P O L I S H J O U R N A L O F E N T O M O L O G Y
P O L S K I E P I S M O E N T O M O L O G I C Z N E

VOL. **77**: 11-29 Bydgoszcz 30 March 2008

Redescription, biology and behaviour of a harpactorine assassin bug *Vesbius sanguinosus* STÅL (Insecta, Hemiptera, Reduviidae)

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ABSTRACT. Redescription of adult *Vesbius sanguinosus* STÅL is given. *V. sanguinosus* laid eggs with sanguineous chorion. A female on an average laid 49.8 ± 3.1 eggs in 9.7 ± 0.65 clusters with 2.8 ± 0.19 to 7.2 ± 0.51 eggs per cluster. The eggs hatched after 7.8 ± 0.51 days. The stadial period of I, II, III, IV and V (to male and female) nymphal instars were 6.2 ± 0.52, 6.8 ± 0.6, 7.2 ± 0.36, 6.1 ± 0.38, 6.6 ± 0.52 and 7.5 ± 0.58 days respectively. Morphometry and illustration of life stages are given with a key to identify the nymphal stages. The sex ratio of male and female was 0.93 : 1. The preoviposition, oviposition and postoviposition periods were 8.6 ± 0.52, 57.51 ± 3.2 and 2.3 ± 0.14 days respectively. The adult males and females lived for 61.2 ± 3.6 and 68.1 ± 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 arousal, approach, nuptial clasp including riding over, genitalia extension and connection achievement and postcopulatory behaviour.

KEY WORDS: *Vesbius sanguinosus*, assassin bug, redescription, biology, nymphal morphology, predation, mating.

INTRODUCTION

The reduviids are abundant, occur worldwide and are highly successful predators and they play a vital role in the biocontrol of insect pests. Moreover, they exploit the most adverse microhabitats of every ecosystem and predating on a wide variety of insect pests. Since they are polyphagous predators they may not be useful as predators on specific pests but they are valuable predators in situations where a variety of insect pests occur. However, they exhibit a certain amount of host as well as stage preferences. Hence, they should be conserved and augmented to be effectively utilized in the Integrated Pest Management Programmes (IPM) (AMBROSE 1999, 2000, 2003, AMBROSE et al., 2003, 2006, 2007). Conservation and augmentation of any biological control agent rely upon its comprehensive knowledge a bioecology, ecophysiology and behaviour. Though information on biology, behaviour of many reduviids is available no such information is documented for any of the *Vesbius* species. Hence, an attempt was made to study the biology and predatory and mating behaviour of *V. sanguinosus*. The available description on *V. sanguinosus* is insufficient (DISTANT 1902) and hence a redescription is included.

MATERIALS AND METHODS

Vesbius sanguinosus STÅL was collected from the foliage of *Tamarindus indicus* L. adjacent to agroecosystem bordering tropical rainforests and scrub jungles in and around Marthandam in Kanyakumari District, Tamil Nadu, India (MSL, 77° 12' 10" E and 8° 17' 38" N). They were reared on the larvae of rice meal moth *Corcyra cephalonica* (Stainton) in plastic containers (5.5 x 6.5 cm) under laboratory conditions (temp. 30 ± 2°C, 75 ± 5% rh, 12 ± 1 hr photoperiod). The adults emerged were allowed to mate. The reduviids reared in the laboratory were used for the experimental studies.

Different 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 plastic containers (50 ml) on the larvae of flour moth *C. cephalonica*. The containers were examined at regular intervals for spermatophore capsules ejected after successful copulation as well as for the eggs laid. Different batches of eggs were allowed to hatch in containers separately. The stadial periods of nymphs and nymphal mortality were recorded. Adult longevity and sex ratio were recorded for the laboratory emerged adults.

Predatory behaviour was observed in 24 hr prey deprived *V. sanguinosus* on two prey viz., *C. cephalonica* larvae and the termite *Odontotermes obesus* Rambur. The mating behaviour of sex starved predation was recorded. Camera lucida illustrations and morphometry of life stages were made with 70 % ethanol preserved specimens. Morphometry of life stages are given in Tables 1 and 2.

RESULTS AND DISCUSSION

Microhabitat

The adults and nymphal instars of *V. sanguinosus* were found inhabiting the foliage of *T. indicus* of Kodayar. It was found feeding on the termite *O. obesus* and the ant *Oecophylla* sp. The life stages were in large numbers in shady and cooler places where hairy caterpillars, midges, hoppers etc. were abundant. Reduviid co-inhabitants were not found along with *V. sanguinosus*.

Redescription

The description of *V. sanguinosus* (DISTANT 1902) is inadequate and it necessiates a redescription with morphometry and additional diagnostic features as follows (Tables 1, 2, Figs 1-11).

Length entire 6.795 ± 0.52 mm, width across eyes 0.45 ± 0.06 mm and maximum width across prothorax and abdomen 1.755 ± 0.154 and 2.07 ± 0.32 mm.

Head, eyes, antennae and membrane fuscopiceous, neck, pronotum, abdomen and corium rubescent and legs fuscorufous.

Head triangular; obsoletely pilose; bulbous postocular separated from shorter anteocular by a deep sulcus; head width equals to postocular length; compound eyes anteriorly placed and laterally protruding; vertex tumid; antennae long, four segmented and pubescent, scape the longest and longer than head, pedicel the shortest and equals to postocular in length; rostrum robust, slightly shorter than head, midrostral segment the longest and distal segment the shortest; neck prominent.

