Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(4): 134-137

Received: 15-05-2018
Accepted: 16-06-2018

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Occurrence of giant African snail, *Achatina fulica* bowdich in coffee growing areas of Karnataka and its management

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Abstract
A survey was conducted in the coffee growing areas of Karnataka, India. Among the three districts (Chikamagaluru, Hassan and Kodagu) surveyed, Kodagu District (Shanivarsanthe) recorded highest infestation of Giant African snail (GAS). Different types of attractive materials and baits were evaluated to find out the suitable and best attractant/bait to manage the GAS population in the field. Among them, chopped raw papaya followed by rice bran with jaggery was considered as effective in attracting highest number of snails. Earlier studies revealed that Methomyl 40 SP bait was effective and recommended for the management of GAS. The present study revealed that Thiodicarb 75 WP bait can be used as alternative for Methomyl for the management of Giant African Snail.

Keywords: Bait, coffee, giant African snail, management, methomyl, thiodicarb

Introduction
The Giant African Snail (GAS), *Achatina fulica* Bowdich is one of the most notorious pest in the world because of its economic, ecological and medical importance [1]. These land snails are abundant in the high rainfall areas of tropical countries. *A. fulica* is a major crop pest consumes over 500 plant species originated in East Africa and spreading across the globe primarily through human activities [2-5]. The introduction of *A. fulica* outside its native range dates back to the early 1800's, when it was spread to Ethiopia, Somalia, Mozambique and Madagascar. The first occurrence outside Africa was in West Bengal (India) through Mauritius in 1847. The World Conservation Union (IUCN) has listed *A. fulica* as one of the world's 100 most invasive species. Besides its adaptability in different ecosystems, *A. fulica* also serves as an intermediate host of rat lungworm, *Angiostrongylus cantonensis* which causes *Eosinophilic meningitis* in human beings [6]. In India, *A. fulica* snail was reported for the first time causing damage to ornamental and vegetable crops in Bangalore during Kharif season [7] and first reported in coffee plantations during 2003 at Araku valley zone of Andra Pradesh [8].This snail was supposed to spread to various parts of India through horticultural trade [9]. As of now, *A. fulica* has been established in almost all states of India and causing a serious threat to agriculture. In general, this snail is most abundant in sites with high human density [10].

A. fulica is a big sized, nocturnal and bisexual land snail. It has a narrow conical shell, contains 7 to 9 whorls when fully grown. The shell is generally reddish brown in colour with weak yellowish vertical markings. Shell length of the adults may exceed 20cm but generally ranges about 5 to 10 cm. The average weight of the snail is approximately 32 g [11]. It is generally regarded as herbivorous, feeding primarily on living and decaying vascular plant matter [5]. The olfactory receptors play a vital role in host finding, being mainly attracted to garden plants [12, 13].

It is an obligate-outcrossing hermaphrodite, which means that one externally fertilized snail can establish a population [14]. *A. fulica* produces large eggs that are 4.5 - 5.5mm in diameter and only hatch at temperatures above 15 ºC [9]. Snails begin laying eggs at six months of age and fecundity lasts approximately 400 days [14]. Snails lay up to 100 eggs in their first year and up to 500 in second year but snails may live up to five years with a total egg clutch of up to 1000 [5]. Egg hatches in few hours to 17 days and mature at around 5 to 15 months depending on the temperature.

Snails are generally nocturnal in habit and often seen resting on plants during daytime on cloudy and rainy days. In hot and dry environmental conditions, they seek shaded and high humid places for shelter. The climatic conditions like high humidity (> 80%) and moderate temperature (9 - 29 ºC) are more congenial for the population build-up of the pest [15]. When conditions are unfavorable, snails can become inactive or go in to a resting period called aestivation in which the body withdraw into their shell and stops feeding. Totally they survive in controlled metabolic activity and control is typically not possible if snails are in this resting condition.

In Karnataka, the first incidence of Giant African Snails was reported in coffee plantations at Bellarahalli village in Shanivarsanthe liaison zone of Kodagu district of Karnataka, India during August 2015. Since then, every year the incidence was noticed during the monsoon season in some coffee growing areas of Karnataka, India. Immediately after noticing in 2015, Entomology team of Coffee Board did surveys and experiments for the management of this pest. Considering the economic importance of the pest, the present experiment was conducted to find a suitable management strategy for this snail.

