https://doi.org/10.3126/adj.v17i1.67872

PREVALENCE OF SNAILS AND FARMERS' PRACTICE TOWARDS THE MANAGEMENT OF GIANT AFRICAN SNAIL, *Achatina fulica Bowdich*, 1822 IN KAPILVASTU, NEPAL

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ABSTRACT

The Giant African Snail (GAS), Achatina fulica Bowdich, 1822, is the world's largest, most damaging, and highly invasive land snail, capable of consuming about 10% of its body weight daily and affecting at least 500 types of plants. Despite the high incidence of this pest, management options are limited and ineffective. In this context, this study was carried out to assess overall snail distribution, damage and management practices adopted by farmers against GAS. A household survey of randomly selected 60 households was carried out using semi-structured questionnaires at Banganga Municipality-01, Kapilvastu, Nepal. The results revealed the prevalence of three different snails: the GAS, Achatina fulica Bowdich, 1822, the Common snail, Indoplanorbis exustus (Deshayes, 1834), and the Paddy Snail or Ghonghi or Ghongi, Pila globose (Swainson, 1822) in moist areas, drains, and grassy lands, among them, GAS causing the most significant damage during the rainy season. The most vulnerable stage of crops to GAS was the vegetative stage of development (53.3%) in vegetables and fruits, with the most preferred crop family being the Cucurbitaceae (45%). The majority of respondents (48%) believed that the lack of effective control measures was the main reason for the growing infestation and extent of damage. The 'Hand-picking and killing' method was considered the most effective and suitable method in the farming community over other control measures. It has been reported that the snail problem has increased over the years, and very little effort has been made by the concerned authorities to manage this pest. In conclusion, snails, especially GAS, pose major challenges to agricultural production in Nepal. Therefore, appropriate and cost-effective management strategies are required for their sustainable management.

Keywords: Ghonghi, Hand-picking, Invasive-pest, Kitchen-garden, Management

1. INTRODUCTION

The mollusks are soft-bodied invertebrates having exterior shells often made of calcium, which make up the second-largest phylum in the animal kingdom. Among the six taxonomic classes viz. Cephalopoda, Monoplacopoda, Amphineura, Scaphopoda, Bivalvia, and Gastropoda that make up this phylum, but only Gastropods include more than 80% of the species (Kumar, 2020a). *Achatina fulica* Bowdich, 1822, the Giant African Snail (GAS), is the most significant molluscan pest of crops (Gołdyn et al., 2016) attacking about 500 different plant species. The Global Invasive Species Database has listed GAS as one of the "100 Worst Alien Invasive Species " (Nelson, 2012). *A. fulica* is nocturnal (Raut & Barker, 2002), a hermaphrodite species (Pawson & Chase, 1984), native to Africa but introduced to tropical areas of the world (d'Ovidio et al., 2019). Land-dwelling mollusks have a simple

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life cycle: they deposit eggs that hatch into offspring, which, although often different in color from adults, have a similar form. Juveniles eat, grow into adults, and reproduce through either hermaphroditism or amphimixis (Wilson, 2007). Due to their high reproductive potential, a single snail can rapidly multiply into a large population, making their management challenging. During the day, they seek shelter in moist, shady areas, but at night, they emerge and damage various crops, resulting in significant economic losses (Kumar, 2020a).

GAS typically affects vegetables, decorative gardens, and small-scale agriculture (Prasad et al., 2004) and also crawls up the walls of houses in large numbers, degrading the aesthetics (Raut & Barker, 2002). The snails are extremely ravenous and easy to feed, devouring almost everything (Carvalho & Silveira Júnior, 2021).

They also serve as a vector of parasitic rat lungworm, Angiostrongylus cantonensis (Chen, 1935), which causes eosinophilic meningitis in humans (Pollard et al., 2008). Additionally, other mammalian species, such as rodents, dogs, and horses, can contract the disease in addition to humans (Pollard et al., 2008). According to data from Samoa, for instance, agricultural losses range from 45 to 85 percent for root crops (*Alocasia spp.,* yam leaves and stems, (*Discorea* spp.), taro petioles and above-ground tubers (*Colocasia*), vegetables (brassicas, sweet and green peppers, pumpkins), and young banana leaves, particularly Cavendish varieties (Pollard et al., 2008). A. fulica has been implicated in the transmission of plant diseases *Phytophthora palmivora* (Butler, 1919) in black pepper (*Piper nigrum* L.), betel pepper (*Piper betel* L.), coconut (*Cocus nucifera* L.), papaya (*Carica papaya* L.), and vanilla (*Vanilla miller*), Taro (*Phytophthora colocasiae* Racib) and *Phytophthora parasitica* Dastur in aubergine/brinjal (*Solanum melongena* L) and tangerine (*Citrus reticulata* Blanco). The relative value of *A. fulica* as a transmission agent in the epidemiology of these illnesses under typical cropping conditions has not been fully defined, even though the significance of these disease organisms is well documented (Gołdyn et al., 2016; Raut & Barker, 2002). It does appear that not much is being done to create better molluscicides (Martin, 1991). Crops of soy and corn suffered yield losses of 50% to 90% due to slug damage (Kumar, 2020a).

In Nepal, Budha and Naggs (2008) reported the first entry of GAS from the eastern part of Nepal, probably originating from India, and distributed it to the Terai region, Siwalik hills, Mahabharat Range's lower slopes, and Mid Hill ranges. Most of the warm, muggy tropics and subtropics are home to *A. fulica*. GAS can tolerate temperatures between 9 to 29°C (48 to 84°F). Air temperatures below 2°C (36°F) cease the activities the snail while above 30°C (86°F) cause aestivation (dormancy) (Nelson, 2012). Therefore, Nepal's Terai (Southern plain of the country) region is the most suitable space for the large-scale infestation the GAS. Metaldehyde, methiocarb, salt, or a mix of these compounds with other molluscicides are frequently used in a variety of bait formulations or foliar sprays for the chemical control of snails. The usage of metaldehyde, which is non-selective, could put the survival of non-target snails, particularly the endemic fauna, in peril (Prasad et al., 2004). There are only a few known bacterial pathogens and almost no viruses that can infect slugs or snails and there are no diseases with a strong potential for commercial development. Additionally, there are no known fungi that affect young or adult molluscs (Wilson, 2007). Despite being largely ignored in the literature on pest control, gastropod mollusk species today pose some of the most serious and difficult-to-solve problems to sustainable agriculture. As other pest groups like insects have seen the development of efficient control measures, gastropods are only now beginning to be recognized as important, particularly in certain crops in kitchen garden and fields (Raut & Barker, 2002). To prevent future infestations from spreading to new areas, swift control measures must be implemented (Nelson, 2012). The first mechanical approach for its management is collecting by hand and subsequent squashing (Kumar, 2020b). Conventional methods of GAS management are labor-intensive, unprofitable, and unsustainable, with many being environmentally unfriendly (Singh et al., 2005). Therefore, there is an urgent need for a management approach that integrate physical and mechanical methods, as well as use of botanicals and chemicals, to reduce crop loss. With the aim of developing a viable and effective management strategy, a study was carried out to identify the prevalent snail species in the study area, their host crops, the affected stages, and the common management practices followed by local farmers.

2. MATERIALS AND METHODS

2.1 SURVEY SITE

Based on the information from the Agriculture Knowledge Centre (AKC), Banganga Municipality-1 of Kapilvastu district, Lumbini Province, Nepal, was purposefully selected for the study. The AKC identified this area as having a serious infestation of giant African snails in its kitchen gardens (Figure 1).