Pronotum broader, dorsally bulbous, pilose, anterolateral margins angularly and obtusely produced and posteriorly truncated; smaller anterior lobe separated from larger posterior lobe by a sulcus; collar obscure; scutellum triangular, moderately acuminate; legs pilose, femora nodulose, three segmented tarsi, midtarsus the longest and proximal tarsus the shortest; hemelytra slightly longer than abdomen, corium smaller and pubescent, membrane larger and shining, proximally fuscopiceous and distally transparent, passing beyond abdomen.

Abdomen oblong, dorsoventrally compressed, eight segmented and with smooth margin; second to fifth segments each with a middorsal intersegmental median opening of abdominal glands; octoon rubescent and moderately pubescent.

Females are larger than males.

Egg and Fecundity

Biology: The eyes were elongately oval with sanguineous
chorion and white operculum (Fig. 12). In the laboratory eggs were laid singly, each egg vertically glued to the substratum.

The preoviposition period of this harpactorine reduviid was 8.6 ± 0.52 days. It 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 *V. sanguinosus* was closer to that of *Sphedanolestes signatus*

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

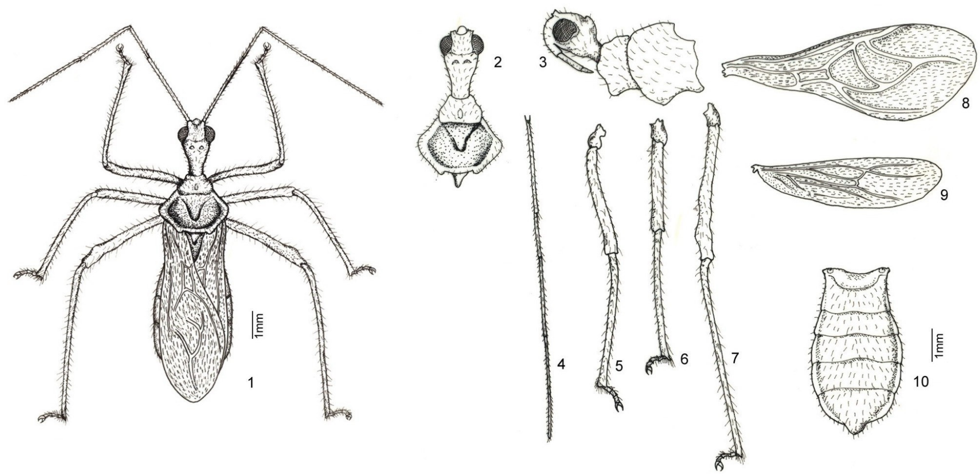
Life stages	Head						Antennal length					Rostral length			
	AO	PO	WBE	DE	HL	HW	S	P	F_1	F_2	EA	BR	MR	TR	ER
First nymphal instar	0.135 ± 0.050	0.270 ± 0.030	0.180 ± 0.024	0.135 ± 0.040	0.540 ± 0.070	0.405 ± 0.060	0.675 ± 0.070	0.360 ± 0.060	0.405 ± 0.062	1.305 ± 0.115	2.745 ± 0.240	0.270 ± 0.021	0.360 ± 0.024	0.045 ± 0.006	0.675 ± 0.080
Second nymphal instar	0.135 ± 0.040	0.585 ± 0.046	0.450 ± 0.052	0.270 ± 0.036	0.990 ± 0.094	0.720 ± 0.090	1.395 ± 0.220	0.630 ± 0.084	0.900 ± 0.120	2.025 ± 0.280	4.950 ± 0.460	0.405 ± 0.070	0.585 ± 0.070	0.090 ± 0.010	1.080 ± 0.140
Third nymphal instar	0.225 ± 0.340	0.720 ± 0.090	0.495 ± 0.060	0.360 ± 0.048	1.305 ± 0.160	0.810 ± 0.104	1.395 ± 0.280	0.630 ± 0.094	0.900 ± 0.086	2.115 ± 0.340	5.040 ± 0.390	0.495 ± 0.066	0.495 ± 0.066	0.180 ± 0.030	1.215 ± 0.160
Fourth nymphal instar	0.270 ± 0.050	0.855 ± 0.092	0.495 ± 0.072	0.405 ± 0.060	1.530 ± 0.180	0.900 ± 0.096	1.755 ± 0.260	0.765 ± 0.086	1.170 ± 0.190	2.295 ± 0.360	5.985 ± 0.520	0.675 ± 0.080	0.675 ± 0.080	0.225 ± 0.460	1.530 ± 0.180
Fifth nymphal instar	0.225 ± 0.048	0.900 ± 0.080	0.495 ± 0.068	0.450 ± 0.050	1.575 ± 0.210	0.900 ± 0.080	1.800 ± 0.360	0.900 ± 0.072	1.170 ± 0.160	2.295 ± 0.480	6.165 ± 0.720	0.675 ± 0.074	0.675 ± 0.074	0.225 ± 0.032	1.530 ± 0.210
Adult male	0.225 ± 0.036	0.900 ± 0.110	0.450 ± 0.030	0.495 ± 0.062	1.620 ± 0.220	0.990 ± 0.140	1.935 ± 0.240	0.900 ± 0.086	1.485 ± 0.036	2.610 ± 0.38	6.930 ± 0.820	0.675 ± 0.086	0.675 ± 0.086	0.225 ± 0.010	1.540 ± 0.180
Adult female	0.225 ± 0.062	0.945 ± 0.980	0.450 ± 0.070	0.495 ± 0.048	1.670 ± 0.320	0.990 ± 0.160	2.115 ± 0.360	0.900 ± 0.072	1.575 ± 0.360	2.655 ± 0.420	7.245 ± 0.840	0.675 ± 0.082	0.675 ± 0.082	0.270 ± 0.040	1.620 ± 0.260

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 rostral segments and ER = entire rostrum.

