Biology and Behavior of Six Species of Reduviids (Hemiptera: Reduviidae: Harpactorinae) in a Cashew Ecosystem[1]

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ABSTRACT   Reduviid species (Hemiptera: Reduviidae) are efficient predators of the sucking pest *Helopeltis antonii* Signoret (Hemiptera: Miridae) on cashew, *Anacardium occidentale* L. (Anacardiaceae). Six species of harpactorine reduviids (Hemiptera: Reduviidae: Harpactorinae) were found feeding on *H. antonii* in cashew in India. They were *Endochus albomaculatus* Stål, *Epidaus bicolor* Distant, *Euagoras plagiatus* Burmeister, *Irantha armipes* Stål, *Panthous bimaculatus* Distant, and *Sphedanolestes signatus* Distant. These species were reared under laboratory conditions [24–32°C, 89–94% RH, 12:12 h (L: D)] on larvae of the greater wax moth, *Galleria mellonella* L. (Lepidoptera: Pyralidae). The incubation period, stadial period, nymphal mortality, fecundity, longevity, and sex ratio were studied for these six species. *Panthous bimaculatus* laid the highest number of eggs and exhibited prolonged incubation period. The incubation period was the shortest in *E. plagiatus*. The nymphal survival rate was highest in *E. plagiatus* and lowest in *E. albomaculatus*. Post-embryonic development from first nymphal instar to adult significantly varied in the six species. The sex ratios of *I. armipes*, *S. signatus*, and *P. bimaculatus* were female-biased, while the sex ratios of *E. plagiatus, E. bicolor,* and *E. albomaculatus* were male-biased. Longevities of both female and male adults of the six reduviid species also significantly varied. The aggressiveness of prey capturing and rostral thrusting varied among species. Post-copulatory cannibalism of males by females was observed only in *E. bicolor*. Numerous desirable biological traits suggest that *E. plagiatus* can be effectively mass cultured.

KEY WORDS   Biological traits, predators, mating, *Helopeltis antonii*, biological control

Reduviids (Hemiptera: Reduviidae) are abundant and highly successful predators, and they play a vital role in the biological control of insect pests of cashew, *Anacardium occidentale* L. (Anacardiaceae) (Bhat et al. 2013). A total of 151 species of insect pests have been reported on cashew (Sundararaju 1993),

prominent among them is *Helopeltis antonii* Signoret (Hemiptera: Miridae), commonly called the tea mosquito bug. The nymphal instars and adults of this insect damage tender shoots, inflorescences, immature nuts, and cashew apples at various stages of development, resulting in a yield loss of 30–50% (Devasahayam & Nair 1986) and even 100% (Sundararaju & Sundarababu 1999). A biological control program against *Helopeltis* spp. using reduviids has been reported from southeast Asia (Rao et al. 1971). The harpactorine reduviid *Endochus inornatus* Stål (Hemiptera: Reduviidae: Harpactorinae) was reported to prey on as many as twenty *H. antonii* per day on cashew in India (Naik & Sundararaju 1982, Devasahayam & Nair 1986). Other harpactorine reduviids, such as *Sycanus collaris* F., *Sphedanolestes signatus* Distant, *E. inornatus*, *Irantha armipes* Stål, and *Occamus typicus* Distant, also were reported as predators of *H. antonii* (Sundararaju 1984, Vennison & Ambrose 1990). Even though they are polyphagous predators, life stages of some harpactorine species exhibit a certain amount of host as well as stage preferences (Ambrose 1999). Hence, they should be conserved and augmented to be effectively utilized in Integrated Pest Management (IPM) programs (Ambrose et al. 2007, Das & Ambrose 2008). Conservation and augmentation of any biological control agent relies upon our comprehensive knowledge of its bioecology, ecophysiology, and behavior.

Six reduviid species (Harpactorinae), *Endochus albomaculatus* Stål, *Epidaus bicolor* Distant, *Euagoras plagiatus* Burmeister, *Irantha armipes*, *Panthous bimaculatus* Distant, and *Sphedanolestes signatus* were recorded as predators of *H. antonii* during the present research. The biology and behavior of *E. plagiatus* (Vennison & Ambrose 1991), *I. armipes* (Das & Ambrose 2008), and *S. signatus* (Vennison & Ambrose 1990) were reported on different diets from different geographical regions. However, there are no such reports for *E. albomaculatus*, *E. bicolor*, or *P. bimaculatus*. In the present study, six species of reduviids were reared on larvae of the greater wax moth, *Galleria mellonella* L. (Lepidoptera: Pyralidae), and their comparative biology and predatory and mating behaviors were documented as baseline information to be used for conservation and augmentation of reduviids as biological control agents against *Helopeltis* spp. in cashew.

Materials and Methods

Biology. Adult reduviids were collected from cashew plantations at the Directorate of Cashew Research, Puttur (12.5° N, 75.4° E; 90 m a.s.l.), in Karnataka State of southern India. They were identified and were reared separately in glass bottles (500 ml capacity) using larvae of greater wax moth under laboratory conditions [24–32°C; 89–94% RH; photoperiod 10:14 h (L: D)]. Virgin males and females that had emerged in the laboratory were allowed to mate in glass rearing bottles. Only adults reared in the laboratory were used in the experimental studies.

The containers were carefully examined twice daily to record the number of eggs laid. Ejection of spermatophore capsules by mated females confirmed successful copulation (Ambrose et al. 2009). Eggs were allowed to hatch in the rearing bottles on wet cotton swabs that helped maintain optimum relative humidity (85%). The cotton swabs were changed periodically in order to prevent

fungal infestations. Mated females were maintained individually in order to record the number of egg batches and eggs per batch. Twenty-five newly hatched nymphs of each species were isolated soon after eclosion and reared individually on first and second instar (5–6 mm) wax moths. When the reduviid nymphs grew larger, fourth and fifth instar wax moth larvae (10–15 mm) were supplied to them. Observations on eclosion, fecundity, egg hatchability, ecdysis, nymphal mortality, adult emergence, sex ratio, and adult longevity for those adults that emerged in the laboratory were made for two generations.

