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First record of new exotic Mealybug species, *Phenacoccus solenopsis* Tinsley, 1898 (Hemiptera: Pseudococcidae), its Host range and abundance in the Eastern Sri Lanka.

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Abstract

Mealybugs (Hemiptera: Pseudococcidae) are a small group of sap sucking insect pests which cause severe economic damage to wide range of homegarden, horticultural and field crops. Therefore, a survey of mealybugs in Batticaloa District of Eastern Sri Lanka was conducted to gather information on their species composition, distribution and pest status. Among the different species identified, the cotton mealybug, Phenacoccus solenopsis Tinsley was found to be the predominant species comprising about 70% of the collected specimens. This species has not been previously reported to occur in Sri Lanka. It now appears to be widespread in the Eastern parts of the country. This is an exotic species originated from USA.

The new mealybug was identified by the authors and confirmed as Phenacoccus solenopsis Tinsley by Dr.C.J.Hodgsn, Department of Biodiversity and Systemic Biology, National museum of Wales, Cardiff, Wales, UK. This first record of P.solenopsis in Sri Lanka, where it was found infesting mainly on shoe flower plants Hibiscus rosa-sinensis. The description of the adult female cotton mealybug is presented in this paper. Samples were collected from twenty five different locations within the study area and twenty six plant species from ten different families were recorded as hosts with various levels of infestations. In addition the abundance of P.solenopsis on the shoe flower plant, which is the major hosts in the homegardens, shows a clear seasonal variation and during the period of study two generations were found. Among the climatic factors, rain fall affects significantly on the abundance of this species. The implications of the introduction of this exotic polyphagous pest species and its potential threat to agriculture in Sri Lanka are discussed in this paper.

Key words: *Cotton Mealybug, Exotic, Hibiscus rosa-sinensis, Phenacoccus solenopsis, Polyphagous pest, Seasonal variation*

INTRODUCTION

Mealybugs are soft bodied, plant sap sucking hemipteran insects of the hemipteran family Pseudococcidae. These are important plant pests worldwide, causing severe economic damage to wide range of vegetable and horticultural crops [1, 2]. Their infestation may cause leaf yellowing, defoliation, reduced growth, and in some cases death of plants. Indirectly they may also damage plants by serving as vectors of plant disease. Apart from these, they produce copious amount of sugary secretion called honeydew [3], which contributes to the development of sooty mould that decreases photosynthesis [4] and may reduce the marketability of plant products such as fruits [5]. In addition, the honeydew secretion attracts ants, which have significant role in the spread of mealybugs from plant to plant and also protect them from their natural enemies.

In Sri Lanka, mealybugs are known as *Venmootu Poochi* (Tamil) and *Piti Makuna* (Sinhala). Up to date there are 38 species of mealybugs reported from Sri Lanka including the recent identification of Papaya mealybug *Paracoccus marginatus* in 2008 which caused a serious threat to the Papaya cultivations and to some other commercial crops (Wijesekara,2009, Personal communication).

A survey was carried out to study the different mealy bugs, their distribution and the degree of damage on different host plants in the homegardens of Batticaloa district, Eastern part of Sri Lanka during the period from May 2008 to December 2008. The species *Phenacoccus solenopsis* which attacks mainly on Shoe flower plant *Hibiscus rosa-sinensis* was found to be the predominant species in the study area. The present study reports the identification, host range and abundance of *P. solenopsis* in relation to climatic conditions in Batticaloa district.

MATERIALS AND METHODS

As part of a research on mealybugs of homegardens in the Batticaloa district, samples of Cotton mealybug *P.solenopsis* were collected from nearly 25 locations of Batticaloa district covering mostly the homegardens, some crop fields, abandoned lands and road sides. Infested plants were categorized according to the parameters given in the table below [6] based on visual observations. During sampling, whole plants were examined using the parameters to determine the infestation levels.

