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Biology of the Lace Bug *Diconocoris distanti* Drake (Hemiptera:Tingidae) : A Pest of Black Pepper (*Piper nigrum* L.) in Sri Lanka

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ABSTRACT. *Diconocoris distanti Drake was identified as a new pest damaging black pepper (Piper nigrum L.) in Sri Lanka. This insect has been reported only from Sri Lanka. Laboratory rearing of D. distanti was carried out to study the life cycle, fecundity and longevity. Adults of D. distanti are black and 5.8–6.2 mm in length. Sex ratio among the lab reared D. distanti adults was 1:1. Pre-ovipositional and ovipositional periods since emergence were 24±3 h and 25±1 days, respectively. A fecundity of 34±1 eggs per female was recorded. Eggs were laid singly, closer to the veins, on the lower surface of leaves but rarely on flower spikes. Eggs were buried in the leaf tissues and covered by a brownish secretion and hatched in 13±1 days at 28±3°C.*

Nymphs passed through five instars with a duration of 3.17±0.09, 4.13±0.09, 5.24±0.14, 5.23±0.1 and 5.32±0.11 days from the 1st to the 5th instar, respectively. Nymphs, unlike the adults, had a flattened body and peripheral hairs of the abdomen which curved upwards. The life cycle was completed in 48 days at 28±3°C and 82±2% RH. Longevity of males was 23–27 days and of the females 32–65 days.

INTRODUCTION

Black pepper (*Piper nigrum* L.) is an important spice is cultivated extensively in the Mid country regions of Sri Lanka primarily as an export crop. Although the potential yield of black pepper is 4000 kg ha^{-1} in Malaysia (Bavappa and Reuttimann, 1990) and 5000–6500 kg ha^{-1} in Thailand (Saranrom, 1993), the average yield in Sri Lanka is only 400 kg ha^{-1}. The low yield in Sri Lanka is due to the several factors of which insect pests play a

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vital role. Until recently only the shoot borer and the thrip were documented as pests of black pepper in Sri Lanka (Wickramasinghe *et al.*, 1996). The black pepper lace bug, *D. distanti* is a new pest on pepper in Sri Lanka and there is no information available on its biology. Thus, a study was conducted to investigate the biology of *D. distanti* which would assist in development of a long–term management strategy for this pest.

MATERIALS AND METHODS

From the matured vines of three common varieties black pepper (*Piper nigrum* L.) namely, Local, Panniyur–1 and Kuching, the plagiotropic branches bearing aerial roots were removed. These were raised in polyethylene bags containing a potting mixture of sand:soil:coir compost at a 1:1:1 ratio and kept in a shady place to facilitate the development of new shoots. Orthotropic branches with aerial roots were removed and kept in polyethylene bags to obtain early bearing plants, as *P. nigrum* generally takes 3–4 years for bearing if plagiotropic branches are used as planting material. This technique is an effective method to produce small, bearing plants within 4–5 months for laboratory culturing of lace bugs.

The adults of *D. distanti* were collected from inflorescence, spikes and leaves of black pepper vines at Matale, Kandy, and Kegalle districts of Sri Lanka during February 1996. They were reared on potted fruit bearing pepper plants in insect rearing cages in the Entomology Laboratory of the Department of Agricultural Biology, University of Peradeniya, Sri Lanka. The rearing cages ($0.62 \times 0.62 \times 0.77$ m^3 in size) were covered with insect proof net on all sides and with a door on one side. Four to five months old rooted cuttings of black pepper were kept in these cages to feed the lace bugs. Rooted cuttings that were damaged by feeding of lace bugs were replaced with new plants.

Leaves of black pepper from cuttings on which insects were reared were removed to obtain *D. distanti* eggs. As indicated by Drake and Ruhoff (1965) the eggs of lace bugs were located on the lower surface of leaves. The females were separated immediately after copulation and transferred to specially designed cages for egg laying. Rooted cuttings of black pepper each having a single leaf on them were placed in these cages. The special egg laying cages were constructed using three rings (9 cm dia.) made of 9.8 cm steel wire and covered with a piece of 30×30 cm^2 insect proof plastic net (100 mesh). The insect proof net was tied over the last placed at the two ends while third ring was placed in the middle. After inserting a leaf into the cage, the

cage was closed by twisting the top ring clockwise or anti–clockwise. They can be kept tightly on the plants and provide sufficient aeration.

The egg laying and feeding habits of the adult females were monitored. During egg laying, the position of the egg was demarcated and the leaves were dissected under a dissecting microscope (magnification 6×4) to obtain details of egg placement on the leaf. Eggs were measured using an ocular micrometer fitted to a microscope (magnification 6×20). Permanent microscopic slides of eggs were made using acid fuchin stain for easy observation and measurement.

