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STUDIES ON BIOLOGY, MORPHOMETRICS AND SUBSTRATE PREFERENCE OF THE BURROWING COCKROACH *PYCNOSCELUS SURINAMENSIS* (L)

Gowrisankar Reddi[1]*, N Sumithramma[1], Vidya Mulimani[1], Sanjay Kumar Pradhan[2] and A R V Kumar[1]

[1]Department of Agricultural Entomology, University of Agricultural Sciences, Bengaluru 560065, Karnataka, India
[2]Hawkesbury Institute for the Environment, Western Sydney University, Penrith NSW, 2751, Australia
*Email: sankargowri399@gmail.com (corresponding author): ORCID ID 0009-0001-6854-5686

ABSTRACT

Biology of the burrowing cockroach *Pycnoscelus surinamensis* (L.) revealed that there are four instars and took 134.8± 4.94 days to complete lifecycle. Morphometric studies showed increase in antennal body length, head width, pronotum length and width from first to fourth instar with peak at adult and other developmental stages well fit into Brooks-Dyar rule. All body parameters showed hypoallometry except pronotum length which showed hyperallometry. In substrate preference studies, the survival was lowest for the treatment without substrate and against the treatments with substrates like leaf litter, cocopeat and vermiculite. The mean number of offspring produced and survived was found to be lower in the treatments without substrate and with leaf litter against the treatments with cocopeat and vermiculite.

Key words: *Pycnoscelus surinamensis*, cockroach, instar, hypoallometry, hyperallometry, young ones, fecundity, substrate, leaf litter, life cycle, morphometrics, instar, pronotum, survival, offspring produced

Cockroaches (Blattodea) are among the oldest insects (Appel, 2021) and are nocturnal, typically ground-dwelling insects that evolved around 359.2 million years ago during Carboniferous period. Cockroaches are thought to have first appeared in the Cretaceous period around 100 million years ago (Grimaldi and Engel, 2005). An estimated 4000 species of cockroaches were recorded worldwide, of which, most of the species were in the tropical areas (Roth, 2003). Less than 30 of the 4000 species of cockroaches have been identified as pests around the world (Hedjouli et al., 2021). The evolution of cockroach proceeded in two lines, one leading to the superfamily Blattoidea (families Cryptocercidae and Blattidae), and the other to the superfamily Blaberoidea (families Polyphagidae, Blattellidae, and Blaberidae) (Mckittrick, 1964). About 1020 described species were included in the family Blaberidae, and is the most recently evolved family that has experienced the most extensive adaptive radiation (Siddiqui et al., 2023). The members of Blaberidae are normally found under logs, in humus, compost files, trash, other debris and some are arboreal. A few species, such as *Pycnoscelis surinamensis* (Linn.) are occasionally found to associate with humans and are commonly known as Surinam cockroach. *P. surinamensis* is found in greenhouses, warmer climates and outdoors besides chicken houses and is a known intermediate host for the chicken eyeworm nematode (Gillott, 2005). It is classified as peri-domestic and can only be found near human constrictions or crops. The species reproduces mostly through parthenogenesis and has almost or entirely female populations (Zangl et al., 2019; Rust et al., 1995).

Adults are about 18-25 mm long with dark brown to black bodies and shiny paler brown wings. At birth, nymphs are 4.5 mm long (Cochran and WHO, 1999). There are 15 species in the genus *Pycnoscelus*, some of which lack character visualisation, such as *P. surinamensis*, *P. indicus* and *P. striata* (Bruijning, 1948). Biology of *P. surinamensis* has not been described in India, probably because of its long life (Rau, 1940). A few studies are available elsewhere in India (Cornwell, 1968). Subsequent observations illustrate that the roaches are widespread (Wright, 1973). It takes six months to complete its life cycle and it has not yet been widely researched, especially in the subtropical region of India (Pomes and Schal 2020; Schal et al., 1984). The visualization outcomes shed light on areas that need further investigation. Very little information is available on *P. surinamensis* currently. So, the present study was conducted to observe and disseminate the information regarding biology, morphometrics and substrate preference of this species.