Behavior. The predatory and mating behaviors of the six reduviid species were studied under laboratory conditions (24–32°C; 89–94% RH). Predatory behavior consisted of stimuli-response-mediated sequences of events, always initiated by a moving prey (Haridas & Ananthakrishnan 1980). This behavior was assessed in prey-deprived (24 h) reduviids separately against wax moth larvae and their natural prey, *H. antonii* adults. Unmated males and females of respective species were grouped for mating in containers (700 ml) provided with cashew twigs and leaves (to provide natural condition) and the sequences of mating behaviors were observed.

Data analysis. All data were expressed as mean ± SE. Statistical differences were evaluated by one-way analysis of variance (ANOVA) followed by post hoc multiple comparison test, Least Significant Difference (LSD), at the 5% level of significance using SPSS 22 software (IBM Corp., Armonk, NY) (IBM Corp. 2013).

Results

The reduviids *E. albomaculatus*, *E. bicolor*, *E. plagiatus*, *I. armipes*, *P. bimaculatus*, and *S. signatus* laid eggs in batches on the bottoms and sides of the rearing bottles and on muslin cloth. Each egg was glued vertically to the substratum. Among the six reduviid species, there was considerable variation in the morphology of eggs, including differences in color, shape, size, chorionic and opercular architecture, and positions of the chorionic collar, sealing bar, opercular plate, and chorionic notch (Figure 1). The numbers of egg batches oviposited by females of *E. plagiatus, I. armipes*, and *S. signatus* were significantly higher than those of *E. bicolor*, *E. albomaculatus*, and *P. bimaculatus* ($F = 12.2$; df = 5, 24; $P < 0.05$) (Figure 2). The number of eggs/batch laid also varied significantly among species ($F = 57.1$; df = 5, 24; $P < 0.05$). *Panthous bimaculatus* (109.8 eggs/batch) laid the highest number of eggs per batch, whereas *E. albomaculatus* (37.2 eggs/batch) and *E. bicolor* (39 eggs/batch) were statistically equal (Figure 3).

Fecundity also differed significantly among species ($F = 59.7$; df = 5, 24; $P < 0.05$). *Panthous bimaculatus* laid significantly more eggs (465 eggs) than *E. bicolor* (203 eggs) and *E. albomaculatus* (181 eggs). The egg hatchability of reduviids ranged from 84–99%. The incubation periods of *E. plagiatus* (5.4 d), *S. signatus* (6.0 d), and *E. albomaculatus* (6.4 d) were shorter than that of *E. bicolor, I. armipes*, and *P. bimaculatus*. Incubation was prolonged for *P. bimaculatus* (21.0 d), significantly longer ($F = 140.0$; df = 5, 24; $P < 0.05$) than the other species (Table 1).

The cumulative survival rates differed significantly among the reduviid species. Survival was lowest for *E. albomaculatus* (13.2%), followed by *E. bicolor*
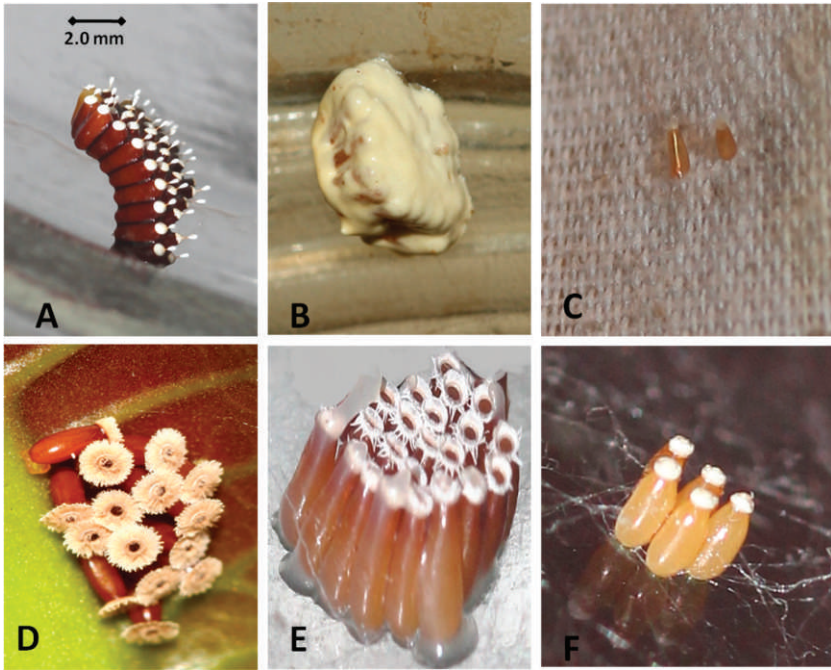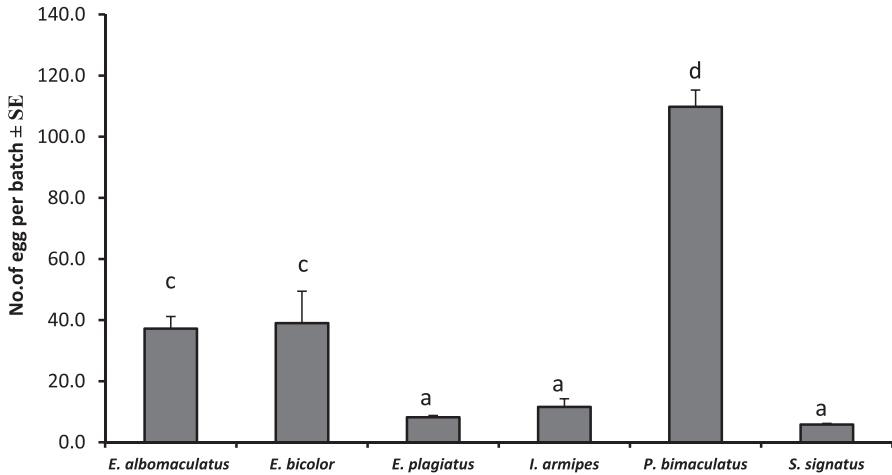
Fig. 1. Eggs of *E. albomaculatus* (A), *E. bicolor* (B), *E. plagiatus* (C), *I. armipes* (D), *P. bimaculatus* (E), and *S. signatus* (F).