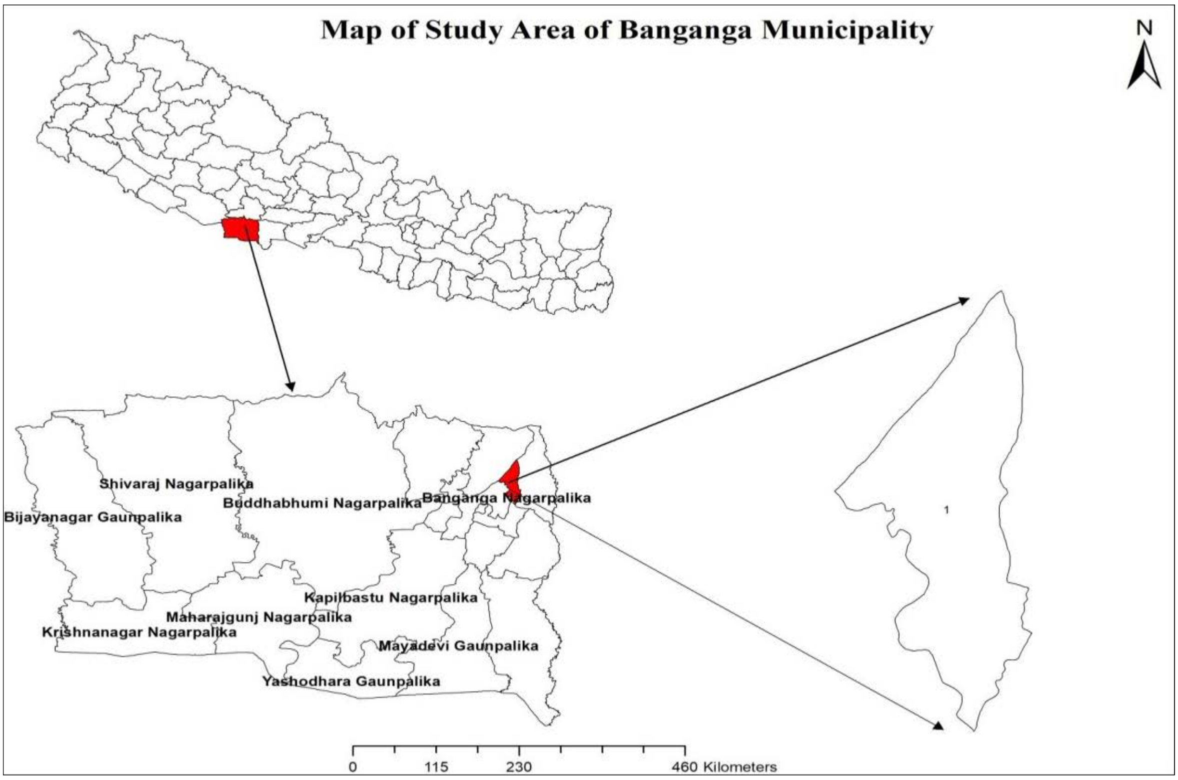

Figure 1. The survey site: Banganga-01, Kapilvastu, Nepal

2.2 QUESTIONNAIRE PREPARATION AND SURVEY

A semi-structured questionnaire was prepared to assess basic information about the Giant African Snail, its distribution, the host affected, the type of damage, and its consequences, along with management practices adopted. The questionnaire was pre-tested with the 10 kitchen garden farmers who were not part of the main survey. After the pre-test, some questions were added, and some were further simplified. An interview was carried out with the head of 60 kitchen garden households selected through the simple random sampling method which constituted the sample of the study. The farming households of the Banganga municipality who grew vegetables throughout the seasons every year constituted the population of the study. The sample size was taken to be almost 5% of the total kitchen garden households. Collected snails were identified by using snail identification manuals authored by Budha (2016). During the interview period, observations were made in person, and records were kept digitally using a camera.

2.3 STATISTICAL ANALYSIS

The data were generated from primary sources i.e., household surveys. Data tabulation and analysis were carried out by using MS Excel 2013 and SPSS (version 16.0). The final report was prepared using MS Word 2019 and Mendeley Desktop (version 1.19.8).