Mated females were separated and one female was introduced to each egg laying cage containing a potted plant with a single leaf. Five such cages were used in the experiment. The lace bugs were transferred after 48 h into a new potted plant with a leaf. After exposure to the females the lower surface of each leaf was examined under a dissecting microscope (magnification 4×6) and the number of eggs was counted. This procedure was continued until no eggs were found on leaves of plants exposed to females. Pre–ovipositional period and fecundity of adults were determined accordingly. The pre–ovipositional period was calculated by allowing newly emerged adult female lace bugs to mate with mature male in a cage and daily observations were made until the commencement of egg laying. The incubation period of the eggs were recorded.

Development of nymphs were closely monitored to determine the number of instars and the duration of each instar. Nymphs were confined to the leaf by keeping them in specially constructed 'Nymphal chambers'. The nymphal chambers were constructed by using two plastic Petri dishes of 5.5 cm dia. Two openings each of the size of 3.3×0.4 cm were made in each petri dish. A piece of muslin cloth was pasted on these holes to prevent the escape of nymphs and to ensure adequate aeration. Each Petri dish was mounted on a piece of regifoam of 7×7×0.6 cm^3 containing 5.4 cm diameter hole in the center. A piece of sponge of the same size was placed above the regefoam and an opeining at a size of 5.4 cm dia. was made. The purpose of pasting the sponge was to avoid damage to the leaf. These chambers were used to rear the first three nymphal instars. In the case of fourth and fifth instars, the same setup was made but with Petri dishes of 8.6 cm dia., a piece of 11×11×1 cm^3 regifoam and 11×11×0.6 cm^3 sponge. The hole was made in the center of the regifoam and the sponge was 8.5 cm in diameter.

The exuviae were collected from the cages in order to calculate the number of instars. Observations on the development of the nymphs were

made three times a day (morning, noon and evening). Dates and time of the commencement of moulting and completion of ecdysis was recorded.

Newly emerged lace bug adults of both sexes were reared in a small cage of 26 cm diameter and 61 cm height to study their longevity. A total of 30 adults of both sexes were held on different months and their life span under laboratory conditions was determined. Insects were transferred to fresh potted pepper plants once in every two days.

The sex ratio of the species was calculated from a random sample of 730 adults. Males and females were separated using the following morphological characters. In the female, the ovipositor was present in the eighth abdominal segment. The abdomen was uniform up to the eighth segment and became narrow in the ninth segment. A gradual narrowing of the abdomen was observed in the males. The posterior sternal sclerites were narrow at the mid line of the abdomen of females and not so in males when seen under a dissecting microscope.

Lace bugs were collected into a container made from a plastic bottle. A large hole was made on the lid and a piece of insect proof net was pasted on it. A male and a female were placed in this container to observe and mating and courtship behaviour.

RESULTS AND DISCUSSION

Description of life cycle stages

Eggs

Eggs of *D. distanti* were translucent, and became yellowish as development proceeds. They are inserted singly into the adaxial surface of the leaves, very closer to the veins. Eggs were rarely found on flower spikes of black pepper. Only two eggs were present in 43 flower spikes examined during flowering. The operculum of the egg was covered with a brownish fluid, which followed over to the lower surface of the leaf as a flattened semicircular disc. Eggs were distributed around the main veins of the leaves.

The chorion of the egg of *D. distanti* was smooth and unsculptured. The eggs had a mean length of 0.87 mm, width at operculum of 0.141 mm, and a width was of 0.291 mm at widest point. According to Rothschild (1968)

the mean length, and width at widest point of eggs of *D. hewetti* were 0.75 and 0.22 mm, respectively. The egg shell was smooth and unsculptured.

The shape of eggs was mostly straight and sometimes wider in the three fourths of the egg towards posterior end whereas some of the eggs were slightly curved posteriorly. Eggs of *D. distanti* hatched in 13±1 days at room temperature (28±2°C).

Nymphal stages

According to Van der Vecht (1934), Drake and Ruhoff (1965) and Rothschild (1968) most of the lace bugs have five nymphal stages. In agreement with those findings, *D. distanti* was also found to have five nymphal instars. The antennal segments of the nymphs of *D. distanti* were clearly distinguishable. All instars and adults had four segmented antennae. The characteristics of the five nymphal instars are presented in Table 1.

Table 1. Some characteristics of the five nymphal instars of *D. distanti*.