(15.0%) and *I. armipes* (22.2%); and it was highest for *E. plagiatus* (54.2%), *S. signatus* (48.2%), and *P. bimaculatus* (47.8%) (Figure 4A). Survival of individual nymphal instars of the six reduviids varied significantly. The survival rate of first instars ($F = 15.1$; df = 5, 24; $P < 0.05$) was highest for *E. plagiatus* (59.6%), *P.*
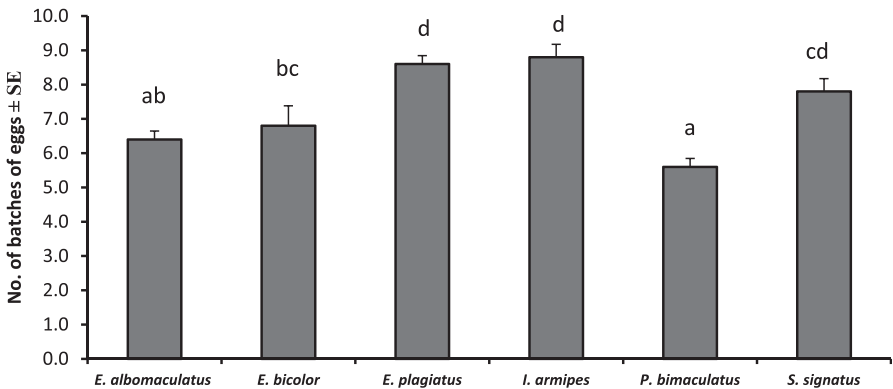
Fig. 2. Mean number of batches of eggs per female of *E. albomaculatus*, *E. bicolor*, *E. plagiatus*, *I. armipes*, *P. bimaculatus*, and *S. signatus*. Bars with common letters indicate means that are not significantly different at $P < 0.05$ (Least Significant difference, SPSS 22).

Fig. 3. Mean number of eggs per batch per female of *E. albomaculatus*, *E. bicolor*, *E. plagiatus*, *I. armipes*, *P. bimaculatus*, and *S. signatus*. Bars with the same letters indicate means that are not significantly different at $P < 0.05$ (Least Significant difference, SPSS 22).

bimaculatus (53.2%), and *S. signatus* (52.4%). Second-instar survival rates were significantly lower for *E. albomaculatus* (28.4%) and *E. bicolor* (25.2%), but were significantly higher for *E. plagiatus* (63.8%) and *S. signatus* (67.6%) ($F = 5.3$; df = 5, 24; $P < 0.05$). The survival rates of third instars ($F = 108.7$; df = 5, 24; $P < 0.05$) were similar for *I. armipes* (52.8%) and *P. bimaculatus* (53.6%), which were significantly lower than *S. signatus* (68.0%) and *E. plagiatus* (74.6%). Fourth-instar survival was significantly ($F = 21.0$; df = 5, 24; $P < 0.05$) higher for *E. plagiatus* (78.4%) and *S. signatus* (74.2%). The survival rate of fifth instars ($F = 72.5$; df = 5, 24; $P < 0.05$) was significantly higher for *E. plagiatus* (79.8%) than the other species (Figure 4B).

The newly hatched, teneral nymphs were fragile, but their cuticles became hardened in 3 to 4 h after emergence. Thereafter, they started feeding, showing

**Table 1. Oviposition and incubation pattern of six species of reduviids.**

Reduviid species	Total eggs laid	% Hatchability	Incubation period (d)
E. albomaculatus	181.4 ± 19.7 c	95.8	6.4 ± 0.2 a
E. bicolor	203.2 ± 10.7 c	97.7	9.8 ± 0.4 b
E. plagiatus	64.6 ± 0.8 ab	84.2	5.4 ± 0.2 a
I. armipes	87.8 ± 0.6 b	98.0	14.4 ± 0.9 c
P. bimaculatus	465.0 ± 44.4 d	99.1	21.0 ± 0.7 d
S. signatus	39.0 ± 2.6 a	84.7	6.0 ± 0.3 a
LSD ($P < 0.05$)	53.4		1.6

