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Potential of *Mallada boninensis* Okamoto (Neuroptera: Chrysophidae), as a biocontrol agent of *Oligonychus coffeae* Nietner (Acarina: Tetranychidae) infesting tea

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Green lacewings are considered to be one of the most effective generalist predators used in biological control. The larvae feed on pest aphids, scales, caterpillars, spider mites etc. infesting a variety of plants (McEwen *et al.*, 2001). Adults are generally not predatory and feed on nectar, pollen or honeydew while a few of them are predatory (Coppel and Mertins, 1977). Studies have demonstrated lacewings as effective predators of aphids, leaf miners, citrus psylla, citrus black fly etc. In recent years use of green lacewing species have been recommended for the IPM programme (Nehare *et a*l., 2004).

Red spider mite (RSM) is an important pest causing considerable crop loss in tea, *Camellia sinensis L.* (O. Kuntze). Severe infestation of this mite ultimately leads to defoliation (Selvasundaram and Muraleedharan, 2003). Control of this pest is mainly achieved by pesticide application. However, the a growing public concern about the impact of pesticides on the environment, pest resurgence, secondary pest outbreaks, development of resistance in arthropods to pesticides, and pesticide residue in the made tea have led to adoptation of integrated pest management approach.

Integrated control measures were suggested for the management of *O.coffeae* in south India (Selvasundaram and Muraleedharan, 2003). Many studies have been documented on the potential of natural enemies on red spider mites. Babu *et al.* (2004) reported the larvae of *Mallada boninensis* as predators of red spider mite in tea ecosystem, but only a little information is available on the biology of this species. Therefore, the present study was carried out to record the life cycle parameters and predatory potential of *M. boninensis* against the red spider mite infesting tea under laboratory conditions, to ascertain the feasibility of mass production of the same using different artificial diets.

Red spider mites were collected from UPASI Tea Experimental Farm in Valparai, Coimbatore District, Tamil Nadu and the RSM infested leaves were immediately transferred onto one year old potted tea plants in the green house. A stock culture was maintained for carrying out various experiments. Adults of red spider mites were transferred onto fresh tea leaves placed on moist cotton wool on the top of a sponge (0.5 inch thick) in plastic trays (42 × 30 × 6.5 cm) and kept at 25 ± 2°C temperature and 75 ± 5 % RH.

Egg masses of green lacewings were also collected from UPASI Tea Experimental Farm. The larvae were individually reared in large plastic containers (7.5 × 7.5 cm) provided with mite infested leaf which were replenished daily, until pupation. The newly emerged adults were sexed and pairs of male and female were introduced into plastic containers provided with an artificial diet (Honey: Glucose: Protinex: Yeast: Water 1:1:1:1:1) v/v for feeding and oviposition. The upper and peripheral sides of containers were covered with opaque paper to prevent penetration of light from outside. Eggs were harvested periodically and placed in separate containers for hatching.

Data on incubation period of eggs, developmental period of each larval instars and pupation period were recorded. The larvae were provided with mixed life stages of red spider mite (eggs, larvae, nymphs and adults) *adlibitum* in plastic containers as described above. Experiment was replicated ten times.

The stage specific predatory potential of different larval instars of lacewing was studied on different life stages of red spider mite. For this 150 numbers of each stage of red spider mite (Eggs, larvae, nymphs and adults) were introduced separately onto tea leaf-square (4 x 4 cm)

placed on moist cotton in Petri plates (9 cm dia) and a single larva of lacewing was introduced. The larvae used for each experiment were less than a day old and starved for 6 h prior to start of experiment by keeping them individually in separate Petri dishes. The number of red spider mite life stages consumed in 24 h were counted using a stereo binocular microscope (Olympus 10 X). The experiment was replicated 10 times.

Details on the life cycle of *M.boninensis* are given in Table 1. Developmental stages consist of an egg, three larval instars, pupae and adult. Earlier research indicated the larval duration of a related species *Mallada astur* (Banks) as 11.6 days (Venkatesan *et al*., 2002) and *Mallada basalis*, 11.8 days (Chang, 2000) which are closes to our observations.

Table 1. Life cycle of *M. boninensis* on *O. coffeae*

Life stages of *O. coffeae*	Duration in days *
Pre oviposition period	7.14 ± 0.89
Egg	5.13 ± 0.16
1ts instar	3.93 ± 0.08
2nd instar	4.72 ± 0.59
3rd instar	4.94 ± 0.18
Total larval period	13.59 ± 0.85
Pupal period	12.92 ± 0.29
Total developmental period (From egg to adult emergence)	31.65 ± 1.32

*Values represent mean of ten replication ± SD

Larval stages of many chrysopids cover the dorsum with debris including their own cast cuticles, remains of prey, and fragments of vegetables or other materials and such larvae are called trash carriers or debris carriers. This could be the protective mechanism for larvae against other predators (Canard and Principi, 1984). Similarly, in *M.boninensis* also this camouflaging behaviour was noticed.

The third instar larvae of *M. boninensis* spin a silken cocoon in which it becomes enclosed. This pupal period lasted for 12.9 ± 0.29 days. The total developmental period from egg to adult was recorded as 31.65 ± 0.26 days with minor variation in the duration of other related species like *M. basalis* (28.1 days) (Chang, 2000).

Data on predatory potential are given in Table 2. Predatory efficiency of *M. boninensis* increased with the advancement of instars. Third instar larvae showed high predation capacity on all life stages of red spider mites when compared to 1st and 2nd instars; this is in line with the observations made by Huang and Enkegaard (2009). Cheng (2007) stated that green lace wings with their high voracity and excellent searching ability have the potential to prevent the development of large mite populations. Chang (2000) and Lee (2003) have demonstrated successful mass production of a related species *M. basalis* on artificial diet in a cost effective manner. Further studies are needed to focus the attention towards developing high quality artificial diet for mass rearing of *M. boninensis* with enhanced egg laying and high rate of survival to minimize the practical difficulties in mass multiplication without depending on the natural host during the off seasons.

Table 2. Predatory potential of *M. boninensis* on *O. coffeae*

Larval instars	Number of red spider mites consumed*		
	Eggs	Nymphs	Adults
1st instar	45 ± 3.34	41 ± 6.95	17.8 ± 1.04
2nd instar	84 ± 4.12	76 ± 1.6	65 ± 3.11
3rd instar	110 ± 7.70	104 ± 2.97	91± 2.04

*Values represent means of ten replication ± SE

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