Characteristics	Nymphal Instars				
	I	II	III	IV	V
Mean Body length (mm)	1.020	1.206	1.809	2.714	3.650
Mean Body width (mm)	0.390	0.525	0.723	1.195	1.665
Mean Length of rostrum (mm)	0.552	0.606	0.898	1.094	1.240
Mean Length of antennal segments					
I	0.064	0.088	0.120	0.164	0.240
II	0.040	0.064	0.064	0.096	0.112
III	0.392	0.568	0.800	1.056	1.440
IV	0.360	0.368	0.416	0.496	0.672
Nymphal period (days)*	3.17±0.09	4.13±0.09	5.24±0.14	5.23±0.10	5.32±0.11

* Data presented as mean±standard error.

The lateral margin of thorax and abdomen of the first nymphal instar extended into short lobes (Figure 1). The peripheral hairs on posterior abdominal segments were long. Eyes were red coloured. In the second instar, the lateral lobes of thorax and abdomen were larger than those of first instar. The body was flattened and the peripheral hairs in the abdomen curved upwards. Eyes were brown coloured. The third instar was similar in colour to that of first and second instars but margin of thoracic tergits were tinged brown. The number of abdominal segments were nine with two posteriorly directed lobes which were larger than those of other parts of the body. Wing pads were developed slightly over first abdominal segment.

The colour of the fourth instar was similar to early stages. Longitudinal brown bands were seen on either side of thoracic segments and on abdominal segments 1–6. Lateral lobes of prothorax, mesothorax, and 5–7 and 9th abdominal segments were brown. Eyes were brown to black in colour. Prothorax and mesothorax were with at least three large lateral lobes. Wing pads were extending slightly over fourth abdominal segment. Lateral lobes of thoracic segments and 4–7, and 9th abdominal segments were large. Lateral lobes of second and third abdominal segments were much smaller than others.

The fifth instar was dark brown. The lateral areas of prothorax, median and posterior parts of mesonotal wing pad were brown colour. Posterior lobes of thoracic segments and 5–7 and 9th abdominal segments were brown colour. Eyes were brown to black in colour. Prothorax and mesothorax were with at least three large lateral lobes. Wing pads were extending over part of fifth abdominal segment.

The total life cycle of *D. distanti* was about 48 days at 28±3^{0}C and 82±2% RH and which would enable *D. distanti* to pass through seven generations per year. The food supply to *D. distanti* would be available through out the year as it feeds on spikes, leaves and tender shoots of black pepper.

Different nymphal instars were found on the spikes and leaves. They moved from leaf to spike for feeding. The final exuviae remains were attached either to veins of the lower surface of the leaf or to spikes. Before moulting, nymphs remain settled on the leaves and a longitudinal splitting of the exoskeleton was observed on the head and this cleavage extended to the metathorax region.

The emerging instar become white, transparent and took about 3–5 h to get hardened while adults emerged from the fifth nymphal instar was