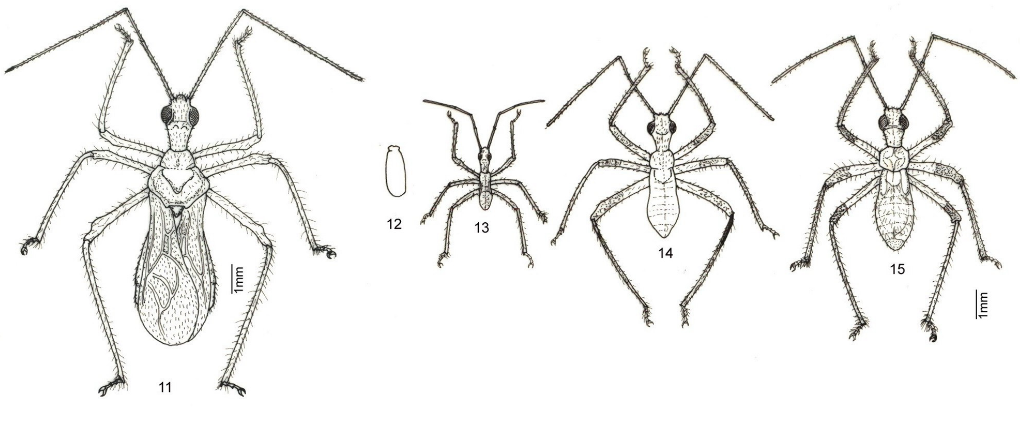
Table 2. Morphometric analysis of prothorax, thoracic appendages and abdomen of life stages of *Vesbius sanguinosus* (in mm; n = 6; $\overline{X} \pm SD$).

Life stages	Prothorax		Tibial length			Wing / Rudiment		Abdomen		Insect Length
	L	W	F	M	H	L	W	L	W	
First nymphal instar	0.315 ± 0.050	0.360 ± 0.038	1.260 ± 0.160	1.170 ± 0.180	1.485 ± 0.182	-	-	0.630 ± 0.080	0.360 ± 0.050	1.530 ± 0.130
Second nymphal instar	0.540 ± 0.060	0.810 ± 0.074	2.115 ± 0.183	2.340 ± 0.320	3.015 ± 0.480	-	-	0.720 ± 0.084	0.450 ± 0.060	2.610 ± 0.190
Third nymphal instar	0.630 ± 0.052	0.675 ± 0.080	2.160 ± 0.280	2.295 ± 0.280	2.970 ± 0.360	0.495 ± 0.031	0.180 ± 0.024	2.160 ± 0.280	1.440 ± 0.180	4.590 ± 0.480
Fourth nymphal instar	0.675 ± 0.082	0.900 ± 0.080	2.835 ± 0.320	2.970 ± 0.320	3.960 ± 0.480	1.845 ± 0.192	0.540 ± 0.070	2.250 ± 0.340	1.800 ± 0.210	5.085 ± 0.312
Fifth nymphal instar	0.720 ± 0.082	0.990 ± 0.095	2.835 ± 0.650	2.925 ± 0.360	4.050 ± 0.480	1.980 ± 0.240	0.540 ± 0.060	3.150 ± 0.360	1.935 ± 0.240	5.940 ± 0.404
Adult male	1.575 ± 0.180	1.755 ± 0.186	2.970 ± 0.266	3.060 ± 0.320	4.275 ± 0.360	4.725 ± 0.560	1.620 ± 0.150	3.375 ± 0.380	2.070 ± 0.320	6.795 ± 0.520
Adult female	1.575 ± 0.120	1.755 ± 0.154	3.150 ± 0.420	3.285 ± 0.480	4.500 ± 0.560	4.950 ± 0.560	1.665 ± 0.240	3.150 ± 0.360	2.115 ± 0.360	6.975 ± 0.490

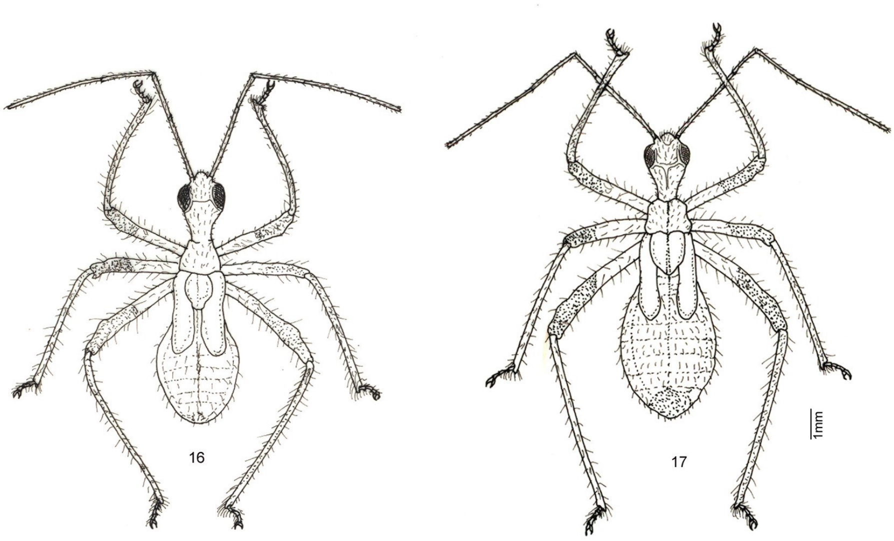
F, M and H = fore, mid- and hind tibia; L = length; W = Width.