MATERIALS AND METHODS

The study was carried out in the Department of Entomology, University of Agricultural Sciences,

Gandhi Krishi Vigyana Kendra (GKVK), Bangalore (13.07N,77.57E) during 2021-2022. A colony of *P. surinamensis* was collected from College of Sericulture, Chinthamani, Karnataka and maintained in the laboratory at the study site. The colonies were maintained in plastic containers (90 × 60 × 15 cm) and were covered with muslin cloth to prevent cockroaches from getting out and other predators from getting in. Cocopeat was provided as basal substrate which served as shelter and gave the cockroaches a place to hide and breed. Rearing boxes were kept clean and hygiene with attention to clean the bottom of the enclosure at 5-7 days interval. The cockroaches were supplied with vegetable kitchen waste as food and water was sprinkled inside the plastic containers in order to provide sufficient moisture required for the cockroaches. Nymphs were reared inside circular plastic containers (20 cm height and 15 cm diameter) by providing food and water as mentioned above. The mixture of carrot, radish, gliricidia leaves, jackfruit leaves and cashew leaves were provided as food at all the times. Care was taken to keep the diet dry to prevent growth of mould, bacteria, mites, beetles etc. The culture maintained in the laboratory was used for further studies.

Lifecycle was studied by maintaining ten adults separately in a plastic container at room temperature nearly (22ºC), average relative humidity of 64%, by providing sufficient vegetable kitchen waste as feed. This species reproduces by ovoviviparity. Adults were inspected regularly and the data regarding young ones laid was recorded on daily basis. Observations such as total number of young ones laid by each female (fecundity of female), days taken to first moult and subsequent moults, duration of each instar, total number of days taken to complete the life cycle and adult longevity were recorded in the data sheets. Morphometrics were carried out using Leica stereozoom microscope (Leica MZ 6, Solms, Germany). 25 nymphs of each instar were collected and was anesthesized using 95% ethanol and measurements were taken. Adults were subjected to freezing in the refrigerator for ten minutes for the studies, as alcohol caused the adults to shrink, making it difficult to measure. The measurements recorded were body length (anterior tip of the head to the tip of the abdomen in nymph and from front of the head to the tip of the wings in adults), antennae length, head width (between the outside edges of the eyes), pronotum length (along the dorsal midline) and width (at its widest point), intraocular distance and forefemur length in mm. The dispersion of the mean values of all biological parameters and body measurements were worked out by calculating standard error of mean (SEm).

The substrate preference of *P. surinamensis* was studied using four treatments and five replications, where ten adults were used per replication making 50 adults per treatment. A circular plastic container (18 cm height, 12.5 cm dia) was used to study the substrate preference of *P. surinamensis* and ten adults were released per replication and was provided with fresh vegetable kitchen waste as food for all the treatments. In the treatment one, the adults were maintained in the container without substrate. In the treatment two, the adults were released into plastic container filled with leaf litter as a substrate for about 4 cm depth and were allowed to lay young ones. In the treatment three, the plastic containers were filled with cocopeat of about 4 cm depth and in the treatment four, vermiculite of about 4 cm depth were filled and adults were released and allowed them to feed and lay young ones. The preference of *P. surinamensis* for suitable substrate was determined by taking the observations at weekly intervals such as survival percent of adults and the growth of young ones.

RESULTS AND DISCUSSION

Biological studies on *P. surinamensis* revealed that there were four instars in the nymphal stage. The mean developmental duration of first, second, third and fourth instar were observed to be 30.5± 1.55, 31.5± 1.55, 34.25± 2.63, 29± 1.08 days and the adult longevity was 111.25± 3.35 days, respectively (Table 1) and the total number of days taken to complete the life cycle was 134.8± 4.94 days. In Turkestan cockroach male and female nymphs developed into adults on an average of 222 and 224 days, respectively (Kim and Rust, 2013). Similar studies in American cockroach, *Periplaneta americana* (L.) revealed that it takes about 160.5 days to 25 months to develop from hatching to the adult stage. The incubation period was found to be 35 days and the interval between the brood varies from 48-82 days (Borah and Hazarika, 2019). Similar type of studies reported an incubation period of 24-38 days with *P. americana* (Perrot and Miller, 2010). The female produces 1-5 broods (3 average). Adult females deposited up to 25 oothecae. The oothecae averaged 16.8 eggs and 13.9 nymphs emerged/ egg capsule, resulting in 82.7% hatching rate. The results are in accordance with those on the egg cases of cockroach that these contained 16-50 eggs (Hahn and Ascerno, 2005). Presence of 12-40 eggs in ootheca has been reported in *P. americana* (Whitworth and Ahmad, 2007). It was observed that the antennal length, head width, body length, pronotum length and pronotum width increased from first to fourth instar and peaked

Table 1. Morphometrics and growth ratios of *P. surinamensis* (in mm) (n=25)

