# 1. INTRODUCTION

## 1.1. Background

The giant African land snail *Achatina fulica* (Bowdich, 1822) is one of the largest terrestrial gastropods with the maximum size reached upto 20 cm in length and one kg weight (Mead, 1961). It is native to east Africa and introduced in several countries of all continent except Antartica (Bequaert 1950, Mead 1995, Simberloff 1995). It is one of the members of the most damaging 100 invasive alien species (Lowe et al., 2000). It is polyphagous snail and eat more than 500 different species of plant (Mead, 1961, Raut and Barker, 2002). This snail is hermaphrodite that both male and female reproductive organs. It is able to survive unfavourable dry and cold conditions by going under aestivation and hibernation respectively. The snail can remains active at a temperature range of 9°C to 29°C, and survives at temperatures of 2°C by hibernation and 30°C or above by aestivation (Smith and Flower 2003).

The African Giant Land Snail is responsible for the substantial ecological and economic impacts in areas where it has been introduced (Raut and Barker, 2002). This snail is one of the most destructive pests affecting subtropical and tropical areas, causing large damages to farms, commercial plantations and domestic gardens. It is found in urban settlements, gardens, agricultural fields, planted forests, riparian zones, scrub/shrublands, road fens, and wetlands. Kitchen gardens, forest edges, road side shrubland, agricultural barren marginal forest patches, river belts and under garbage deposits are the places where it can produce massive number of young individuals. It is comparatively low in numbers in the natural forest habitats, however it is found nearby forests from urban settlements and spreading in the natural forests (Mead, 1995; Vansconcelos and Pile, 1999). Invasive species are also considered to be leading cause of decline or loss of native biodiversity (Kohli et al., 2004).

It is one of the most serious pest of vegetable crops and devour virtually anything found in the garden (Chamberlin, 1952). Snail cause extensive damage to important food, crops, eat crops reducing yield and making them unsuitable for sale. It has been spreading very rapidly due to high reproductive capacity (Raut and Baker, 2002) and pose a serious conservation problem by eating native plants. Therefore, introduction of single snail to a

new area is enough to start a colony (Rees, 1951). It also act as vector of human disease eosinophilic meningitis, which is caused by *Angiostrongylus cantonensis* (Morera and Cespedes, 1971).

This snail is also an intermediate host of nematode parasite *Angiostrongylus* spp. (Morera and Céspedes, 1971). *A. fulica* is also a vector for several pathogens and parasites. The snail is an intermediate host to *Angiostrongylus cantonensis* (Provic et al. 2000), the etiological agent of meningoencephalic angiostrongiliasis (Wallace and Rosen, 1969). It was reported from China (Chen et al. 2005); Brazil (Carvalho et al. 2003) and Taiwan (Provic et al. 2000).

*A. fulica* mature first as males and producing only sperms and later become hermaphrodite. In this case mate securing behaviour and mating frequency may differ between young (male) and old (hermaphrodite) adults. Young individuals are able to produce only sperms not eggs. Therefore, young adults have to mate with old adults that are able to produce eggs (Tomiyama, 2000). A single old individual has many chances of copulation with many young adults. It can multiply rapidly and establish a new population within a short period of time. It can lay up to 1,200 eggs per year (Prasad et al. 2004). By assuming that the snails mature in nine months after hatching, produce four batches of eggs a year of 150 eggs each, and live for at least five years, Mead (1961) estimated the number of one gravid individual snail can produce at the end of a three year period, if all lived, would total nearly 8 billion. With numbers building up exponentially in multiple geometric series, another two years would increase to over 16 quadrillion.

In Nepal, altogether 179 alien plant and 64 alien animal species have been reported (Budha, 2015; Shrestha, 2016). *A. fulica* is one of the worst invasive animal species in Nepal which was introduced in 1930s from India (Raut, 1992; Budha and Naggs, 2008). Now, this snail is widespread throughout Tarai region of Nepal from Jhapa to Kanchanpur along with some warmer parts of mid hill districts (Rawat, 2019). It feeds on wide varieties of cultivated plants causing significant economic losses in Nepal (Budha and Naggs, 2008).

There are sporadic studies of this snails have been published in Nepal such as Raut (1991), Budha and Naggs (2008), Bhagat an Subba (2013) and Rawat (2019) but there is

virtually no information available about this snail in the historical city of Nepal, Janakpur. The present study aims to know the current status of *A. fulica* in Janakpur area.

## 1.2 Objectives

The main objective of this study is to find current status of *A. fulica* in Janakpur area. The specific objectives are to;

i) find distribution of *A. fulica* in different settlements in Janakpur,

ii) explore duration of *A. fulica* introduction, dispersal, impacts and local control measures in Janakpur.

## 1.3 Rationale of the Study

The African Giant Land Snails is the most problematic animals all over the world due to its pestiferous nature and vector of nematode parasite. It is one of the most rapidly spreading invasive animals. The control of this snail is almost impossible in well established areas. Therefore, assessment of its current status in different areas in Nepal where it is introduced is highly needed to develop control mechanism and to prohibit further spread of this snail in new areas. There are sporadic studies found on *A. fulica* in Nepal (Raut,1991; Budha and Naggs, 2008; Bhagat an Subba 2013; and Rawat, 2019) but there is virtually no information available about this snail in the historical city of Nepal, Janakpur. The present study aims to know the current status of *A. fulica* in Janakpur area.

## 1.4. LIMITATIONS OF THE STUDY

This study is the rapid assessment of *A. fulica* in Janakpur area to know the current status. There are only selected villages or settlements are chosen for this study so this study does not reflect the conclusion of entire Janakpur area. This study was conducted within the limited time period.

# 2. LITERATURE REVIEW

The giant African land Snail is a fast growing polyphagous mollusc pest which is native to East Africa but spread many parts of the world, causing negative impact on local faun as well as natural habitat. It easily transported by means of transportation viz. vehicles and packaging materials and undergo aestivation in cooler unfavourable conditions to disperse it beyond its natural range (MeNeely et al., 2001). Due to its invasive nature it has negative impacts on biodiversity and increase risk of disease (Rodriquez, 2006). There are several studies conducted across the world on this invasive land Snail such as distribution pattern, biology, life history, nature and extent of damage and management efforts. In Nepal, Raut (1999) reported this snail in eastern Nepal.

## 2.1 Biology and Life History

*A. fulica* is the largest land snail measuring upto 20 cm in length. The colour varies however, commonly light brown, with brown and cream bands on the shell. The color becomes lighter towards the tip of the shell in old shells. There are from seven to nine whorls, shell aperture ovate-lunate. In live animal the mantle is dark brown with rubbery skin. There are two pairs of tentacles on the head: a short lower pair and a large upper pair with round eyes situated at the tip. Eggs are spherical to ellipsoidal in shape (4.5-5.5 mm in diameter) and are yellow or creamy.

*A. fulica* is nocturnal and a protandric hermaphrodite, with the male gonad maturating first (Fischer and Costa, 2010). It generally attains sexual maturity at the age of 5-8 months under field conditions (Mead, 1961). After a single mating, it can produce a number of batches of fertile eggs over a period of months. It lays eggs on ground in batches of 100 to 400, with up to 1200 being laid in a year (Mead, 1961). It has an average life span of 3-5 years (Raut and Barker, 2002). The sexually mature snail lays eggs ranged from around 30 to 300 clutch size.

## 2.2 Habit, Habitat and Distribution

*A. fulica* is one of the most destructive pests affecting subtropical and tropical areas, causing large damage to farms, commercial plantations and domestic gardens. It is found on tree trunk, building wall, wetlands, garden and garbage deposits during favourable conditions. But in dry seasons hide under moist places such as crevices, vegetation and all

other possible hiding places. *A. fulica* is also an intermediate host of nematode parasite *Angiostrongylus cantonensis.*

*A. fulica* is native to the coastal East Africa and is widespread as an invasive species in all continents with tropical and subtropical climates such as Asian countries Japan, Bangladesh, China, India, Indonesia, Malaysia, Philippines, Nepal, Thailand and Sri Lanka. It has also spread to several Pacific islands including Hawaii and Fiji. More importantly, within recent times it has spread to countries of the Western Hemisphere as well, including Brazil, Martinique, Guadeloupe, St. Lucia and Barbados (Raut and Baker, 2002).

Budha (2013) documented alien and invasive alien fauna of Nepal including *A. fulica*. He further listed 64 alien fauna of Nepal (Budha, 2015). The rate of spread has been very rapid in Nepal. Budha and Naggs (2008) prepared the first distribution map of *A. fulica.* Later this snail introduced in almost all Tarai district. Recently outbreak of this snail was noticed in Surkhet district (Rawat, 2019).

Human activities are the main factor of the dispersal of *A. fulica.* Its abundance is also high in human habitation (Takeda, 1988) deliberately and unintentionally. The species has been introduced to new regions due to its food value (Cowie and Robinson 2003). Raut and Barker (2002) and Fischer et al., (2010) summarize the dispersal sequence of the species, which was introduced to Madagascar prior to 1800 from Kenya, but was not accepted as an edible species. However, the species was attributed medicinal properties and it was introduced to Mauritius and thence to many islands in Indian Ocean. From there, it was introduced to India and Sri Lanka. By the 1930's, the species had been spread throughout East Asia. Subsequent dispersal continued into the Pacific aided in part, by the Second World War and postwar commerce (Raut and Barker, 2002). Since the mid-20th Century, the species reached Papua New Guinea, Tahiti, New Caledonia, Vanuatu, French Polynesia, American Samoa, Samoa and Federate States of Micronesia (Raut and Barker, 2002 and references therein) and is now present in most parts of the Indo-Pacific (Cowie, 2000).

Escapes from abandoned breeding facilities, accidental transport with building materials, waste and plants, and use as fishing bait have contributed to the local spread. Some unintentional modes of dispersal are through water pipes, irrigation canals and during

constructions attached to machine in Nepal (Budha and Naggs, 2008; Bhagat and Subba, 2013).

## 2.3 Pestiferous Nature

*A. fulica* is world most damaging 100$^{th}$ invasive alien species (Lowe et al., 2000). It is a polyphagous pest. Its preferred food is decayed vegetation, animal matter, lichens, algae and fungi. However, the potential of the snail as a pest only became apparent after having been introduced around the world into new environment (Rees, 1951). The seedling or nursery plants are highly damaged than other stage. In more mature plants, the nature of the damage varies with the plant species, sometimes involving defoliation and in other involving damage to stem, flower or fruits (Chamberlin,1952). Young snails preferred plant of soft texture, while with the increasing size, the pest consumed a variety of food plants (Thakur, 1998) listed four categories of plants (viz. garden flowers and ornamentals, vegetables, mature plants and bark) that are likely to be damaged by *A. fulica*.

## 2.4 Impact Studies

*A. fulica* has a voracious appetite and has been recorded as attacking different kinds of economically, ornamental and medicinal plants (Raut and Barker, 2002) although it has a preference for breadfruit, cassava, papaya, peanut, rubber and most species of legumes and cucurbits. The economic impact of *A. fulica* was considered to be so profound that the new discipline of economic malacology was formulated by zoologist Albert Mead (Mead, 1961) to take account of a pest species which appeared to be threatening already inadequate food supplies in poor regions of the world. Mead devoted his book to the economic impact of *A. fulica*. There had been reports that the species would devour virtually anything found in the garden.

It is difficult to quantify the damage wrought by *A. fulica* to gardens and crops, but suffice to say that it is considered by most authorities to be the most damaging land snail in the world. However, Civeyrel and Simberloff (1996) believe that the damage done to endemic species of snail by ill-judged biological control programmes outweighs the impact of the pest species. The dramatic population crashes commonly observed in populations of *A. fulica* which had increased rapidly in size following introduction into new environments, may well lessen the deleterious long-term economic impact of the

species, though it remains a serious pest in many areas. Raut and Barker (2002) cite several examples of the production of some crops that has proved unsustainable in certain infested areas.

Indirectly *A. fulica* may have an impact as a vector of plant diseases as it has been implicated in the transmission of *Phytophthora palmivora* (Schotman, 1989; Raut and Barker, 2002).

## 2.5 Uses of Achatinoid Snails

In West Africa, and particularly in Côte d'Ivoire, *A. fulica* are consumed (Otchoumou et al., 2004). Snail meat is also known as "Congo meat" in Nigeria (Fagbuaro et al., 2006). There are various studies on the nutritional properties of the meat of *A. fulica* (e.g. Barboza et al., 2006; Babalola and Akinsoyinu, 2009). *A. fulica* are also used as chicken feed (Barboza and Romanelli, 2007; Diomandé et al., 2008), fish feed in Sri Lanka and India (Suresh, 2007). It is also used in biological laboratories such as clinical experiments, neurobiology and electrophysiology (Zhang et al., 1996), endocrinology (Bose et al., 1997), comparative biochemistry and physiology (Kholodkevich et al., 2010), reproductive biology (Sretarugsa et al., 1991), parasitology (Utomo et al., 1991), immunology (Harris et al., 1992), molecular biology (Obara et al., 1992), and as a source for producing chemicals (Lesbani et al., 2013).

In Nepal, *A.fulica* was used as feed to fish *Clarias batrachus* (Budha and Naggs, 2008). It was also found that crows, monitor lizards, the common mongoose, swans, pigs and poultry feed on this snail in Nepal (Bhagat and Subba, 2013).

## 2.6 Control Measures of *A. fulica*

A vast body of literature has accrued on the various methods of control available for *A. fulica (*e.g. Mead, 1961; Raut and Barker, 2002; Fischer and Costa, 2010). Half of Mead's 1961 book on the economic impact of the giant African snail was devoted to control. Perhaps the major problem with testing the efficacy of control measures in experiments is the ability to distinguish the level of success of the method under test and the natural demographic crashes that are a renowned feature of the population dynamics of this species. One of the officially documented examples of eradication is Florida, USA, in 1969 (Schotman, 1989).

Metaldehyde is the most common chemical control against *A. fulica* however it was not completely effective (Mead, 1979; Raut and Ghose 1984). Raut and Barker (2002) state that although a number of molluscicidal chemicals are available, rarely they are developed or registered specifically for use against *A. fulica*. The FAO (Schotman, 1989) suggest that metaldehyde poison baits can be effective in small scale cultivation, but are not practicable elsewhere. Sharma and Agarwal (1989) recommended the use of 5% metaldehyde pellets, but only in conjunction with wider sanitation and physical control measures.

Various insecticides and fungicides were tested against *A. fulica* by Kakoty and Das (1987) who found that only copper sulfate solution produced high mortality rates. An insecticidal bait has also been tested by Sarkar et al., (1997). Rao et al. (2003) looked at the effect of single and binary treatments of plant-derived molluscicides on reproduction and survival, and on different enzyme activities in the nervous tissue of *A. fulica*. Although results were positive, it was agreed that the sublethal exposure of these molluscicides on snail reproduction is a complex process. Saxena and Mahendru (2000) evaluated the efficacy of different baits (wet wheat, gram, barley and corn flour) and insecticides (malathion, trichlorfon and mexacarbate) against *A. fulica*, at different concentrations. The results showed that wet wheat flour was the best bait. Ciomperlik et al., (2013) conducted bioassays and caged field trials in Barbados, to compare the acute toxicities of molluscicide formulations on the neonate, juvenile, and adult development stages of *A. fulica* and three non-target snail species.

Common salt is an effective dehydrating agent and most commonly used method to manage snail population (Shah, 1992; Prasad et al., 2004, Budha and Naggs, 2008; Bhagat and Subba, 2013). Another chemical method to control the snail include sprinkling lime and bleaching powder surrounding plants and other hiding places to stop the movement of the snail from one to another place (Jadhav et al., 2016).

In physical controls, snail are collected and destroyed when they seen and searched from the hidden sites. The snails can then be killed by sprinkling with salt or by exposure to the sun.Snails can be collected every day and destroyed by crushing or drowning.

## 2.7 Natural enemies of *A. fulica*

Some predators of *A. fulica* were Indian glow worm *Lamprophorus tenebrosus, terrestrial snails Gonaxis quadrilateralis, G. kibweziensis* and *Euglandina rosea,* Terrestrial flat worm *Platydemus manokwari* (Davis and Butler, 1964; Nishida and Napompeth, 1975; Muniappan et al., 1986; Muniappan, 1987). Among avian fauna *Centropus sinensis, Dendrocitta vagabunda, Tytoalba* and *Bubulcus ibis* and ducks reported as the effective predator of *A. fulica* (Mead, 1961; Raut and Ghose, 1979; Jayashankar, 2013) and also mongoose *Herpestes mungo* (Srivastava et al., 1992).

*A. fulica* is rapidly spreading in different countries either accidentally or intentionally but the main reason for dispersal is human agency. Likewise, in Nepal also snail is expanding its range but the mode of dispersal, impacts and control measures are not properly recorded. *A. fulica* adversely affect the crops production, causing significant economic damage and also have impact on surrounding environment and native fauna. Among different control method, physical method is easy and cost effective but not sufficient to control the snail population. Salt is most effective among chemicals while some species were found to be used to control the snail but that have also negative impact on native species. In Nepal, biological method were not found to be used so need to develop cost effective and appropriate method to control snail population.

# 3. MATERIALS AND METHODS

## 3.1 Study Area

The study was carried out in Janakpur Sub-metropolitan city of Province No. 2. It is the headquarter of Dhanusha district and currently capital of the province which is located in between $26^0 43' 43''$ N latitude and $85^0 55' 30''$ E longitude with an area of 100.20 $km^2$ . A total population of the city was 173,924 in 2015 which is the largest among five sub-metropolitan city of Nepal.


**Map 1. Survey settlements in Janakpur**

## 3.2 Climate

Janakpur has humid subtropical climate. April to June are hot, dry and windy following the rainy season from July to September and a cool dry season from October to January and short spring from February to March. The major rivers surrounding Janakpur are Dudhmati, Jalad Rato, Balan and Kamala.

**Flora and Fauna**: The trees found in the Dhanusa District consist of sal (*Shorea robusta*), karma (*Adina cordifolia*), sisau (*Dalbergia sissoo*), khayer (*Acacia catechu*), Botdhainro (*Lagerstroemia parviflora*), asna (*Terminalia alata*), simal (*Bombax ceiba*),

jamun (*Syzygium cumini*), satisal (*Dalbergia latifolia*), aap (*Magnifera indica*), bhorla (*Bauhinia vahlii*), satibair (*Rhus parviflora*), babiyo (*Eulaliopsis binata*), bans (*Dendroclamus strictus*), neem (*Azadirachta indica*), gambhari (*Gmelina arborea*), papal (*Ficus religrosa*), bakaino (*Melia azedarach*), bhalayo (*Semecarpus anacardium*), rajbriksha (*Cassia fistul*a), dabdabe (*Garuja pinnata*), gayo (*Bridelia retusa*), siris (*Albizzia mollis*), utanki (*Bauhinia malabarica*).

The wildlife bird species found in the Dhanusa District are kalij (*Lophura leucomelana*), mayur (*Pavo cristatus*), and dhukur (*Streptopelia chinensis*). Among these, the kalij is among the Protected Species.

## 3.3 Socio- economic Conditions

Agriculture is the major economy of Dhanusha district. About 90% of citizens of this districts are involved in the cultivation of wheat and rice. Rice is the major output. Dhanusha still relies mostly on old age techniques such as bullock- cart for transportation and bull plow for tilling the agriculture field. However, this is a slow introduction of modern techniques such as tractor for goods transportation, thrasher and so on. Even most are dependent upon the remittances. Main ethnic groups of Janakpur are Yadav, Shah, Jha, Gupta, Kayesta, Mallah, Chhetri, Bramahan, Musahara, Dom and Muslim. Ram-Janakimandir is the most holy places for Hindus which is located at the heart of Janakpur. Vivaha Mandap, Ganga Sagar, Dhanush Sagar, the sacred ponds in Janakpur.

## 3.4 Data Collection

Extensive surveys were conducted at different places of Janakpur in 2018 for three months (September, October, November). Attention was given to note the occurrence of the giant African land snails from all possible niches. Since the snail are nocturnal, less number were found during day hours as they hide themselves under stone (aestivation). The survey was conducted using semi structure questionnaire to the local people of Janakpur at different wards. The survey included focal group discussion at agriculture office of Janakpur and Baghwani and individual interview. To know the species abundance, habitat was categorized into garden, forest, khet, non irrigated fields (bari), grassland, river bank and other places and respondents were asked questions. Priorities were given to those who have more knowledge about the *A. fulica* as key information.

Focal group discussion was carried in two places which included Staff, officers of Janakpur agriculture Office and Baghwani. There were total 200 respondents among them

### 3.4.1 Direct Observations and Identification

All visited sites were directly observed whether the snail present in the area and know the relative abundance of the snail, pestiferous nature of the snail. Some representative samples were collected and brought to the Department of Zoology, T.U. for taxonomic confirmation. In general the snail is easily identified by its shape, size and colour.

### 3.4.2 Questionnaire Survey

The structured questionnaire was prepared (Appendix 1). The questionnaire form was filled in the field by asking various aspects of the land snail such as introduction period, abundance, impacts, control measures, damage done by the snail with respondents of different sex and age group from different localities (see Table 1).

## 3.5 Data Analysis

Collected data were entered in the Microsoft Excel sheet. Simple statistical tools such as average, percentage, mean as well as descriptive analysis was used to compare the collected data. Different charts, tables were formulated in from the data to simplify the presentation of the data.

# 4. RESULTS

## 4.1 Distribution of *Achatina fulica* in Janakpur

*Achatina fulica* was reported in almost all surveyed settlements in Janakpur. Based on the respondents ranging from 23 years to 65 years of age group, *A. fulica* seems to be introduced long ago during 40-45 years back in Janakpur. The distribution of the snail in the surveyed settlement is given in Table 1. The bold letters indicate the duration of the first sighting by the respondents.

**Table 1: Distribution and spread of *A. fulica* in surveyed villages of Janakpur**

| Possible Arrival time | Settlements of first sightings by the respondents | Respondents' Age group | No. |
|---|---|---|---|
| 0-5 years | Basahiya, Basbitti, Bhramapura, Bindhi, Devpura Rupetha, Gaushala, Gopalpur, Janak chowk, Laxmipurbagewa, Lohana, Mahuwa, Paniyar Than, Pipra, Ramanand Chowk, Shiva Chowk, | 25-65 years | 32 |
| 6-10 yrs | Basahiya, Basbitti, Bhramapura, Bindhi, Devpura Rupetha, Gaushala, Gopalpur, Janak chowk, Laxmipurbagewa, Lohana, Mahuwa, **Paniyar Than**, Pidari chowk, Pipra, Ramanand Chowk, Shiva Chowk | 24-60 years | 102 |
| 11-15 yrs | **Basbitti, Bhramapura, Bindhi, Devpura Rupetha**, Gaushala, **Gopalpur, Janak chowk,** Lohana**, Mahuwa, Pidari chowk**, Pipra, **Ramanand Chowk, Shiva Chowk** | 23-65 years | 29 |
| 16-20 yrs | **Laxmipurbagewa** | 23-25 years | 2 |
| 21-25 yrs | **Pipra** | 48 years | 1 |
| 26-30 yrs | **Bhramarpura** | 44 year | 1 |
| 31-35 yrs | **Gaushala** | 57-65 years | 2 |
| 40-45 yrs | **Lohana** | 55 year | 1 |

Figure 1 shows the duration of arrival and response of informants on the occurrence of this snail in Janakpur. Highest number of informants informed that the snail was found in their areas for 0- 5 years and 6-10 years period. However some informants saw the snails in their areas more than 30-45 years ago (Figure 1).

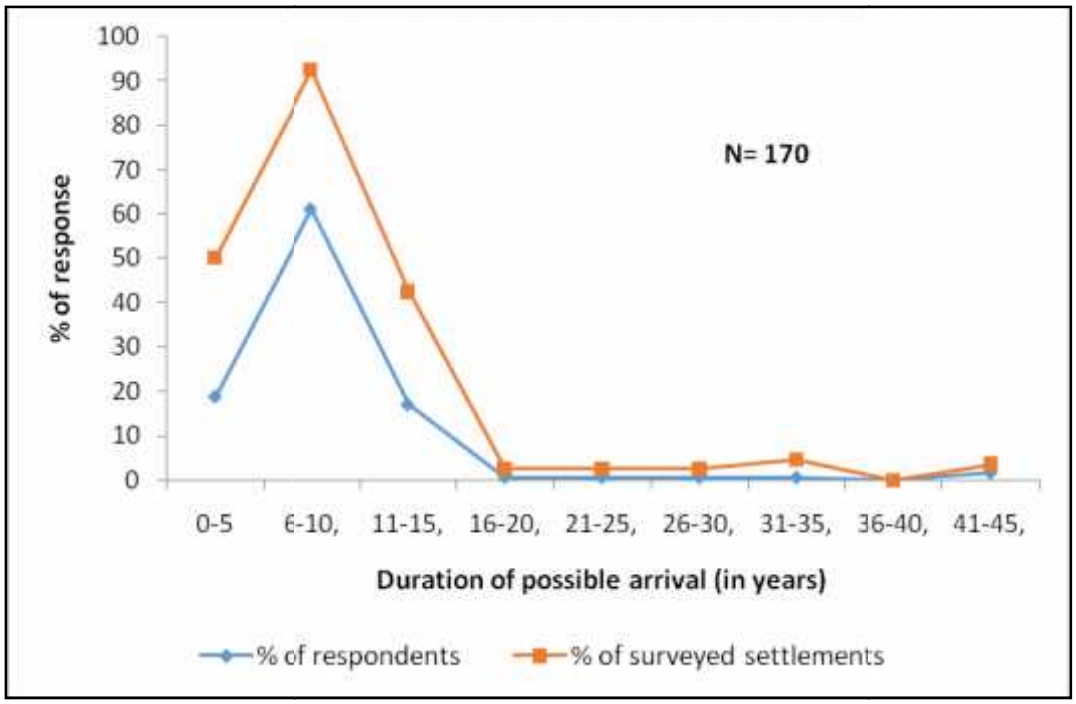



**Figure 1. Duration and spread of *A. fulica* in Janakpur**

Out of 170 respondents 84 percent respondents said that the snail is not visible throughout the year but 16 percent respondents said that the snail is found throughout the year (Figure 2).

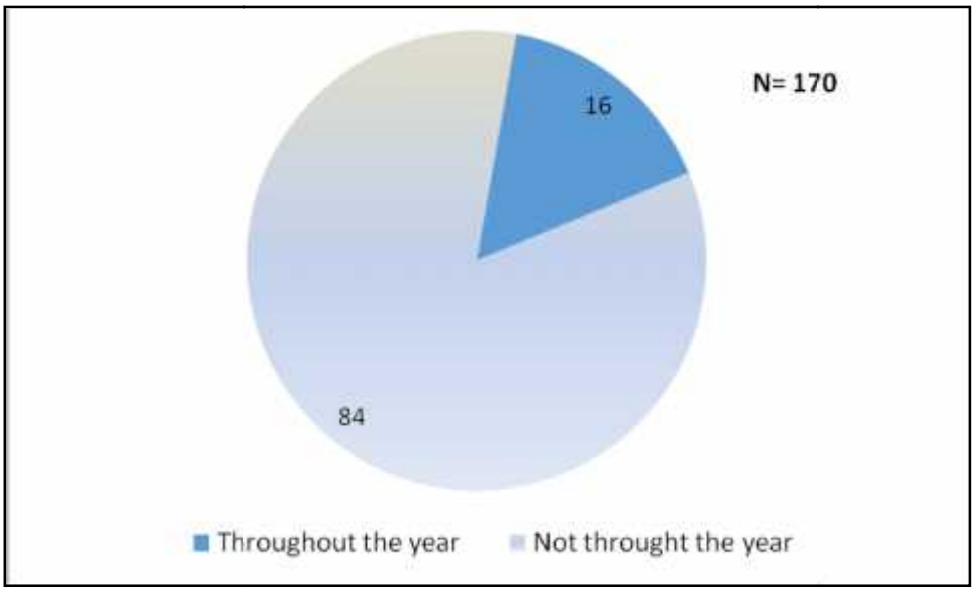



**Figure 2. Visibility of *A. fulica* noted by the respondents**

Figure 3 indicates that *A. fulica* is seen by most of the respondents during the rainy season from Asar to Asoj. The snail abundance is decreasing from Mangsir onward (Figure 3).

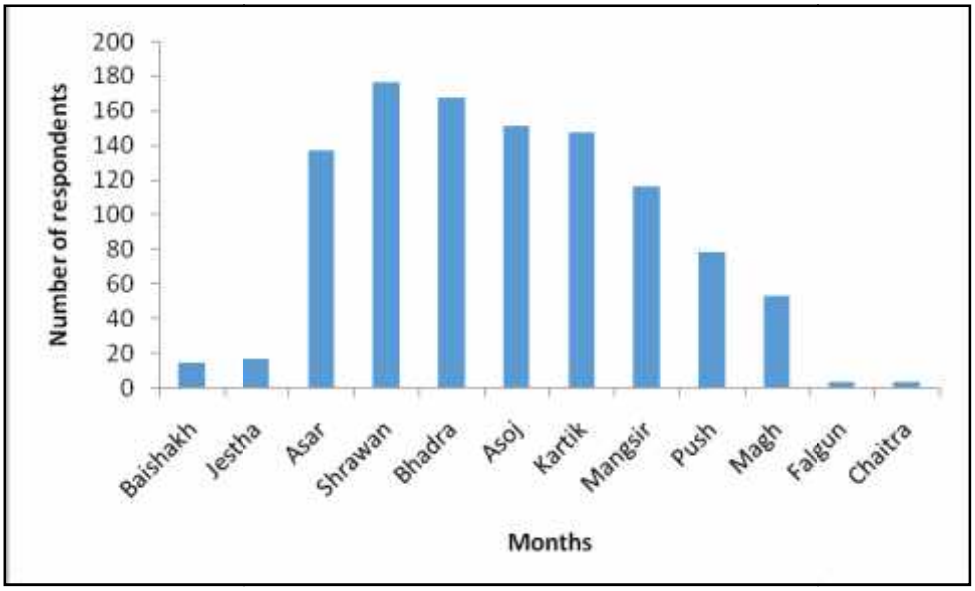



**Figure 3. Monthly occurrence of *A. fulica***

## 4.2 Abundance of *A. fulica* in different habitat types

*A. fulica* was reported in different habitat types viz. Garden, forest, forest edge, khet land, bari, grassland and riverbank. The highest number of snails were reported from garden and bari following lowest in forest and forest edge and moderate in grassland and river bank (Figure 4).

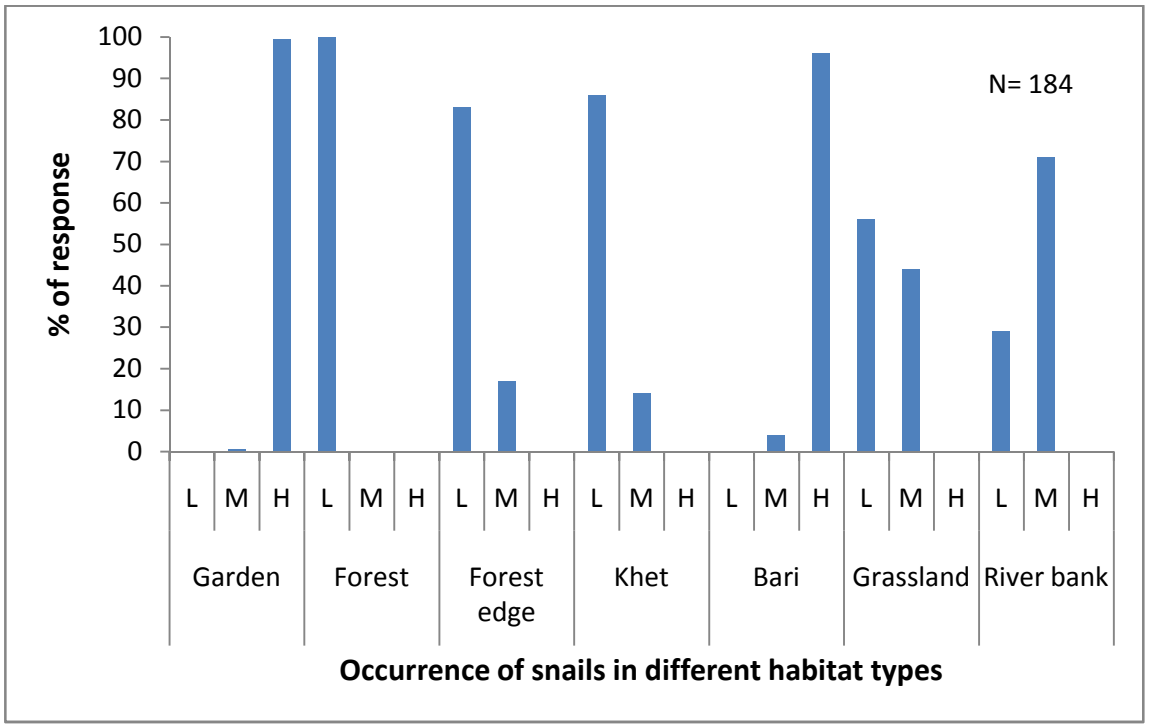



**Figure 4. Occurrence of snails in different habitat types**

The snail individuals were seen abunant on wall of houses and schools, along road side during favourable weather conditions. Other areas are kitchen gardens, drainage, around wells and water canals (Figure 5).


**Figure 5. Mostly seen sites of *A. fulica* in Janakpur**

## 4.3 Impacts on the Local Environment

Out of the 103 respondents 70 percent respondents experienced about the impoacts on the local environment due to this snail but 30 percent respondents have no idea abou the impacts due this snail (Figure 6).

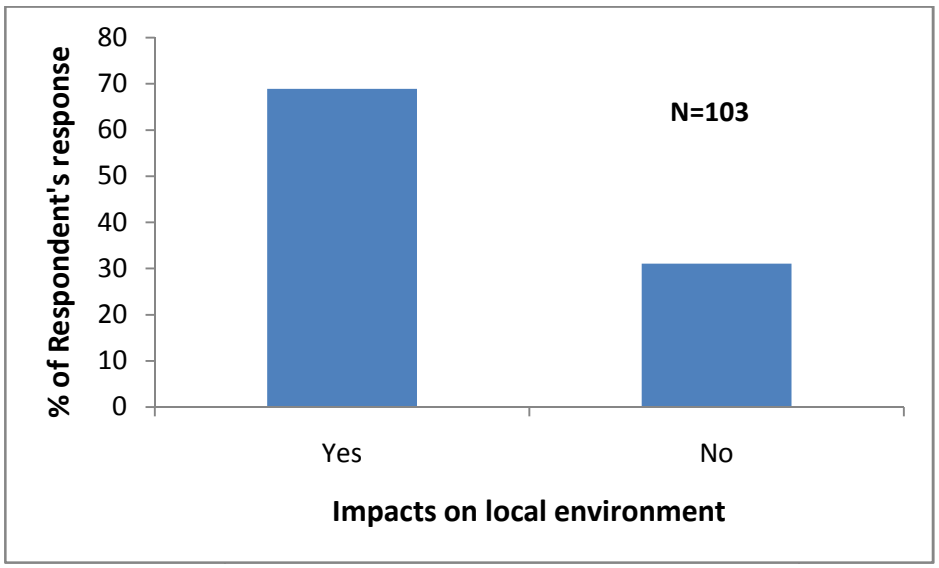
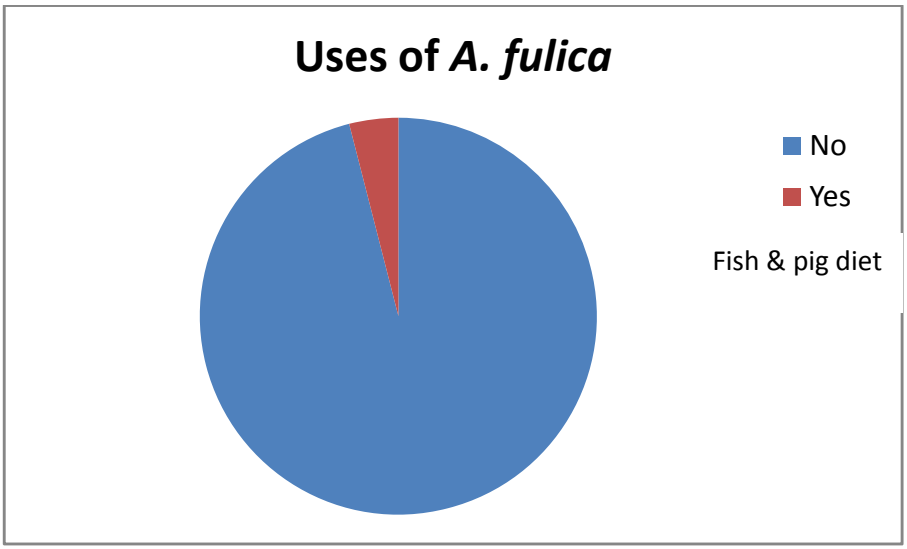



**Figure 6. Impacts on the local environment by A. fulica**

## 4.4. Uses of *A. fulica*

Nearly 94 percent respondents informed that they have no idea about the use of the snail but 6 percent respondents use the snail for fish diet and pig diet in the area. Some respondents seen that common myna eat the eggs of *A. fulica* (Figure 7). Few respondents informed that shells were used for decoration purposes.




**Figrue 7. Uses of *A. fulica***

## 4.5 Local Control Measures of *A. fulica*

Out of total 195 respondents interviewed 103 persons gave their response on the control measures of *A. fulica.* Locally adopted control measures of *A. fulica* includes collections and pouring salt over the snails, curshing the live individuals, remove the hiding places and searching egg mass and destroy them. Collection and pouring salt over the snail was found the most effective control techniques adopted by the local people (Figure 8).

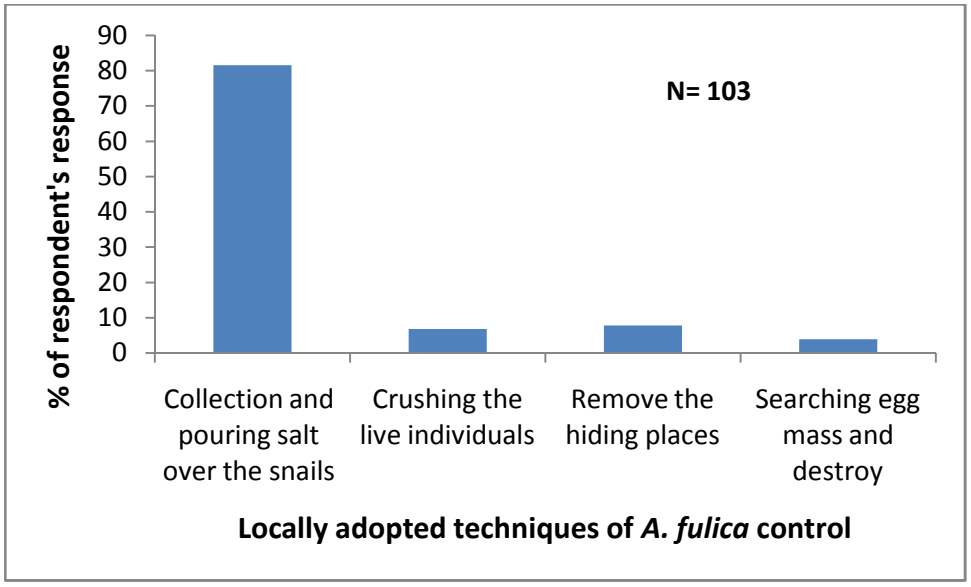



**Figure 8. Local control measures adopted against *A. fulica* in Janakpur**

# 5. DISCUSSION

The Giant African Snail is one of the most notable species of land snails throughout the globe because it is listed among the worst one hundred destructive invasive alien species (Lowe et al. 2000). Most land snails are herbivorous and they aggregate in regions providing the greatest potential for food and shelter. It is found in urban settlements, gardens, agricultural fields, planted forests, riparian zones, scrub/shrublands, road fens, and wetlands in Nepal. Kitchen gardens, forest edges, road side shrubland, agricultural barren marginal forest patches, river belts are the places where it can produce massive number of young individuals. It is rare in the natural forest habitats, however it is found nearby forests from urban settlements and spreading in the natural forests.

This study indicates that *A. fulica* was probably introduced in Janakpur for about 40-45 years ago. According to the respondent the first sighting seems to be Lohana then Gaushala, and Pipra. Pipra is connected with railway line. It was spread in almost all locations of Janakpur within about 10 years. It was most abundant in the garden and bari land. This snail is generally abundant in human habitation in many countries (Takedo, 1988, Ahmend and Raut, 1991).

The most sighted locations of *A. fulica* were wall of buildings, road sides, garden, drainage, and other moist locations such as wells and canal. These habitats are also noted in many other countries (Thakur and Kumari, 1998; Raut and Baker, 2002). When *A. fulica* established then severe infestation tends to be along roadway too (Numazawa et al., 1988). Population can be observed in old walled buildings and boundary walls (Budha and Naggs, 2008) and also on decaying materials in decomposition and next to garbage deposits (Albuquerque et al., 2008).

About 94 percent people have noticed about the impacts of this snail but only few people were not aware about the impacts on the local environment. Budha and Naggs (2008) also noticed the negative impacts on the local environment due to this snail such as producing slime, bad odor, itching/irritation if comes in contact with excreta and slime of this snail.

The respondents (16%) said that *A. fulica* can be seen throughout the year but 84 % said that the occurrence of this snail was seasonal. Similar trend was noticed by Rawat (2019).

Although this is considered as the serious pest of vegetable crops such as cauliflower, cabbage, beans, lady's finger, sponge gourd, brinjal, pumpkin, papaya and cucumber (Bhagat and Subba, 2013), cabbage was the most preferred plant among vegetables followed by cauliflower (Thakur and Kumari, 1998). Local people were facing its pestiferous nature but initiation of its control are not yet advocated in Janakpur however in Surkhet district local government encouraged to local people by paying per kg to collectors (Rawat, 2019).

# 6. CONCLUSION

In Janakpur, this snail was introduced about 40-45 years ago and currently found in almost everywhere. Based on the 195 informants the most preferred habitat in the study area included garden followed bari, roadside, river side, and irrigational canal within urban settlements. The control measures of *A. fulica* eradication includes collections and pouring salt over the snails, cursching the live individuals, remove the hiding places and searching egg mass and destroy them. Collection and pouring salt over the snail was found the most effective control techniques adopted by the local people.

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## Appendix 1

# Questionnaire Survey: African Giant Land Snail, Janakpur, 2017

**PERSONAL BACKGROUND OF RESPONDENT**

Date: ---------- Place: ----------VDC/Municipality: ---------- Ward No--

Name of Respondent: ---------- Age:---------- Sex: ----------

Education:---------- Occupation---------- --- Phone number: ----------

**INTRODUCTION/ARRIVAL/ESTABLISHMENT**

1. Have you ever seen *Achatina fulica* (Local name/language---------- ? Yes/No.

   If yes, how many years ago you have seen it first (write year i.e. 2040 BS, 2020 BS etc?----------where did you see it first (*Please write the name of the place and habitat*) ?

   Khet ☐ Bari ☐ Roadside ☐ Riverside ☐ Other specify ☐

2. Have you seen this snail in other places/villages too? Yes ☐ b. No ☐

   If yes where?----------

3. Do you see African giant snail throughout the year? Yes ☐ No ☐ If no, in which month is it seen? *Tick mark in the next column.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Baisakh | | Sawan | | Kartik | | Magh | |
| Jestha | | Bhadra | | Mansir | | Falgun | |
| Asar | | Asoj | | Push | | Chaitra | |

4. Where is this species found? (0= absent, 1= less than 10, 2= more than 10)

| Habitat | Abundance | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Garden | | | |
| Forest | | | |
| Forest edge | | | |
| Paddy field | | | |
| Khet | | | |
| Bari | | | |
| Grassland | | | |

| | | | |
|---|---|---|---|
| River bank | | | |
| Other | | | |

**PATHWAYS**

5. Please give the route from where it has came (write name of place of the origin)

   ---

6. How it was entered in your tole or village?

| | |
|---|---|
| Someone carried and released at the garden | |
| came accidentally | |
| Through transportations such as water pipe, packing material etc | |
| Not known | |
| other means specify | |

**IMPACTS**

7. List damaged crops/vegetables by this species? *The most damaged one first and so on*.

| S.N | Name of crops | Area planted (Kattha/Bigah) | Production per Kattha/Bigaha | