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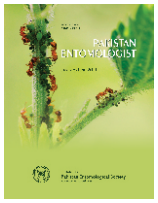

PREDATORY POTENTIAL OF FIVE COCCINELLID PREDATORS AGAINST COTTON MEALY BUG *PHENACOCCUS SOLENOPSIS* (TINSLEY) IN LABORATORY AND FIELD CONDITIONS FROM SINDH, PAKISTAN

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ABSTRACT

Lady bird beetles are predators of different agricultural pests such as aphids, mealy bugs, whiteflies, jassids, psyllids and scale insects. Among these pests, the cotton mealy bug is a very serious pest in the Asian countries specially Pakistan and India. In Pakistan very little work has been done on biological control against crop pests using predatory ladybird beetles. In the present study five species of the family Coccinellidae were evaluated against the cotton mealy bug, *Phenacoccus solenopsis* (Tinsley). In order of predatory potential, fourth instar larvae of *Brumoides suturalis* and adults of *Coccinella septumpunctata* showed high predatory potentials as compared to *Hippodamia variegata*, *Menochilus sexmaculatus* and *Hyperaspis maindroni*.

Keywords: Biological control, Coccinellid, Predators, *Phenacoccus solenopsis*, Sindh, Pakistan

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops in Pakistan and is the source of large amount of foreign exchange. Since its extensive cultivation, as a monoculture crop, it is attacked by many chewing and sucking insects (Saeed *et al*., 2007). The sucking insect pests include whitefly, aphid, thrips, mealy bugs and mites, whereas, grass hopper, termite, weevils and lepidopteron insects are predominated among chewing insect pests. Mealy bug is a serious pest of cotton and resulted in severe damage to cotton during the last few years (Solangi *et al.,* 2008; Nagrare *et al*., 2009).

The cotton mealy bug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae), was reported originally on ornamental and fruit crops in the United States (Tinsley, 1898) and regarded as an exotic pest in South East Asia, including India and Pakistan.

From 2005 and onwards, it has been recorded as a serious pest of cultivated cotton *Gosspium hirsutum* in Pakistan (Abbas *et al*., 2007; Hodgson *et al.*, 2008). Beside cotton it also attacks a number of other crops, ornamentals and fruit trees (Aijun *et al*., 2004).According to Arif *et al.* (2002), it causes severe economical loss to cotton, brinjal, okra, tomato, sesame, sunflower and China rose with plant death in severe conditions. Sahito *et al.* (2011) checked the present status and conducted a survey of *Phenacoccus solenopis* (Tinsley). They studied the effect of bio-ecological factors on its population in different ecological zones of Sindh. Although a number of chemicals are effective against this mealy bug (Anonymous, 2010) but their overuse in the long term may result in insecticide resistance, resurgence and other problems.

There is a strong need to investigate other options for sustainable management of *P. solenopsis*. The biological control is one of the effective means of achieving insect control (Pedigo, 2004). Predator's response to variation in prey density has always remained a central theme in ecological theory (Hassel and May, 1974; Kareiva and Odell, 1987) and in biological control (Beddington *et al*., 1978; Murdoch *et al*., 1985). A predator that responds numerically by aggregating attacks and oviposition to locations with higher prey density is thought to be an ideal method for

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suppressing pest populations before they reach to the damaging levels (Murdoch *et al*., 1985; Murdoch and Briggs, 1996).

The Coccinellid beetles are considered to be of great economic importance in agro-ecosystem as they can be successfully employed in the biological control of many injurious insects (Agarwal *et al.,* 1988). Coccidophagy is an ancestral characteristic of the family Coccinellidae and there are many tribes and genera of Coccidophagous Coccinellid viz; Sukunahikonini, sticholotidini, scymnini (*Cryptolaemus, Nephus, Diomus, Sidis*), Hyperaspini (*Hyperaspis* spp.), Telsimiini, Chilicorini (*Chilicorus, Exchomus*), Coccidullini (*Rhyzobius*), Azyini, Exoplectrini, Noviini (*Novius, Rodolia*) and Coccinellini (*Neda*) (Giorgi *et al*., 2009; Hodek and Honek, 2009). *Cryptolaenus montrouzieri* is also known as "Crypts". This predator is a very efficient natural enemy of mealybugs, with both larvae and adults preying on this pest (Gautam, 1996).