Parameters	Infestation levels
1: Incidental	i. Only a few individuals of the mealybug casually found. ii. No breeding individuals observed.
2: Low	i. All stages of mealybug found in low number. ii. No adverse symptoms observed on the plant.
3: Medium	i. All stages of mealybug found in large number. ii. Wilting and yellowing of plant leaves appeared. iii. Infested plants normally survived.
4: High	i. All stages of mealybug found in very large number. ii. Almost all plant parts covered with mealybug showing white appearance. iii. Excessive leaf and flower shedding. iv. Most of the plants died in the infested area.

The collected specimens together with their host material were brought to the laboratory of Department of Zoology, Eastern University and they preserved in 70% alcohol. Adult female mealybugs were slide-mounted for identification using a method outlined by McKenzie [7] Initially the insects were cleared for three days at room temperature in potassium hydroxide (10% KOH) and DPX was used instead of Canada balsam for mounting. The keys and the illustrations .of Hodgson *et al.* [8] were used to identify the species. Length and width measurements of body, prothoracic, mesothoracic and metathoracic legs and antenna were taken with the aid of a microscope fitted with a micrometer eye piece.

In addition, to study the abundance of the predominant species in relation to the climatic factors, the particular mealy bug populations were collected twice in a month during the period of eight months from May 2008 to December 2008 within the study area. Approximately four-five inch terminal portions of shoots per plant were sampled at random from twenty five matured Shoe flower plants of same age and size (height above 5 feet). The number of adults, 1st 2nd and 3rd instar nymphs were counted using hand lens. Simultaneously the records of temperature and rainfall during the period of sampling were obtained from the Meteorological Department of Batticaloa. The data obtained were analyzed by Pearson Correlation Analysis using the Statistical package Minitab 14.0.

RESULTS AND DISCUSSION

The predominant mealybug species of Batticaloa District which is abundant on the Shoe flower plants was identified as *Phenacoccus solenopsis* Tinsley, 1898 and the slide mounted specimens were confirmed by Dr.C.J.Hodgson, Department of Biodiversity and Systematic Biology, National Museum of Wales, Cardiff, Wales, UK. This species was not previously reported from Sri Lanka and this is the first record of if its presence in the country.

Identification

The genus *Phenacoccus* can usually be diagnosed, based on the following characteristics of the adult female; antennae usually 9-segmented; legs well developed, claw usually with a well-developed denticle; translucent pores absent from hind coxae, but sometimes present on hind femur and tibia; cerarii numbering 1–18 pairs, each with lancoelate setae and trilocular pores, often on protruding membranous areas; dorsal setae usually short and lancoelate, sometimes with trilocular pores close to setal sockets; circulus usually present between abdominal segments III and IV; multilocular disc pores usually present in rows on venter and sometimes on dorsum; quinquelocular pores generally present on venter and occasionally on dorsum; oral collar tubular ducts often present on dorsum and venter, dorsal ducts often larger than ventral ducts but sometimes ducts all one size; oral rim ducts absent; eyes without associated discoidal pores (modified from Williams, 2004).

Adult females of *P. solenopsis* can be separated from those of the other *Phenacoccus* species known from southern Asia by using the following key [8].

1. Quinquelocular pores present on venter, at least near mouthparts most ***Phenacoccus*** spp.
- Quinquelocular pores entirely absent from dorsum and venter..... 2

2. Multilocular disc pores present on both dorsum and venter.....***Phenacoccus kozari*** Williams
- Multilocular disc pores restricted to venter..... 3

3. Multilocular disc pores present medially on abdominal segments IV–IX, restricted to bands across posterior margin of each segment; multilocular disc pores very rarely present on submarginal areas of abdomen and then restricted to segments VI & VII; antenna usually 8 segmented..... ***Phenacoccus solani*** Ferris
- Multilocular disc pores present medially on abdominal segments VI–IX (rarely also 1 or 2 on V), scattered across full depth of segment VII between anterior to posterior margins; also usually present submarginally on some abdominal segments (about equally frequent on segments II–VI when present); antenna usually 9 segmented.....***Phenacoccus solenopsis*** Tinsley

Adult females of *P.solenopsis* are pale yellow to almost orange in colour, generally highly dusted with white powdery wax, with short, fine lateral wax filaments and one pair of terminal filaments usually one fourth of the total length of the body. In a wax removed body, dorsum with a series of dark dorsal markings as follows: a pair of "exclamation marks" on head, about six pairs of transverse markings across pro and mesothorax, possibly absent on the metathorax, and with pairs of dark transverse markings on each abdominal segment; also with a submarginal line of dash marks on thorax and abdomen and venter with dark circulus. In specimens with wax coating only three pairs of transverse markings can be observed on the dorsal thoracic region (Figure 1).