The means (±SE) in the same column followed by the same letters are not significantly different at $P < 0.05$ (LSD, SPSS 22).
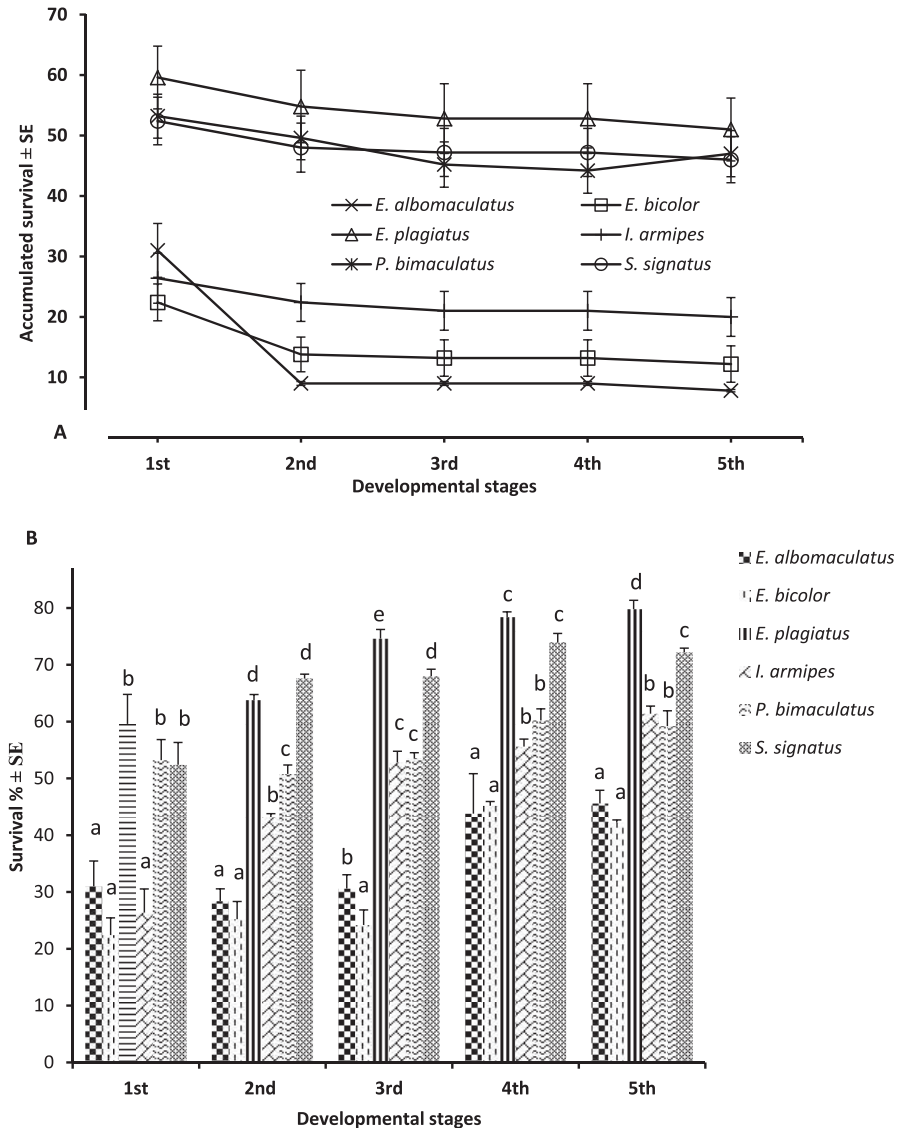
Fig. 4. Accumulated survival (A) and stage-specific survival (B) of *E. albomaculatus*, *E. bicolor*, *E. plagiatus*, *I. armipes*, *P. bimaculatus*, and *S. signatus*. Bars with the same letters indicate means that are not significantly different at $P < 0.05$ (Least Significant difference, SPSS 22).

preference for small and sluggish larvae. Nymphal instars of the reduviid species differed greatly in shape and size during their development (Figure 5). The developmental periods of first instars were significantly faster for *E. plagiatus* (5.2 d) than for the other species ($F = 56.5$; df = 5, 24; $P < 0.05$). *Endochus albomaculatus* (15.0 d) and *I. armipes* (12.2 d) showed the slowest development
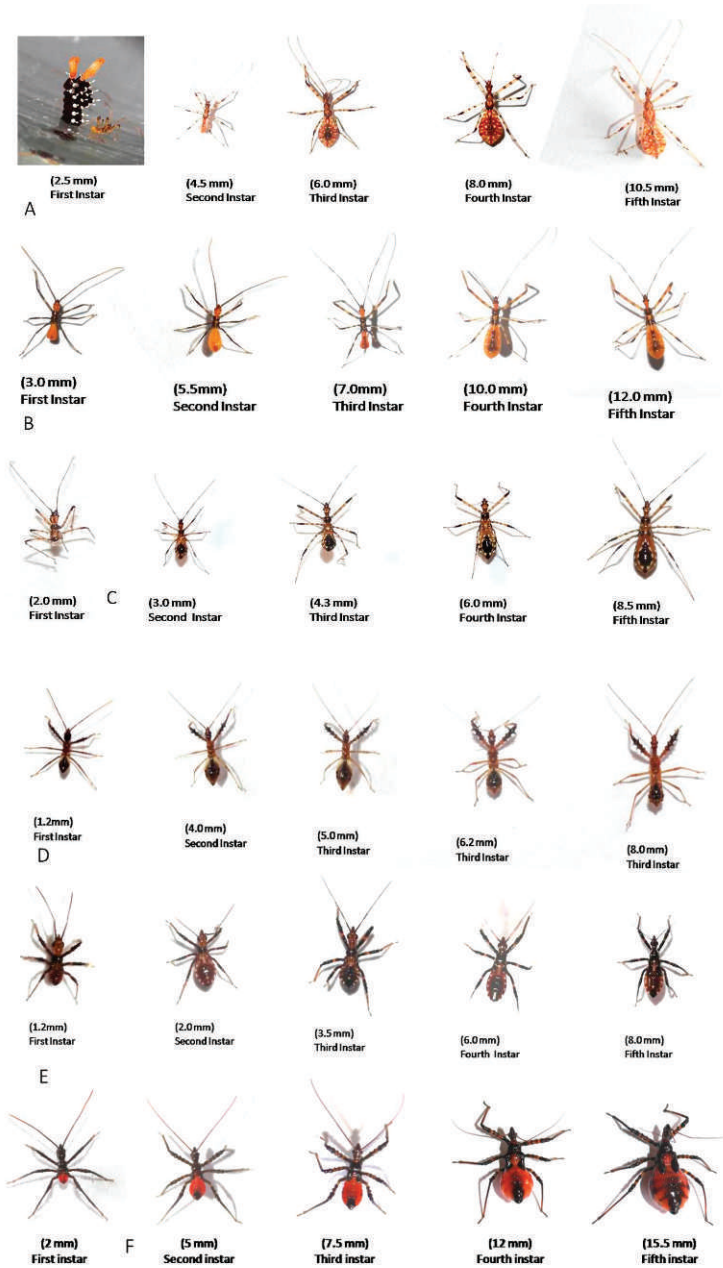
Fig. 5. First, second, third, fourth, and fifth nymphal instars of *E. albomaculatus* (A), *E. bicolor* (B), *E. plagiatus* (C), *I. armipes* (D), *P. bimaculatus* (E), and *S. signatus* (F).