Instar	Duration	Antennal length (Mean± SEm)	Head width (Mean± SEm)	Body length (Mean± SEm)	Pronotum length (Mean± SEm)	Pronotum width (Mean± SEm)	Intraocular distance (Mean± SEm)	Forefemur length (Mean± SEm)
Morphometrics								
I	30.50± 2.18	2.24± 0.07	1.41± 0.06	5.77± 0.23	0.85± 0.03	2.69± 0.04	0.81± 0.02	0.74± 0.01
II	31.50± 1.55	3.49± 0.11	1.97± 0.06	10.36± 0.26	1.45± 0.1	3.81± 0.04	1.37± 0.01	1.26± 0.02
III	34.25± 2.63	5.35± 0.15	2.53± 0.02	15.04± 0.25	2.63± 0.04	6.38± 0.06	1.71± 0.04	1.76± 0.02
IV	29.00± 1.08	6.35± 0.12	2.91± 0.06	18.67± 0.34	3.76± 0.12	7.55± 0.04	1.90± 0.02	2.04± 0.02
Adult	111.25± 3.35	7.12± 0.19	2.85± 0.08	22.17± 0.57	4.31± 0.12	7.68± 0.11	1.99± 0.06	2.28± 0.02
Growth ratios								
Growth ratios		Antennal length (in mm)	Head width (in mm)	Body length (in mm)	Pronotum length (in mm)	Pronotum width (in mm)	Intraocular distance (in mm)	Forefemur length (in mm)
II/I		1.558	1.397	1.795	1.706	1.416	1.691	1.703
III/II		1.533	1.284	1.452	1.745	1.675	1.248	1.397
IV/III		1.187	1.150	1.241	1.486	1.183	1.111	1.159
Adult/IV		1.121	0.979	1.187	1.146	1.017	1.047	1.118

at the adult stage (Fig. 1). All the body parameters like antennal length, head width, body length, pronotum width and fore femur length showed hypoallometry while the pronotum length showed hyperallometry (Fig. 2). The present findings agree with the fact that a series of allometric changes occurred at morphological level during the development of an insect (Borah and Hazarika, 2019). Observations from the morphometric studies also revealed that, the body measurements of the nymphs and adult was found to be significantly larger than the preceding instar in all cases except the pronotal length between the fourth instar and adult stage. In invasive Turkestan cockroach, *Blatta lateralis* they observed that in all cases except the pronotal length between the fourth and fifth instars, each instar was significantly larger than the preceding instar (Lee et al., 2021). According to the Brooks-Dyar rule (1890): median growth ratio for paurometabolous insects varies from 1.4 to 1.7 and this equation that, postmoult size divided by premoult size is a constant.

In the analysis of the present study, the growth ratios of body parameters were calculated, although the results of analyses support the Brooks-Dyar rule, they do not follow the rule and the values of ratios were decreasing from the first instar to adult and they were not constant. Similar to this in *Blaptica dubia* there were seven instars and the growth ratio followed the Brooks-Dyar rule (Wu H, 2013). He observed the growth ratio of pronotal length, pronotal width and head width were 1.26, 1.24, and 1.19, respectively. *B. dubia* shared a similar growth pattern with other paurometabolous insects (Wang et al., 2021).

Data on the effect of substrate on the survival and number of offspring produced revealed that among the four treatments, the treatment (T_1) without substrate varied significantly and were able to survive only up to eleven weeks. There was no significant difference with respect to survival and offspring production between leaf litter, cocopeat and vermiculite substrates whose survival was highest up to 16 weeks. The mean number of offspring laid in different treatments was observed. Among the four treatments, the treatment (T_1) without substrate and the treatment (T_2) with leaf litter has lower mean values of young ones compared to the treatment (T_3) cocopeat and the treatment (T_4) vermiculite, which had significantly higher mean values of young ones. The findings of substrate preference studies were similar with the investigations that reported highest mature weight, survival and overall performance index depended on the substrate on which the cockroach

