Management of the giant African snail, *Achatina fulica* (Bowdich) (Stylommatophora: Achatinidae) in India

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ABSTRACT: The giant African snail, *Achatina fulica* (Bowdich) is one of the most extensively studied snails because of its economic, ecological and medical importance. An array of literature concerning its management is on record, both at global and the Indian context. This review provides an account of all management measures devised against *A. fulica* in different agri-horticultural ecosystems of India, serving as an update of currently known measures and possible impetus for designing future measures. Recommending an integrated approach involving cultural, mechanical, chemical and biological methods seems inevitable to manage the impact of the snail on Indian agriculture.

Keywords: *Achatina fulica*, giant African snail, IPM, molluscicides, metaldehyde baits

INTRODUCTION

The giant African snail, *Achatina* (*Lissachatina*) *fulica* (Bowdich) (Stylommatophora: Achatinidae), a native of east Africa has invaded many countries in the world and established as a polyphagous pest (Raut and Barker, 2002). It is reported to feed on at least 500 different types of plant species (Capinera, 2011) and is extensively studied snail of economic, ecological and medical importance (Mead, 1979; Raut and Ghose, 1984; Srivastava, 1992; Raut and Barker, 2002; Fontinilla *et al.*, 2007).

BIOLOGY

*Achatina fulica* carries a narrow, conical shell, half as wide as its length. The shell of fully grown adults has 7 to 9 ridges, or whorls. It is normally reddish-brown with faint yellowish vertical markings. The length of the adult shell may exceed 20 cm (8"), but usually averages between 5 and 10 cm and weighs, on average, 32 g. They are obligate-outcrossing hermaphrodites. The eggs, measuring 4.5 mm to 5.5 mm in diameter, hatch at temperatures above 15°C. Hatched snails become mature adults in 6 to 12 months and remain fertile for 400 days. A snail lays up to 100 and 500 eggs during the first and second years, respectively. Although the fertility rate declines after the second year, giant African snails may live up to 5 years, yielding a total of up to 1,000 eggs (Raut and Barker, 2002; Invasive Species Specialist Group, 2012). Raut and Barker, (2002) have enumerated numerous management measures practiced world over in addition to those in India. The present review is updated in addition to strategies mentioned in the former, thus serving as an update of currently known *A. fulica* management measures and intended to serve as a possible source for designing future measures.

GLOBAL PEST STATUS

*Achatina fulica* has been recorded in every continent except Antarctica and is a major crop pest across the globe (Mead, 1979; Raut and Barker, 2002) (Fig. 1). It is a classic example of an introduced species and has been listed as one of the world's 100 most invasive species by the International Union for Conservation of Nature and Natural resources (IUCN) (Lowe *et al.*, 2000). The giant African snail has gained attention due to its large size, supposed medicinal properties and its potential as human or animal food source (Mead, 1979; Raut and Barker, 2002) and its success as an introduced species is attributed to several factors *viz*., high reproductive capacity, voracious feeding habit, inadequate quarantine arrangements and human aided dispersal (Fontinilla *et al.*, 2007).

In India, it was believed to have been introduced in Chouringhie gardens of Calcutta in 1847 by the British Conchologist William Henry Benson and from there on spread to many states of the country in course of time (Mead, 1961). According to Malacologist Naggs (1997),...
although Benson had got the snail to India from Mauritius, he had handed over them to a friend before leaving India and it was the friend who released them in his garden. This perhaps has led to the large scale invasion of the snail in different parts of the country. Recent genetic studies indicate that all *A. fulica* now occurring throughout South Asia, Southeast Asia and the Pacific region are derived from one haplotype (Fontinilla *et al.*, 2007), the source being a single pair of specimens released in Chouringhie in 1847. On Andaman's, it is reported to have been introduced by the Japanese during the Second World War, indicating a second route of introduction of the pest into India (Srivastava, 1992).

**DISPERAL AND PEST STATUS IN INDIA**

Surveys carried out in India have revealed that, since its introduction, more than 140 years ago in Calcutta, *A. fulica* has spread and established in different parts of the country (Raut and Ghose, 1984; Srivastava, 1992; Raut and Barker, 2002) (Fig.2), reflecting the snails alarming invasive characteristics *viz.*, high reproductive rate (Fig.3) and generalist consumptive patterns. It is known to cause serious damage on different crops in India (Table 1 and Figures 4-6).

**MANAGEMENT**

The snail almost invariably assumes pest status when introduced to areas of favorable climate clearly pointing to the lack of significant population regulation by pathogens, parasites and predators, at least in the early phases of invasion by the pest. In pursuit of managing the pest, diverse management options including cultural, mechanical, biological and chemical, have continued to play a major role. Some of the main pest control methods practiced in Indian agro-ecosystems is reviewed in this article.

