominent.

Thorax: Pronotum small, bulbous and glossy, with a pair of middorsal erect spines, mesonotum with a pair of middorsal suberect spines; legs pilose, anterior femora sparingly pilose with one prominent dorsal distal suberect spine and two erect small spines and four pairs of ventral spines arranged in a row and three pairs of tubercles in between these two rows of spines, mid- and hind femora devoid of spines, tarsi two segmented, basitarsus the shortest and distitarsus the longest.

Abdomen: Abdomen moderately rugulose, dorsally swollen and pilose with two pairs of middorsal suberect spines located on the third and the fourth segments.

II instar

Total length from head to abdomen 3.285 ± 0.42 mm (Fig. 14).

Colour: Head, antennae, pronotum and foretibiae ochraceous, neck, femora and tibiae testaceous, abdomen fuscous.

Structure:

Head: Head with prominent ecdysial line; intercalary segments, occurring in between scape, pedicel and basiflagellomere.

Thorax: Pronotum granular with two pairs of middorsolateral suberect spines; mesonotum with a pair of anterior middorsal suberect spines; legs pilose with clavate and straight hairs.

Abdomen: Abdomen convex; three middorsal openings of abdominal glands on third, fourth and fifth segments.

III instar

Total length from head to abdomen 5.535±0.49 mm (Fig. 15).

Colour: First labial segment, forefemora and venter of abdomen ochraceous, antennae ochroleucus, anterolateral regions of abdomen yellow.

Structure:

Head: Head oval, a broad piceous annulation in between anteocular and postocular; three pairs of spines: a pair of erect spines on vertex, second pair of erect spines one behind each antenna and the third pair of suberect spines on the postocular; neck distinct with a pair of dorsolateral suberect spines.

Thorax: Pronotum bulbous; scutellum prominent with a pair of middorsal spines; wing rudiment visible and spinulose; legs covered with stiff hairs, anterior femora prominently spinulose with four pairs of lateral spines, one long distal erect spine and two proximal spines at equally spaced intervals and three pairs of tubercles in between the two rows of spines.

Abdomen: Abdomen covered with spinules and dorsally convex and tuberculate, less pronounced connexivum; anterodorsal region with three prominent pairs of dorsolateral suberect spines.

IV instar

Total length from head to abdomen 6.48 ± 0.72 mm (Fig. 16).

Colour: antennae, labium and leg ochraceous, wing rudiment ochroleucus.

Structure:

Head: Head covered with spinules, with four pairs of erect dorsal spines: one pair on vertex, one behind each antenna and two pairs of suberect spines on the postocular; pilose with very few clavate hairs; labium, longer than head.

Thorax: Pronotum with two pairs of dorsolateral suberect spines; wing rudiments granulose and tuberculate reaching up to third abdominal segment; femora nodulose, forefemora with one robust dorsal distal spine followed successively by two pairs of spines, one pair very closely and ventrolaterally placed, four pairs of serially arranged suberect spines, three pairs of distinct tubercles in between of spines two rows, spines less prominent on the mid- and hind femora, legs richly pilose.

Abdomen: Abdomen dorsally pulvinate and with a pair of dorsal suberect spines on the third and fourth segments; dorsolateral margins of abdomen spinulose; octoon richly pilose with straight and clavate hairs.

V instar

Total length from head to abdomen 7.875 ± 0.821 mm (Fig. 17).

Colour: three terminal abdominal segments and forefemora distally piceous, anteromiddorsal region of abdomen yellow.

Structure:

Head: Head spinulose, distinctly pubescent with straight and clavate hairs, neck with a pair of dorsal and a pair of lateral suberect spines.

Thorax: Pronotum with a pair of prominent anteromiddorsal and a pair of posteromiddorsal spines; wing rudiments reach up to fourth abdominal segment; forefemora bear a cluster of long fine hairs and characteristically spinose with a long dorsal rectus distal spine followed by three pairs of short dorsal spines and four pairs of ventrolateral spines, three pairs of prominent tubercles arranged in between two rows of spines, fore- and midtibiae and hind legs obscurely spinulose but richly pilose.

Abdomen: Abdomen convex with serrated connexivum bearing stumpy lateral spines; third and fourth segments each with a pair of prominent, suberect, dorsal, piceous spines and fifth segment with a pair of middorsolateral spines and a pair of obscure dorsal spines on sixth and seventh segments.

Nymphal key:

Though immatures of true bugs (III to IV instar) are identified by the length of the wing pads the following key facilitates the identification of all the five stages of immatures with additional diagnosing characters (Tab. 1 & 2)

Key for the identification of nymphal instars of *I. armipes*

1. Head width either equals to pedicel length or longer than basiflagellomere and second labial segment separately, anteocular shorter than third labial segment, width between eyes equals to the length of second labial segment, distiflagellomere longer than hind tibia, wing rudiments absent ....(2)

\- Head width shorter than pedicel, basiflagellomere and second labial segment separately; anteocular longer than third labial segment; width between eyes shorter than second labial segment, distiflagellomere shorter than hind tibia; wing rudiments present ....(3)

2. Head as long as midtibia, head width greater than pedicel and basiflagellomere lengths separately; postocular length equals to width of abdomen, width between eyes equals to length of basiflagellomere; pedicel as long as first labial segment; scape longer than midtibia and labium separately; basiflagellomere and midlabial segment equal in length, foretibia shorter than hind tibia .... I instar

