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Laboratory evaluation of chemicals against Giant African Snail, *Achatina fulica* bowdich and bio-assay studies on silkworm, *Bombyx mori* (L.)

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ABSTRACT

Giant African snail, *Achatina fulica,* a molluscan pest is posing a serious threat to mulberry in few hot spot areas of Karnataka, Tamil Nadu and other states. The snail is a highly polyphagous damaging more than 500 plant species including fruit crops, vegetables, ornamental plants and field crops. Its conspicuous occurrence is noticed during rainy season. The climatic conditions like high humidity (>80%) and moderate temperature (9 - 29° C) are more congenial for the population build-up of the pest. With regard to management strategies, among physical method of trapping, papaya stem waste was found to be the best material followed by mulberry shoots and cabbage. Among chemical baits evaluated Metaldehyde (2.5% DP) was found highly specific and efficient against target organism in all weather conditions causing highest mortality due to excessive secretion of mucus compared to Dichlorvos and Methomil baits. The bio-assay studies revealed that Metaldehyde bait is non-toxic to silkworms both by direct contact with silkworm in the rearing bed as well as by feeding mulberry leaves from the mulberry plants treated with Metaldehyde pellets applied to the soil around the mulberry plant base followed by irrigation.

Key words: *Achatina fulica*, *Bombyx mori*, Bait, Metaldehyde, Mulberry, Molluscicide, Specific, Bio-assay.

INTRODUCTION

Mulberry (*Morus* spp.) is inhabited by various insect pests like Pink mealy bug (*Maconellicoccus hirsutus*), Papaya mealy bug (*Paracoccus marginatus*), leaf roller (*Diaphania pulverulentalis*), thrips (*Pseudodendrothrips mori*), white fly (*Dialeuropora decmpuncta*) Bihar hairy caterpillar (*Spilosoma obliqua*), jassid (*Emposca flaviscens*) and cutworm (*Spodoptera litura*) etc. which brings down the leaf productivity and quality by 20-25% (Rajadurai *et al.,* 2005, Dandin & Giridhar, 2010, Narendra Kumar *et al*, 2011).

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In recent years, a non-insect pest, *Achatina fulica* Bowdich (Giant African snail) (Phylum: Mollusca, class: Gastropoda, order: Stylommatophora, family: Achatinidae) known for its destructive nature on cultivated plants where ever it occurs, most damaging land snail pests rank next only to insects (Ravi Kumara *et al*., 2007). It has spread to most of the Indo-Pacific areas including India, Sri Lanka, Malaysia, China, Taiwan, Japan, Philippines, Hawaii etc., (Anonymous, 2000). As the snails live up to five years with a total egg clutch up to 1,000 and 100 hatchling snails could produce 1 trillion individuals in a little over 7 years (Raut and Barker, 2002).

The snail is a highly polyphagous, nocturnal pest damaging more than 500 plant species including fruit crops, vegetables, ornamental plants and field crops. It feeds on all parts of the mulberry plant including the outer tender bark (Fig.1). Besides, the stinking smell of mucus layer released by them averse the silkworms from feeding (Shree *et al*., 2006). It is conspicuous occurrence is generally noticed during rainy season and the climate conditions like high humidity (>80%) and moderate temperature (9°C - 29° C) are more congenial for the population build-up of the pest (Thakur, 1998 and 2003).

Figure-1. Damage of mulberry plants by giant African snail

In recent times with change in environmental conditions abiotic and biotic factors, like temperature, rainfall, humidity, fertilizer doses, irrigation methods, natural enemy complex etc. this pest *Achatina fulica*, hitherto considered endemic and minor has become a major pest to mulberry threatening the sericulture industry especially in southern sericultural belt of Karnataka (Narendra Kumar *et al.,* 2011; Sreenivas *et al*., 2011). Considering economic threat of the pest in mulberry ecosystem the present study was conducted to evaluate the effective chemical baits against snails and safety to silkworm.

MATERIALS AND METHODS

The study was conducted at the insectary of Pest Management Laboratory (PML), Central Sericultural Research and Training Institute (CSR&TI), Mysuru. *Achatina fulica*, were reared in control conditions (Fig.2) for evaluation of effective trapping materials and chemical baits and also bio-assay studies of the identified chemical for its safety to silkworms.

