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Ecotypic variation in the biology of *Acanthaspis quinquespinosa* Fabricius 1781 (Hemiptera: Reduviidae: Reduviinae) from peninsular India

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Abstract

The development, oviposition pattern and morphometrics of the reduviid predator *Acanthaspis quinquespinosa* Fab. was studied in relation to the different habitats it inhabits (tropical rainforest, scrub-jungle and semiarid zones). Populations inhabiting tropical rainforest were larger, had shorter developmental, pre-ovipositional and incubation periods and longer adult longevity, together with higher fecundity and hatch ability.

Keywords: assassin bug, biological control, entomophagous insect

Introduction

Acanthaspis quinquespinosa Fabricius 1781 is an alate, warningly colored, crepuscular, entomosuccivorous, polyphagous and multivoltine assassin bug found in the tropical evergreen forests, scrub jungles, semiarid zones and agroecosystems of peninsular India (Sahayaraj 1991). Intensive collection in Tamil Nadu shows that *A. quinquespinosa* distributed in tropical rainforests (Keeriparai, Patchaimalai, Surlitheertham), scrub jungles (Marunthuvazhmalai, Sivanthipatti), semiarid zones (Kanyakumari, Pollachi, Tambaram, Usarathukudieruppu) and agroecosystems (cotton and groundnut crops). It is a recognized predator of larvae and nymphs of many pest insects such as *Laphygma exiguae* Hubner (Lepidoptera : Bombycidae) (Butani 1958), *Mylabris purtulata* (Thunberg) (blister beetles; Coleoptera: Meloidae) (Ambrose 1988), *Odontotermes wallonensis* (Isoptera: Termitidae) (Rajagopal 1984), *Dysdercus koenigii* (Fab.), *D. laetus* Kirby (cotton-stainer bugs, Hemiptera: Pyrrhocoridae) (Lakkundi 1989), *Helicoverpa armigera* Hubner (American bollworm, Lepidoptera: Noctuidae), *Spodoptera litura* (Fab.) (leaf caterpillar, Lepidoptera: Noctuidae), *Pectinophora gossypiella* Saunders (pink bollworm, Lepidoptera: Gelechiidae) and *Corcyra cephalonica* Stainton (Rice meal moth, Lepidoptera: Galleriidae) (Sahayaraj 1991).

The bioecology (Ambrose 1983) and ethology (Ambrose *et al.* 1986) of this bug have been studied, and new methods for its mass rearing (Lakkundi 1989; Sahayaraj 1991). Since knowledge of distribution and heterogeneity of habitat occupancy is a pre-requisite for any biocontrol programme, here I investigate the biology of this predator in relation to different habitats.

Materials & Methods

Adults were collected from three different habitats of Tamil Nadu (India): Patchimalai (a tropical rainforest in the Perambalur district); Usarathukudieruppu (a semi-arid zone in the Tuticorin district); and Sivanthipatti (scrub jungle in the Tirunelveli District). In order to interpret the diverse characteristics manifested by the different populations, the insect community (possible prey) of their respective habitats was also sampled (see Table 1).

Table 1. Characteristics of three habitats from peninsular India

Habitat	Character	Co-inhabitants	Other predators
Patchaimalai (78°40'E, 11°2'N)	Tropical forest	*Chrotogonus sp.* *Odentotermes obesus* Rambur *Camponotus compressus* (Fab.) Carabid beetles	*Acanthaspis pedestris* Stål *Neohaematorrhophus therasii* Ambrose & Livingstone
Sivanthipatti (77°47'E, 8°30'N)	Scrub jungle	*Chrotogonus sp.* *O. obesus* Carabid beetles	*Edocla slateri* Distant *N. therasii* *Coranus nodulosus* Ambrose & Sahayaraj *Rhinocoris marginatus* Fab. *Ectomocoris tibialis* Distant *Oncocephalus annulipes* Stål
Usarathukudieruppu (77°56' E, 8°22'N)	Semi arid	*O. obesus*	*Acanthaspis siva* Distant, *A. pedestris* *Ectomocoris cardiger* Stål, *Allaeocramum quadrisignatum* Renter *Acanthaspis* sp.

Each adult was maintained in a separate plastic vial (6.5 cm height, 6 cm diam.) and fed on the stored-grain pest *Corcyra cephalonica* Stainton (Lepidoptera: Galleridae) under laboratory conditions (temperature 30 ± 2 °C, RH 80-85%, photoperiod 11L:13D h). To obtain eggs, several replicates of about 10 pairs of adults from the initial field collection were placed in the same plastic vials, each supplied with *C.cephalonica ad libitum*. The different batches of eggs laid by the laboratory-emerged adults were collected and allowed to hatch separately in plastic containers with wet cotton swabs. To maintain optimum humidity, the cotton swabs were changed once every two days to prevent fungal attack.

Since preliminary observations suggested that nymphs sometimes prey on each other when confined, the following studies used isolated individuals. Forty newly-emerged nymphs were placed individually in plastic vials. Nymphal instars as well as adults were fed *ad libitum* with the caterpillars of *C.cephalonica*, with unconsumed prey being changed every 2-3 days. To determine the developmental time and survival of the nymphal instars, the containers were checked daily. The sex was recorded for each insect within 3 h of eclosion. Adults were maintained until death and their adult longevity recorded. Fecundity was examined by placing individual teneral females with a male of same age. Eggs laid over each 24-hr period were collected and the number of batches of eggs, the number of eggs in each batch and the total number of eggs laid by a female were recorded. Each batch of eggs was allowed to hatch in individual containers, and the incubation period, and frequencies of zero and 100 percent hatching recorded. An index of oviposition days was calculated as the percentage of egg-laying days in the total adult life of a female (Ambrose 1980).

Adult morphometric data (length of head, antennae, prothorax, tibiae, tibial pad, wing, abdomen length, total length, and width of head, prothorax, wing and abdomen) were recorded using ocular micrometers from adults preserved in 70% ethyl alcohol. Data for fecundity and hatchability, nymphal developmental period and adult longevity were transformed to ensure homogeneity of variances (tested using Bartlett's test). The data were analyzed by Anova with post-hoc comparisons (using Duncan's multiple-range test). Similar tests compared male and female of each ecotype separately, and also males and females of different ecotypes. Correlation were made between the total body length of each ecotype and the fore-, mid- and hind-tibiae (Zar 1974).

Results

Patchaimalai is one of the eastwardly directed branches of the Western Ghats. At lower elevations it has an apron of scrub jungle, whilst higher elevations have a corona of tropical rainforest, with bordering agroecosystems present south of Trichirappalli. *Acanthaspis pedestris*, *Neohaematorrhophus therasii* and *A.quinquespinosa* were collected. The bug was found only at lower altitudes where the prey *Camponotus compressus*, *Odentotermes obesus*, carabid beetles, and *Chrotogonus* sp. prevail. The possibility of these bugs taking many prey was higher here than in the other two habitats. *A.quinquespinosa* was found underneath stones along with another reduviid, *N. therasii*.

Sivanthipatti is a scrub-jungle, situated near Palayamkottai far away from areas of tropical rainforest. *A.quinquespinosa, Edocla slateri, N. therasii, Coranus nodulosus*, *Rhinocoris marginatus*, *Ectomocoris tibialis* and *Oncocephalus annulipus* were collected from this habitat. Adjacent to this habitat are cultivated fields where cotton, paddy, groundnut and vegetables are grown. *A.quinquespinosa* was present underneath stones, along with *O.obesus, Chrotogonus* sp. and carabid beetles. The possibility of preying on insect pests from the adjacent agroecosystems was fairly high.

Usarathukudieruppu is a semi-arid zone situated near Sathankulam, but further away from tropical rainforest than Sivanthipatti. The only available food in this habitat, and hence the staple of *A.quinquespinosa* was *O.obesus*. *Acanthaspis siva*, *A.pedestris, Ectomocoris cardiger*, *Allaeocranum quadrisignatum* and *Acanthaspis* sp. were collected from this habitat. *A.quniquespinosa* was found along with another reduviid *A.siva* on the bark of *Tamarinadus indica*.

There was no perceptible color variation among the nymphal instars or the adults of the three habitats. The head, cephalic, thoracic and abdominal appendages (Table 2a,b) were larger in specimens from Patchaimalai, followed by Sivanthipatti and then Usarathukudieruppu, but statistical significance for the differences was patchy. For total body length, Patchaimalai individuals of both sexes were longer than the other two ecotypes. The conclusion is that different environments affect the growth of this predator. Irrespective of ecotype, males were smaller than females, but this was not statistically significant except for the antenna, wing and abdomen.

Table 2a. Ecotypic diversity in morphometrics of the head and cephalic appendages of *A.quinquespinosa* (mean ± SE, values in mm)

		Head		Antennal	Rostral
		length	width	length	length
Usarathukudieruppu	Male	2.04 ± 0.04^{a}	1.34 ± 0.04^{a}	12.22 ± 0.30^{a}	2.42 ± 0.21^{a}
	Female	2.27 ± 0.03^{A}	1.40 ± 0.03^{A}	13.29 ± 0.08^{A}	2.48 ± 0.09^{A}
Sivanthipatti	Male	2.34 ± 0.03^{a}	1.38 ± 0.02^{a}	12.95 ± 1.13^{b}	2.61 ± 0.04^{a}
	Female	2.52 ± 0.06^{A}	1.47 ± 0.02^{A}	13.93 ± 0.12^{A}	2.75 ± 0.04^{A}
Patchaimalai	Male	2.53 ± 0.02^{b}	1.42 ± 0.02^{b}	13.15 ± 0.54^{b}	2.73 ± 0.03^{b}
	Female	2.74 ± 0.05^{B}	1.54 ± 0.63^{A}	14.32 ± 0.63^{B}	2.88 ± 0.05^{A}

Values carrying same lower-case (males) or upper-case (females) in a column are not statistically different (at $p < 0.05$)

Table 2b. Ecotypic diversity in the morphometrics of the prothorax and abdomen of *A.quinquespinosa* (n=sample size, means ± SE, values in mm)

			Prothorax		**Tibial length**			**Tibial pad length**		**Wing**		**Abdomen**	
	Sex	**n**	**L**	**W**	**FT**	**MT**	**HT**	**FT**	**MT**	**L**	**W**	**L**	**W**
Usarathu-kudierupp	M	8	3.04 ± 0.21^{a}	3.22 ± 0.05^{a}	3.56 ± 0.04^{a}	4.38 ± 0.07^{a}	6.12 ± 0.31^{a}	1.48 ± 0.02^{a}	1.30 ± 0.02^{a}	9.64 ± 0.44^{a}	3.48 ± 0.13^{a}	10.64 ± 0.34^{a}	5.12 ± 0.19^{a}
	F	12	3.05 ± 0.11^{A}	3.64 ± 0.10^{A}	3.86 ± 0.11^{A}	4.46 ± 0.08^{A}	6.82 ± 0.10^{A}	1.57 ± 0.02^{A}	1.42 ± 0.05^{A}	10.53 ± 0.05^{A}	3.98 ± 0.37^{A}	12.04 ± 0.18^{A}	5.21 ± 0.04^{A}
Sivanthi-patti	M	14	3.22 ± 0.05^{a}	3.57 ± 0.09^{a}	3.92 ± 0.06^{b}	4.44 ± 0.13^{a}	7.31 ± 0.13^{b}	1.64 ± 0.01^{a}	1.44 ± 0.03^{a}	10.21 ± 0.19^{b}	3.92 ± 0.06^{a}	10.71 ± 0.15^{a}	5.44 ± 0.12^{a}
	F	18	3.40 ± 0.05^{A}	3.77 ± 0.08^{A}	4.16 ± 0.06^{B}	4.82 ± 0.07^{B}	7.34 ± 0.10^{B}	1.76 ± 0.03^{B}	1.52 ± 0.02^{A}	10.98 ± 0.12^{B}	4.00 ± 0.11^{A}	13.14 ± 0.25^{B}	6.02 ± 0.08^{B}
Patchai-malai	M	10	3.34 ± 0.08^{b}	3.68 ± 0.02^{b}	4.02 ± 0.07^{c}	4.87 ± 0.03^{b}	7.89 ± 0.05^{c}	1.71 ± 0.02^{b}	1.53 ± 0.04^{a}	10.92 ± 0.11^{c}	4.13 ± 0.04^{b}	11.25 ± 0.08^{b}	5.77 ± 0.06^{b}
	F	24	3.51 ± 0.06^{B}	3.84 ± 0.06^{A}	4.57 ± 0.12^{C}	5.21 ± 0.08^{C}	8.04 ± 0.09^{C}	1.83 ± 0.04^{B}	1.68 ± 0.07^{A}	11.57 ± 0.02^{C}	4.57 ± 0.03^{B}	13.84 ± 0.11^{C}	6.13 ± 0.16^{B}

L = length, W = width, FT = fore tibia, MT = mid tibia, HT = hind tibia
Values carrying same lower-case (males) or upper-case (females) letter in a column are not statistically different (at $p<0.05$)

The pre-oviposition period was calculated from the first day of adult life to the first day of the deposition of egg. It varied between 14 and 17 days, with the shortest value in females from Patchaimalai (Table 3): this ecotype had also relatively longer life spans. The highest mean number of eggs per female was observed in females from Patchaimalai, significantly higher than females from the other two habitats. Fecundity was correlated with hatchability and hatching percentage (Table 3). The mean number of eggs per female was roughly equal to the mean number of eggs per batch multiplied by the mean number of batches of eggs laid per female. The highest hatchability, hatching percentage, and frequencies of zero and 100% hatching were observed in the Patchaimalai ecotype, followed by those of Sivanthipatti and then Usarathukudieruppu (Table 3).

Table 3. Ecotypic variation in the oviposition pattern, incubation period and hatchability of *A.quinquespinosa* (values are means ± SE)

Parameters	**Usarathukudieruppu n=12**	**Sivanthipatti n=18**	**Patchaimalai n=24**
Pre-oviposition period (d)	15.00 ± 7.00 b	16.66 ± 4.46 c	14.62 ± 0.16 a
No. of batches of eggs laid	10.25 ± 1.08 a	14.66 ± 2.88 b	15.07 ± 0.76 b
Total no. of eggs laid	45.75 ± 3.32 a	49.66 ± 9.76 a	82.79 ± 1.25 b
Minimum number of eggs/batch	1.50 ± 0.29 a	01.16 ± 0.16 a	1.62 ± 0.43 a
Maximum number of eggs/batch	8.00 ± 0.00 a	08.16 ± 0.90 a	8.66 ± 0.25 a
Average number of eggs/batch	4.53 ± 0.28 b	03.37 ± 0.22 a	4.89 ± 0.16 b
Oviposition index (in days)	28.50 ± 1.83 a	37.06 ± 3.02 b	49.25±1.13 c
Incubation period	13.20 ± 0.40 a	13.18 ± 0.40 a	13.06±0.41 a
Total no. of nymphs hatched	32.25 ± 3.85 a	34.16 ± 6.98 a	67.22±2.54 b
Hatching percentage	69.79 ± 3.97 a	69.85 ± 4.62 a	81.20±1.96 b
Egg mortality (in %)	30.20 ± 3.97 b	27.69 ± 5.56 b	17.56±0.87 a
Frequency of 0% hatching	0.75 ± 0.25 a	01.83 ± 0.91 b	0.52±0.16 a
Frequency of 100% hatching	5.50 ± 0.64 a	06.50 ± 1.36 b	7.82±0.07 b
Post oviposition period (d)	2.00 ± 0.70 a	02.50 ± 0.72 a	2.03±0.47 a

Within a row, mean values followed by the same letter are not significantly different (at $p<0.05$)

The incubation period of the Patchaimalai ecotype was the shortest, followed by Sivanthipatti and then Usarathukudieruppu, but these differences were not significant (Table 3). Uniformly the first instar was the shortest, and the fifth the longest; the total developmental period was longest in Sivanthipatti and shortest in Patchaimalai, a significant difference.

Nymphal mortality was not observed in the IV and V instars of any ecotype studied. The younger nymphal instars (I to III) had greater mortality except in the Sivanthipatti ecotype, where the only nymphal deaths were recorded in the first instar. The lowest total nymphal mortality was from individuals from the Patchaimalai habitat, and the highest in those from Usarathukudieruppu.

Females lived significantly longer than males. Laboratory breeding indicated that *A.quinquespinosa* is a multivoltine reduviid. Males and females from Patchaimalai lived significantly longer than the other ecotypes (Table 4). A female-biased sex ratio was observed in all ecotypes, and there were some differences among ecotypes (see Table 4). This suggested that there was no correlation between the adult longevity and the sex ratio.

Table 4. Ecotypic variation in the duration of the instars and adults (in d), and sex ratio of *A.quniquespinosa* (values are means ± SE, with sample size in brackets).

	1st instar	**2nd instar**	**3rd instar**	**4th instar**	**5th instar**	**hatch to adult**	**male**	**female**	**male: female**
Usarathukudieruppu	12.4 ± 0.2 a (32)	15.7 ± 0.3 a (26)	13.3 ± 1.0 a (24)	14.7 ± 2.1 a (20)	18.7 ± 0.9 b (20)	72.4 ± 3.7 a (20)	24.0 ± 2.1 a (8)	26.0 ± 2.0 a (12)	0.66 : 1
Sivanthipatti	11.3 ± 1.1 a (34)	12.3 ± 1.1 a (32)	14.4 ± 1.2 a (32)	14.7 ± 0.9 b (32)	20.1 ± 1.5 c (32)	73.7 ± 2.7 a (32)	33.5 ± 4.2 b (14)	38.8 ± 6.5 b (18)	0.77 : 1
Patchaimalai	9.0 ± 0.8 b (36)	9.1 ± 0.6 b (34)	10.7 ± 0.9 b (34)	12.5 ± 1.0 b (34)	16.0 ± 0.9 a (34)	58.1 ± 0.9 b (34)	89.1 ± 2.8 c (10)	104.2 ± 3.4 c (24)	0.42 : 1

Within a column means followed by the same letter are not significantly different (at $p<0.05$)

Discussion

Individuals of the same species collected from different habitats exhibited quite different morphological features, but members of one habitat could successfully breed with members of another habitat. Ecological interactions may operate in a locally different manner on this predator, resulting in local specialization which may cause reproductive isolation over a prolonged period of ecological isolation. Mayr (1969), Ambrose (1978), Vennison (1989), Kumaraswami (1991) and Sahayaraj (1991) considered this type of ecotypic specialization as an ecological race, or habitat race or ecotype. According to Mayr (1979), "there is no evidence to differentiate ecological races from geographical races". Observations in other reduviids such as *A.pedestris* (Ambrose & Livingstone 1997), *Sphedanalostus aterrimus* and *R.marginatus* (Ambrose 1986, 1987), *E.tibialis* and *N.therasii* (Sahayaraj 1991), and this study on the ecotypic variation of *A.quinquespinosa* unequivocally corroborate Mayr's view.

Insect size appears to be affected along a gradient from tropical rainforest to scrub jungle. In the rainforest (Patchaimalai) the appendages are more elongate, perhaps shortening with the significant reduction in body size in scrub-jungle populations. This was suggested by the correlations between body size and the size of individual appendages of these two ecotypes. Patchaimalai had very low correlations (r=-0.074, 0.0538 and 0.1626 for fore-, mid- and hind-tibiae, respectively), but these apparently increased in the Sivanthipatti ecotype (r=0.0325, 0.3527 and 0.2484, respectively). Although on average larger in Patchaimalai, this population has the shortest developmental period and the longest adult longevity. Normally when body size decreases, both the developmental period and adult longevity also decrease. Ambrose & Livingstone (1987) and Sahayaraj (1991) reported that reduviids present either in the tropical rainforest or adjacent were larger, and this study confirms their observations.

There is a direct correspondance between adult longevity and pre-oviposition period in *A.quinquespinosa*, but not in the sister-species *A.pedestris* (Ambrose & Livingstone 1987). The oviposition period was longer than the pre-oviposition period in all three ecotypes; this is a desirable feature from the point of view of biological control. The highest fecundity rates with highest hatching percentage were observed in the Patchaimalai ecotype. This might be associated with the longest adult longevity, the lowest frequency of 0% and highest frequency of 100% hatching in this ecotype. Thus the ecotype with the longest lifespan began to oviposit earlier and laid more eggs over a larger number of oviposition days. This is contrary to observations by Ambrose & Livingstone (1987) in *A.pedestris*: individuals with a shorter adult lifespan began to oviposit earlier over a larger number of oviposition days. Soil types are known to have an influence on the diversity of soil-inhabiting fauna of insects: well-aerated soil with plenty of organic matter attracts adult insects for egg laying.

The longest stage was the fifth instar, and the shortest was the first instar in all three ecotypes. Other estimates of the developmental period (hatch to adult) for this species are 66.9 (Lakkundi 1989) and 61.0 (Sahayaraj 1991) in a mass-rearing study. In the present study this parameter was only 58.1 in the Patchaimalai ecotype in individual rearings. Hence I suggest that *A.quinguespinosa* collected from this ecotype can be used for mass production. Fewer males emerged from the Patchaimalai ecotype, and they lived longer. Therefore the possibility of multiple mating was high, resulting in higher fecundity. Both males and females of the population in scrub jungle (Sivanthipatti) lived for a shorter length of time than the tropical rainforest ecotype (Patchaimalai). This contradicts data for *A.quadrisignatum* (Sahayaraj 1991), a reduviid that also lives in scrub jungle. In all ecotypes, female adult longevity was longer than that of males.

Biologically, the ecotype of the rainforest was found to be more suitable for both reproduction and growth than those of the scrub jungle and semi-arid zone. Reduviids with tibial pads, such as *A.quinquespinosa*, are mainly present in semi-arid zones (Ambrose 1980, Vennison 1989, Sahayaraj 1991), supported by the observation of running and pouncing behaviour of this reduviid. Patchaimalai tropical rainforest individuals have a shorter developmental period, longer adult longevity, high fecundity and high hatchability. The ecotypic diversity of *A.quinquespinosa* therefore depends upon the type of habitat where they live. The higher availability of different types of prey in rainforest boosts reproduction and speeds development.

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الملخص العربى

الاختلاف النمطى فى بيولوجية النوع *اكانثوبيس كينولويسينيديا* فابريشيس 1781 (رتبة نصفية الأجنحة: رديوفيدا-ريديوفينيى) بشبه الجزيرة الهندية.

ك.ساهايارج

مركز أبحاث حماية المحاصيل، قسم علم الحيوان، كلية سانت زافيير، بالياموكتاى- 627002، الهند.

تم دراسة النمو وآلية وضع البيض بالاضافة الى القياسات المورفولوجية لاحد أنواع البق المفترسة من فصيلة ريديوفينيى (*اكانثوبيس كينولويسينيديا* فابريشيس 1781) وعلاقتها بالبيئات المختلفة التى تعيش فيها (الغابات المدارية المطيرة- الغابات الشجيرية و المناطق شبه الجافة).
أوضحت الدراسة أن العشائر التى كانت تقطن الغابات المدارية كانت أكبر فى الحجم، ذات فترات نمو أقصر، تضع أعداداً أقل من البيض مع قضاء فترات أقل خلال مراحل النمو بالاضافة الى زيادة فى طول عمر الحشرات الناضجة والتى تميزت أيضاً بالخصوبة العالية ونسبة فقس عالية للبيض.