\- Head length subequals to midtibial length, head width equals to pedicel and basiflagellomere lengths separately; postocular length lesser than width of abdomen, width between eyes lesser than length of basiflagellomere, pedicel shorter than first labial segment; scape length equals to midtibia but slightly shorter than labium; basiflagellomere longer than midlabial segment; fore- and hind tibia equal in length .... II instar

3. Head slightly longer than midtibia; scape slightly longer than labium; basiflagellomere and second labial segment equal in length; third labial segment length equals to wing rudiment width; wing rudiment shorter than abdominal width .... III instar
- Head either shorter than or equals to midtibia; scape length either equals to or shorter than labium; basiflagellomere longer than second labial segment; third labial segment shorter than wing rudiment width; wing rudiment longer than abdominal width 4
4. Head longer than wing rudiment; scape equals in length to labium and midtibia separately; pedicel shorter than first labial segment and basiflagellomere separately; midtibia equals in length to labium but longer than wing rudiment .... IV instar
- Head shorter than wing rudiment; scape shorter than labium and longer than midtibia; pedicel equals to first labial segment length but slightly longer than basiflagellomere; midtibia shorter than labium and wing rudiment separately .... V instar

Nymphal mortality. Abnormal hatching and moulting resulted into 2.8 ± 0.24, 3.1 ± 0.2, 3.2 ± 0.2, 0.2 ± 0.01 and 1.6 ± 0.11 % mortalities in I, II, III, IV and V nymphal instars. Thus, 10.9 ± 1.16 % of nymphs died during their postembryonic development and the survival rate was about 89 %.

Adult longevity and Sex ratio. The females of *I. armipes* lived longer (86.4 ± 4.6 days) than the males (76.9 ± 6.1 days). The sex ratio (male : female) of *I. armipes* among the adults emerged from the laboratory was male biased (1 : 0.94).

Behaviour

Predatory behaviour. *Irantha armipes* exhibited a pin and jab mode of predation in a sequence of acts. The sequential pattern of predatory behaviour was observed in 24 hr prey deprived predators on two different prey, viz. larva of rice meal moth *C. cephalonica* and termite *M. obesi* as follows: arousal - approach - capturing - paralysing - sucking - postpredatory behaviour (Tab. 5, Fig. 18).

Arousal. The visual stimulus from the moving prey excited an arousal response in *I. armipes*.

Approach. *Irantha armipes* approached its prey, orienting towards the prey and remaining motionless until the prey came closer to the predator. The predator approached again if the prey was large or it escaped the predator. *I. armipes* remained calm for a few minutes between approaches.

Capturing. *Irantha armipes* first pinned and jabbed the lateral side of the prey with the extended labium. Thereafter, it firmly holds the prey with its forelegs. Capturing was quicker in older immatures and adult females irrespective of the prey species (Tab. 5).

Paralysing. After prey was pinned and jabbed and captured, the predator paralysed it by injecting toxic saliva. As observed for capturing, paralysing was also quicker in older immatures and adult females (Tab. 5).

Prey transportation. After paralysing, *I. armipes* transported the prey to a safe and secluded place for feeding. In field conditions too, *I armipes* was found to transport prey to shady places and even occasionally to secluded places.

Probing and Sucking. Once the prey was transported to a safer and secluded place, *I. armipes* probed the prey by passing its labial tip over the prey and selecting suitable sites for sucking. Thereafter, it frequently inserted and withdrew the stylets to suck the predigested body fluids of prey. As observed for capturing and paralysing, sucking was quicker in older immatures and adult females (Tab. 5).

Postpredatory behaviour. *Irantha armipes* cleaned its antennae and labium with its foretibial combs to remove foreign materials such as defensive secretion, irritant exudation etc. of prey.

Death feigning was also exhibited by the nymphal instars of *I. armipes* during predation.

Impact of prey. Though the sequential acts of predatory behaviour of *I. armipes* on both the larva of *C. cephalonica* and *M. obesi* were similar, the prey type influenced predation. For instance, the life stages of *I. armipes* more quickly captured, paralysed and sucked a termite than a larva of *C. cephalonica* (Tab. 5). This could be attributed to the larger size of the *C. cephalonica* larva when compared to *M. obesi*.

Mating behaviour. *I. armipes* is polygynous as well as polyandrous. The sequential acts of mating behaviour, viz. excitation - approach - riding over - copulation - postcopulatory acts were observed in laboratory reared sex starved *I. armipes* (Fig. 19).

Excitation. Arousal of mating partners was initiated by the sight of the opposite sex. The sex starved *I. armipes* got aroused instantaneously after sighting a female. The aroused males exhibited excitation and antennal extension towards females in a tibial juxtaposition resembling a peculiar pouncing posture. *Irantha armipes* got aroused quickly within 0.52 ± 0.04 min and thereafter started briskly chasing the female.

Approach. The aroused males approached the females with extended labium and antennae. The ready to mate females responded with antennal extension and labial stridulation. Thereafter, the motionless females submitted themselves to the males within 0.98 ± 0.08 min. The approach response was completed once the males touched the females with their antennae and placed their legs over females.

Riding over. The male *I. armipes* clasped the female with its legs and pressed her pterothorax region with his labial tip and remain in the riding over-dorsoventral position for about 14.5 ± 1.1min before copulation.

Copulation. At the culmination of riding over the males relaxed the characteristic pterothoracic labial pinning, assumed a dorsolateral position and placed his legs over her pterothorax. Thereafter, the male extended its genitalia and achieved connection within 0.14 ± 0.01 min. Retraction and reinsertion of genitalia were observed on rare occasions due to incompatibility of genital connection.