Evaluation of trapping materials under mechanical methods:

Plant materials and organic substances such as papaya stem waste, banana sheath waste, sugarcane bagasse, areca leaf waste, vegetable waste (especially cabbage), etc., are known to attract snail population towards them. Among them locally and easily available materials viz. papaya stem waste, cabbage and mulberry shoots were selected for evaluation.

In this experiment, five kilograms each of split papaya stem waste, cabbage and left out mulberry shoots were placed in two rows randomly with 3 replications at a distance of 10 feet in an isolation chamber of dimension 40 ft x 30 ft having mulberry plantation with 3 ft x 3 ft spacing. A known number of snails (50 numbers) were released at the centre of each replication in the evening hours. After 15 hours, numbers of snails attracted and hiding under different trapping materials were counted. The standing mulberry crop was considered as control. The trapping material harboring more number of snails was considered as the most effective trapping material.

Figure-2. Snail rearing

Evaluation of chemical baits against snails:

Three chemicals *viz.*, Metaldehyde, Methomil and Dichlorovos were selected for evaluation of their impact on the snails. Ten adult snails were kept in an aerated plastic box (size 12” dia) and 2-3 Metaldehyde pellets (Fig.3) were kept in each box for direct contact with silkworm along with control (no pellets) with three replications. The mortality of snails was recorded at intervals of 24 hours for 6 days. The experiment was repeated with 3 trials.

Figure-3. Metaldehyde pellets

In another set of experiment, Dichlorvos (76% EC) bait was prepared by mixing 250 ml dichorovos with 200.0g fermented Jaggary solution and 1000.0 g wheat floor. The bait was fed to 10 snails and observed for mortality at 24 hrs interval. Simultaneously control batch was also maintained.

Similarly, Methomil (40SP) bait was prepared by mixing 10.0 g chemical to the 200.0 g fermented jaggary solution and 1000.0 g wheat bran with 400.0 ml water. The bait was fed to 10 snails individually in an aerated plastic round box. Simultaneously control batch was also maintained. The observation on the mortality was recorded at 24 h interval.

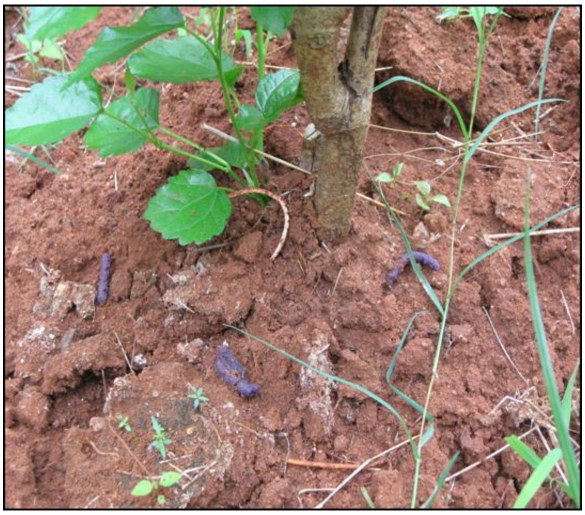
Bio-assay studies of Metaldehyde (2.5%) for the safety of silkworms

This experiment was conducted in the laboratory by utilizing 4^{th} age silkworms till spinning. A total of 50 silkworms in 3 replications and 3 trails were maintained in small plastic rearing trays (size: 2' x 3') by following standard rearing procedure as per Kawakami (2001). Mulberry leaf was fed to silk worm along with 10-15 metaldehyde pellets in the rearing trays to assess the toxicity (Fig.4).

Figure-4. Silkworm rearing with metaldehyde pellets

Data on mortality of silkworms at 24 h interval were recorded. Similarly, mulberry leaf harvested from the mulberry plants treated with Metaldehyde pellets applied to the soil around the mulberry plant base followed by irrigation was also evaluated for phytotoxicity (Fig.5). Mulberry leaves harvested from the treated plants were fed to silkworm at the intervals of 5, 10, 15, 20, 25 days after treatment (DAT).