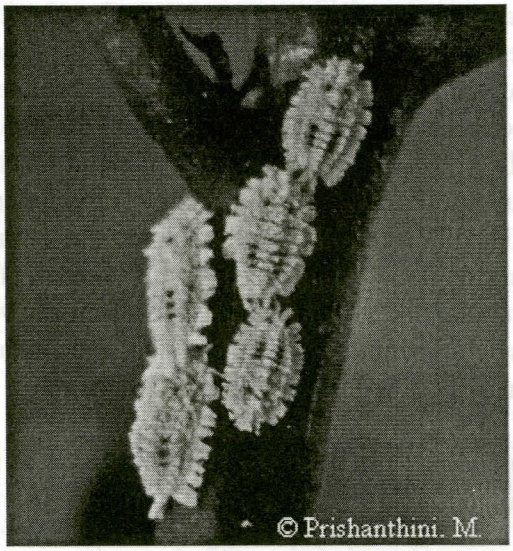

Figure 1: Adult females of *Phenacoccus solenopsis* (Tinsley)

Mounted specimen (Figure 2) is oval in outline, 4.4±0.20 (3.0-6.4) mm long, 2.43±0.12 (1.3-3.4) mm wide; anal lobes moderately developed; antennae each 9 (rarely 8) segmented, each antenna 435±11.22 µm (405 - 485) long ; legs well developed, Metathoracic leg measurements (µm): coxa 258.55±9.61 (1.3 - 3.4); trochanter + femur 328.7 ±13.44 (258 - 412); tibia 272.95 ± 12.67 (183 - 354); tarsus 108.55 ± 6.07 (69 – 164) ; claw 33.3 ±1.13 (23 - 42); all metacoxa without pores; circulus present, oval, occasionally slightly constricted laterally, rather variable in size ; cerarii distinct, numbering 18 pairs; oral collar tubular ducts restricted to venter; quinquelocular pores absent; multilocular disc pores absent dorsally, present medially on venter of posterior 4 (occasionally 5) abdominal segments; claws each with a small denticle. (Values represent Mean ± S.E, n=20).