In Pakistan many species of Coccinellid predators are reported to be very effective to control many insect pests, particularly small and soft bodied insects. According to Michaud (2001), there are more than 4000 species of Coccinellids around the world. Among these, common species, which are found in Sindh Province of Pakistan, are 7-spotted beetle (*Coccinella septempunctata* L.), Transverse beetle (*Coccinella transversalis* F.), 11-spotted beetle (*Coccinella undecimpunctata* L.), striped beetle, *Brumus sutuaralis* F.), Zigzag beetle (*Menochilus sexmaculatus* F.), 9-spotted beetle, *Hippodamia variegata*, *Scymnus* spp, *Stethorus punctum* and many others are common predators of different sucking insect pests of several crops (Hashmi, 1994; Lohar, 2001).

Brumoides suturalis is the most voracious predator of mature and immature stages of mealy bug on different field and vegetable crops of Sindh (Lohar, 2001). Mahmood *et al.* (2010) studied the historical perspective and achievements in biological management of cotton mealy bug *Phenacoccus solenopsis* (Tinsley) in Pakistan. Shera *et al.* (2010) studied potential impact of *Coccinella septumpunctata* L. against *Phenacoccus solenopsis* and *Aphis gossypii* Glover (Aphidae: Homoptera). Neetan and Aggarwal (2011) recorded different natural enemies from mealy bug colonies which include four coccinellid predators, one parasitoid and one Chrysopid species. Arif *et al.* (2011) investigated predatory potential of *Menochillus sexmaculatus, Coccinella septempunctata, Brumus suturalis, Hippodemia convergens* and their four instars against first instar nymphs of cotton mealy bug, *Phenacoccus solenopsis,* under laboratory conditions. Ghafoor *et al.* (2011) studied the predatory potential of *Cryptolaemus montrouzieri* on Cotton Mealy bug under laboratory conditions. Kaydan *et al.* (2012) found eight Coccinellid species belonging to five genera which are listed as *Exochomus* Rebtd, *Hyperaspis* Rebtd, *Nephus* Mulsant, *Pharoscymnus* Bedel and *Scymnus* Kugel. All these feed on scale insect species belonging to the families Coccidae, Diaspididae, Eriococcidae and Pseudococcidae. Khuhro *et al.* (2012) determined the feeding potential of the lady bird beetle, *Brumus suturalis* Fabricius on cotton mealy bug, *Phenacoccus solenopsis* (Tinsley) in laboratory and field conditions. Khan *et al.* (2012) investigated the predatory potential of *Chrysoperla carnea* and *Cryptolaemus montrouzieri* larvae on different stages of the mealybug, *Phenacoccus solenopsis*. Present study was carried out to investigate the predatory potential of five species of the family Coccinellidae against the cotton mealy bug, *Phenacoccus solenopsis* under laboratory and field conditions.

MATERIALS AND METHODS

Culture of Mealybug

The leaves and shoots of cotton with mealy bug infestation were collected and brought into the insectary of Department of Zoology, University of Karachi, Pakistan. The adult males and females were then separated with the help of camel hair brush. The first instar nymphs from the culture were selected for the experimentation of the present research study.

Collection and rearing of Coccinelid predatory beetles

The adults of five coccinellid predatory beetles, *Coccinella septumpunctata*, *Menochilus sexmaculatus*, *Hippodamia variegata*, *Brumoides suturalis* and *Hyperaspis maindroni* were collected from the cotton plants of the research field situated in the Department of Zoology, University of Karachi. These Coccinellids were reared on the mealy bug population cultured in the insectary in separate cages. Only the fourth instar larvae and adults of different Coccinellids were used for different experimentations in the present research studies.