rate as first instars. For second instars ($F = 4.5$; df = 5, 24; $P < 0.05$), the development times were comparatively similar for *S. signatus* (6.8 d), *E. plagiatus* (7.8 d), and *E. bicolor* (8.2 d), which were significantly faster ($F = 4.5$; df = 5, 24; $P < 0.05$) than for the other species. Developmental duration was significantly ($F = 14.9$; df = 5, 24; $P < 0.05$) longer for *P. bimaculatus* (11.2 d) as third instars than it was for *E. plagiatus* (7.0 d) and *E. bicolor* (7.6 d). *Panthous bimaculatus* (9.8 d) and *E. albomaculatus* (10.1 d) developed significantly ($F = 8.2$; df = 5, 24; $P < 0.05$) slower compared with other species as fourth instars. The period from fifth instar to adult emergence was not significantly different among any of the six reduviid species (Table 2). Total postembryonic developmental period from first nymphal instar to adult emergence was significantly different among species ($F = 22.5$; df = 5, 24; $P < 0.05$), ranging from 36.8 d for *E. plagiatus* to 57.5 d for *E. albomaculatus*. Nymphal development of *E. plagiatus* was significantly faster than it was for *E. bicolor, S. signatus, I. armipes, P. bimaculatus*, or *E. albomaculatus*.

    Sex ratios were female-biased in *I. armipes*, *S. signatus*, and *P. bimaculatus* and male-biased in *E. plagiatus, E. bicolor*, and *E. albomaculatus* ($F = 7.1$; df = 5, 24; $P < 0.05$) (Table 3). The longevities of both female and male adults also significantly differed ($F = 19.2$; df = 5, 24; $P < 0.05$). Longevity of both sexes of *S. signatus* was significantly shorter than that of the other five species (Table 3).

    Feeding behavior. All six species of reduviids exhibited a "pin and jab" (Ambrose 1999) mode of predation (Ambrose 1999) in a sequence of acts (Figure 6). The pattern of predatory behavior was observed for predators that had been deprived of prey for 24 h. Sequentially, behaviors exhibited by all six reduviid species were arousal, approach, capture, rostral thrust, paralyzing, sucking, and post-predatory behaviors. These observations were made for predators on both wax moth larvae and *Helopeltis* adults. Prey type influenced predation for all six species of reduviids. For instance, the reduviids more quickly captured, sucked, and paralyzed a *H. antonii* adult than they did wax moth larvae.

    Arousal and approach. The movements of prey excited an arousal response in the reduviids. Predators approached their prey and remained motionless until the prey came closer. Sometimes, they repeated the approach when the prey was larger.

    Capture and rostral thrust. The reduviids held the prey with their tibial combs on their forelegs and pinned and jabbed (rostral thrusting) the dorsal side of the prey with an extended labium. This act was performed more aggressively based on the time interval in the order *P. bimaculatus* > *I. armipes* > *E. bicolor* > *S. signatus* > *E. plagiatus* > *E. albomaculatus*.

    Paralyzing. After prey were pinned and jabbed, the reduviids paralyzed them by injecting toxic saliva (Edwards 1961). After prey were paralyzed, *I. armipes* and *S. signatus* transported them beneath leaves and twigs for a safe and secluded place for feeding. Relocation of prey was not observed in *P. bimaculatus, E. bicolor, E. plagiatus*, or *E. albomaculatus*.

    Probing and sucking. After paralyzing their prey, the reduviids probed with their rostral tip into suitable sites for sucking out the body fluids of the prey. This was done by frequently inserting and withdrawing the stylet.

    Post-predatory behavior. The reduviids cleaned their antennae with their foretibial combs to remove prey debris. Death feigning also was exhibited by nymphs and adults of *I. armipes* and *S. signatus* during predation.

**Table 2. Development period of six species of reduviids.**

Reduviid species	Stadial period (d) (Mean ± SE)					
	I	II	III	IV	V	Total
E. albomaculatus	15.0 ± 0.6 d	10.4 ± 0.5 bc	9.8 ± 0.5 c	10.1 ± 0.9 c	12.2 ± 1.6	57.5 ± 1.8 d
E. bicolor	8.8 ± 0.2 b	8.2 ± 0.2 ab	7.6 ± 0.4 a	8.8 ± 0.2 b	10.6 ± 0.2	43.8 ± 0.2 b
E. plagiatus	5.2 ± 0.2 a	7.8 ± 0.2 ab	7.0 ± 0.3 a	7.2 ± 0.2 a	9.6 ± 0.4	36.8 ± 0.6 a
I. armipes	12.2 ± 0.7 c	10.2 ± 0.8 bc	8.8 ± 0.4 bc	8.4 ± 0.2 ab	13.0 ± 0.6	52.6 ± 0.4 c
P. bimaculatus	8.6 ± 0.4 b	12.0 ± 2.0 c	11.2 ± 0.5 d	9.8 ± 0.4 c	11.6 ± 1.1	53.2 ± 3.4 cd
S. signatus	8.8 ± 0.2 b	6.8 ± 0.2 a	8.8 ± 0.2 bc	7.2 ± 0.2 a	13.0 ± 0.6	44.6 ± 0.7 b
LSD (P < 0.05)	1.3	2.8	1.2	1.2	NS	4.8

The means (±SE) in the same column followed by the same letters are not significantly different at $P < 0.05$ (Least Significant Difference, SPSS 22); NS = Nonsignificant F value in ANOVA.

