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BIOLOGICAL OBSERVATIONS OF *HIMERTULA VIDHYAVATHIAE* SP. NOV (ORHTOPTERA: TETTIGONIIDAE: PHANEROPTERINAE) UNDER LABORATORY CONDITIONS

*N. SENTHILKUMAR, A. KARTHIKEYAN, K.P. SANJAYAN, V. MAHALINGAM and M.C. MURALIRANGAN

G.S. Gill Research Institute, Guru Nanak College, Chennai – 42.
* Present Address & Corresponding author
Rain Forest Research Institute, Jorhat, - 785 001, Assam. (INDIA)

Abstract

From a global perspective the tettigoniids or the long-horned grasshoppers, appear to be a lesser known group of orthopteroid insects, probably because of the difficulties in sampling, laboratory rearing, and also because of its behavioural and ecological uniqueness. Available information on the bioecological characteristics of tettigoniids around the world is very meager. Moreover, no record is available on the biology of Tettigoniidae of Indian subcontinent. The paper presents the mating and ovipositional behaviour of undescribed tettigoniids species *Himertula vidhyavathiae* sp. (nov)Ingrisch and Muralirangan, 2003

Introduction

Orthoptera is one of the largest orders of the class Insecta, and includes the well-known grasshoppers, locusts, crickets, katydids and mantids. They form a dominant group of herbivorous insects throughout the world, and their high diversity, functional importance, sensitivity to disturbance make them potentially useful bioindicators for land management. Tettigoniids or the long-horned grasshoppers or katydids (Superorder: Orthopteroidea; Order: Orthoptera; Suborder: Ensifera; Superfamily: Tettigonoidea; Family: Tettigoniidae) are some of the most conspicuous and abundant members of tropical insect communities. The number of known species of the family Tettigoniidae currently exceeds 6200 and they are assigned to over 1000 genera (Naskrecki and Otte, 1999). Most of them occur in the tropical and subtropical regions of the world. In the Indian subcontinent, about 250 species have so far been recorded, though little is known about the fauna of Tamil Nadu. In the tropics, they form an important component of the food web, being eaten by amphibians, reptiles, birds, rodents, bats, primates and insects. They are known to occur in a wide variety of habitats, ranging from the littoral zone of the seashore to grasslands, forests, and mountaintops, well above the tree line. Katydids are also considered important since they are known to attack cereals, orchards, cultivated vegetation and cause damage to plantation crops like tea, coffee, tuber crops, as well as other crop plants by feeding on various parts of the plant, as well as by causing physical injury to the plant during oviposition. The faunal diversity of grasshoppers – long horned and short horned grasshoppers – is unique in the sense that they are capable of causing extensive damage to vegetation, often serving as serious pests, damaging crops like rice, millets, vegetable crops, etc. The role played by these insects in the context of marking wild vegetation notably diverse weeds, including grasses, as reservoirs are also important. While considerable information exists in relation to short-horned grasshoppers or acridids, the role played by tettigoniids has not been evaluated in terms of their systematics, biology, ecology as well as reproductive dynamics. As no such work has been reported in the Indian context for the species, the present study has been initiated to describe mating and ovipositional behaviour of *H. vidhyavathiae* sp. (nov).

Materials and Methods

Insects collected from the grassland in Chennai`, located 13° N Latitude and 80° E Longitude, were reared in insect cages (20 liter capacity; 30x30x30cm wooden framed with fine iron mesh cage, mesh size of about 0.5mm with glass front) at 20-30°C (Mean 23°C) with 60-80% relative humidity and photoperiod of 16:8 (L:D) hours. Newly hatched nymphs were reared singly in muslin topped 0.5-liter capacity plastic jars, at a mean temperature of 23°C and a relative humidity of 60%. They were reared on baby corn (an immature flowering part of *Zea mays*), which was cut into small pieces and kept in plastic jars for early nymphs. Placed a wet cotton wad to maintain high humidity and also to provided water. However, for the later developmental stages, large pieces of corn were provided. The food was replenished every other day. A paper cup of 100ml capacity filled with fine sieved soil was provided in the cage as an oviposition site. Few drops of water were added to the soil oftenly to keep the soil wet. Eggs from the egg pods were transferred to an incubation chamber consisting of a damp filter paper in a muslin topped 0.5 liter capacity plastic jar. The eggs were incubated at room temperature and under normal lighting conditions. Water was added to the filter paper in the incubation chamber daily to maintain the required moisture. Newly hatched nymphs were reared as per the methods mentioned earlier. Fresh food was provided every day and care was taken to remove all excreta and unfed food regularly to maintain a healthy culture as well as to prevent fungal infection. As the nymphs grew, they were transferred to insect cages (30x30x30cm) in order to provide more moving space to reduce the incidence of malformations and wing deformities. Such malformations were prevalent among the older nymphs reared in smaller and crowded jars. Since all stages ate their own exuvia soon after moulting, the nymphs were carefully marked with red nail polish (Lakme) on the dorsal side of pronotum. The disappearance of the marking, accompanied by detectable increase in body size, confirmed moulting facilitating the recording of nymphal development periods. All experiments were replicated five times with 24 individuals each, before drawing any conclusion.

Results

The species *H.vidhyavathiae* sp nov. was collected from grasslands in Chennai about 250 m above sea level. Some other individuals were found in similar areas upto 1800 m, but were more common at lower elevations (Ingrisch and Muralirangan, 2003). The species occurred in a variety of habitats including grassy patches near agricultural fields, wastelands, high altitude grasslands, and forests. It is a nocturnal species, active during night especially during twilight. It is attracted towards blue and yellow lights. During day time individuals of this species hide under bushes. Males camouflage with the background green flora. Brown morphs were prevalent during dry seasons. Habitus of this species both male and female have illustrated in Figure **1 and 2** respectively.

Mating behaviour

Males and females of *H. vidhyavathiae* do not resemble each other. They are sexually dimorphic and of different sizes. The males are smaller than the females. Males when sexually mature, make a species specific mild calling sound to attract conspecific females for mating. If the female is receptive, she also touches male with her antennae. When the male is antennated by a conspecific individual, he backs up to a receptive potent mate, along her sides. Then the male grasps her with his cerci and flips into the mating position (i.e., male engages the female with his cerci and then rotates a full 180 º facing away from the female, and hanging from her (upright position). The female is also in hanging position opposite to the male, maintain its forelegs hold by clasping the branch of the plant or any other support). Within 2-5 minutes of copulation, a series of abdominal contractions are initiated by male to release the spermatophores. After 10-15 minutes of copulation, the male produces intense backward and forward abdominal contractions for another 9-10 minutes. Subsequently, both male and female remain quite (stationary period). After 25-43 minutes of copulation and prior to disengaging, the female eats up more than 75% of the spermatophylax. Male also fight with the female to eat the spermatophylax, but female allows male to eat only 10-15% to avoid loss of spermatophore. Following this, the female enters the refractory period. During this period, the female resists advances of males several times by jumping away. On several occasions, it was noticed that female tries to pull off the mating males by dragging them against branches. Observations have also revealed that if the male is not sexually mature, it rejects the female by kicking with hind legs and vice-versa. The sequence of events depicting the mating behaviour of *H. vidhyavathiae* are reported in the form of a flow chart **(Fig. 3)**.

Ovipositional behaviour

Normally in this species, oviposition takes place in the soil, during 6 pm to 8 pm. The females oviposit by thrusting their ovipositor in the soil in a normal sitting position. The female searches for a suitable oviposition site by examining the soil surface with its antennae and maxillary palp. Following this, the female settles on the ground and inserts the ovipositor vertically into the soil. During insertion, the ovipositor valves were seen sliding back and forth against each other. The ovipositor is short and saber shaped so that they can insert it fully. Egg laying did not automatically follow the insertion of the ovipositor. In most cases, eggs were laid immediately, but some times the female walked slowly over the soil, inserting and withdrawing its ovipsitor at regular intervals, before finding an acceptable site. The release of eggs during oviposition was indicated by a subtle twitching/quivery movement of the abdominal tip. Single egg after releasing from gonophore, took 6-7 seconds to emerge from the ovipositor. As an egg was laid, the tip of the ovipositor was slightly withdrawn by slowly moving up and down, without touching the egg, but ensuring that the egg became embedded by disloged soil particles. The intensity of this movement was found to be increase for subsequent eggs. Where more eggs were to be laid, the ovipositor was not withdrawn but repositioned adjacent to the previous egg, and the egg laying sequence repeated. After which the ovipositor was withdrawn from the soil. The ovipositor tip was then scrapped backwards over soil surface, to disguise the ovipositional site. Some times however, the site was left without any cover up.

Eggs were laid in the soil at depths of about 0.4-1.0cm and were oriented at a slight angle. Eggs laid during a single oviposition were found to be touching with each other or separated by only a thin film of soil.

Life cycle

H. vidhyavathiae is a cohort species, 3-4 overlapping generations were found during this study. A single female laid an average of 182.5±12.4 eggs in 7-8 batches. Each batch had 1-22 eggs. Some times unfertilized eggs were found scattered on the surface of the soil (Ingrisch per. obs.).

Egg: Eggs are small, laterally flattened and oval in shape. The length, width and thickness of the egg are 3.2, 1.0, and 0.2-0.4 mm respectively.

Embryonic period: Eggs of the tropical katydids develop without dormancy and hatch in 47-64 days after oviposition (22-26 ºC) (Ingrisch, 1998). However, in this species average range of incubation period observed was 32.25±1.79 –134.25±11.88 days.

Hatching pattern of nymphs: Most of the eggs hatched within two hours after midnight (12-2hrs am) although the eggs began to hatch from 18 hrs and ended by 12hrs in the afternoon of the next day (**Fig. 4**). The average number of eggs hatched were 144.75±9.6 ranged between 135 and 158 eggs. Average percent of hatchability was 80.46±2.9% ranged from 76.47 to 83.16%. Newly hatched nymphs weighed 2.34mg, and had length of 10mm. The colour of the nymph is pale white at the time of hatching, which turned to light brown in 2hrs, then to dark brown in 4-6 hrs and in the next day it turned green.

Nymphal instars: *H. vidhyavathiae* passed through 6-7 nymphal instar stages. The average duration of post embryonic development (PED) period is presented in Table 2. In case of 6 instar stages, PED was 38.5±9.26 days while 7 instar stages had little longer PED i.e., 46.75±11.23 days. The colour (green) of the nymphs deepened during later instar stages. Wing buds started to appear from 5th instar but in case of female ovipositor buds were seen apparently from 4th instar onwards.

Adults: Adults are sexually dimorphic the males are smaller and leaner than females. Males are dark green in colour and females are uniform light ochreous brown in colour. In case of male the tegmen reaching apical third of post femur, hind wings projecting and just surpassing hind knee. But in female tegmen reaching just behind middle of post femur; hind wings not reaching hind knees. In female ovipositor is short, rather little curved and margins strongly dentate towards apex.

Measurements: (in mm) body ♂ 13.5, ♀ 15.0; pronotum ♂ 3.3, ♀3.7; tegmen ♂ 13.5, ♀ 12.5; tegmen – width ♂ 2.7, ♀2.8; hind wings projection ♂6.0; anterior femur ♂ 4.3, ♀4.7; post femur ♂ 16.5, ♀16.5; post tibia ♂ 18.5, ♀ 18.5; ovipositor ♀ 5.2.A total of 120 adults were considered for sex proportion determination. Out of this, 18 adults were died due to handling error. Out of remaining 102 individuals 52 were passed through 6 instar cycle (17 female:53 males), while 50 passed through 7 instar cycle (36 females:14 males). On the evidence of the present observation, it could appear that there is no variation in the proportion of males and females.

Discussion

The present study provides basic information on the *H. vidhyavathiae* sp.(nov) mating and oviposition behaviour in India. Numbers of workers have studied the mating behaviour of the genus *Decticita* (Rentz, 1963) and mate choice experiments between *Pterophylla beltrani* and *P. robertsi* (Barrientos, 1998). Investigation was also carried out on the ovipositional behaviour of the bush cricket *Decticus verrucivorous* (Cherrill *et al*., 1991). Barrientos (1998) reported that the average mating time of *P. robertsi* was 38.58 minutes. Result from this present study on mating behaviour of *H. vidhyavathiae* is similar to that of mating behaviour of the genus *Decticita* (Rentz, 1963). Male and female of the *Pterophylla* spp. consumed the spermatophylax fully (Barrientos, 1998). Similar observations were also seen from this present investigation on *H. vidhyavathiae*.

Cherill *et al*., (1991) reported the detailed observations of ovipositional behaviour of *Decticus verrucivorous*. Observations from this investigation on *H. vidhyavathiae* are also supporting their observations. Here, female s frequently inserted and withdraw their ovipositor from the substratum as if testing its suitability. Females of *H. vidhyavathiae* showed a significant preference for oviposition in soil, rather than plant parts. Such results tend to coincide with that of Cherrill *et al*., (1991) in Britain and Ingrisch & Boekholt (1982) in Germany who studied ovipositional preferences of some tettigoniids. However, soil pH, moisture content and particle size are also important determinants of female behaviour (Ingrisch & Boekholt, 1982) but these factors were not controlled in the present study.

Results from this investigations revealed that the females of the genus *Himertula* sp. lay eggs in the soil rather than the plant parts. Number of eggs laid by single female (164-190 eggs) with 1-22 eggs/batch), the distribution of eggs and morphometry of eggs give us basic information about egg biology of the genus. Eggs of *H. vidhyavathiae* do not undergone diapause and hatch in 30-150 days after oviposition. Eggs of tropical katydid *Lipotactes minutus* develop without dormancy and hatch 47-64 days after oviposition (Ingrisch, 1998).

Conclusion

Males and females of *H. vidhyavathiae* are sexually dimorphic. Mating and ovipositional behaviour have also been described. This species passed through 6-7 larval instars cycle. From this study it is concluded that *H. vidhyavathiae* can be reared in the laboratory to study the bioecological characteristics if it attains pest status to develop a management protocol.

Acknowledgement

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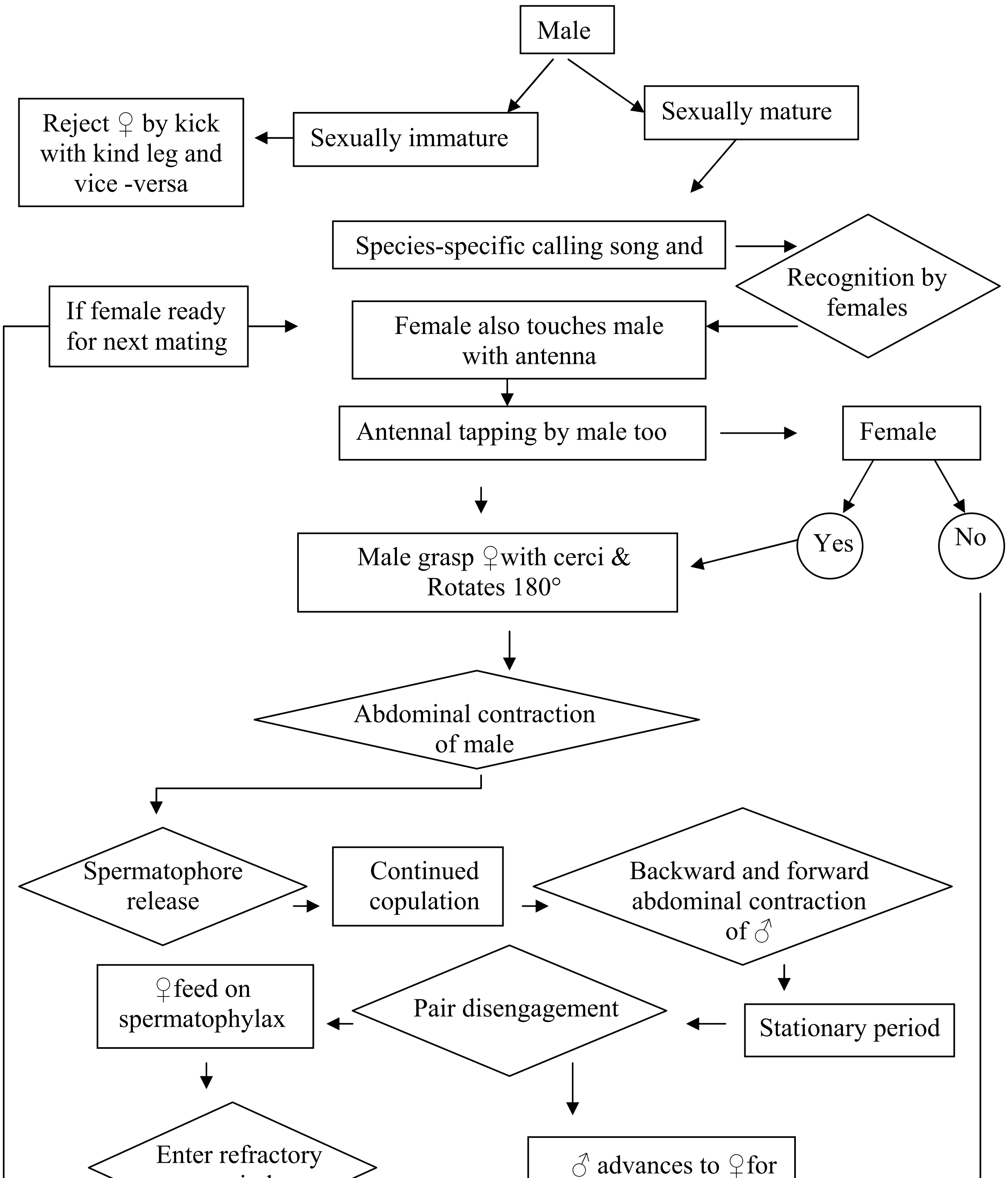
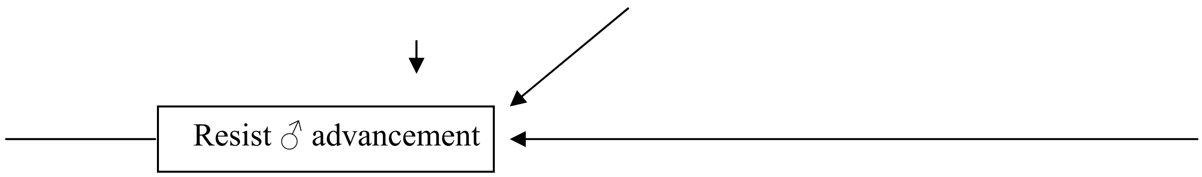
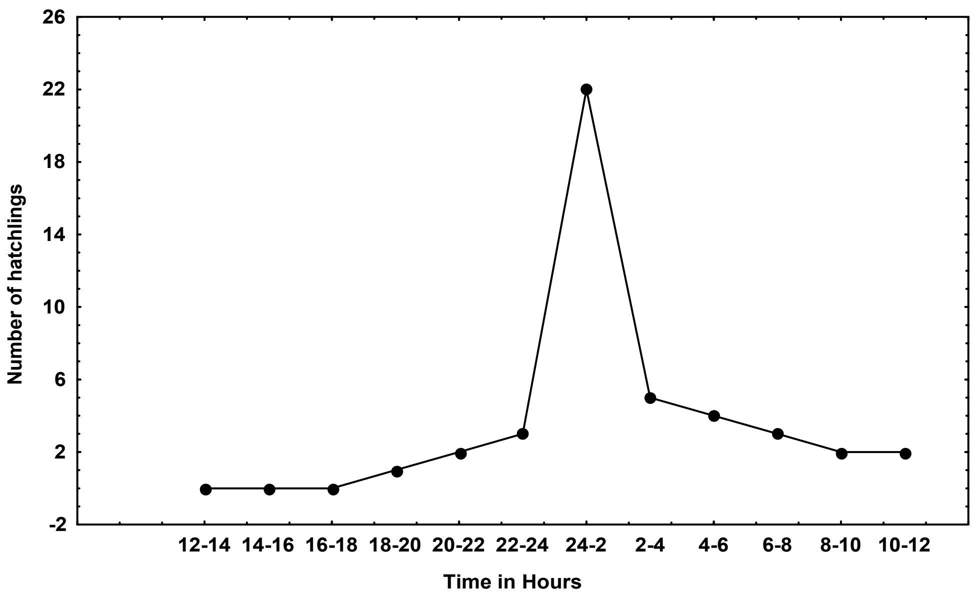
Fig. 3


Male
Sexually immature
Sexually mature
Reject ♀ by kick with kind leg and vice -versa
Species-specific calling song and
Recognition by females
If female ready for next mating
Female also touches male with antenna
Antennal tapping by male too
Female
Yes
No
Male grasp ♀with cerci & Rotates 180°
Abdominal contraction of male
Spermatophore release
Continued copulation
Backward and forward abdominal contraction of ♂
♀feed on spermatophylax
Pair disengagement
Stationary period
Enter refractory
♂ advances to ♀for



Flowchart of mating behaviour of *H. vidhyavathiae* sp. (nov)

Fig. 4



Pattern in the hatching of *H. vidhyavathiae* eggs in a single day

Table 1

Observations on biological parameters of *H. vidhyavathiae* under laboratory conditions

Number of nymphal instars	= 6-7
Post embryonic development period in days	= 46.75 ± 11.23 – 7 nymphal instars
	= 38.5 ± 9.26 - 6 nymphal instars
Post embryonic development period (range) in days	= 32-56
Preoviposition period in days	= 15.3 ± 5.3 days
Oviposition period in days	= 70.3 ± 9.98
Oviposition period in days	= 57-84
Mean number of eggs laid by female	= 182.5 ± 12.4 eggs
Number of eggs laid by female (range)	= 164-190 eggs
Number of eggs laid per batch	= 1-22
Incubation Period in days	
(Embryonic development period)	= 32.25 ± 1.79 – 134.25 ± 11.88
Incubation Period (range) in days	= 30 - 150
Eggs hatchability	= 80.46 ± 2.9% (76.47-83.16%)
Eggs hatched	= 144.75± 9.6 eggs
Eggs hatched (range)	= 135-158 eggs
Mature adults in days	= 12-22
Mature adults in days average in days	= 16.88± 3.48
Life span of adults in days	= 69-134
Life span of adults in days	= 96.16± 27.13
Total life span (Both male and female) in days	= 128-340
Total life span (Both male and female) in days	= 247.2± 77.12

Range given in parenthesis
Values are mean ± SD of 5 replicates of 24 insects

Table 2

Post Embryonic Development period of *H. vidhyavathiae* under laboratory conditions

Instars	Nymphal instars in days	
	6 – instar satges	7 – instar stages

I	7± 1.83 (5-9)	8.25±2.22 (5-10)
II	6.25±1.71(4-8)	5.5±1.73 (3-7)
III	6.5±1.73 (4-8)	6.25±0.96 (5-7)
IV	5±1.41 (3-6)	6.25±1.71 (4-8)
V	5.5±1.91 (4-8)	6.00±1.83 (4-8)
VI	8.25±1.5 (7-10)	5.75±2.06 (4-8)
VII		8.75±1.5 (7-10)
Average	38.5±9.26	46.75±11.23
Range	27-46	32-56

Range given in parenthesis

Values are mean ± SD of 5 replicates of 24 insects