Figs 1-10. *Vesbius sanguinosus* Stål: 1– male: 2,3 – head and thorax, dorsal and lateral views, 4 – antennae, 5-7 – fore-, mid- and hind legs, 8 – forewing, 9 – hind wing and 10 – abdomen.



Figs 11-15. *Vesbius sanguinosus*: 11 – female, 12 – egg and 13-15 – I-III nymphal instars.



Figs 16-17. *Vesbius sanguinosus*:16, 17 – IV,V nymphal instars.

Distant (VENNISON & AMBROSE 1990) and *Sphedanolestes himalayensis* Distant (DAS et al. 2007).

A female *V. sanguinosus* on an average laid 9.7 ± 0.65 batches of eggs with a total number of 49.8 ± 3.1 eggs. Different batches of eggs contained a minimum number of 2.8 ± 0.19 eggs, a maximum number of 7.2 ± 0.51 eggs and an average of 5.12 ± 0.56 eggs per batch. The fecundity observed in *V. sanguinosus* was moderate and closer to that of *Endochus umbrinus* Distant and *Euagoras plagiat*
us (Burmeister) though many harpactorine reduviids lay higher number of eggs (Table 3) (AMBROSE 1999, AMBROSE et al. 2006, 2007, DAS et al. 2007).

The oviposition period of *V. sanguinosus* was about 57.51 ± 3.2 days and it was closer to that of *S. himalayensis* (DAS et al. 2007), *S. minusculus* Bergroth (AMBROSE et al., 2006) and *Sphedanolestes* sp. (DAS, 1996). The index of oviposition period (percentage of egg laying days, (AMBROSE 1980) was 14.86 ± 0.96 days and it was closer to that of *Irantha armipes* (STÅL) (DAS 1996).

Hatching

The fertilized egg turned swollen and reddish prior to hatching whereas the unfertilized eggs become shrunken after a few days. The eggs hatched after 7.8 ± 0.51 days (Table 4). The incubation period of *V. sanguinosus* was closer to that of many harpactorines such as *Coranus*, *Polididus*, *Sphedanolestes* and *Rhynocoris* species (AMBROSE 1999). The hatching percentage of *V. sanguinosus* was relatively higher (87.55 ± 6.99%), a diagnostic characteristic feature of harpactorine tropical rainforest reduviids (Table 3) especially found among the members of *Coranus*, *Scipinia, Sphedanolestes* and *Sycanus* and closer to that of *Zelus exsanguis* Stål (AMBROSE 1999, AMBROSE et al. 2006, 2007, DAS et al. 2007). Though 0% (2.8 ± 0.16) and 100% (5.8 ± 0.49) hatchings were recorded among different batches of eggs, there were frequent 100% hatchings than 0% hatchings (Table 3). This might have ensured a relatively higher fecundity. The newly hatched nymphs were fragile and they become tanned 3 to 6 hrs after emergence and thereafter started feeding, showing preference to small and sluggish prey.

Table 3. Oviposition pattern and hatchability of *Vesbius sanguinosus.*

Parameters	*V. sanguinosus*
Adult female longevity in days	68.41 ± 4.6
Preoviposition period in days	8.60 ± 0.52
Postoviposition period in days	2.30 ± 0.14
Index of oviposition days	14.86 ± 0.96
Total number of batches of eggs	9.70 ± 0.65
Total number of eggs laid	49.80 ± 3.10
Average number of eggs per batch	5.12 ± 0.56
Minimum number of eggs per batch	2.80 ± 0.19
Maximum number of eggs per batch	7.20 ± 0.51
Total number of nymphs hatched	43.60 ± 3.60
Hatching percentage	87.55 ± 6.90
Frequency of 0% hatching	2.80 ± 0.16
Frequency of 100% hatching	5.80 ± 0.49
Incubation period in days	7.80 ± 0.51

Moulting and Stadial period

The I, II, III, IV and V to male and V to female stadial periods of *V. sanguinosus* were 6.2 ± 0.52, 6.8 ± 0.6, 7.2 ± 0.36, 6.1 ± 0.38, 6.6 ± 0.52 and 7.5 ± 0.58 days (Table 4). As observed in other harpactorines the longest stadium was the fifth (V to female). But the shortest IV stadium observed in *V. sanguinosus* was recorded in a few harpactorines such as *S. himalayensis* (DAS et al. 2007) whereas it was generally either II or III stadium (AMBROSE 1999, AMBROSE et al. 2006, 2007). The total stadial period from first nymphal instar to adult was 38.6 ± 2.1 days (Table 4) and it was the shortest stadial period observed closer to among harpactorines and closer to that of *Coranus* species (AMBROSE 1999).

Nymphal morphology

The following passages briefly describe the nymphal morphology (Figs 13 -17).

Table 4. Incubation and stadial periods (in days) of *Vesbius sanguinosus* ($\overline{X}$ ± SD, n = 20).

Incubation period	Stadial period						
	I	II	III	IV	V-male	V-female	I-adult
7.8 ± 0.51 [6.8]	6.2 ± 0.52 [6-8]	6.8 ± 0.60 [6-8]	7.2 ± 0.36 [6-8]	6.1 ± 0.38 [5-7]	6.6 ± 0.52 [6-8]	7.5 ± 0.58 [7-9]	38.6 ± 2.10 [30-40]

I instar

Total length 1.53 ± 0.09 mm

Head, proximal part of scape, tibiae, distal femora and octoon dark ochraceous, eyes tawny, distal flagellar segment and neck luteous and proximal femora pronotum and abdomen rufous.

Head oblong with prominent longitudinal middorsal ecdysial line; compound eyes compressed within the lateral head contour; much shorter anteocular separated from postocular by a distinct sulcus, anteocular as long as diameter of eye, postocular length equals to first rostral segment length; antennae four segmented, richly pilose, distal flagellar segment the longest and pedicel the shortest; rostrum three segmented, longer than head, third segment the shortest, second segment the longest; neck prominent.

Pronotum gibbous and pilose, anterior pronotatal lobe, smaller, broader and bulbous and separated from narrower and larger posterior pronotal lobe by a deep sulcus; collar obscure; legs moderately pilose, mostly with clavate hairs, hind tibia the longest and midtibia the shortest, midtarsus the longest and distal tarsus the shortest.

Abdomen elongate, eight segmented, obscurely pilose and margin abbreviated.

II instar

Total length 2.61 ± 0.19 mm.

Head, eyes, antennae, tibiae, distal femora and octoon dark ochraceous, pronotum, abdomen and proximal femora rubescent and femora with a flavous annulation.

Head oblong and obscurely pilose; eyes slightly laterally protruding, anteocular shorter and separated from longer postocular by a moderately shallow sulcus; antennae long, four segmented, sericeous, distal flagellar segment the longest, pedicel the shortest; rostrum long, three segmented, third rostral segment the shortest and midsegment the longest and subequals to pedicel; neck prominent.

Pronotum broader and obscurely pilose, anterior pronotal lobe tumid, smaller and deeply sulcated from the larger posterior lobe, posterolateral angles rounded; legs pilose, most hairs clavate, femora prominently distally dilated just in front of a flavous annulation, hind tibia the longest and foretibia the shortest, tarsi three segmented, midtarsus the longest and proximal tarsus the shortest.

Abdomen margin abbreviated and moderately pilose.

III instar

Total length 4.59 ± 0.48 mm.

Head, eyes, proximal region of scape, rostrum, tibiae and distal femora fusco-piceous, antennae and seventh and eighth abdominal segments ochraceous and neck, pronotum and proximal femora deeply rubescent.

Head oblong, obscurely pilose; eyes slightly protruding; shorter anteocular sulcated from longer postocular; vertex tumid; antennae long, sericeous, four segmented, moderately pubescent, scape slightly longer than head, distal flagellar segment the longest, pedicel the shortest; rostrum robust, long, three segmented, midrostral segment subequals to proximal rostral segment; neck abbreviated but prominent.

Pronotum large, pulvinate, pilose, anterior bulbous lobe separated from posterior lobe by a deep sulcus; collar obscure; scutellum rudimentary; wing buds extend up to second abdominal segment; legs pilose, only few hairs clavate, flavous annulation obliterated, distal femoral dilation prominent, hind tibia the longest and foretibia the shortest, tarsi three segmented, midtarsus the longest and proximal tarsus the shortest.

Abdomen elongate, dorsally bulbous, moderately pilose with smooth margin and as long as foretibia.

IV instar

Total length 5.085 ± 0.312 mm.

Head, antennae, rostrum, tibiae, distal femora and seventh and eighth abdominal segments fusco-piceous, neck, pronotum, scuttellar rudiment and wing rudiment, abdomen and proximal femora deeply rubescent.

Head triangular, moderately pilose; eyes prominent, slightly laterally protruding; shorter anteocular demarcated from longer bulbous postocular by a deep sulcus; vertex tumid; antennae richly pilose, distal flagellar segment the longest, pedicel the shortest, scape longer than head; rostrum, robust, first segment subequal in length to second segment, distal segment the shortest; neck prominent.

Pronotum large, broader and pilose, anterior pronotal segment bulbous; antero- and posterolateral edges obtuse; collar obscure, scutellum prominent with acute terminus; wing rudiments levigate and extend up to fourth abdominal segment; legs richly pilose, most hairs clavate, femora dilated distally closer to the tibio-femoral junction, hind tibia the longest, foretibia the shortest, midtarsi the longest and proximal tarsi the shortest.

Abdomen eight segmented, pubescent and with smooth margin.

V instar

Total length 5.94 ± 0.404 mm.

Head, eyes, antennae, tibiae, distal femora, distal part of seventh abdominal segment and octoon fusco-piceous and neck, pronotum, wing rudiment and proximal femora rubescent.

Head triangular, moderately pilose, eyes prominent, vertex tumid; anteocular shorter than bulbous postocular and its length, equals to head width; antennae long, four segmented and pilose, scape shorter than head, distal flagellar segment the longest, pedicel the shortest; rostrum three segmented, robust, mid- and proximal rostral segments almost equal in length and longest; neck prominent.

Pronotum broader, bulbous, pubescent, anterior pronotal lobe separated from posterior lobe by a transverse sulcus; antero- and posterolateral angles obtuse; collar obscure; scutellar rudiment prominent; wing rudiments long and levigate; legs richly pilose, femora distally nodose, hind tibiae the longest, foretibia subequals to midtibia, midtarsi the longest and proximal tarsi the shortest.

Abdomen elongate slightly longer than midtibia but shorter than hind tibia and sparsely pubescent with smooth margin, octoon prominent.

Nymphal key

The following key identifies the instars of nymph (Table 1, 2, Figs 13-17).