Materials and Methods

The study was initiated by collecting all relevant scientific information on the species. Survey and field experiments were conducted by the Division of Entomology, Central Coffee Research Institute (CCRI), Balehonnur, Chikamagaluru District, Karnataka, India during 2015- 16, 2016-17 and 2017-18. Initially after noticing the incidence of this snail, a complete survey was carried out in all the coffee growing areas of Karnataka and recorded the distribution. Since then every year regular surveys have been carried out and recorded the incidence and dispersal of the snail.

To identify possible management strategy, a field experiment was conducted to evaluate the best attracting materials to the snail in a private estate at Balehonnur during September 2015 with 10 replications per treatment. The bait material used were Wet Gunny bags

(44×26.5”), Wet gunny bags sprinkled with beer, Papaya stems (200 g), Chopped Papaya leaves (200 g), Chopped Raw papaya (200 g), Wooden logs (60 × 24”), Rice bran with jaggery (250 g) and Beer with salt.

Based on the preliminary studies, Chopped Raw papaya and Rice bran with jaggery were used as bait material to study the efficacy of different pesticides/chemicals during October 2015 in a private estate at Balehonnur. These chemicals were added to the bait material and mixed thoroughly. The treatments were replicated 10 times are as follows: T_1- Metaldehyde @ 2.5%; T_2- Rice bran (60kg) + Methomyl (1kg) + Jaggery (6kg); T_3 - Rice bran (60 kg) + Chlorpyriphos 20 EC (1 L) + Jaggery (6 kg); T_4 - Rice bran (60 kg) + (Chlorpyriphos 50 EC + Cypermethrin 5EC) 240 ml + Jaggery (6 kg); T_5 - Rice bran (60 kg) + Jaggery (6 kg) as control.

In 2017, as of Methomyl 40SP was not available in the markets of Karnataka. Considering the economic importance of this serious pest as well as realizing the paucity of Methomyl 40SP in the market, field experiments were conducted in a private coffee plantation to evaluate certain chemicals to find out alternate for Methomyl. Chemicals *viz*., Metaldehyde 2.5% pellets (1.5 kg/acre), Malathion 30 EC (600 ml), Thiodicarb 75 WP (160 g), Monocrotophos 36 SL (600 ml), Carbofuran 3 G (600 g), Dichlorovos 76 EC (300 ml) and Snail Guard @ 50 ml/litre of water was tested by mixing with bait (60 kg Rice bran + 6 Kg Jaggery) during July, 2017 to evaluate their effectiveness against Giant African Snail. Metaldehyde 2.5% and Snail Guard are available as ready to use molluscicides and were directly applied. Rice bran and jaggery alone without chemical was used as control.

Preparation of bait

Dissolve 6 kg of jaggery in required quantity of water. Insecticides/chemicals were mixed with fine rice bran powder (60 kg) and add the jaggery solution to rice bran mixture while continuously mixing the material. Consistency of the mixture should not be too dry or too wet.

The treatments were imposed in 10 x 10 feet square area by placing small round balls (approximately 250g) in between four coffee plants. Dried or fallen leaves were placed above or beside the poison baits. The bait fed snails died near the spot which could be easily collected and disposed after recording the number of dead snails. The observations were recorded on 1st and 2ndday after application of treatments at early morning hours. Total number of snails attracted towards the poison bait and number of dead snails were recorded. These snails secrete mucus profusely and unable to withdraw their body completely inside the shell and later turn black were considered as dead snails. Their mean mortality was worked out as under. Differences between treatments on different attractants and baits were studied using analysis of variance (ANOVA) and means were separated by Duncan’s multiple range test (DMRT).