Identification of Mealy bugs and Coccinellids

The mealy bug species was identified by Dr Gillian Watson, Senior Insect Biosystematist, California Department of Food and Agriculture, Plant Pest Diagnostic Center, U.S.A. whereas the Coccinellids were identified by the author himself and confirmed by Dr. Claudio Canepari, an authority of the family Coccinellidae from Italy.

Evaluation of predators

Two sets of Petri dishes were prepared for larvae and adults of Coccinellids. One thousand first instar nymphs of *Phenacoccus solenopsis* with infested shoots were placed in each Petri dish. Ten fourth instar larvae and ten adults (5 males + 5 females) of each Coccinellids were collected from the cultured population and released in each Petri dish for each one thousand first instar nymphs. The Petri dishes were observed daily for counting the number of consumed and unconsumed nymphs of mealy bug till the predator's fourth instar metamorphosed in to pupae. For the studies of field condition insect nets of different sized were used. Only the first instar nymphs of the mealy bug were allowed to infest on cotton plants. The number of first instars of mealy bug were counted before the release of fourth instar larvae and adults of different Coccinellids on them.

The experiments in laboratory and field were carried out at temperature 25 ± 3°C, 35 ± 5°C and humidity 62 ± 6% and 78 ± 4%.

Results

Consumption rate of fourth instar larvae of Coccinellids

The results (Table1-1) revealed that the fourth instars of *B. suturalis* (53.56 ± 2.1) showed more predatory potential than that of *C. septumpuctata* (49.65 ± 2.3), *H. variegate* (47.94 ± 2.3), *M. sexmaculatus* (41.38 ± 2.4) and *H. maindroni* (18.5 ± 1.8) under laboratory conditions. Under field conditions, fourth instar of *B. suturalis* (43.5 ± 2) exhibited more predation followed by *H. variegata* (40 ± 3.9), *C. septumpunctata* (37.91 ± 2.6), *M. sexmaculatus* (32.3 ± 3.5) and *H. maindroni* (11.1 ± 2.5) (Table -2).

Table 1
Consumption rate of different life stages of Coccinellids in laboratory conditions.

	Life stages of C occinellids	
Coccinellid Sp	Adult	Larva
Coccinella septumpunctata	36.80 ± 3.2	49.65 ± 2.3
Menochilus sexmaculatus	29.12 ± 1.8	41.38 ± 2.4
Hippodamia variegata	30.93 ± 2.3	47.94 ± 2.3
Brumoides suturalis	35.22 ± 1.6	53.56 ± 2.1
Hyperaspis maindroni	24.8 ± 2	18.5 ± 1.8

Table 2
Consumption rate of different life stages of Coccinellids in Field conditions.

	Life stages of C occinellids	
Coccinellid Sp	Adult	Larva
Coccinella septumpunctata	27.74 ± 2.3 c	37.91 ± 2.6
Menochilus sexmaculatus	20.2 ± 3.5	32.3 ± 3.5
Hippodamia variegata	21.1 ± 3.4	40 ± 3.9
Brumoides suturalis	24 ± 2.4	43.5 ± 2
Hyperaspis maindroni	15 ± 1.2	11.1 ± 2.5

Consumption rate of adults of Coccinellids

Among adults, *C. septumpunctata* (36.80±3.2, 27.74±2.3) showed significantly higher predatory potential followed by *B. suturalis* (35.22 ± 1.6, 24 ± 2.4), *H. variegata* (30.93 ± 2.3, 21.1 ± 3.4), *M. sexmaculatus* (29.12 ± 1.8, 20.2 ± 3.5) and *H. maindroni* (24.8 ± 2, 15 ± 1.2) in laboratory (Table -1) and field conditions, respectively (Table - 2).