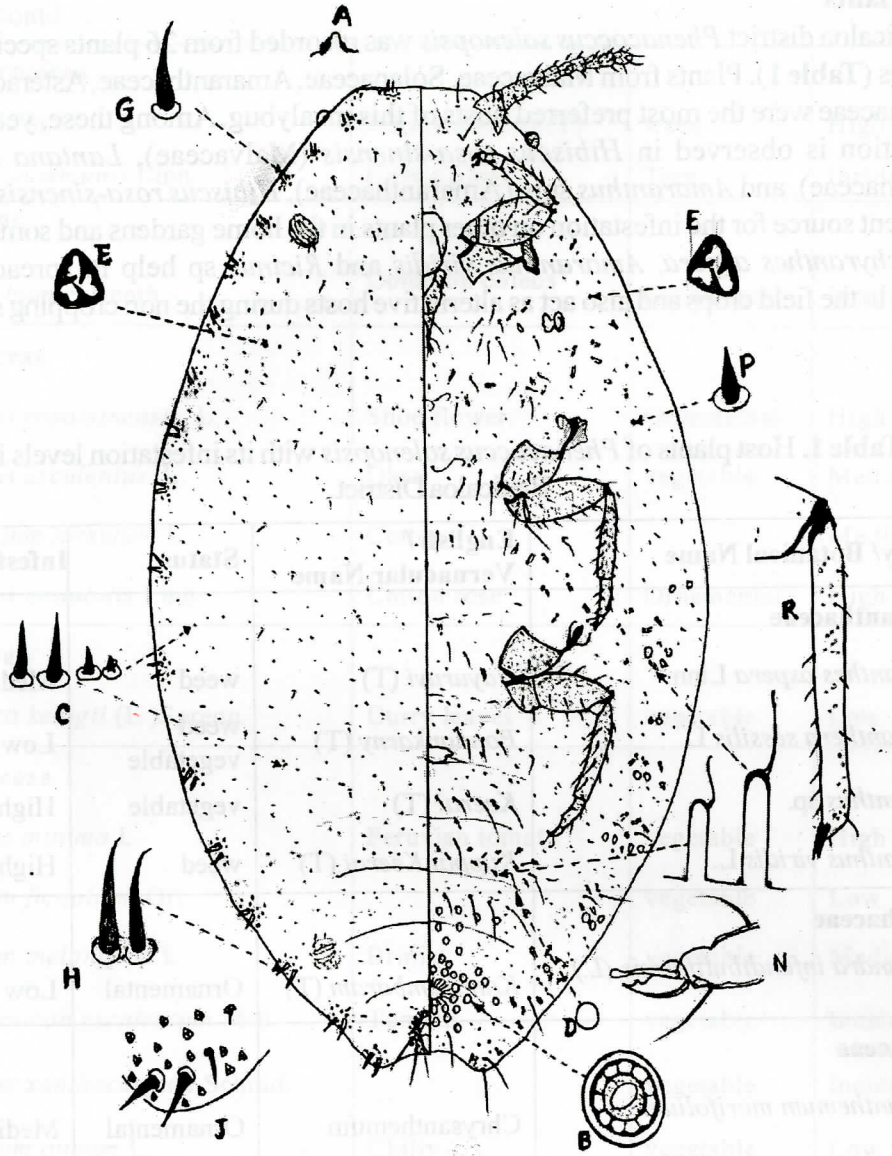

Figure 2: Adult female of *Phenacoccus solenopsis* Tinsley,1898. (Modified from Hodgson *et al.*, 2008) **A:** Preantennal pore; **B:** Multilocular disc pore; **C:** Dorsal lancoelate setae; **D:** simple (discoidal) pore; **E:** Trilocular pore; **F:** Minute sclerotized pore; **G:** Spinose seta on anterior cerarii; **H:** Spinose setae on more posterior cerarii; **J:** Cerarius C18; **L:** Large oral collar tubular duct; **M:** Small oral collar tubular duct; **N:** Claw; **P:** Ventral lancoelate seta, **R:** Metafemur and metatibia showing translucent pores.

Host Plants

In Batticaloa district *Phenacoccus solenopsis* was recorded from 26 plants species of 10 families (**Table 1**). Plants from Malvaceae, Solanaceae, Amaranthaceae, Asteraceae and Verbenaceae were the most preferred hosts of this mealybug. Among these, year round infestation is observed in *Hibiscus rosa-sinensis* (Malvaceae), *Lantana camara* (Verbenaceae), and *Amaranthus* spp. (Amaranthaceae). *Hibiscus rosa-sinensis* act as a persistent source for the infestation on other plants in the home gardens and some weeds like *Achyranthes aspera, Amaranthus viridis* and *Ricinus* sp help in spread of the species to the field crops and also act as alternative hosts during the non cropping seasons.

Table 1. Host plants of *Phenacoccus solenopsis* with its infestation levels in Batticaloa District

Family/ Botanical Name	English / Vernacular Name	Status	Infestation
Amaranthaceae			
Achyranthes aspera Linn.	*Nayuruvi* (T)	weed	Medium
Alternanthera sessilis L.	*Ponnankarny* (T)	weed / vegetable	Low
Amaranthus sp.	*Keerai* (T)	vegetable	High
Amaranthus viridis L.	*Kuppai Keerai* (T)	weed	High
Acanthaceae			
Crossandra infundibuliformis (L.) Nees	*Kanakambaram* (T)	Ornamental	Low
Asteraceae			
Chrysanthemum morifolium Ramat.	Chrysanthemum	Ornamental	Medium
Chrysanthemum indicum	Chrysanthemum	Ornamental	Low
Helianthus annuus L.	Sun flower	Ornamental	High
Basellaceae.			
Baselia alba L.	Spinach	vegetable	Medium

Table 1 contd....