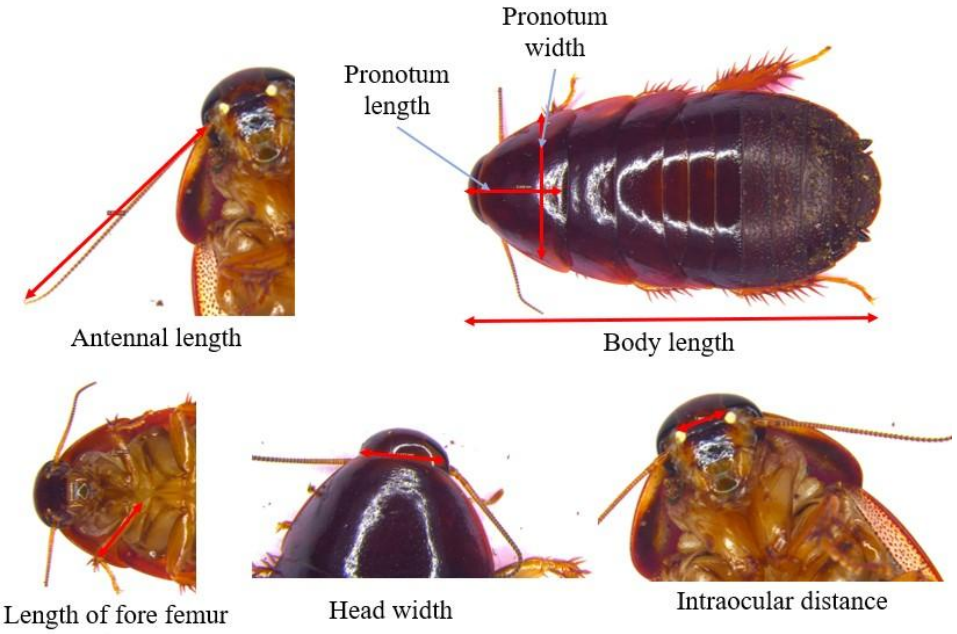

Fig. 1. Morphometrics of *P. surinamensis*

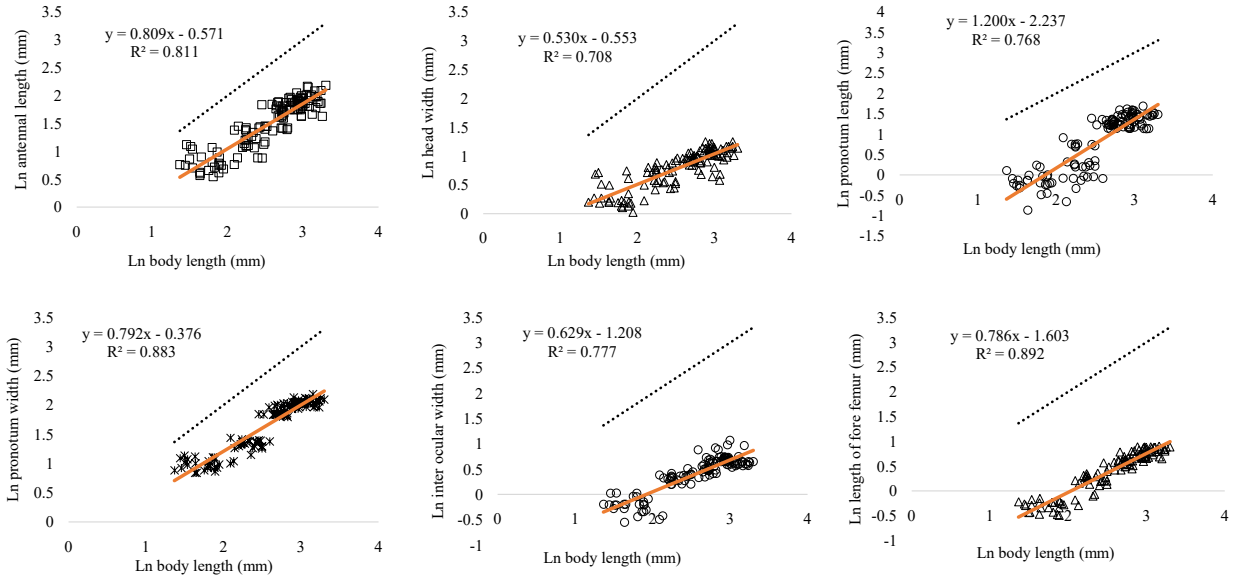

Fig. 2. Ontogenetic scaling of body parts measured through the developmental stages in *P. surinamensis.* (Values plotted on a log-log scale using natural logarithms)

was maintained (Ngaira et al., 2022). The outcome was similar with the findings that had investigated the site preference and oviposition behaviour for oothecal deposition by *Supella longipalpa* (F.) females (Benson and Huber,1989). They stated that, the behavioural sequence and oviposition site preference were determined by type of substrate on which the insects were maintained (Miller and Smith, 2020; Smith et al., 1999). Leaf litter, cocopeat and vermiculite have the ability to store moisture and thus influenced the stability of temperature (Weinstein, 1994). More studies would reveal the ideal condition of temperature and humidity for better survival of these roaches. Lack of any substrate resulted in dry and wet conditions coupled with fluctuations in temperature condition (Rahimian et al., 2019). Thus, humidity and temperature factor may have significant impact on the survival and growth of *P. surinamensis*.

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AUTHOR CONTRIBUTION STATEMENT

Sumithramma N conceptualized and framed the research proposal, Gowrisankar Reddi conducted the experiment, curated data and prepared original draft. Vidya Mulimani, Sanjay Kumar Pradhan, A. R. V. Kumar contributed to the samples, analyzed the results and corrected draft. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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