3. RESULTS

3.1 TYPES OF SNAILS COLLECTED AT THE FIELD

Three different types of snails, i.e., GAS, *Achatina fulica* Bowdich, 1822, Common snail, *Indoplanorbis exustus* (Deshayes,1834), and paddy snail or Ghongi, *Pila globose* (Swainson,1822) were identified (Budha, 2016) from the crop field of respondents (Figure 1; a, b, c). All the respondents noticed the presence of snails in the kitchen garden during the rainy season. Among them, the highest percentage (66.7%) observed all three types of snails, while 33.3% observed only GAS.

a **b** **c**

(a) *Indoplanorbis exustus (Deshayes,1834)* (b) *Pila globosa (Swainson,1822)* (c) *Achatina fulica Bowdich, 1822*

Figure 1. Different types of snails collected from Banganga-01, Kapilvastu, Nepal

3.2 SEASONAL DAMAGE, HOSTS PLANTS AND DAMAGE SYMPTOMS OF GAS

Rainy-season vegetables were found to be the most affected (78.3%), followed by winter vegetables (21.7%), as shown in Figure 2. No damage was observed in summer season vegetables. Among different developmental stages of plants, the vegetative stage was the most vulnerable (53.3%), followed by the seedling stage (25%). The lowest damage was observed during fruiting stage (8.4%) (Figure 3). Among the different hosts plants, respondents revealed that the highest damage was in cucurbits (45%), followed by fruits (25%), with the lowest damage observed in solanaceous crops (10%) (Figure 4). Defoliation (40%) was found to be the most severe symptoms of damage, followed by slime trails (26.7%) (Figure 5). Ribbon-like excrement was the least severe damage symptom observed (15%) (Figure 7).

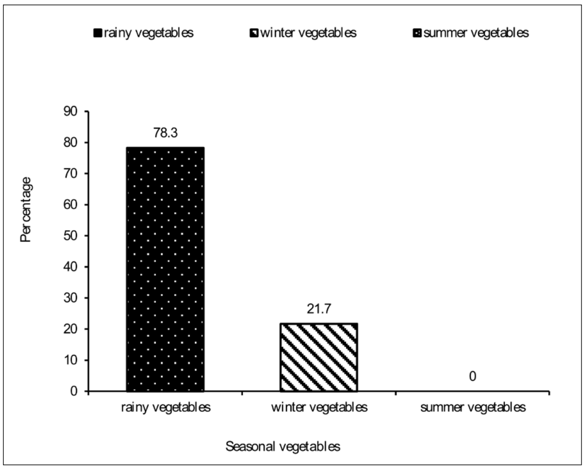

Figure 2. Affected rates of vegetables based on the season by Giant African Snail

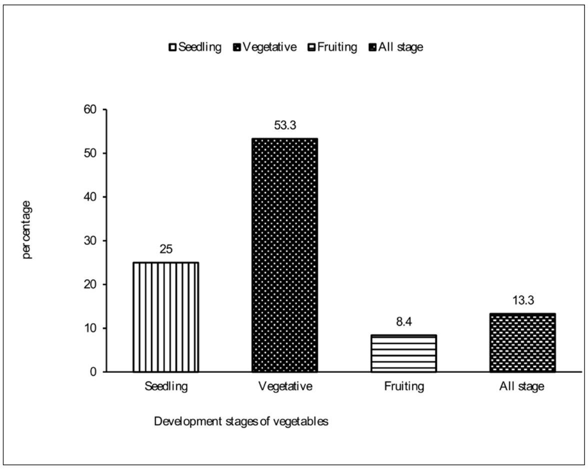

Figure 3. Stage of development of vegetables damaged by Giant African Snail

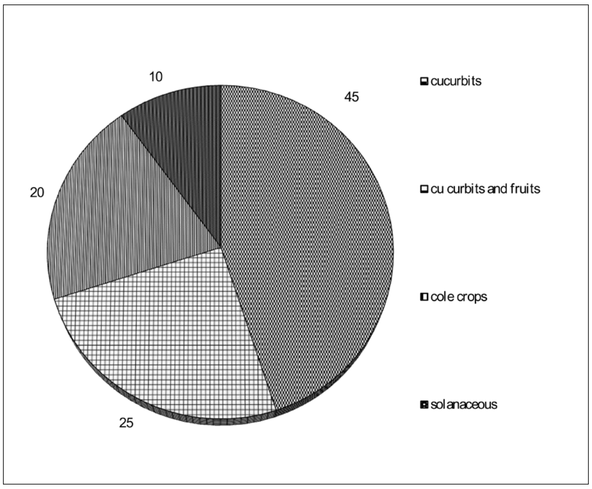

Figure 4. Hosts affected by Giant African Snail

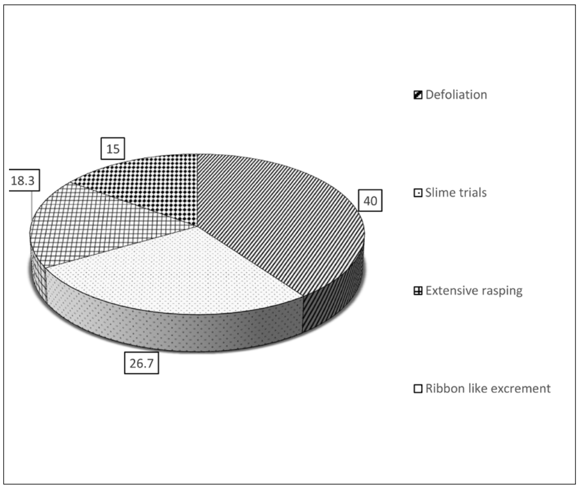

Figure 5. Sign of damage of Giant African Snail

3.3 TYPES OF DAMAGE

Respondents also reported that the highest percentage of damage was to crops (53.3%), followed by crops and the environment (28.3%), which includes disease transmission and the production of foul-smelling excrement. The lowest damage was observed in human health (8.3%), as GAS can transmit parasitic nematode, which causes serious health issues in humans and animals (Figure 6). Figure 7 shows the ribbon-like excrement symptoms of Giant African Snails observed in the kitchen garden.