Figure-5. Application of metaldehyde pellets to mulberry plants



RESULTS AND DISCUSSION

Evaluation of trapping materials:

Certain plant materials and organic substances such as papaya stem waste, banana sheath waste, sugarcane bagasse, areca leaf waste, vegetable waste (especially cabbage), etc are known to attract snail population towards them.

Number of snails attracted in 24 h by different trapping materials is presented at Table 1. The number varied significantly with different materials. The results revealed the papaya stem waste has attracted maximum number of snails (17.91) followed by mulberry shoots (13.82) with least preference to cabbage (7.49).

Table – 1. Evaluation of trapping materials under mechanical methods (Av. of 3 trials)

Sl. No.	Treatments	No. of Snails trapped	Rank of Treatments
1.	T-0 (control)	3.78^{D}	5
2.	T-1 (papaya stem)	17.91^{A}	1
3.	T-2 (Cabbage)	7.49^{C}	3
4.	T-3 (mulberry shoots)	13.82^{B}	2
5.	Escaped	7.00^{C}	4
	General Mean	10.00	
	p-Value	<.0001	
	CV(%)	23.71	
	SE(d)	1.043	
	LSD at 5%	2.1246	

(Means with at least one letter common are not statistically significant using Fisher's Least Significant Difference)

Therefore, papaya stem waste can be used for trapping the snails in the mulberry gardens, in the absence of which left out mulberry shoots can be used. The above result has been supported by the studies conducted by Ravikumar *et al.,* (2007) in the Areca eco-system in Shivamogga, wherein papaya stem waste attracted maximum snail population (55.66) on exposure for 24 h, followed by vegetable waste (48.33), fishmeal (18.33), areca leaf waste (15.33), banana sheath waste (10.00), sugarcane bagasse (3.33), leaf litter (3.33) and FYM (1.0). Similarly, Mahendale and Bhagwat (2004) also confirmed that cabbage fresh leaf waste was second best attractant next to papaya stem waste for trapping purpose.

Evaluation of chemical baits/pellets against snails:

With regard to three chemicals baits evaluated, the molluscicide, Metaldehyde (2.5%) was found to be more effective compared to Dichlorvos and Methomil baits. The mortality of snails due to various chemicals screened is presented at Table 2. Metaldehyde caused a mortality of 70% two days after treatment and 100% mortality four days after treatment. However, no mortality was recorded with dichlorvos and methomil bait on day-1 and 3.33% and 1.11% on day-2 after treatment and highest mortality was recorded with dichlorvos 96.67% and methomil 75.56% on day-6.

According to Javaregowda (2006) metaldehyde (2.5%) was found to be most effective and registered highest mortality after one day followed by Monocrotophos bait. Utility of different dosage of metaldehyde is reported by different workers in different horticulture ecosystems. Sharma and Agarwal (1989) reported 5 % metaldehyde pellets at 25 kg/ha to manage the snails and Basavaraju *et al.,* (2000) reported 2.5% metaldehyde pellets effective in controlling the snail occurring on betel vine (*Piper betel*) in Karnataka during kharif. Under lab conditions Basavaraju *et al.,* (2001), found metaldehyde pellets as most effective against *A. fulica*, compared to methomyl and carbofuran. The results of field experiments showed that Metaldehyde application (25 kg 2.5% metaldehyde pellets/ha) all along the borders of newly-established betel vine gardens was effective against snails. Rao and Singh (2002) reported mortality ranging from 49 to 74 snails per plant using Snail Kill (*i.e,* metaldehyde).

Ravikumara *et al*. (2007) found highest number of snails attracted to papaya stems waste bait along with metaldehyde (6.0 kg metaldehyde bait per acre). Metaldehyde based traps placed during or just after the onset of monsoon were effective in controlling snails in vanillary in Tamil Nadu (Vanitha *et al.,* 2008). Metaldehyde 2.5% pellets (25 Kg/ha) along with methomyl 40SP@10g/Kg of fermented food bait (50 Kg wheat bran+5 Kg Jaggery+yeast 30 g/ha) gave 70% control (Shevale and Bedse, 2009). Javaregowda

Table–2. Laboratory Evaluation of chemicals against snails (Av. of 3 trials)

Sl.No.	Treatment	% Mortality (day-wise)					
		Day- 1	Day- 2	Day- 3	Day- 4	Day- 5	Day- 6
1.	Metaldehyde	6.67	70.00	95.56	100	100	100
2.	Dichlorvos	0	3.33	57.78	78.89	87.78	96.67
3.	Methomil	0	1.11	6.67	43.33	58.89	75.56
4.	Control	0	0	0	0	0	0

Table–3. Bio-assay studies of Metaldehyde (2.5%) pellets on silkworm rearing bed along with mulberry leaf.