Key for the identification of nymphal instars

1. Head shorter than rostrum; postocular shorter than or equals to midrostral segment in length; scape longer than abdomen; pedicel equals to or longer than abdominal width; rostrum longer than abdomen; midrostral segment longer than prothorax; prothorax width either equals to or greater than abdominal width; wing rudiments absent …………………..……………………………………………………………… **(2)**

-. Head length either greater or equals to rostral length; postocular longer than midrostral segment; scape shorter than abdomen; pedicel shorter than abdominal width; rostrum shorter than abdomen; midrostral segment either shorter than or equals to prothorax; prothorax narrower than abdomen; wing rudiments present …………………… (**3)**

2. Head width equals to the length of first flagellar segment; anteocular length equals to diameter of eye; postocular length equals to first rostral segment and shorter than second rostral segment; width between eyes exactly half of abdominal width; pedicel as long as midrostral segment and equals to prothorax width and abdominal width separately; second flagellar segment longer than foretibia; midrostral segment length equals to prothorax width; prothorax and abdomen equals in width ……..…… **I instar**

-. Head width shorter than first flagellar segment length; anteocular length shorter than diameter of eye; postocular longer than first rostral segment and equals to second rostral segment; width between eyes equals to abdominal width; pedicel longer than midrostral segment and abdominal width separately and shorter than prothorax width; second flagellar segment shorter than foretibia; midrostral segment length lesser than prothoracic width; prothroax broader than abdomen ……………..…………… **II instar**

3. Anteocular length greater than wing width; width between eyes equals to wing length; pedicel as long as prothorax; rostrum longer than wing rudiment; third rostral segment as long as wing width; prothorax longer than wing; prothoracic width greater than wing length ……………………………………..……………………. **III instar**

-. Anteocular length lesser than wing width; width between eyes lesser than wing length; pedicel longer than prothorax; rostrum shorter than wing rudiment; third rostral segment shorter than wing width, prothorax shorter than wing; prothoracic width lesser than wing length ……………………………………….……………………………… **4**

4. Head as long as rostrum; head and prothorax of equal width; head width greater than pedicel length; anteocular longer than third rostral segment; postocular length lesser than head width and pedicel length separately; second flagellar segment longer than abdomen; second rostral segment and prothorax equal in length; fore - and midtibiae separately longer than abdomen ………………..……………………………. **IV instar**

-. Head longer than rostrum; head width lesser than prothoracic width; head width equals to pedicel length; anteocular and third rostral segment equal in length; postocular length equals to head width and pedicel length separately; second flagellar segment shorter than abdomen; second rostral segment shorter than prothorax; fore- and mid tibiae separately shorter than abdomen …………………………..……….... **V instar**

Nymphal mortality

Abnormal hatching and moulting resulted into 4.2 ± 0.31, 5.6 ± 0.31, 7.8 ± 0.4, 2.9 ± 0.22 and 2.2 ± 0.14 % mortalities in I, II, III, IV and V nymphal instars. Thus, 22.7 ± 1.4 % of nymphs died during their postembryonic development and the survival rate was about 77.3%. The nymphal mortality observed in *V. sanguinosus* was comparatively greater among tropical rainforest harpactorines (AMBROSE 1999, AMBROSE et al. 2006, DAS 1996, DAS et al. 2007) but much higher nymphal mortality was recorded in a tropical rainforest harpactorine reduviid *Endochus migratorius* Distant (51.35%) (AMBROSE et al. 2007).

Adult longevity and sex ratio

The females of *V. sanguinosus* lived longer (68.1 ± 3.6 days) than the males (61.2 ± 3.6 days). Adult females living longer than males are not uncommon in harpactorines, a mechanism that facilitates enhanced fecundity (AMBROSE 1999).

The sex ratio (male: female) of *V. sanguinosus* among the adults emerged from the laboratory was female biased (0.93:1). A similar female biased sex ratio was observed in several harpactorines such as *Alcmena*, *Brassivola*, *Euagoras*, *Irantha*, *Sphedanolestes* and *Sycanus*, a mechanism that facilitates enhanced fecundity multiple mating (AMBROSE 1999).

Behaviour

Predatory behaviour

V. sanguinosus exhibited 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., flour moth *C. cephalonica* larva and the termite *O. obesus* as follows: arousal - approach - capturing - paralysing - sucking - postpredatory behaviour as observed in many harpactorine reduviids (AMBROSE 1999, AMBROSE et al. 2007) (Table 5, Fig. 18).

Arousal

The visual stimulus from the moving prey excited an arousal response in *V. sanguinosus*. The importance of vision in locating the prey and the subsequent arousal response was further proved by eye blocking experiments (AMBROSE 1999). Moreover, it was further discussed that antennal contact of the prey was not essential in reduviid predators as they do not touch any part of the prey's body before pinning and jabbing (DAS 1996). This was further proved by the fact that antennectomized reduviids successfully pinned and jabbed their prey (AMBROSE 1999).

Approach

The approach of *V. sanguinosus* totwards its prey was similar to that of any typical nontibial pad reduviid approach, in which the predator oriented towards the prey and remained motionless until the prey came closer to the predator. The predator approached again if they prey was larger or it got slipped off from the predator's hold due to its agility.

Capturing

V. sanguinosus first it pinned and jabbed the lateral side of the prey by the extended rostrum. Though different first attack sites such as anntennal bases, leg joints, junction between head and thorax, rear end etc., were reported for many reduviids many harpactorines attack the prey laterally as observed in *V. sanguinosus* (AMBROSE 1999). Thereafter, it firmly hold the prey by forelegs with tibial combs.

Paralysing

After prey was pinned and jabbed and captured, predator paralysed it by injecting toxic saliva. The haemolytic neurotoxins present in the salivary glands especially in the anterior lobes paralyse the prey (AMBROSE 1999). *V. sanguinosus* did not transport the prey after paralysing a behaviour observed in many reduviids (DAS 1996, AMBROSE 1999).