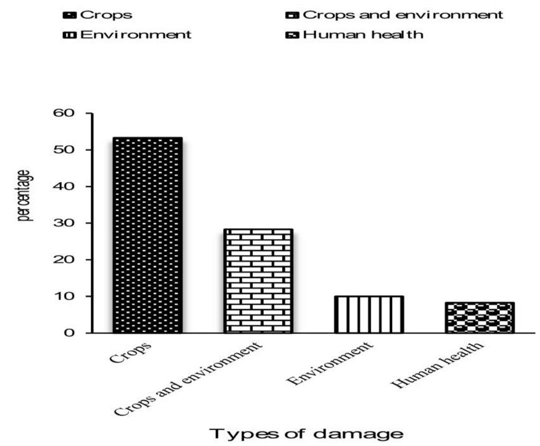

Figure 6. Type of damage caused by Giant African Snail

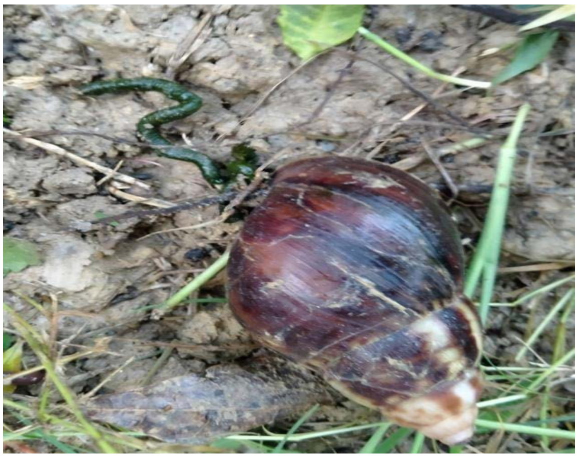

Figure 7. Ribbon-like excrement of Giant African Snail

3.4 INFESTATION FACTOR AND MANAGEMENT EFFORTS

Besides this, crop production practices were revealed as an influencing factor for infestations. Among these, a lack of effective control methods (48.3%) was found to be the primary factor, followed by poor drainage (26.7%). Excessive weed growth contributed (18.3%), while minimum tillage (6.7%) was the least contributing factor (Figure 8). All respondents were involved in different management efforts, with the highest percentage of involvement recorded in mechanical methods (46.7%) due to their cost-effectiveness and ease. This was followed by the use of salt (31.7%). The use of chemicals had a 21.7% response, while no response was found for the use of botanicals (Figure 9).

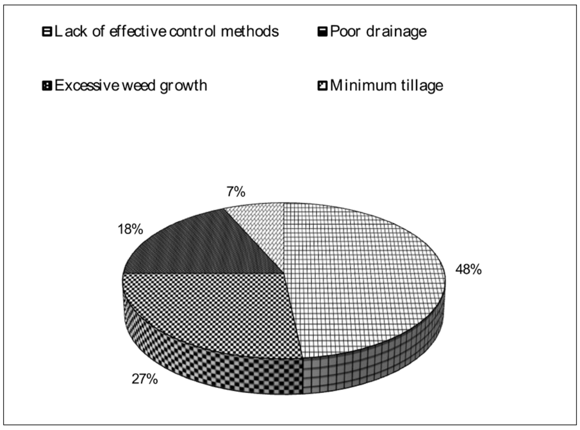

Figure 8. Crop protection practices influencing the Giant African Snail infestation

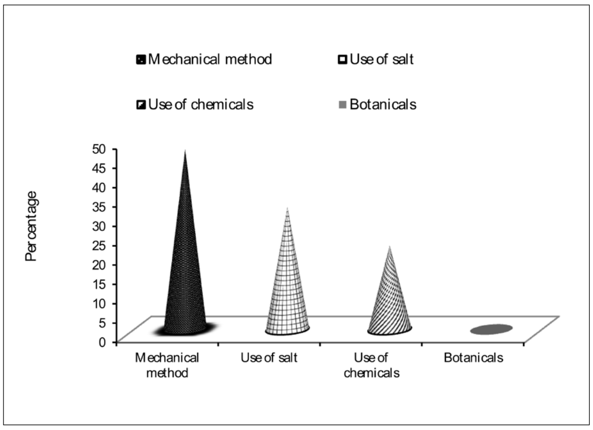

Figure 9. Crop protection interventions applied against the Giant African Snail

3.5 RANKING OF CONTROL EFFORTS AGAINST GAS

Hand-picking and killing were found to be the most frequently followed control measures, followed by the use of salt, while the use of chemicals was least preferred method (Table 1). Additionally, farmers were found to practice throwing pests into water canals, onto roads for crushing, or using rice husk as a barrier around crops.

Table 1. Ranking of control efforts adopted by farmers against *A. fulica* at Banganga, Kapilvastu in 2020

Control measures	Total score	Rank
Hand-picking and killing	6	1
Use of salt	5	2
Throwing in water canals	4	3
Throwing on the road for crushing it	3	4
Use of rice husk as a barrier around crop	2	5
Use of chemicals	1	6

4. DISCUSSION

Our study was limited to kitchen garden of surveyed households There was very little literature available assessing the status of snails and addressing the issues related to the Giant African Snail (GAS) in Nepal. Despite some farmers complaining about insect damage, the GAS is still mostly a concern for household kitchen gardens, primarily targeting vegetable crops (Pollard et al., 2008), which aligns exactly with our findings. GAS was found to be the most prevalent snail in the area, similar to the distribution reported in Africa (Raut & Barker, 2002), the Caribbean sub-region (Pollard et al., 2008), coastlines of Assam, Tamil Nadu, Odisha, Kerala, and West Bengal (Kumar, 2020a), and the Andaman and Nicobar Islands in the Bay of Bengal (Prasad et al., 2004). Prasad et al. (2004) reported that three families; Cucurbitaceae, Cruciferae, and Leguminoseae sustained the most harm, corresponding to our finding that cucurbit crops were mostly affected (45%). However, tuberous crops such as *Discorea* spp. and *Alocasia* spp. are equally affected by GAS in Caribbean sub-regions (Pollard et al., 2008). Fruits ranked second in the kitchen garden in our study, but in the Caribbean sub-region, numerous fruit trees, including tannia, pineapple, mango, breadfruit, coconut, and citrus, are equally harmed (Pollard et al., 2008). This may be due to the prevalence of fruits as the main crop in the study area. Similarly, ornamental plants such as hibiscus, gliricidia, variegated immortelle, croton, aloe, and ornamental palms are also affected if present in the kitchen garden (Pollard et al., 2008) , but our study was not solely limited to ornamentals.

GAS rely on the availability of moisture; hence, their activity is limited to the monsoon season (Raut & Barker, 2002), which aligns with our findings showing that rainy-season crops are predominantly affected. Additionally, Carvalho and Silveira Júnior (2021) in Brazil reported that during the rainy season, when precipitation rises by about 2276.9 mm, the majority of locals (approximately 82% of the interviewees) confirmed a significant increase in the prevalence of GAS, corroborating our observations. Higher rainfall corresponds to increased sexual activity among the snails. For example, in May and June 2007, with rainfall measuring 180 mm and 202 mm, respectively, 41% and 43% of the snails were sexually active. In contrast, only 5% and 9% of the snails were sexually active in January and February, the months with the least amount of rainfall (19 mm and 37 mm, respectively) (Silva & Omena, 2014). Although we did not record precipitation and moisture levels during the survey period, the highest response percentage regarding infestation of rainy-season vegetables was reported (78.3%). This could be attributed to increased sexual activity during the rainy season (Silva & Omena, 2014). The inactivity observed during the winter season may be due to the onset of dry weather, which triggers *A. fulica* to undergo aestivation (Kumar, 2020a; Raut & Barker, 2002).

GAS primarily harm vegetables and are seen as a serious issue in kitchen and backyard gardens (Budha & Naggs, 2008; Thiengo et al., 2007), which corroborates our results. We found the vegetative stage to be mostly vulnerable, similar to the report of Budha and Naggs (2008), but in contrast to the finding of Raut and Barker (2002), who reported seedling or nursery stage is most vulnerable irrespective of the crop. Like Raut and Barker (2002), we also have reported defoliation to be a mostly noticed symptoms of infestation. Raut and Ghosb (1983) reported leaf consumption as the most preferred feeding behavior in castor, drumstick, pothos, fig, bottle gourd, papaya, etc. which supports our finding where defoliation symptoms gained the highest (40%) response. In general, people adopted diversified practices of gathering and killing, using salt, throwing in water canals, throwing on the road for crushing, use of rice husks as a barrier around the crop, use of chemicals such as metaldehyde (Sajeev & Vijayan, 2014). Our findings reported the gathering and killing method to be the mostly adopted method of management followed by the use of salt which exactly matches with the previous results (Budha & Naggs, 2008; Kumar, 2020b; Raut & Barker, 2002; Thiengo et al., 2007; Shah, 1992).

5. CONCLUSION

The Banganga Municipality-01 of Kapilvastu, Nepal offers ideal conditions for the survival, growth, and reproduction of the GAS. GAS has been found to be very destructive in kitchen gardens, especially during the rainy season. However, most farmers have little knowledge regarding the consequences of their presence and management practices. Different management efforts have been adopted, with hand-picking being a major practice, followed by the use of salt and the application of chemical pesticides. If proper strategies and awareness regarding GAS management are developed by stakeholders, including local government, and concerned organizations, better control of GAS could be achieved. Additionally, healthy, and fresh crops could be harvested from the kitchen garden with minimal GAS trouble if managed rationally.

DECLARATION

The authors declare no conflict of interest.

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