Table 3. Sex ratio and adult longevity of six species of reduviids.

Reduviid species	Sex ratio (Female: Male)	Longevity (d)	
		Females	Males
E. albomaculatus	1:1.0 ab	84.2 ± 2.8 c	73.6 ± 4.4 c
E. bicolor	1:1.3 b	93.6 ± 2.8 c	87.2 ± 4.5 d
E. plagiatus	1:1.3 b	64.0 ± 6.4 b	59.8 ± 2.4 b
I. armipes	1:0.7 a	62.4 ± 5.9 b	60.6 ± 0.5 b
P. bimaculatus	1:0.8 a	94.0 ± 3.4 c	93.8 ± 2.5 d
S. signatus	1:0.7 a	46.6 ± 3.8 a	41.4 ± 0.7 a
LSD ($P < 0.05$)	0.34	11.2	7.8

Means (±SE) in the same column followed by the same letters are not significantly different at $P < 0.05$ (Least Significant difference, SPSS 22).
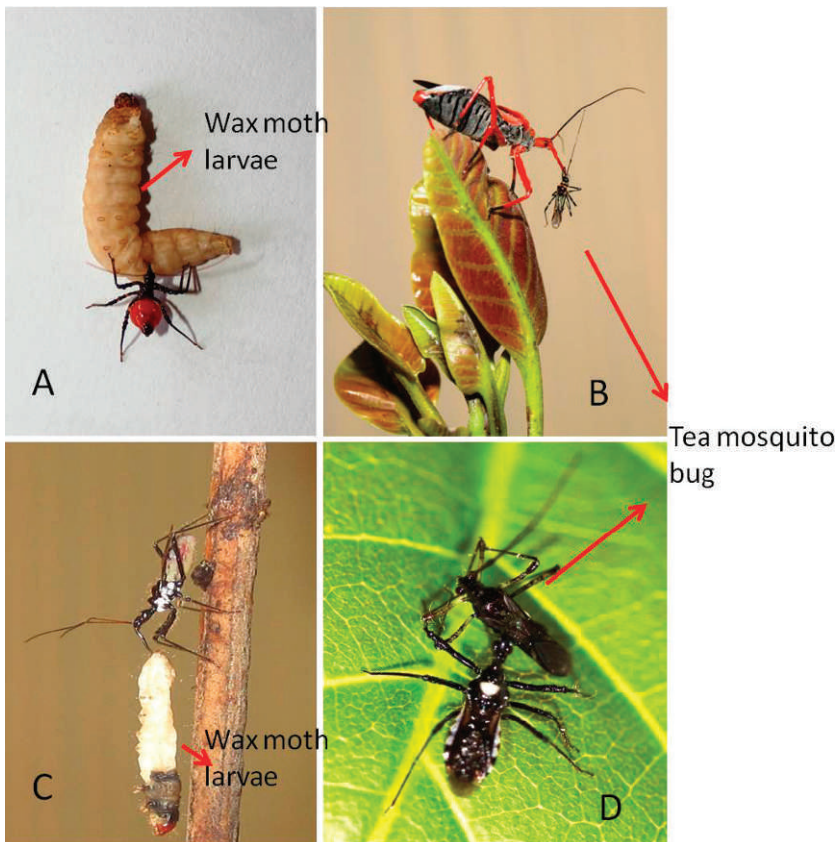
Fig. 6. Pin and jab predation for *P. bimaculatus* (A&B) and *S. signatus* (C&D) on wax moth larva and tea mosquito bug.
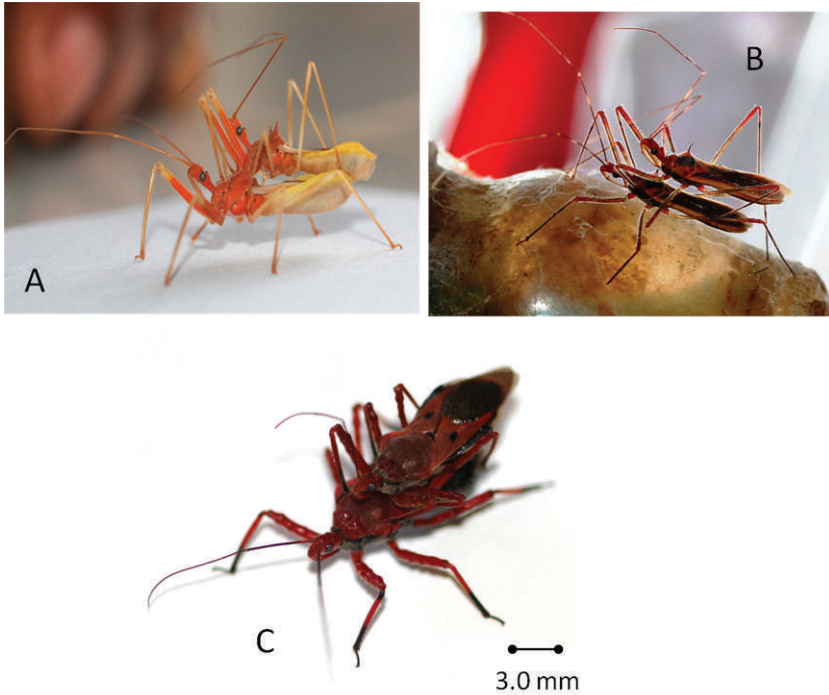
Fig. 7. Riding over behavior of *E. bicolor* (A), *E. plagiatus* (B), and *P. bimaculatus* (C).