Euphorbiacea			
Jatropha sp	*Kattamanakku* (T)	weed	High
Ricinus communis Linn.	Castor plant	Tree	Incidental
Labiatae			
Coleus blumei Benth.	Common coleus	Ornamental	Incidental
Malvaceae			
Hibiscus rosa-sinensis L	Shoe flower	Ornamental	High
Hibiscus esculentus L.	Okra	vegetable	Medium
Gossypium hirsutum L.	Cotton		Medium
Hibiscus mutabilis Linn.	Cotton rose	Ornamental	High
Rutaceae			
Murraya kenigii (L.)Spreng.	Curry leaves	vegetable	Low
Solanaceae			
Physalis minima L.	Peruvian tomato	vegetable	High
Solanum ficijolium Ort.		vegetable	Low
Solanum melangena L.	Brinjal	vegetable	Medium
Lycopersicon esculentum Mill.	Tomato	vegetable	Incidental
Solanum xanthocarpum Schrad.		vegetable	Incidental
Capsicum annum L.	Chilly	vegetable	Low
Solanun irilobarum.L.	*Thoothuvali* (T)	vegetable	Low
Verbenaceae			
Lantana camara L.	Lantana	Ornamental/ weed	Medium
Vitex irifolia	*Nochchi* (T)	Medicinal herb	Low

(T) - Local Tamil Name

Almost all home gardens with ornamentals, vegetable crops and weeds mentioned in **Table 1** have higher level of infestation than that of the field crops. The commercial crop fields cultivated mainly with *Solanum melangena, Hibiscus esculentus, Lycopersicon esculentum* and *Capsicum annum* were free of mealybug infestations probably due to the heavy and frequent usage of chemical pesticides. A moderate level of infestations was observed in the small scale vegetable gardens. This might be due to the minimal use of chemical pesticides by those farmers and the applications were irregular without a proper timing. On the other hand it could be found that the use of chemical pesticides in homegardens is very much limited. During the survey, it was observed that the insecticide prohibited for use in agriculture, Malathion, is the only chemical pesticide used by the home gardeners, and a very small percentage of them use this to control mealybugs. Most of the home gardeners use mechanical control measures such as the application of highly pressurized hose of water over the affected plants and destruction of the affected plants. Soap water and ash mixed sprays also in use traditionally by some people.

In this study area some level of natural control was observable. It is achieved through the predatory activity of Lady Bird beetles, their larvae and Lace wing larva. There are some tiny parasitic hymenopterans observed with parasitic activity on *P.solenopsis*. Generally reliance on synthetic pesticide is not always advisable because they may result in environmental and health hazards, pest resistance, resurgence and ultimately discontinuation of their use. Therefore more research on the identification of locally available natural enemies is important.

Seasonal Variation

The abundance of *P.solenopsis* on shoe flower plants (*Hibiscus rosa-sinensis*) which are the major hosts in the home gardens shows a clear seasonal variation. During the period of study two generations were found. The total number of live individuals was considered as population index for this insect on Hibiscus plants in Home gardens. Results of this study showed that the population index had two peaks of seasonal abundance (Figure 3). The first one, the highest, was on 1st May- 15th May 2008. The second one was on 1st August 2008. The half-monthly means of total alive individuals were 363 and 209 individuals / 5 terminals respectively. On the contrary the lowest population index was in 1st November 2008 (34 individuals/ 5 terminals) and it became zero for the month of December. The results above showed that the *Phenacoccus solenopsis* had two main periods of seasonal abundance on shoe flower plants under the local conditions at Batticaloa. The first one was during early warmer months and the second period was during early rainy months.

Among the climatic factors, rainfall affects significantly with a strong positive correlation on the abundance of this species. Temperature showed a positive correlation on the abundance of this species. The correlation coefficient values for rainfall, maximum temperature and

minimum temperature with the population of mealybugs was -0.757, 0.659 and 0.788 respectively. Similar findings were obtained by Dhawan *et al* (2009) in a study of distribution of *Phenacoccus solenopsis* Tinsley in cotton in relation to weather factors in Southwestern districts of Punjab, as there was a positive correlation among the percent field infestation and temperature, whereas negative correlation was observed with rainfall [9]. Figures 4 and 5 indicate the impact of rainfall and maximum and minimum temperatures on the abundance of *P.solenopsis* during the period of study in the Batticaloa district.

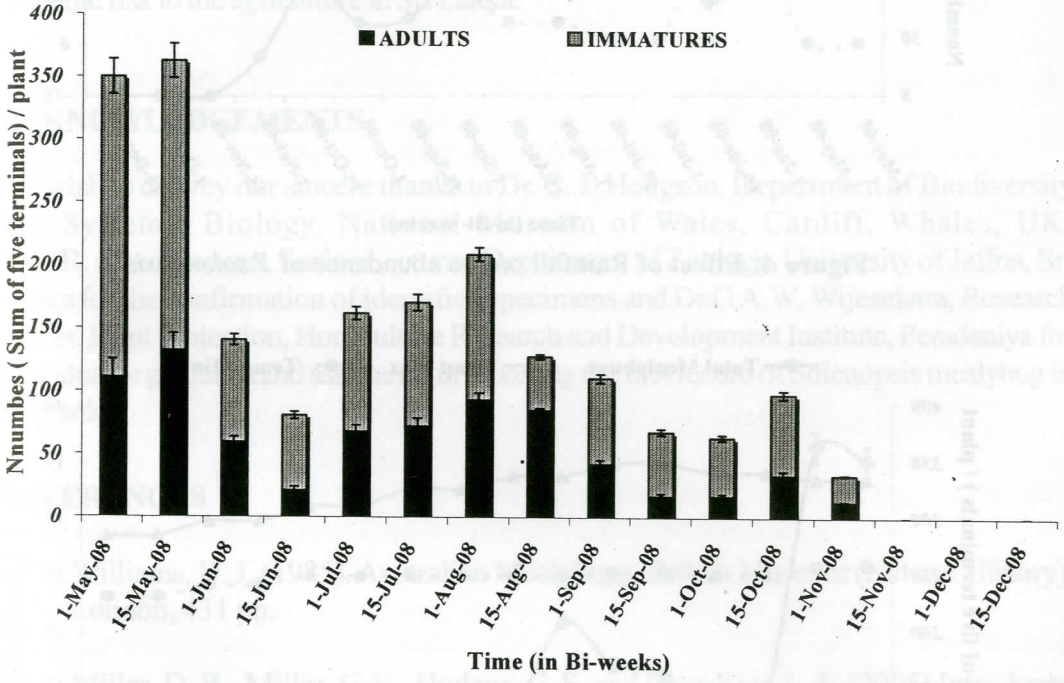

Figure 3: Fluctuations in the population of *P.solenopsis* during the period from May 2008 to December 2008. (Double headed arrows shows peaks of population).

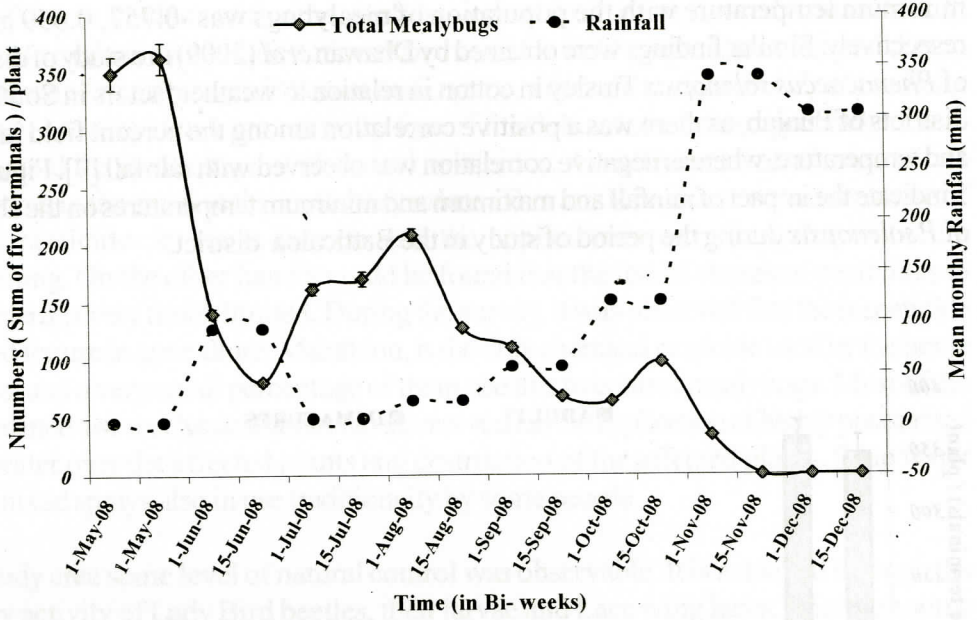

Figure 4: Effect of Rainfall on the abundance of *P.solenopsis*

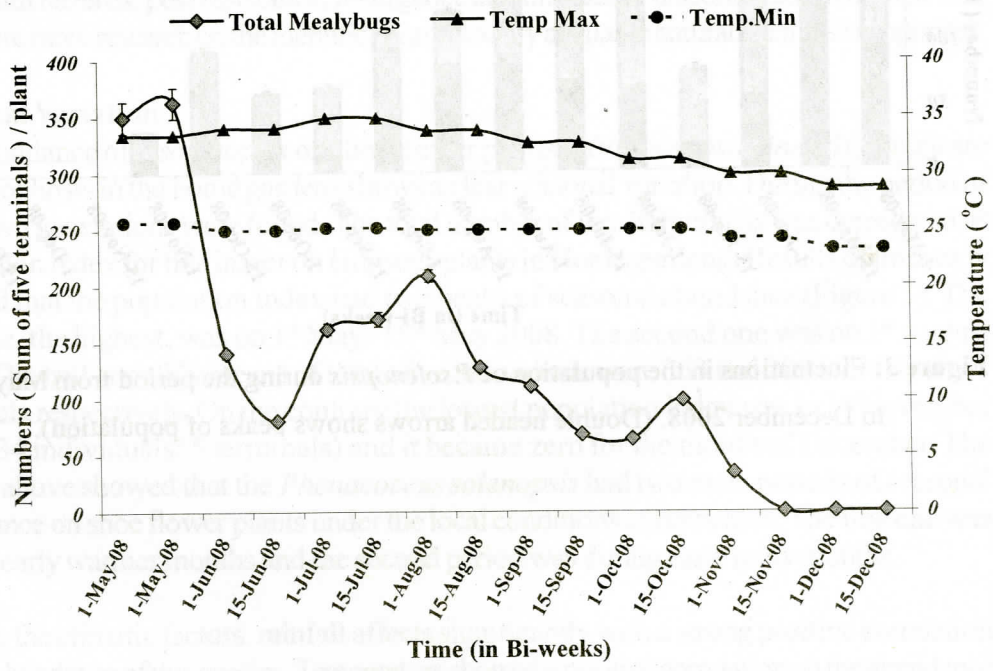

Figure 5: Effect of Maximum and Minimum temperatures on the abundance of *P.solenopsis*

P. solenopsis is an exotic species originated from the USA [10] and had already spread to many countries of Asian and African continents [11]. Further long term researches on the mealybug *Phenacoccus solenopsis* which is firstly recorded Sri Lanka, including its distribution all over the country, hosts, ecology and control measures with the special concern to ecosafety measures as the biological control and botanical control is necessary. Wide host range of *P.solenopsis* requires attention for alternate control measures. Information regarding biological parameters of insects and their host preference for feeding and oviposition are very important to develop alternate strategies effective for its control like other important insects. In addition, studying the population dynamics of this pest with the long term records of climatic changes will be useful to manage the pest problem and to avoid its spread and potential risk to the agriculture in Sri Lanka.

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