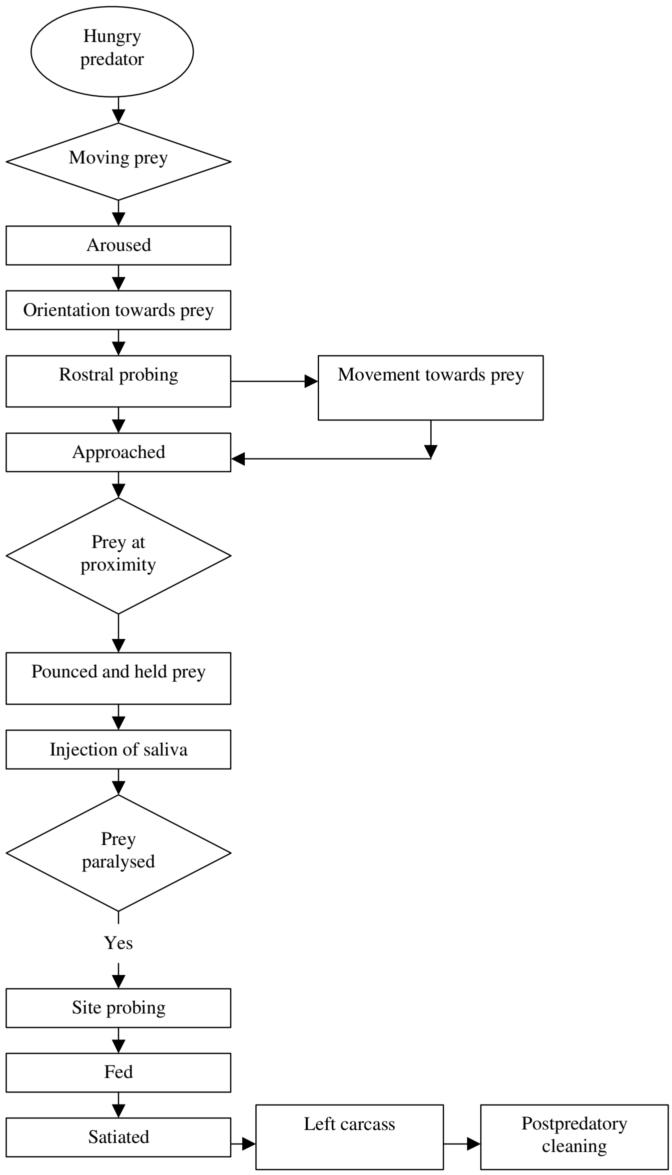


Fig. 18. Flow chart showing predatory behaviour of *Vesbius sanguinosus*.

Probing and sucking

After paralysing, *V. sanguinosus* probed the prey by passing its rostral tip over the prey and selected suitable sites for sucking. Thereafter, it frequently inserted and withdrawn the stylets to suck the predigested body fluids of prey.

Postpredatory behaviour

V. sanguinosus cleaned its antennae and rostrum by its forelegs to remove foreign materials such as defensive secretion, irritant exudation etc. of prey.

Congregational feeding was found among the nymphal instars of *V. sanguinosus* during predation. But cannibalism observed in many reduviids was not recorded in *V. sanguinosus* (AMBROSE 1999).

Impact of prey

Though the sequential acts of predatory behaviour of *V. sanguinosus* on both the larvae of *C. cephalonica* and *O. obesus* were similar, the prey type influenced predation. For instance, the life stages of *V. sanguinosus* quickly capture, paralyse a termite than a larva of *C. cephalonica* (Table 5). This could be attributed to the larger size of the *C. cephalonica* larva when compared to *O. obesus*. Such prey influenced predation as a function of prey-predator interaction was reported for several reduviids (AMBROSE 1999).

Impact of age on predation

As the life stages grew the efficiency of predatory acts such as capturing, paralysing and sucking also increased. This might be attributed the predators' size governed predatory efficiency and the larger quantum of toxic saliva available for paralysing the prey. Thus, the size of the predator in relation to prey size plays a vital role in prey capturing (AMBROSE 1999).

Mating behaviour

V. sanguinosus was polygamous as well as polyandrous. The sequential acts of mating behaviour viz., arousal - approach - nuptial clasp including riding over - copula - ejection of spermatophore capsule were observed in laboratory reared sex starved *V. sanguinosus* (Fig. 19).

Arousal

Arousal of mating partners was initiated by the sight of the opposite sex as observed in other reduviids and confirmed by eye blinding experiments. The sensilla in the antennae also play a role in arousal as confirmed by antennectomy experiments (AMBROSE 1999). The sex starved *V. sanguinosus* got aroused instantaneously after sighting a female. The aroused males exhibited excitation and antennal extension towards females in a tibial juxta-position resembling a peculiar pouncing posture. *V. sanguinosus* got aroused slowly after

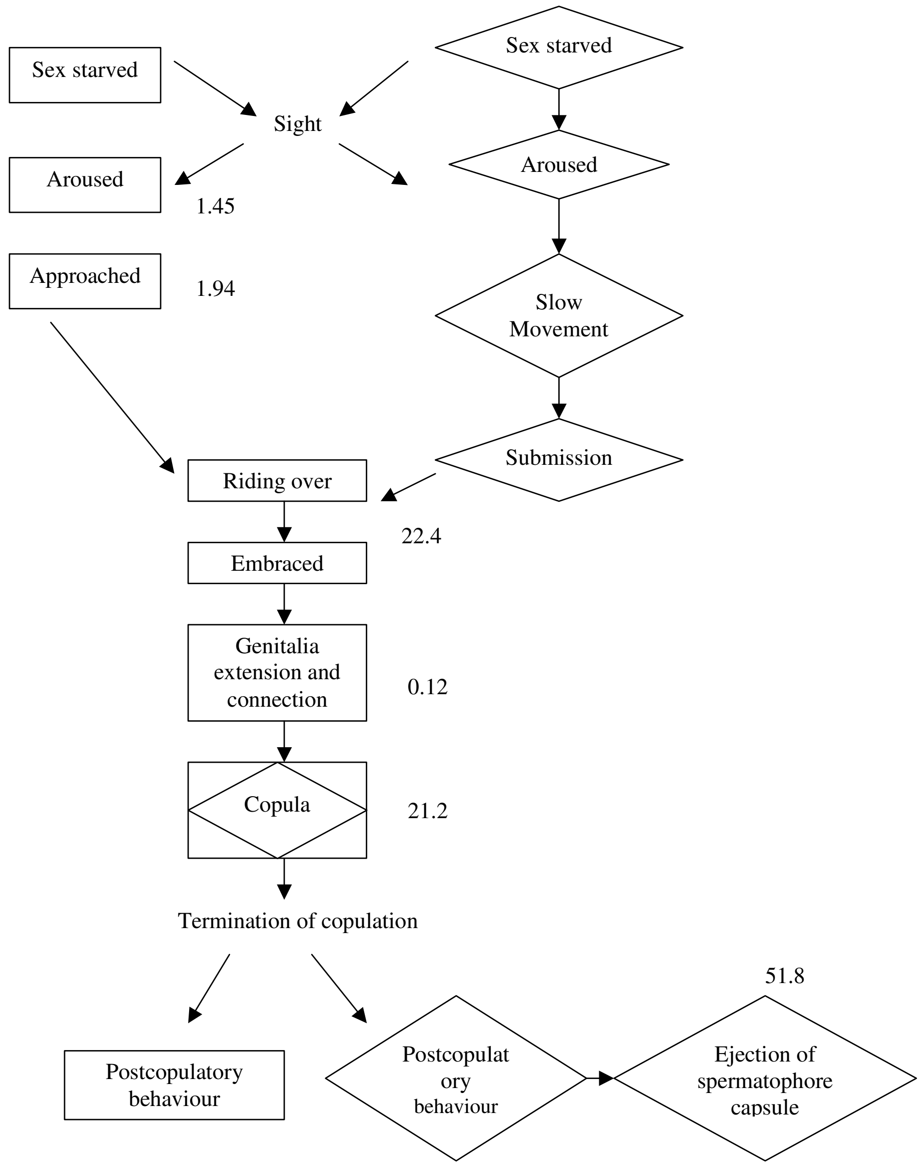


Fig. 19. Flow chart showing mating behaviour of *Vesbius sanguinosus*.

1.45 ± 0.12 min and thereafter started slowly chasing the female whereas brisk chasing was reported in several other tropical rainforest harpactorine reduviids (DAS 1996, AMBROSE 1999).

Approach

The aroused males approached the females with extended rostrum and antennae. The females of *V. sanguinosus* often moved away from the approaching females and finally exhibited willingness with antennal extension and rostral stridulation. Thereafter, the motionless females submitted themselves to the males within 1.94 ± 0.17 min. The approach response got completed once the males touched the females with their antennae and placed their legs over females. Such submission of motionless females to approaching males was reported for several other reduviids (AMBROSE 1999).

The precopulatory female cannibalism over male reported in some species of reduviids was not observed in *V. sanguinosus* (AMBROSE 1999).

Nuptial clasp including riding over

The male *V. sanguinosus* clasped the female with its legs and pressed her pterothorax region with his rostral tip and remain in the riding over - dorsoventral position for about 22.4 ± 1.9 min before the extension of genitalia and achieving connection. The duration of riding over, a diagnostic characteristic feature of harpactorine reduviids varied from a few minutes to 3 days (AMBROSE 1999).

Genitalia extension and attainment of connection

At the culmination of riding over the males relaxed the characteristic pterothoracic rostral pinning, assumed a dorsoventral position and placed his legs over her pterothorax. The dorsolateral position of copula in *V. sanguinosus* was also reported in several harpactorine reduviids (AMBROSE 1999). Thereafter, the male extended its genitalia and achieved connection within 0.12 ± 0.01 min. Retraction and reinsertion of genitalia were observed on rare occasions due to incompatability of genital connection.

Copulation

After the attainment of genital connection the mating partners remained motionless and perform copulation. Intermittent vibration of antennae, tibial brushing against each other or against substratum, genitalia grooming etc., were observed during copula and then become slowed down just prior to termination of copulation (AMBROSE 1999). The copulation lasted for 21.2 ± 1.4 min. The termination of copulation, was indicated by drooping down of antennae by both male and female and thereafter 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 the partners. Postcopulatory cannibalism of female over male as reported for certain harpactorine and peiratine reduviids was not found in *V. sanguinosus* (AMBROSE 1999). The successful completion of copulation was indicated by the ejection of spermatophore capsule 51.8 ± 3.9 min after the termination of copulation (AMBROSE 1999). Seasonal variation in mating behaviour reported in some harpactorine reduviids was not observed in *V. sanguinosus* (AMBROSE 1999).

Acknowledgements

The authors are grateful to the authorities of St. Xavier's College (Autonomous) for facilities. One of us (DPA) gratefully acknowledges the financial assistance received from Department of Science and Technology, Govt. of India (SR/SO/AS-14/2001 dated 18th Feb. 2003).

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Received: December 03, 2007
Accepted: February 12, 2008