Mating behavior. The sequential acts of mating behavior observed in the six species of reduviids were termed arousal, approach, riding over, and copulation.

Arousal and approach. The excitation of mating partners was initiated by the sight of opposite sex. Virgin reduviid males were aroused instantaneously after sighting females of their own species. The intensity of arousal varied among species based on time interval (*P. bimaculatus* > *E. bicolor* > *E. albomaculatus* > *E. plagiatus* > *I. armipes* > *S. signatus*). Virgin males approached females with extended antennae and rostrum. The approach response was completed once the males touched the females with their antennae and placed their legs over them.

Riding over. The male clasped the female with his legs and pressed her pterothorax region with his labial tip, and they remained in the riding over-dorsoventral position (Figure 7). This behavior was much longer compared with the other mating acts, and the duration of the riding over behavior was in the order *P. bimaculatus* > *E. bicolor* > *E. albomaculatus* > *E. plagiatus* > *I. armipes* > *S. signatus*.

Copulation. At the culmination of riding over, males extended their genitalia and achieved connection with the females, where they remained motionless during copulation (Figure 8). The duration of copulation differed among species
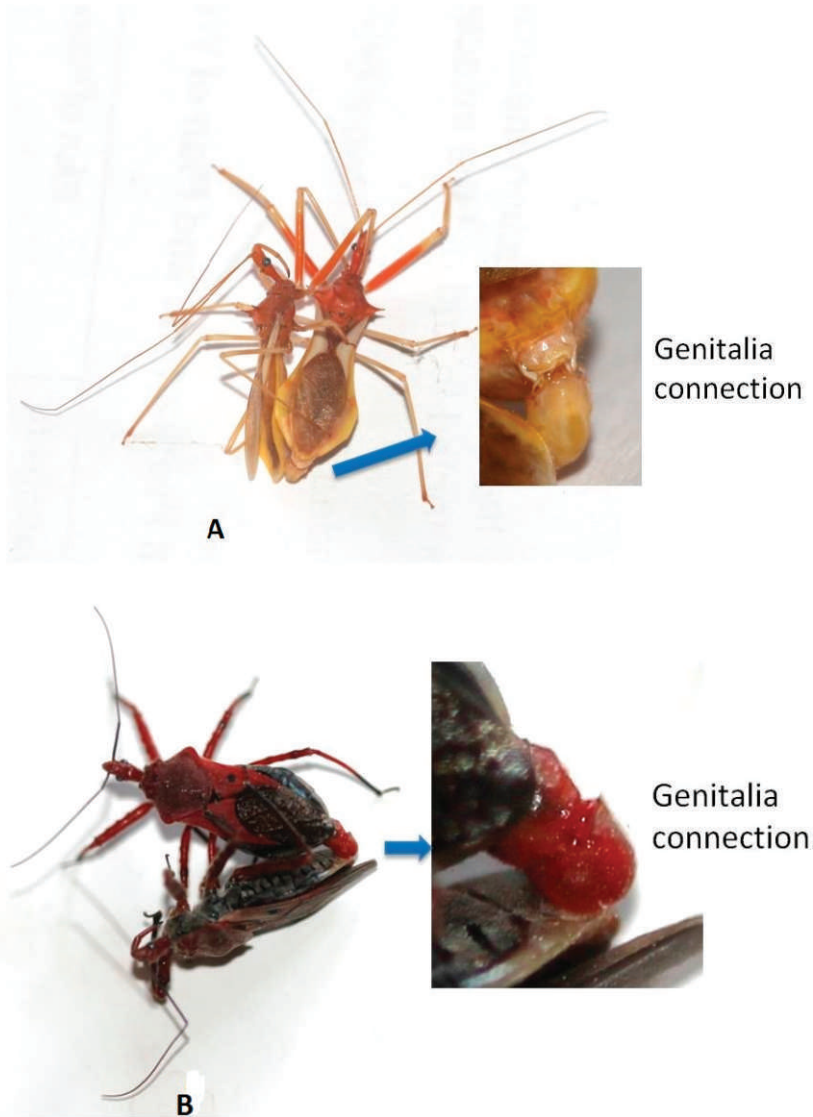
Fig. 8. Mating behavior of *E. bicolor* (A) and *P. bimaculatus* (B) during copulation.

(*P. bimaculatus* > *E. bicolor* > *E. albomaculatus* > *E. plagiatus* > *I. armipes* > *S. signatus*). The end of copulation was characterized by the drooping down of antennae by both males and females, followed by separation of mating partners. The successful completion of copulation was evidenced by the ejection of the spermatophore capsule by females after termination of copulation. Post-copulatory cannibalism of males by females was observed only in *E. bicolor* (Figure 9).

Fig. 9. *E. bicolor* female exhibiting post-copulatory cannibalism of male.