Results and Discussion

Invasive pest species are one of the top threats to crop biodiversity. Once an invasive species establishes, it is very difficult to check their growth, population buildup, spread and damage or economic loss caused to the crop. Reddy and Sreedharan [8] reported high incidence of GAS from coffee growing areas of Araku valley zone in Visakha agency areas of Andhra Pradesh during the rainy season of 2003. In case of Giant African Snails, early identification of the incidence, spreading and management will result in reducing pest density. So, after noticing the incidence of snail at Shanivarsanthe, Kodagu District during 2015, survey on the snail was carried out extensively in the coffee growing areas of Karnataka. From the survey, spreading/dispersion of snail was noticed in 50 acres in and around Shanivarsanthe, whereas in Chikamagaluru District, the incidence was only restricted to two private estates, near Balehonnur during 2015. Because of its low potential for active dispersal, GAS activity is restricted to few areas, but they can reach high densities [4]. The survey was continued in 2016 and not much incidence was noticed. This may be due to less rainfall in the particular year. In 2017, a sudden outbreak of the snail was noticed and again survey was conducted. The population density of snails ranged from 1 to 2/coffee plant and 2 to 4 numbers/m^2 was noticed on the ground, surrounding paths and open places of coffee estates. In snail noticed estates, crops like banana, beans, cabbage, cucumber, cauliflower, tomato, pepper and chillies were severely affected. The damage was more pronounced in young seedlings in the field and nursery of these crops in Araku valley zone. In addition, the snails caused nuisance on walking paths in fields due to their slimy trails and broken shell pieces that could cause injuries. This survey information considered as a foundation stone for future research and also brought to limelight of growing problem which needs to be curtailed in the budding stage to avoid further consequences.

The response of *A. fulica* attracted towards different attractants in one night period in two different locations is presented in Table 1. Number of Giant African snails attracted varied significantly with different attractants tested. In both locations, maximum attraction was noticed in Chopped raw papaya and rice bran with jaggery. Least number of attraction was noticed in Beer with salt. Number of snails attracted by chopped papaya leaves and papaya stems were on par and significantly differed with wet gunny bags sprinkled with beer. Ravikumara *et al*. [16] recorded highest number of snails attracted to papaya stem waste followed by vegetable waste.

All the experiments were carried out using rice bran because of its low cost and easy availability. The snail mortality after 24 and 48 hrs of different chemicals tested with Rice bran and Jaggery varied significantly (Table 2). Mortality of snails ranged from 0 to 55.5. Among the treatments, highest mortality of snails observed in baits with Methomyl 40 SP followed by Metaldehyde 2.5% P after 24 hrs and 48hrs. No mortality was recorded in baits mixed with Chlorpyriphos 20 EC and Chlorpyriphos 50 EC + Cypermethrin 5 EC. Basavaraj *et al*. [17] recorded 100% mortality of giant African snail under laboratory condition using Methomyl 40 SP and metaldehyde. However, Methomyl registered less mortality in field condition compared to Metaldehyde. Shevale and Bedse [18] reported 70% control using Methomyl 40 SP at the rate of 10g / kg of fermented food bait (50kg wheat bran + 5 kg Jaggery + 1500g yeast)/ha and metaldehyde (2.5%) pellets (25kg/ha). Sharma and Agarwal [19] reported 5% Metaldehyde pellets at 25kg/ha to manage the snail and Basavaraju *et al*. [20] reported 2.5% Metaldehyde pellets effectively control the snail occurring in betelvine in Karnataka. Further, Rao and Singh [21] observed that mortality ranged from 49 to 74 snails per plant using Metaldehyde. Based on the result of this study Methomyl 40 SP and Metaldehyde was recommended for the management of snail.

During 2017, due to non- availability of Methomyl in the market which demanded an alternate chemical for the management of snail. The chemicals tested for the management of giant African snail in 2017 under field condition are listed in table 3.The experiment carried out to find out the alternate for Methomyl yielded Thiodicarb 40SP as very effective in case of killing the snails at the rate of 160g/ 60 kg rice bran and 6 kg jaggery followed by Metaldehyde. Number of snails killed after 24 hrs was more in Metaldehyde but in the second day more catch was found in Thiodicarb. It was evident that all the tested chemicals induced mortality to varying degrees. However, the most effective chemical was Thiodicarb followed by Metaldehyde. Moreover, for better performance, the chemical should not be dissolved and washed away in rains because in general, the snails are active during the rainy season. The Metaldehyde pellets were dissolved in rains and found no pellets after the cessation of rain. Firth *et al*. [22] found that Thiodicarb is effective as Methiocarb and more effective than Metaldehyde against slug, *Derocesas reticulatum* and *D. panormitanum* in vegetable crops. Thiodicarb is a non-systemic carbamate insecticide whose acetylcholinesterase activity is related to its main Methomyl degradation product [23]. Thiodicarb consist essentially of two Methomyl moieties joined through their amino nitrogen by sulphur, is rapidly degraded to S-Methomyl-N-[(Methylcarbamoyl)oxy] thioacetamide (Methomyl) in the stomach [24].