In copula mating partners remained motionless with intermittent vibration of antennae, tibial brushing against each other or against substrate, genitalia grooming etc., and these intermittent acts became slowed down just prior to termination of copulation. The copulation lasted for 31.2 ± 1.8 min. The termination of copulation was indicated by drooping down of antennae by both male and female followed by separation of mating partners. After separation the male moved away from the female whereas the female remained motionless for a short period.

Postcopulatory acts. Antennal grooming, genitalia brushing and cleaning of hind legs were observed in both partners. The successful completion of copulation was indicated by the ejection of spermatophore capsule 52.3 ± 4.6 min after the termination of copulation. Postcopulatory cannibalism of female over male and seasonal variation in mating behaviour were not observed in *I. armipes*.

Discussion

The egg of *I. armipes* morphologically closely resembles the egg of another African harpactorine *Nagusta punctaticollis* Stål (Cobben, 1968, Ambrose, 1980). The preoviposition period of *I. armipes* was longer than that of members of subfamilies such as Ectrichodiinae (7.0 days) and Salyavatinae (6.07 days) whereas shorter than that of members of subfamilies Stenopodainae (14.3 days) and Triatominae (30.4 days) (Ambrose, 1999). Among harpactorines, the preoviposition period of *I. armipes* was close to that of *Sphedanolestes signatus* Distant (Vennison & Ambrose, 1990) and *S. himalayensis* (Das et al., 2007). The fecundity in *I. armipes* was moderate since many harpactorine reduviids lay higher numbers of eggs (Ambrose, 1999; Ambrose et al., 2006, 2007; Das, 1996; Das et al., 2007).

The incubation period observed in *I. armipes* (Tab. 3) was closer to that of many harpactorines such as *Coranus*, *Scipinia*, *Sphedanolestes* and *Rhynocoris* (Ambrose, 1999). The hatching percentage of *I. armipes* was relatively higher (91.08 ± 7.8%), closer to that of another harpactorine *Alcmena spinifex* (Thunberg), a diagnostic characteristic feature of harpactorine tropical rainforest reduviids especially found among the members of *Scipinia, Sphedanolestes* and *Sycanus*. The more frequent 100% hatchings than 0% hatchings observed in *I. armipes* as in many other harpactorine reduviids presumably ensures a relatively higher fecundity (Ambrose, 1999; Ambrose et al., 2006, 2007; Das, 1996; Das et al., 2007).

As observed in other harpactorines, the longest stadium was the fifth (V nympha instar to adult female) in *I. armipes*. But the shortest I stadium observed in *I. armipes* was recorded only in few harpactorines such as *Sphedanolestes minusculus* Bergroth (Ambrose et al., 2006) and *A. spinifex* (Das, 1996) whereas it was generally either II or III stadium. The duration of the entire immature development in *I. armipes* was closer to that of many harpactorines such as *Coranus, Lanca* and *Sphedanolestes*. The nymphal mortality observed in *I. armipes* was lower when compared to nymphal mortalities observed among other Oriental harpactorines (Ambrose, 1999; Ambrose et al., 2006, 2007; Das, 1996; Das et al., 2007).

Adult females of *I. armipes* living longer than males is not uncommon feature in harpactorines, a mechanism that promotes multiple mating with males of different age groups and subsequently facilitates enhanced fecundity. The male biased sex ratio observed in *I. armipes* is similar to that of several other harpactorines as well as non-harpactorine reduviids, a mechanism that promotes multiple mating (Ambrose, 1999; Ambrose et al., 2007).

The sequential pattern of pin and jab mode of predation observed in *I. armipes* was similar to that of several other harpactorine reduviids. The importance of vision in prey location and subsequent arousal response in predation of *I. armipes* was proved by eye blinding experiments in many assassin bugs (Ambrose, 1999, Ambrose et al., 2007). Moreover, it was further discussed that antennal contact of the prey was not essential in reduviid predators such as *I. armipes* as they do not touch any part of the prey's body before pinning and jabbing (Das, 1996). This was further shown by the fact that antennectomized reduviids successfully pinned and jabbed their prey (Ambrose, 1999). The approach of *I. armipes* towards its prey was similar to that of any typical non-tibial pad reduviid. Though many harpactorines attack the prey laterally as observed in *I. armipes* different first attack sites such as antennal bases, leg joints, junction between head and thorax, rear end etc. were also reported for many reduviids. (Ambrose, 1999).

Irantha armipes could paralyze the prey by haemolytic neurotoxins present in the salivary glands, especially in the anterior lobes as reported for several other reduviids (Ambrose, 1999). The prey transportation to secluded place by *I. armipes* prior to sucking was similar to that of *Brassivola* spp. whereas it was seldom observed in harpactorines such as *Vesbius* spp. (Das, 1996). Hence, it appears to be species specific (Ambrose, 1999).

Congregational feeding and cannibalism observed in many reduviids were not recorded in *I. armipes* when they are mass reared (Ambrose, 1999). The prey influenced predation as a function of prey-predator interaction observed in *I. armipes* was reported for several reduviids. The size of life stages of *I. armipes* in relation to prey size plays a vital role in prey capturing. This might be attributed to the predators' size governed predatory efficiency and the larger quantity of toxic saliva available for paralysing the prey. (Ambrose, 1999).

The sequential acts of mating observed in *I. armipes* conformed to those of several other harpactorine reduviids. The primary role of vision in the excitation of mating partners was confirmed by eye blinding experiments in several reduviids. In addition, sensilla in the antennae of *I. armipes* also play a role in mating arousal as confirmed by antennectomy experiments in several other reduviids (Ambrose, 1999).

The male chasing the female and submission of motionless females to approaching males observed in the mating behaviour of *I. armipes* was also reported for many reduviids. The precopulatory female cannibalism over male reported in some species of reduviids was not observed in *I. armipes*. Though riding over prior to copulation is a diagnostic characteristic feature of harpactorine reduviids, the duration of riding over varied from a few minutes to 3 days in different species. The dorsolateral copulation observed in *I. armipes* is common in several other harpactorine reduviids. The slowing down of antennal vibration and tibial brushing prior to termination of copulation and ejection of spermatophore capsule after successful copulation observed in *I. armipes* were also recorded for several other reduviids. The postcopulatory cannibalism of female over male and seasonal variation in mating behaviour reported for certain harpactorine reduviids are absent in *I. armipes* (Ambrose, 1999).

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References

Ambrose D.P., 1980: Bioecology, ecophysiology and ethology of reduviids (Heteroptera) of the scrub jungles of Tamil Nadu, India. - Ph.D. thesis, University of Madras, Madras. India, 229 pp.

Ambrose D.P., 1999: Assassin bugs.- New Delhi, India, Oxford & IBH Publishing Company Private Limited & New Hampshire, U.S.A., Science Publishers, Incorporation, 337 p.

Ambrose D.P., 2000: Assassin Bugs (Reduviidae excluding Triatominae). In: Heteroptera of Economic Importance. Carl. W. Schaefer, A.R. Panizzi (eds.), Florida, U.S.A.: CRC Press, 695-712 p.

Ambrose D.P., 2003: Biocontrol potential of assassin bugs (Hemiptera: Reduviidae).- *Journal of Experimental Zoology*, **6:** 1-44.

Ambrose, D.P., 2006. A checklist of Indian assassin bugs (Insecta: Hemiptera: Reduviidae) with taxonomic status, distribution and diagnostic morphological characteristics. - *Zoos' Print Journal,* **21**(9): 2388-2406 plus 34 web supplement pages.

Ambrose D.P., Kumar S.P., Subbu G.R., Claver M.A., 2003: Biology and prey influence on the postembryonic development of *Rhynocoris longifrons* (Stål) (Hemiptera: Reduviidae), a potential biological control agent.- *Journal of Biological Control*, **17:** 113-119.

Ambrose D.P., Kumar S.P., Nagarajan K., Das S.S.M., Ravichandran B., 2006: Redescription, biology, life table, behaviour and ecotypism of *Sphedanolestes minusculus* Bergroth (Hemiptera: Reduviidae).- *Entomologia Croatica*, **10:** 47-66.

Ambrose D.P., Gunaseelan S., Krishnan, S.S., Jebasingh V., Ravichandran B., Nagarajan K., 2007: Redescription, biology and behaviour of a harpactorine assassin bug *Endochus migratorius* Distant. *Hexapoda*, **14:** 12-21.

Breddin, G., 1903: Neue Raubwanzen. *Bulletin Societe Entomologique de France*, 17: 169, 170, 177, 178.

Breddin, G., 1909: Rhynchoten von Ceylon gesammelt von Dr. Walter Horn. Soc. Annals de la Societe Entomologique de Belgique, 53: 250-309.

Chen, W., Zhao, P., Cai, W., 2005: The discovery of the Genus *Irantha* Stål, 1861 (Heteroptera: Reduviidae: Harpactorinae) from China, with the description of a new species - *Annales Zoologici*., **55**(1): 107-109.

Claver, M.A., Ambrose, D.P., 2001a: Evaluation of *Rhynocoris kumarii* Ambrose & Livingstone (Hemiptera: Reduviidae) as a potential predator of some lepidopteran pests of cotton - *J. Biol. Control*., **15**: 15-20.

Claver, M.A., Ambrose, D.P., 2001b: Impact of augmentative release of *Rhynocoris kumarii* Ambrose & Livingstone (Heteroptera: Reduviidae) on *Dysdercus cingulatus* (Fabricius) (Hemiptera: Pyrrhocoridae) population and damage on cotton - *J. Biol. Control.,* **15**: 119-125.

Cobben R.H., 1968: Evolutionary trends in Heteroptera Part I. eggs, architecture of shells, gross embryology and eclosion. Centre for Agriculture, Public Document Mageningen. Annual Report, 1-465.

Das S.S.M., 1996: Biology and behaviour of chosen predatory hemipterans. - Ph.D thesis, Madurai Kamaraj University, Madurai, India.

Das S.S.M., Krishnan S.S., Jebasingh V., Ambrose D.P., 2007: Redescription, postembryonic development and behaviour of a harpactorine assassin bug *Sphedanolestes himalayensis* Distant (Hemiptera: Reduviidae).- *Entomologia Croatica* (in press).

Distant W.L., 1902: The fauna of British India including Ceylon and Burma. Rhynchota Vol. II (Heteroptera). (London). Taylor and Francis Limited, 1-503 pp.

Dohrn, F.A., 1860: Beiträge zu einer monographischen Bearbeitung der Familie der Emesina - *Linnaea Entomologica,* **14**: 207-253.

Grundy, P.R., Maelzer, D.A., 2000a: Predation by the assassin bug *Pristhesancus plagipennis* (Walker) (Hemiptera: Reduviidae) of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) and *Nezara viridula* (L.) (Hemiptera: Pentatomidae) in the laboratory - *Australian Journal of Entomology,* **39:** 280-282.

Grundy, P.R., Maelzer, D.A., 2000b: Assessment of *Pristhesancus plagipennis* (Walker) (Hemiptera: Reduviidae) as an augmentated biological control in cotton and soybean crops - *Australian Journal of Entomology,* **39:** 305-309.

Grundy, P.R., Maelzer, D.A., Bruce, A., Hassan, E., 2000a: A mass rearing method for the assassin bug *Pristhesancus plagipennis* - *Journal of Biological Control,* **18:** 243-250.

Grundy, P.R., Maelzer, D.A., Collins, P.J., Hassan, E., 2000b: Potential for integrating eleven agricultural insecticides with the predatory bug *Pristhesancus plagipennis* (Hemiptera: Reduviidae)- *J. Econ. Entomol.,* **93:** 584-589.

Livingstone, D., Ravichandran, G., 1988: Two new species of Polididusaria from southern India (Heteroptera: Reduviidae: Harpactorinae) - *Journal of Soil Biology & Ecology*, **8**(2): 117-121.

Maldonado, C., 1990: Systematic catalogue of the Reduviidae of the world (Insecta: Heteroptera). Caribbean Journal of Science edition, University of Puerto Rico, Puerto Rico, pp. 694.

Stål, C. 1855: Nya Hemiptera - *Ofversigt of konglia Vetenskaps - Akademiens forhandlinga.*, **11**: 181-192.

Stål, C. 1861: Nova methodus familias quasdam Hemipterorum disponendi – *Of K. Sv. Vet. Ak. Foerh. Handl.*, **18**: 195-212.

Stål, C. 1866: Bidrag till Reduviidernas käennedom - *Of versigt of konglia Vetenskaps - Akademiens forhandlinga*, **23**: 235-302.

Vennison S.J., Ambrose D.P., 1990: Biology and behaviour of *Sphedanolestes signatus* Distant (Insecta: Heteroptera: Reduviidae) a potential predator of *Helopeltis antonii* Signoret.- *Uttar Pradesh Journal of Zoology*, **10:** 30-43.

Walker, F., 1873: Catalogue of the specimens of Hemiptera: Heteroptera in the collection of the British Museum. Part VIII. Printed for the Trustees, London. 8: 1-220.

www 2.nrm.se/en/het_nrm/a/irantha_armipes.html

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Tab. 1: Morphometric analysis of head and cephalic appendages of life stages of *Irantha armipes* (in mm; n = $\overline{X}$ 6; ± SD)

Life stages	Head						Antennal length					Labial length			
	AO	**PO**	**WBE**	**DE**	**HL**	**HW**	**S**	**P**	**F_1**	**F_2**	**EA**	**BR**	**MR**	**TR**	**ER**
First nymphal instar	0.18 ± 0.02	0.405 ± 0.05	0.27 ± 0.03	0.135 ± 0.02	0.72 ± 0.08	0.36 ± 0.04	0.855 ± 0.09	0.315 ± 0.04	0.27 ± 0.03	1.125 ± 0.15	2.565 ± 0.28	0.315 ± 0.04	0.27 ± 0.03	0.225 ± 0.03	0.81 ± 0.09
Second nymphal instar	0.225 ± 0.03	0.495 ± 0.052	0.315 ± 0.038	0.18 ± 0.028	0.9 ± 0.11	0.36 ± 0.044	0.945 ± 0.097	0.36 ± 0.042	0.36 ± 0.04	1.305 ± 0.18	2.97 ± 0.37	0.405 ± 0.05	0.315 ± 0.042	0.27 ± 0.04	0.99 ± 0.14
Third nymphal instar	0.54 ± 0.07	0.855 ± 0.09	0.495 ± 0.05	0.225 ± 0.03	1.62 ± 0.19	0.585 ± 0.06	1.755 ± 0.19	0.72 ± 0.08	0.675 ± 0.08	1.935 ± 0.24	5.085 ± 0.64	0.72 ± 0.09	0.675 ± 0.075	0.315 ± 0.046	1.71 ± 0.19
Fourth nymphal instar	0.585 ± 0.06	1.08 ± 0.097	0.54 ± 0.07	0.315 ± 0.04	1.98 ± 0.24	0.63 ± 0.071	2.115 ± 0.28	0.9 ± 0.096	0.945 ± 0.096	2.34 ± 0.29	6.3 ± 0.75	0.99 ± 0.12	0.72 ± 0.086	0.405 ± 0.05	2.115 ± 0.28
Fifth nymphal instar	0.63 ± 0.07	1.17 ± 0.15	0.585 ± 0.062	0.36 ± 0.048	2.16 ± 0.26	0.675 ± 0.072	2.295 ± 0.28	1.08 ± 0.14	1.035 ± 0.13	2.475 ± 0.36	6.885 ± 0.72	1.08 ± 0.19	0.855 ± 0.092	0.495 ± 0.06	2.43 ± 0.31
Adult male	0.675 ± 0.075	1.215 ± 0.18	0.585 ± 0.06	0.36 ± 0.04	2.25 ± 0.28	0.675 ± 0.076	2.475 ± 0.31	1.125 ± 0.18	1.08 ± 0.12	2.61 ± 0.38	7.29 ± 0.84	1.08 ± 0.24	0.855 ± 0.102	0.495 ± 0.052	2.43 ± 0.35
Adult female	0.72 ± 0.08	1.44 ± 0.19	0.675 ± 0.071	0.405 ± 0.042	2.565 ± 0.31	0.72 ± 0.086	2.835 ± 0.29	1.26 ± 0.191	1.215 ± 0.39	2.97 ± 0.39	8.28 ± 0.95	1.305 ± 0.19	0.99 ± 0.11	0.63 ± 0.072	2.925 ± 0.36

AO = anteocular, PO = postocular, WBE = width between eyes, DE = diameter of eyes, HL = head length, S = scape, P = pedicel, F_1 and F_2 = first and second flagellae, EA = entire antenna, BR, MR and TR = basal, medial and terminal labial segments and ER = entire labium.

Tab. 2: Morphometric analysis of prothorax, thoracic appendages and abdomen of life stages of *Irantha armipes* (in mm; n = 6; $\overline{X}$ ± SD)

Life stages	Prothorax		Tibial length			Wing / Rudiment		Abdomen		Insect Length
	L	W	F	M	H	L	W	L	W	
First nymphal instar	0.241 ± 0.04	0.275 ± 0.04	0.945 ± 0.09	0.72 ± 0.08	0.99 ± 0.09	-	-	0.495 ± 0.05	0.405 ± 0.05	1.845 ± 0.21
Second nymphal instar	0.345 ± 0.05	0.413 ± 0.06	1.125 ± 0.16	0.945 ± 0.092	1.125 ± 0.14	-	-	1.575 ± 0.18	1.035 ± 0.12	3.285 ± 0.42
Third nymphal instar	0.724 ± 0.086	0.827 ± 0.09	1.98 ± 0.24	1.575 ± 0.17	2.025 ± 0.25	0.9 ± 0.08	0.315 ± 0.04	2.79 ± 0.31	1.53 ± 0.18	5.535 ± 0.49
Fourth nymphal instar	1.03 ± 0.09	1.137 ± 0.14	2.7 ± 0.31	2.115 ± 0.26	2.79 ± 0.29	1.935 ± 0.22	0.495 ± 0.56	2.97 ± 0.34	1.71 ± 0.21	6.48 ± 0.72
Fifth nymphal instar	1.206 ± 0.082	1.0 ± 0.18	2.835 ± 0.342	2.16 ± 0.28	2.88 ± 0.32	2.25 ± 0.26	0.585 ± 0.62	3.735 ± 0.39	2.07 ± 0.25	7.875 ± 0.821
Adult male	1.755 ± 0.19	2.025 ± 0.28	3.05 ± 0.36	2.25 ± 0.29	3.195 ± 0.36	4.95 ± 0.58	1.53 ± 0.17	4.5 ± 0.492	2.295 ± 0.26	8.82 ± 0.95
Adult female	2.16 ± 0.24	2.34 ± 0.29	3.465 ± 0.39	2.7 ± 0.34	3.6 ± 0.41	5.985 ± 0.69	1.8 ± 0.192	5.625 ± 0.62	3.24 ± 0.35	11.025 ± 1.19

F, M and H = fore-, mid- and hind tibia; L = length; W = Width.

Tab. 3: Oviposition pattern and hatchability of *Irantha armipes*

Parameters	***I. armipes***
Adult female longevity in days	86.4 ± 4.6
Preoviposition period in days	9.8 ± 0.62
Postoviposition period in days	4.5 ± 0.29
Index of oviposition days	14.78 ± 0.09
Total number of batches of eggs	12.9 ± 0.86
Total number of eggs laid	97.28 ± 3.2
Average number of eggs per batch	7.54 ± 0.62
Minimum number of eggs per batch	3.1 ± 1.2
Maximum number of eggs per batch	8.82 ± 0.71
Total number of nymphs hatched	88.6 ± 8.4
Hatching percentage	91.08 ± 7.8
Frequency of 0% hatching	1.6 ± 0.11
Frequency of 100% hatching	17.4 ± 0.39
Incubation period in days	9.1 ± 0.77

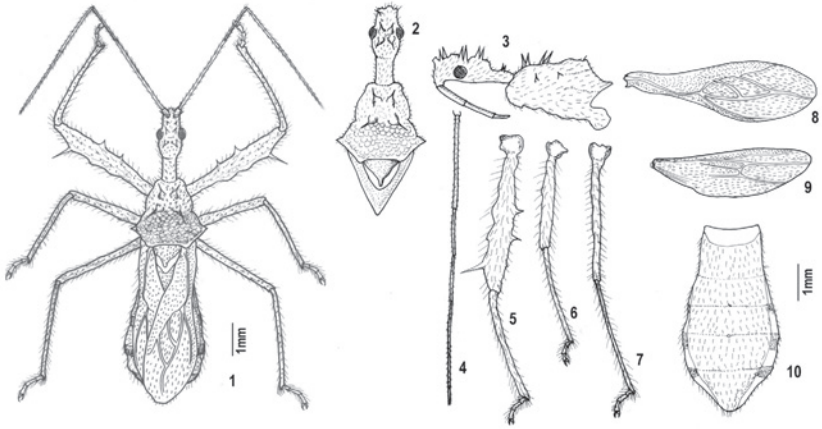
Tab. 4: Incubation and developmental periods (in days) of *Irantha armipes* $\overline{X}$ (± SD, n = 20)

Incubation period	**Developmental period**						
	I	**II**	**III**	**IV**	**V-male**	**V-female**	**I-adult**
9.1 ± 0.77 [8-10]	8.2 ± 0.67 [7-9]	9.4 ± 0.78 [8-11]	10.1 ± 0.91 [9-11]	9.8 ± 0.82 [8-10]	9.8 ± 0.68 [8-11]	11.2 ± 0.91 [10-12]	51.8 ± 4.2 [42-53]

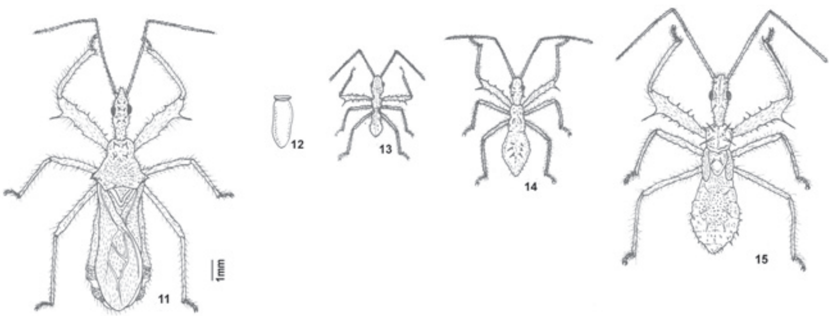
values in parantheses indicate the range.

Tab. 5: Chronology of predation (in min) of life stages of *Irantha armipes* on *Corcyra cephalonica* and *Microtermes obesi* (n = 6; $\overline{\mathbf{X}}$ ± SD).

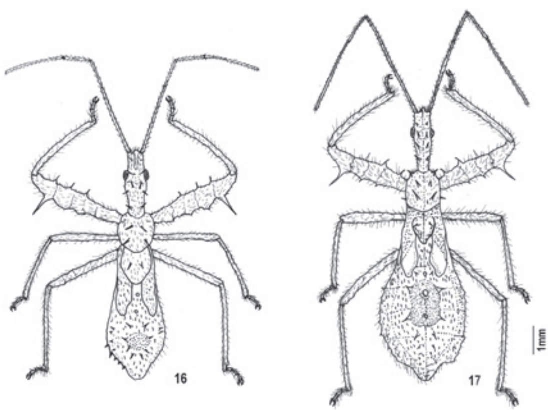
Prey	Time (in min) taken for predatory acts	Stage					
		I nymphal instar	**II nymphal instar**	**III nymphal instar**	**IV nymphal instar**	**V nymphal instar**	**Adult**
Corcyra cephalonica	Capturing	3.0 ± 0.24	2.2 ± 0.19	1.9 ± 0.12	1.7 ± 0.11	1.6 ± 0.14	1.2 ± 0.11
	Paralysing	9.6 ± 0.76	8.2 ± 0.64	4.6 ± 0.31	4.0 ± 0.28	3.1 ± 0.21	2.6 ± 0.18
	Sucking	204.3 ± 13.8	162.4 ± 12.3	151.3 ± 10.6	139.2 ± 9.31	110.8 ± 9.8	90.3 ± 7.2
	Total duration	216.9 ± 14.6	172.8 ± 11.4	157.8 ± 9.8	44.9 ± 10.62	15.5 ± 8.62	94.1 ± 7.86
No. of Piercing and sucking sites		22.6 ± 1.8	20.3 ± 1.2	14.2 ± 1.4	13.6 ± 1.5	12.4 ± 1.1	11.8 ± 1.06
Microtermes obesi	Capturing	2.1 ± 0.202	1.7 ± 0.11	1.1 ± 0.104	0.92 ± 0.08	0.62 ± 0.05	0.41 ± 0.04
	Paralysing	7.4 ± 0.62	5.8 ± 0.41	4.2 ± 0.32	2.3 ± 0.18	1.9 ± 0.11	1.1 ± 0.102
	Sucking	186.2 ± 12.1	168.2 ± 10.2	122.6 ± 11.8	92.8 ± 7.8	53.2 ± 4.2	24.6 ± 1.2
	Total duration	195.7 ± 10.6	175.7 ± 11.2	127.9 ± 9.9	96.02 ± 7.5	55.72 ± 4.96	26.11 ± .172
No. of Piercing and sucking sites		18.4 ± 1.2	14.8 ± 1.1	12.1 ± 1.02	9.2 ± 0.86	7.2 ± 0.68	6.1 ± 0.48



Figs. 1-10: *Irantha armipes*: 1. male, 2&3. head and thorax, dorsal and lateral views, 4. antenna, 5-7. fore-, mid- and hind legs, 8. forewing, 9. hind wing and 10. abdomen.



Figs. 11-15: *Irantha armipes*: 11. female, 12. egg, 13-15. I-III nymphal instars.



Figs. 16-17: *Irantha armipes*: 16 & 17. IV&V nymphal instars.

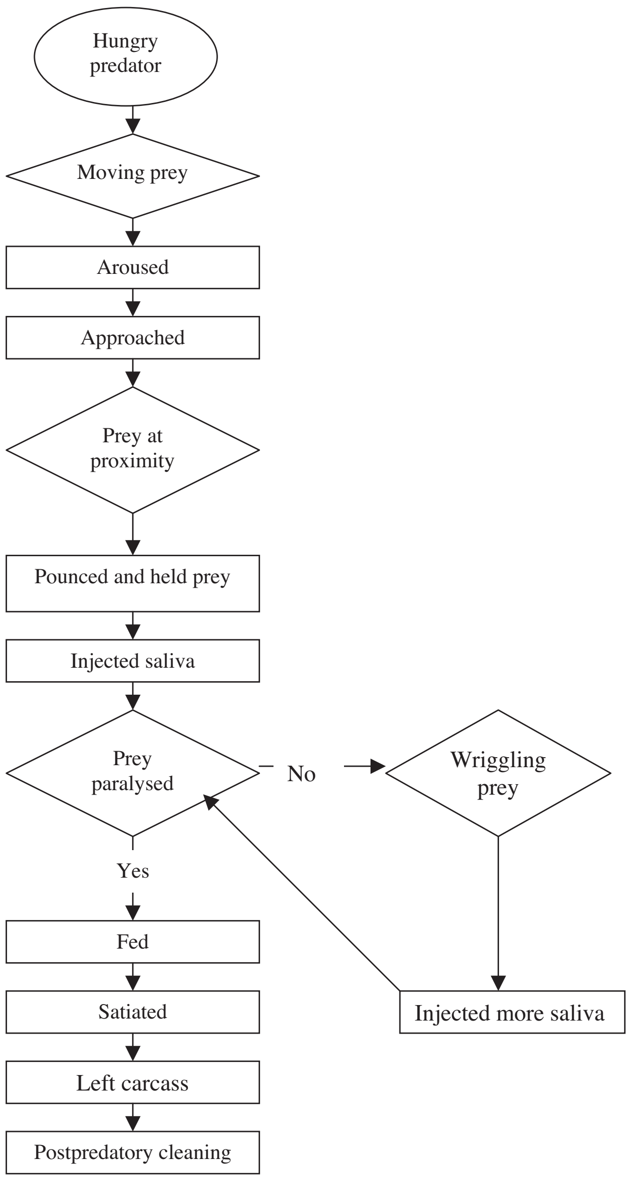


Fig. 18: Flow chart showing predatory behaviour of *Irantha armipes*.

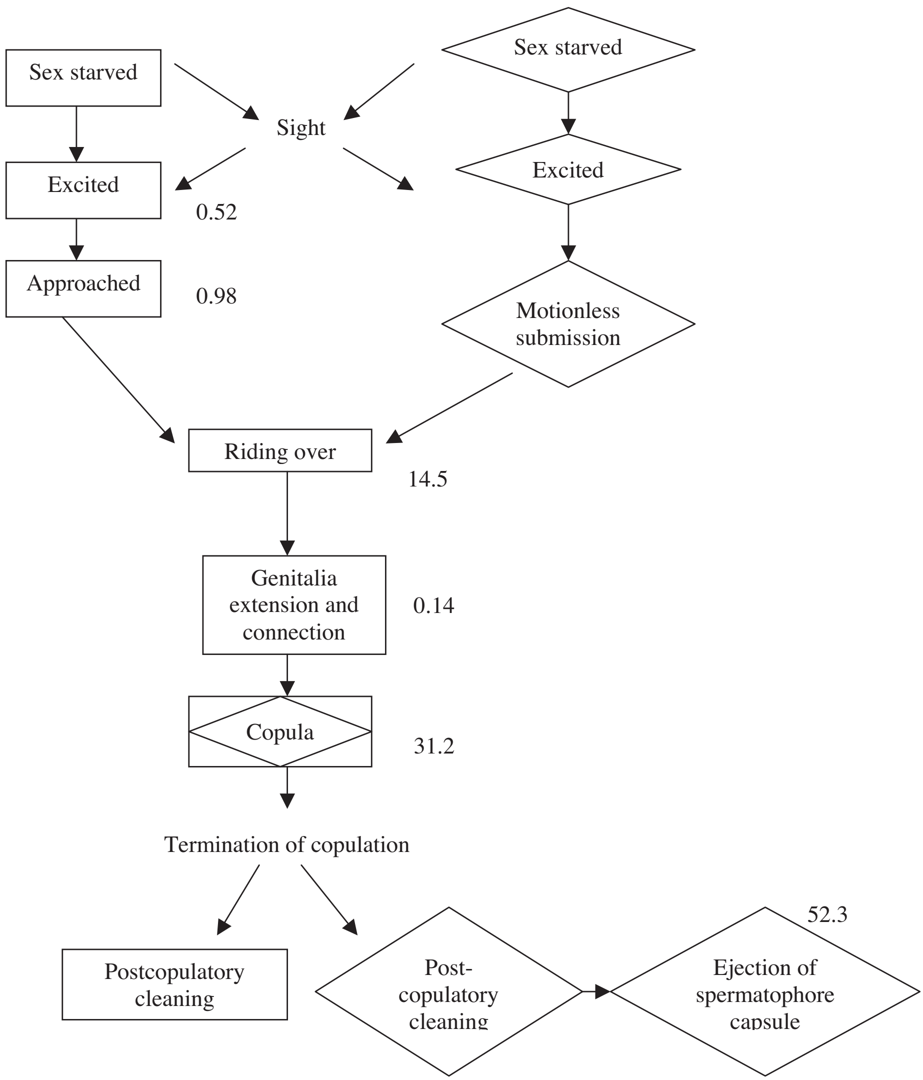


Fig. 19: Flow chart showing mating behaviour of *Irantha armipes*