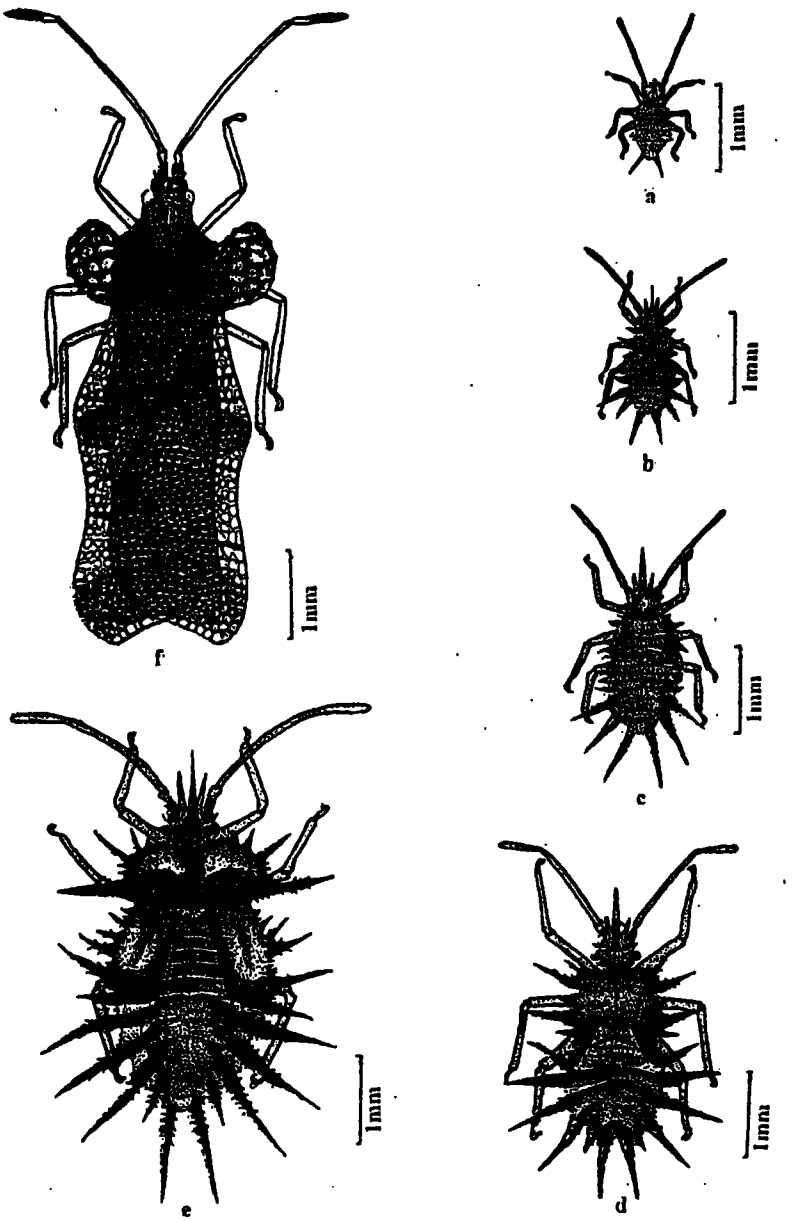

Figure 1. **The five nymphal instars and adult of *Diconocoris distanti*. (a) First instar; (b) Second instar; (c) Third instar; (d) Fourth instar; (e) Fifth instar; (f) Adult.**

initially white and after 6–7 h the adult become black due to hardening. The first and second instars were small however, they can be seen through closer observation with naked eye. The first instar nymph was found to be movable and in several instances they were found to move from leaf to spike.

Adult

Adult bugs are small, black and 5.82–6.21 mm in length. The black head bears five long black spines. The antennae are four segmented, pale coloured with first and apical three–fourths of fourth segments black. Bucculae was black, broad and closed in front. Pronotum was black except the posterior edge, convex, and coarsely punctate. Hood was light brown, moderately high and measure as 0.12 mm. Paranota enormously developed into finger like but anteriorly curved. The height of the visible netted darker portions height was 1.05 mm in male and 1.23 mm in female from the horizontal surface of the pronotum. The hemelytra are black with coastal area pale and slightly concave. Hind wings are membranous.

When both sexes were held together, males lived for 25±2 days and female lived for 32–65 days. However, one female lived for 94 days under the laboratory conditions of 28±3°C and 82±2% RH. The reason for reduced longevity in male lace bugs is not known. The adults were provided with only pepper leaves as food in this study. Fecundity was 34±1 eggs at 28±3°C and ovipositional period was 25±1 days. The sex ratio of *D. distanti* was found to be 1:1.

Mating behaviour

The reproductive organs were not fully developed in the newly emerged adults. The pre–oviposition period was estimated by subtracting one day from the time of first egg was observed. The sexual maturity period of female was 10.5±1.5 days. The female took 24±3 h (approximately one day) to start laying of eggs from the time of copulation. The sexual maturity period of males was found to be 20±2 h. They become receptive for mating only after this period.

A similar mating behaviour has been observed in *D. hewetti* (Rothschild, 1968). Prior to copulation the males of *D. distanti* vigorously fanned both hemelytra for about 6–9 minutes. This action was maintained with a free hemelytron while mating. Just prior to copulation the male comes

closer to female and inserts one fourth of its one hemelytron in between the abdomen and wings of the female. When fanning stopped, the male aedeagus was inserted into female vagina. The period of copulation lasted 50–65 minutes. It has been recorded 15–30 min for *D. hewetti* (Rothschild, 1968). Rothschild (1968) also reported that several males made attempts to mate with a single female simultaneously in *D. hewetti*. In one instance two males mated with a female of *D. distanti* for 35 and 65 min, respectively.

CONCLUSIONS

A species of lace bug collected from black pepper in the Mid country of Sri Lanka was identified as *Diconocoris distanti*. Adults of *D. distanti* are black and small with two finger like projections on the dorsolateral sides of pronotum. Eggs are inserted singly into the lower surface of pepper leaves, closer to veins.

D. distanti under goes five nymphal instars. The nymphs are flattened and the abdomen possesses peripheral hairs curved upwards. Nymphal periods of first, second, third, fourth and fifth instars are 3.17±0.09, 4.13±0.09, 5.24±0.14, 5.23±1 and 5.32±0.11 days, respectively. The total life cycle of this pest took 48 days that would enable the pest to produce seven generations annually.

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