**Cultural control**

Sharma and Agarwal (1989) have recommended control measures including field sanitation by removing possible hiding places such as bushes and debris from fields to manage the snail menace.

**Mechanical or Physical control measures**

Adults of *A. fulica* are large enough to be seen easily and handpicking them from resting sites (garbage, weeds and house refuse) in the evening and the morning is crucial for managing the snails (Sharma and Agarwal, 1989; Shah, 1992). Snails are susceptible to different types of traps like food bait traps, hence several trapping devices have been used to monitor and manage the nocturnal snails. Physical barriers to prevent movement of snails reported by different authors in Raut and Barker (2002) include the use of a strip of bare soil around the crop, a fence with a screen of corrugated tin or security wire mesh. Ditches dig around the field and daily collection of snails. Protection of valuable horticultural plants during vulnerable seedling stage by ringing them with a strip of cardboard dipped in a suspension of metaldehyde. However no such physical barriers are
reported from India. Ravikumara et al., (2007) recorded highest number of snails attracted to papaya stem waste, followed by vegetable waste, fishmeal waste, areca leaf waste, banana sheath waste, sugarcane bagasse, leaf litter and farmyard manure. Handpicking, involving a considerable labour expense was found to be very effective in commercial nurseries in Bangalore south taluk (Jayashankar et al., 2009, 2010). As fecundity is a best indicator of invasive population of the snail (Jayashankar, 2010), management efforts therefore should include understanding of the reproductive behaviour to predict and perhaps impede, its spread in the introduced area. The snail is regarded sacred and referred to as Basavanna hula (in Kannada - The holy bullock incarnation) hence, there is a sense of stigma in eradicating it, more over some farmers believe it to be harmless facilitating crop growth (Jayashankar, 2011).

Chemical control measures

Molluscicides like metaldehyde are indispensable for the management of malacoafaunal pests in agri-horticultural ecosystems and there has been increasing interest in the use of different chemical formulations to curtail their imminent havoc. However, in most cases they are found to be non-selective and believed to endanger the survival of non-target snails, including the endemic fauna (Prasad et al., 2004).

Organic compounds

Metaldehyde

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 betle) 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

Fig. 2. DIVA-GIS generated map indicating current status and distribution of A. fulica in different states of India

- Reported as serious pest
- Reported, further details on pest status unavailable
- Reports unavailable
- Point of introduction into India and probable human aided dispersal

Table 1. Incidence of *A. fulica* on different hosts in India

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Host Plant</th>
<th>Reference</th>
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| 1     | *Eranthemum* spp. *Bougainvillea, Brassica oleracea* var. *botrytis,*  
|       | *B. o. var. capitata, B. campestris* var. *rapa, Phaseolus aureus,*  
|       | *Vigna radiata*                                                            | (Balasubramanian and Kalayanasundaram (1973))                             |
| 2     | *Vitis vinifera, Cajanuse cajan, Sesamum indicum, Amaranthus tricolor,*  
|       | *Beta vulgaris, Trichosanthes dioica*                                      | Singh and Roy (1977)                                                     |
| 3     | Ornamental plants                                                          | Veeresh et al. (1979)                                                    |
| 4     | *Ipomoea batatas, Cucurbita maxima, Tagetes patula, Carica papaya,*  
|       | *Luffa cylindrica, Lochnera rosea*                                         | Singh and Roy (1979)                                                     |
| 5     | *Morus rubra, M. indica, M. laevigata, M. serrata*                         | Thangavelu and Singh (1983)                                              |
| 6     | *Camelia sinensis*                                                         | Kakoty and Das (1988)                                                    |
| 7     | *Allium oleraceum, Solanum melongena, Lactuca sativa, Zea mays,*  
|       | *Sorghum, Saccharum, B.o. var. caulorapa*                                   | Sharma and Agarwal (1989)                                                |
| 8     | *Morus* sp.                                                                | Shree and Kumar (2002)                                                   |
| 9     | *Piper betle, Capsicum annum, Areca catechu, Musa sp.,*  
| 10    | *Averrhoa carambola, A. bilimbi, Moringa oleifera*                         | Prasad et al. (2004)                                                    |
| 11    | *Abelmoschus esculentus, Cucumis sativus, Solanum melanogenan,*  
|       | *Solanum lycopersicum, Tagetes patula, Catharanthus roseus,*  
|       | *Luffa aegyptiaca, Vigna unguiculata, Cucurbita pepo, Amaranthus tricolor,*  
|       | *Trichosanthes dioica*                                                     | Sheela Thakur (2004)                                                    |
| 12    | Home gardens and Flower pots                                               | Mavinkurve et al. (2004)                                                 |
| 13    | Coffee, *Musa* sp., *Phaseolus, B. capitata, Cucumis sativus,*  
| 14    | *Vanilla planifolia*                                                       | Vanitha et al. (2008)                                                   |
| 15    | *Solanum lycopersicum, Cucumis sativus, Morus sp, Rosa sp.*  
|       | *Tagetes sp, Arachis hypogaea, Phaseolus vulgaris, Carica papaya*         | Sridhar et al. (2012)                                                   |

Vine gardens was effective against snails. Rao and Singh (2002) reported mortality ranging from 49 to 74 snails per plant using SnailKil (a.i., metaldehyde). According to Javaregowda (2006), metaldehyde (2.5%) was most effective and registered highest mortality after one day of application, followed by monocrotophos bait. Ravikumara et al. (2007) found highest number of snails attracted to papaya stems waste bait along with metaldehyde (6 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).