Sl. No.	Treatment	Mortality of snails (%)									
		Day- 1	Day- 2	Day- 3	Day- 4	Day- 5	Day- 6	Day- 7	Day- 8	Day- 9	Day- 10
1.	Metaldehyde (2.5%) pellets with rearing bed	No Mortality									
2.	Control	No Mortality									

Table-4. Bio-assay studies of mulberry leaves harvested from mulberry plants treated with Metaldehyde (2.5%) pellets applied to the soil around the mulberry plant base fed to silkworm.

Sl. No.	Treatment	Mortality of snails (%)				
		Day- 5	Day- 10	Day- 15	Day- 20	Day- 25
1.	Mulberry leaf harvested from Metaldehyde treated plant	No Mortality				
2.	Control	No Mortality				

(2006) and Ravikumar *et al.,* (2007) also reported the superior efficacy of metaldehyde and the least effectiveness of lime powder against *A. fulica,* which is in conformity with the present findings.

The mode of action of metaldehyde on snails and slugs was investigated in detail in several studies by Triebskorn *et al.* (Triebskorn, 1989; Triebskorn & Ebert, 1989; Triebskorn & Schweizer, 1990; Triebskorn *et al.*1998). The main findings of these studies were that the mucus cells of slugs and snails, typical for land molluscs, essential for land–life are irreversibly destroyed. It is also observed that the mortality of snails was caused due to excessive secretion of mucus in the laboratory studies (Fig.6). These findings also enlighten the fact that Mataldehyde is a highly specific molluscicide.

Figure-6. Mortality of snails due to excessive secretion of mucus

Bio-assay studies of Metaldehyde (2.5%) for the safety of silkworms

In the present study, when the Metaldehyde palettes were fed to silkworm along with mulberry leaf in the rearing trays so as to cause physical contact with the silkworms, no mortality was observed (Table -3). Similarly, mulberry leaves harvested from mulberry plants treated with Metaldehyde pellets applied to the soil around the mulberry plant base were fed to silkworms then also no mortality of silkworms was observed (Table-4). This clearly reveals that Metaldehyde is non-toxic and safe to silkworms. The results were supported by Bieri (2003). Srivastava and Upadhyay (2013); Bieri (2003) has revealed that metaldehyde is not phytotoxic and no cases of negative effect have been recorded on insects, annelids, wild living mammals and fishes. It acts as a highly specific molluscicide and efficient against both snails and slugs. Further, the chemical does not show any tendency to accumulate in soil, water bodies, plants and mammals. Under natural conditions it completely degrades to carbon dioxide and water.

CONCLUSION

Giant African snails emerging as serious pests with devastating effect in traditional sericultural areas of Karnataka, Tamil Nadu and other states with high incidence leading to a leaf yield loss to the extent of 10% in mulberry as per the field estimation conducted at CSR & TI, Mysuru during 2012-13. They are nocturnal in habit with several alternate host plants. Their infestation starts with the onset of monsoon and under go either hibernation or aestivation during severe winter or summer and hence farmers should keep a vigil over the pest during rainy season. Papaya stem waste serves as a good locally available material for trapping the snails.

If the population is too high, the host specific and effective molluscicide Metaldehyde (2.5%) pellets can be used for effective management of Giant African snails and it is safe to silkworm in all stages and non-phytotoxic. This study is also in conformity of the findings of Bieri (2003) who reported that metaldehyde is not phytotoxic and no cases of negative effect has been recorded on insects, annelids, wild living mammals and fishes. It acts as a highly specific molluscicide and efficient against both snails and slugs and can be used at any stage of silkworm rearing.

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Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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