Table 1: Number of snails attracted by different attractants

Treatment No		Mean no. of snails attracted ± SE*	
		Location 1	Location 2
T1	Wet Gunny bags	14.3 ± 1.35d	13.6 ± 1.12d
T2	Wet Gunny bags sprinkled with beer,	24.1 ± 1.70c	21.7 ± 1.15c
T3	Papaya stems	31.4 ± 1.43b	29 ± 0.80bc
T4	Chopped Papaya leaves	37 ± 2.20b	34.1 ± 1.54b
T5	ChoppedRaw papaya	54 ± 1.48a	53.3 ± 1.64a
T6	Wooden logs	6.2 ± 0.41e	4.5 ± 0.70e
T7	Rice bran with jaggery	52 ± 1.64a	50.2 ± 2.09a
T8	Beer with salt	2.2 ± 0.55ef	1.5 ± 0.42f

*Means followed by the same letter do not differ significantly at $P = 0.05$ according to DMRT.

Table 2: Efficacy of different chemicals/ baits against *A. fulica* in the year 2015

Treatment No		Mean no. of snails dead ± SE*	
		After 24 hrs	After 48 hrs
T1	Metaldehyde 2.5% P	45.2± 0.57b	29.6± 0.45b
T2	Rice bran (60kg) + Methomyl (1kg) + Jaggery (6kg)	55± 1.23a	41± 2.63ab
T3	Rice bran (60 kg) + Chlorpyriphos (1 L) + Jaggery (6 kg)	0± 0c	0.2± 0.13c
T4	Rice bran (60 kg) + (Chlorpyriphos + Cypermethrin) @ 240 ml + Jaggery (6 kg)	0± 0c	0± 0c
T5	Rice bran (60 kg) + Jaggery (6 kg)	0 ± 0c	0± 0c

*Means followed by the same letter do not differ significantly at $P = 0.05$ according to DMRT.

Table 3: Efficacy of different chemicals/ baits against *A. fulica* in the year 2017

	Treatments	Mean mortality ± SE		Mean mortality ± SE
		After 24 hrs	After 48 hrs	
T1	Metaldehyde 2.5%	32.66 ± 4.63 a	10.3 ± 2.3ab	21.48 ± 3.47
T2	60 kg Rice bran + 6 Kg Jaggary + Malathion 30 EC	3.33 ± 0.88bc	5.33 ± 0.88bc	4.33 ± 0.88
T3	60 kg Rice bran + 6 Kg Jaggary + Thiodicarb 75 WP (160 gm)	25.00 ± 10.01ab	20.66 ± 3.48a	22.83 ± 6.75
T4	60 kg Rice bran + 6 Kg Jaggary+ Monocrotophos 36 SL (600 ml)	15.33±7.33abc	10.33 ± 6.35ab	12.83 ± 6.84
T5	60 kg Rice bran + 6 Kg Jaggary + Carbofuran 3 G (600 gm)	8.66 ±4.25abc	7.66±4.63bc	8.16 ± 4.44
T6	60 kg Rice bran + 6 Kg Jaggary + Dichlorovos 76 EC (300 ml)	9.33 ± 2.40abc	5.33 ± 2.60bc	7.33 ± 2.50
T7	Snail Guard @ 50 ml/litre	0.66 ± 0.33c	1.66 ± 0.66c	1.16 ± 0.50
T8	60 kg Rice bran + 6 Kg Jaggary	0.00±0.00d	0.00±0.00d	0.00±0.00

*Means followed by the same letter do not differ significantly at $P = 0.05$ according to DMRT.

Conclusion

The findings of the present study, clearly indicated that Thiodicarb 75% WP can be used as an effective alternative for Methomyl 40 SP for the effective management of GAS

Acknowledgement

The authors are grateful to the Director of Research, Coffee Board for support and encouragement during the study. We would like to thank Mr. Shaji Philip, CEO, Devadhanam Estate for allowing us to carry out all our experiments in the estate and Mr. Benny, Manager, Devadhanam Estate, Balehonnur for the assistance in data collection and facilities provided for carrying out the experiments.

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