**Organophosphates**

Basavaraju et al., (2001) recorded 100% mortality using baits prepared with monocrotophos (600 ml monocrotophos 36 SL + 60 kg rice bran + 6 kg jaggery/ha), carbofuran, methomyl and metaldehyde pellets under laboratory conditions. However monocrotophos bait recorded the lowest snail mortality compared to
metaldehyde followed by methomyl and carbofuran. Panigrahi and Raut (1993) injected dichlorvos at 1.0 ml into 15-20 g pieces of vegetable or fruit baits (Solanum lycopersicum, Cucumis sativus, Trichosanthes dioica, Vigna unguiculata and Hibiscus esculentus), against A. fulica and showed that the poisoned tomato and T. dioica was accepted by the snail and in all cases the pests died after consuming the baits. Saxena and Mahendra (2000) found wet wheat flour (5-10g/snail) bait to be effective compared to gram, barley and conflour and dichlorvos (1.2, 2.5, 3.0 & 3.5 mg/snail) provided more than 90% mortality in A. fulica with the mentioned concentrations compared to malathion, trichlorofon and mexacarbate less than 96 hours. The control trial set by Justin et al., (2008) against the snails suggested that spray of garlic extract (2%) or Neemazal (2 ml/L) as effective as soil application of phorate (Phorate 5G; 5 g/vine) granules in controlling the snails on vanilla vines.

**Carbamates**

Basavaraju et al., (2001) observed 100% mortality under laboratory conditions using carbofuran (600 g carbofuran 3G + 60 kg rice bran + 6 kg jaggery/ha) bait against the snail. However it recorded less mortality compared to metaldehyde followed by methomyl and monocrotophos. Basavaraju et al., (2001) used methomyl (600 ml methomyl 12.5 L + 60 kg rice bran + 6 kg jaggery/ha) bait against the snails and recorded 100% mortality under laboratory conditions. However, methomyl registered less mortality in the field compared to Metaldehyde. Shevale and Bedse (2009) recorded 70% control using methomyl 40SP at the rate of 10g/Kg of fermented food bait (50 Kg wheat bran+5 Kg...
Jaggery+1500g yeast)/ha and metaldehyde (2.5%) pellets (25 kg/ha).

**Pyrethroids**

Rao and Singh (2002) found cypermethrin to be effective against *A. fulica*.

To summarize the understanding on management strategies using baits, a few precautions are mandatory to follow. It is good practice to apply baits after a site is watered or irrigated, as this stimulates snail activity, increasing the likelihood that baits will be eaten. However, none of the baits are completely effective because molluscs sometimes learn to avoid toxicants or may detoxify pesticides, recovering from sub-lethal poisoning. (http://ohioline.osu.edu/ent-fact/pdf/0020.pdf). Also, the ability of the snail to develop resistance is not monitored and remains to be explored.

**Inorganic compounds**

Kakoty and Das (1988) recorded 100% mortality using copper sulphate to manage the snails infesting tea estates. Sajeev (2011) adopted a control method of initially baiting the snail using cabbage leaves followed by spray with Tobacco decoction, made with Copper sulphate mixture (TDCS mixture). In addition to molluscicides, sodium chloride (common table salt), is proven to be an effective dehydrating agent and may be used as a barrier application on the perimeter of known/ suspected snail-infested areas (Shah, 1992). However, frequent renewal of such barriers during periods of rain or high relative humidity was recommended. Karnataka et al. (1998) recorded hundred per cent mortality after 96 hours at 5 per cent spray of sodium chloride.

**Botanicals**

The most effective concentration of the extract from Kernels of the fruit of *Thevetia peruviana* (Pers.) was 20 per cent; it killed 100 per cent of snails within a day, when the extract was exposed on the soil in experimental trays or when it was applied on potato slices offered as food to the gastropods (Panigrahi and Raut, 1994). Rao and Singh (2002) found *Cedrus deodara* oil to be more toxic among molluscicides of plant origin against *A. fulica* in single treatments while in binary treatments a combination of *Cedrus deodara*+*Allium sativum* to be more toxic. Softwood cutting fences made of alligator apple (*Anonona glabra*) acted as snail repellents to protect the nursery beds (Prasad et al., 2004). The control trial set by Justin et al., (2008) against the snails suggested that spray of garlic extract (2%) or Neemazal (2 ml/L).