Correlation between Mealy bug and Coccinellid Populations

The relationship between mealy bug population and predatory Coccinellids was studied statistically by using correlation coefficient. The population of Coccinellids was found to have strong positive correlation with the population of mealy bug. The straight line equations were determined among the larvae and nymphs of mealy bug as y = 1242.36 + 46.83x, y = 1281.81 + 52.27x, y = 1105.70 +49.93x, y = 438.40 +48.53x and y = 560.93 + 58.77xfor *B. suturalis*, *C. septumpunctata*, *H. variegata*, *M. sexmaculatus* and *H. maindroni*, respectively. Among adults and nymphs of mealy bug, the straight line equations were calculated as y = 0.20 + 284.38x, y = 224.36 + 175.71x, y = 327.23 + 221.78x, y = 522.92 + 130.60x and y = 197.26 + 151.66x for *B. suturalis*, *H. maindroni*, *M. sexmaculatus*, *H. variegata* and *C. septumpunctata,* respectively (Fig. 1).

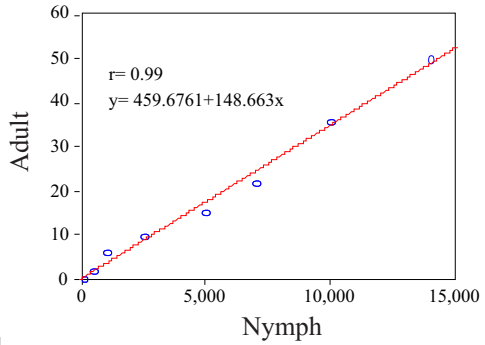

Fig.1
Coccinella septumpunctata adults and larvae on *Phenacoccus solenopsis* nymphs.

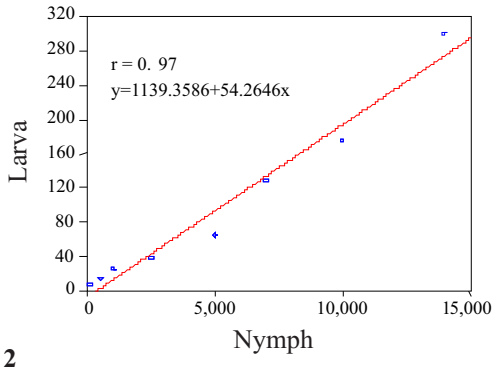

Fig. 2
Coccinella septumpunctata adults and larvae on *Phenacoccus solenopsis* nymphs.

DISCUSSION

Many researchers conducted the same research in different areas of Sindh. For example, Mahmood *et al.* (2011) recorded the Coccinellids: *B. suturalis* (Fabricius), *S. coccivora* (Ayyar), *S.* sp*, Nephus* sp.*, Cheilomenes sexmaculatus* (Fabricius), *C. septempunctata* (L)*, Hyperaspis* sp., *Adonia* sp. and *Exochomus* sp. feeding on *P. solenopsis*. According to above researcher's findings, *B. suturalis* was found consistently on all population levels of the mealybug on all the plants examined, while others were mostly found on high mealybug populations. Sahito *et al.* (2011) conducted a study on the effects of biological factors on the populations of *P. solenopsis* in different locations of Khairpur, Naushahro Feroze, Sanghar, Matiari, Hyderabad, Mirpurkhas, and Tando Allahyar districts and recorded *C. septumpunctata* predating on this mealybug.

The above findings support the present study that the mealy bug, *P. solenopsis* (Tinsley) is predated by different Coccinellids in Sindh.