Discussion

Biological studies on reduviids, their conservation and augmentation, and their utilization in biological control of insect pests have been gaining momentum in recent years (Sahayaraj 2007, Schaefer & Panizzi 2000). The data presented herein clearly show that *E. albomaculatus, E. bicolor, E. plagiatus*, *I. armipes, P. bimaculatus*, and *S. signatus* exhibited variation in oviposition, nymphal development, survival, sex ratio, and longevity when fed wax moth larvae. The wax moth larvae used as prey in the present study also have been used in the successful rearing of *Rihirbus trochantericus* Stål var. *luteous* (Hemiptera: Reduviidae) (Bhat et al. 2013). All six species laid eggs on the bottom and sides of the culture bottles and on muslin cloth as reported for other reduviids, such as *Edocla slateri* Distant (Vennison & Ambrose 1986), *Coranus soosaii* Ambrose & Vennison (Vennison 1989), and *C. spiniscutis* Reuter (Claver & Reegan 2010) (Hemiptera: Reduviidae). Das & Ambrose (2008) found that *I. armipes* laid eggs in batches on the bottom of rearing containers vertically glued to the substratum. This species laid an average of 12.9 batches of eggs when reared on *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae), which was higher than observed

in this study (8.8 batches). In the current study, the number of eggs per batch was least for *S. signatus*. Similarly, *S. signatus* was reported to lay one to six eggs per batch when reared on *Heliothis armigera* Hübner (Lepidoptera: Noctuidae) (Vennison & Ambrose 1990). There is no literature pertaining to the number of batches of eggs or the number of eggs per batch for *E. albomaculatus, E. bicolor*, and *P. bimaculatus*. The present study highlighted that *P. bimaculatus* laid the highest number of eggs per batch (109 eggs). Under laboratory conditions, the eggs hatched at different rates among all six species, showing variation in incubation period among species (Ambrose et al. 2009). *Euagoras plagiatus* had a shorter incubation time (5.4 d) compared with the other species, which is an important prerequisite for mass culture. The hatching percentage of all six species was high (84–98%), a diagnostic typical feature of harpactorine reduviids, presumably ensuring a relatively high fecundity (Das 1996, Ambrose et al. 2007, Das et al. 2007).

As observed in other harpactorines, the fifth instar had the longest developmental time and was similar in the six species studied. Total development time of *E. plagiatus* from first nymphal instar to adult was shorter compared with the other species studied. A shorter developmental time is an advantage for mass rearing techniques (Sahayaraj 2004). Das & Ambrose (2008) found that *I. armipes* finished their nymphal developmental period in 51.8 d, and Vennison & Ambrose (1990) reported a nymphal developmental period of 49–58 d for *S. signatus*, which is close to the 52.6 and 44.6 d, respectively, found in the present study.

Nymphal survival of reduviids varied greatly in this study, ranging from 13% for *E. albomaculatus* to 54% for *E. plagiatus*. Mortality in the youngest nymphs apparently was due to their inability to feed, as dead reduviids were found generally without significant intestinal content. Mortality also was observed during molting. Nymphal mortality varied among species, and those species with the least mortality should be considered for mass culture programs (Sahayaraj 2007).

A female-biased sex ratio was seen in *I. armipes*, *S. signatus*, and *P. bimaculatus*, whereas a male-biased sex ratio was observed in *E. plagiatus, E. bicolor*, and *E. albomaculatus*. Many harpactorines, as well as non-harpactorines, exhibit male-biased sex ratios, a mechanism that promotes multiple mating. Females living longer than males are common in harpactorines, a mechanism that promotes multiple mating with males of different age groups, and subsequently facilitates enhanced fecundity (Ambrose 1999, Ambrose et al. 2007).

The same sequential pattern of the pin and jab mode of predation was observed in all species. Prey movement was an important stimulus in the primary sensory input for arousal in predation by reduviids (Ambrose 1999, Kumar et al. 2011). The sensory hairs of the forelegs (Putchkova 1979), tibial pads (Ables 1978), and antennal perception of kairomones and allomones (Rani & Wakamura 1993) play a major role in prey capturing. The six species of reduviids studied here predated by using their antennae, eyes, and tibial combs similar to *Rhynocoris kumarii* Ambrose & Livingstone (Hemiptera: Reduviidae) predating on *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) (Claver & Ambrose 2001). The size of the predator relative to prey size plays a vital role in prey capture (Ambrose 1999). In the present study, all six species easily handled natural prey, adults of *H. antonii*, and laboratory prey, larvae of *G. mellonella*. However, the

reduviids more quickly captured and consumed *H. antonii* adults than they did larvae of *G. mellonella*. This could be due to the larger size of *G. mellonella* larvae compared to an *H. antonii* adult. Prey influenced predation as a function of prey-predator interaction has been reported for several reduviids (Ambrose 1999).

All six species were polygamous and polyandrous. The sequential acts of mating were similar to other harpactorine reduviids. The primary role of vision in the excitation of mating partners has been confirmed by eye-blinding experiments (Ambrose 1999) in several reduviids. In the same study, the duration of riding over, a diagnostic feature of harpactorine reduviids, varied from a few minutes to 1-3 d (Ambrose 1999). The dorsolateral copulation position in all six species also was reported in several harpactorine reduviids (Ambrose 1999, Das & Ambrose 2008). In our study, congregational feeding was found among the nymphal instars of all six species during predation. However, cannibalism observed in *E. albomaculatus*, *E. bicolor, I. armipes*, and *P. bimaculatus* was not recorded in *E. plagiatus* and *S. signatus*, which is similar to what has been reported for *Vesbius sanguinosus* Stål (Hemiptera: Reduviidae) (Das & Ambrose 2008) and *Cydnocoris gilvus* Brum. (Hemiptera: Reduviidae) (Srikumar et al. 2014).

In summary, the present study provides initial insight into the biological traits of six reduviid species in a cashew ecosystem. Of particular importance are characteristics that facilitate mass culturing and inundative releases. Desirable features, such as larger batches of eggs, shorter incubation and developmental periods, and less nymphal mortality, were most prevalent in *E. plagiatus*. Other species with high nymphal survival rates were *S. signatus* and *P. bimaculatus*. *Euagoras plagiatus* and *S. signatus* did not exhibit cannibalistic behavior. All of these reduviids are efficient predators of *H. antonii*, and these findings may help improve future IPM strategies against this pest in cashew.

Acknowledgments

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