**Biological control measures and Natural enemies**

*A. fulica* almost invariably assumes pest status when introduced to areas of favourable climate clearly points to the lack of significant population regulation by pathogens, parasites and predators, at least in the early phases of pest invasion (Simberloff and Gibbons, 2004).

**Microbes**: A solution of bacterial pathogen that causes leucoderma-like disease extracted from dead snails sprayed on healthy snails provided significant control. Raut and Panigrahi (1989) reported 8 different types of pathogen caused disease in *A. fulica*. Spraying an aqueous extract of diseased *A. fulica* onto snails and their food plants gave satisfactory control (Srivastava et al., 1985).

**Invertebrates**: The predatory turbellarian flatworm, *Platydemus manokwari*, introduced in late 1981 and early 1982 effectively reduced the snail population infesting cover crops (*Pueraria* sp. and *Centrosema* sp.) in about 20 months in the Philippines (Muniappan et al., 1986). Such introductions has not yielded necessary relief in India wherein effective bio-control agents including *P. manokwari*, *Bipalium indica*, predatory snails *Euglandina rosea* (Ferussac) and *Gonaxis quadrilateralis* (Preston) have either led to destruction of native snails after introduction or failed to establish due to low reproductive potential when compared to the high reproductive potential that of the giant African snail (Srivastava et al., 1992). Neither did reliance on the local carnivorous snail, *Gulella (indoennea) bicolor*, served any success as it was susceptible to chemicals used against the pest (Srivastava et al., 1985). In Andaman Islands, the former authors also recorded a predatory millipede, *Orthomorha* sp., and hermit crabs, *Coenobita* spp., actively predating the snails and were not affected by molluscicides.

**Vertebrates**: Several vertebrate enemies of *A. fulica* have been reported by various workers in the Indian subcontinent. Avian fauna including *Centropus sinensis*, *Dendrocitta vagabunda*, *Tyto alba* and *Bubulcus ibis* and ducks are reported as effective predators of *A. fulica* (Mead, 1961; Raut and Ghose, 1984; Srivastava, 1992; Tehsin and Sharma, 2000; Jayashankar, 2011). The bandicoot rat, *Bandicota indica* was observed to be an effective predator especially for its nocturnal habit and the ability to locate both active and aestivating snails (Raut and Barker, 2002; Jayashankar, 2011). However, to employ a serious pest to control another pest is not advisable (Raut and Barker, 2002). The mongoose,
**Herpestes mungo** is reported feeding on the giant African snail in Ceylon (Sri Lanka) (Srivastava, 1992). Buddha and Naggs (2007) have reported live individuals of *A. fulica* being eaten by crows, monitor lizards, common Mongoose, Swans and Pigs in Nepal. Das (1995) mentioned that, India star tortoise, *Geochelone elegans* though herbivorous in nature is known to eat animals including *A. fulica*, in captivity.

**Miscellaneous initiatives**

**Feed and fertilizer:** According to the information gathered by Buddha and Naggs (2007) from local people in rural parts of Nepal, *A. fulica* is used by fish farmers as a diet for *Clarias batrachus*. Srivastava *et al.* (1984) and Aboua (1990) recommend the use of snail both as feed and fertilizers due the high percentage of phosphate and lysine in the snail flesh. Educational campaign such as “Operation – Eat *Achatina fulica*” has been recommended and practiced in some countries with dense population of *A. fulica* to promote its consumption (Asamoah, 1999) and thereby regulate the snail population. Though there are no reports of snails consumed as part of nutritional diet in India, similar awareness would facilitate the use of snails as feed to poultry, piggery and also to be used in scientific studies.

**Public participation:** Creating awareness among public and farmers should be an active component of any control method adopted for wide area management. Sajeev (2011) has initiated such an effort in Kerala to manage the giant snail menace. The awareness program is designed to bait the snail using cabbage leaves followed by spraying tobacco decoction - Copper sulphate mixture (TDCS mixture).

**CONCLUSION**

Despite different management measures described above it has been observed that naturalised populations of *A. fulica* often eventually decline greatly following establishment. Such a decline is often preceded by an exponential increase phase and a stable phase (Mead 1961, 1979, Raut and Barker, 2002). Simberloff and Gibbons (2004) suggest a do-nothing approach to management as a potential rationale for species in which spontaneous collapse has been repeatedly observed. In conclusion an integrated approach is emphasized by various workers to manage the outbreak of the snail menace in different agro-ecosystems of the country. Tackling the menace of *A. fulica* warrants community approach as in case if other pests like rats, for its effective minimization or eradication.

**REFERENCES**


Review on giant African snail


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