Neetan and Aggarwal (2011) reported that *B. suturalis* was more abundant in the colonies of *P. solenopsis* than other

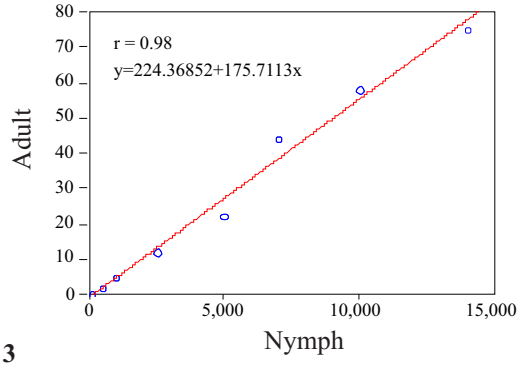

Fig. 3
Menochilus sexmaculatus adults and larvae on *Phenacoccus solenopsis* nymphs

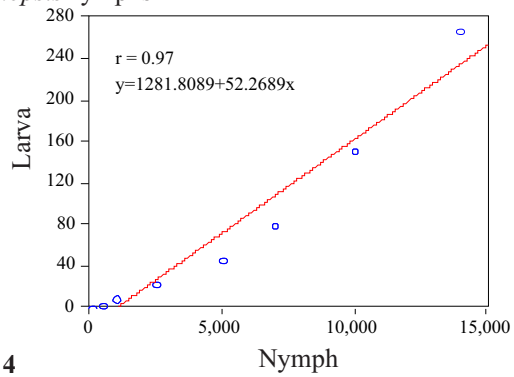

Fig. 4
Menochilus sexmaculatus adults and larvae on *Phenacoccus solenopsis* nymphs

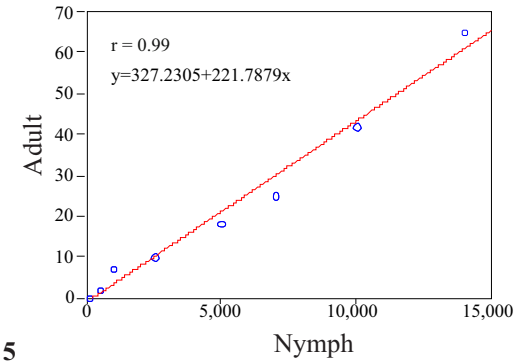

Fig. 5
Hippodamia variegata adults and larvae on *Phenacoccus solenopsis* nymphs

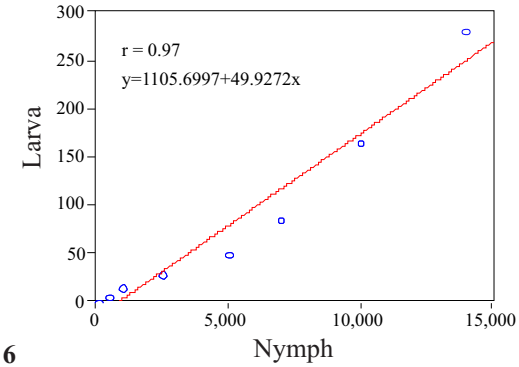

Fig. 6
Hippodamia variegata adults and larvae on *Phenacoccus solenopsis* nymphs

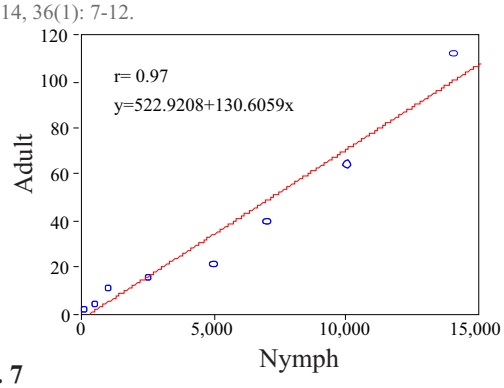

Fig. 7
Brumoides suturalis adults and larvae on *Phenacoccus solenopsis* nymphs

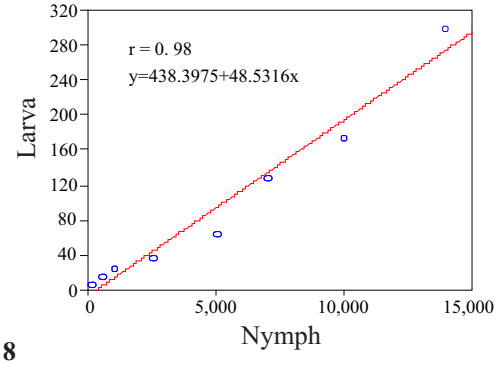

Fig. 8
Brumoides suturalis adults and larvae on *Phenacoccus solenopsis* nymphs

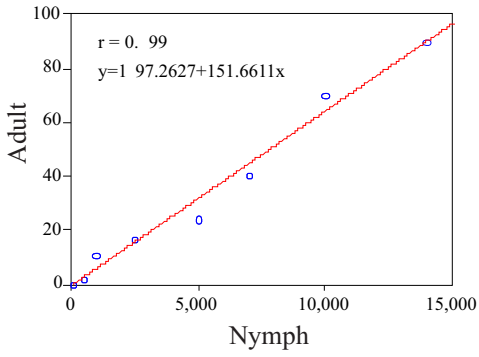

Fig. 9
Hyperaspis maindroni adults and larvae on *Phenacoccus solenopsis* nymphs

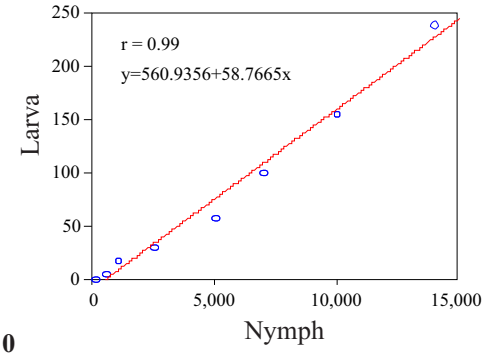

Fig. 10
Hyperaspis maindroni adults and larvae on *Phenacoccus solenopsis* nymphs

Fig. 1-10
Correlation and regression between population density of coccinellids and *Phenacoccus solenopsis* on cotton.

Coccinellids. Their findings support the present research. Similarly, Mahmood *et al.* (2010) reported that *B. suturalis* was consistently present on all population levels of the mealy bug, *P. solenopsis* while others species of Coccinellid were mostly found on high mealy bug populations. This prooves higher predation rate of this Coccinellid species than others. In the present study *B. suturalis* proved more potential Coccidophagous species than other Coccinellids. According to Arif *et al* (2011), the per-day consumption of fourth instar of some native predatory species of Coccinellids ranged from 37 to 46 nymphs, being significantly higher by *H. convergens* and lower by *M. sexmaculatus*. These findings were found significantly different from that of other life stages. Adults of all predatory Coccinellid species ranged from 22-26 nymphs but found higher in C. *septempunctata* and lower in *B. suturalis* in case of adults. The present study corrected misidentified species in the finding of Arif *et al.* (2011) as *Hippodamia variegata* and *Brumoides suturalis* .In the present investigation, the mean per day consumption of the fourth instar larvae and adults of the Coccinellids in both laboratory and field conditions were slightly higher than the above-mentioned findings According to Khuhro *et al.* (2012), the fourth instar of *B. suturalis* devoured maximum mean number of mealy bugs (55.11±1.38) whereas, adult females devoured more number of mealybugs' nymphs (131.51±2.10) than male adults (129.57±314) per day under laboratory conditions. The field results showed that fourth instar of *B. suturalis* devoured more mean number of mealy bugs (34.6±1.41) whereas adult females devoured more mean number (72.03 ± 6.16) than male adults (69.9 ± 6.31) per day. These results supported the results of present study regarding consumption rate of fourth instar larvae but are contradictory to the results regarding adult consumption. The reason may be attributed to the variation in the life stage of the mealy bug offered for Coccinellid predators. The finding of Shera *et al* (2010) showed that the perday consumption of *Phenacoccus solenopsis* by *Coccinella septumpunctata* varied from 24 to 25.40.The similar trend of consumption was also observed in the present investigation.

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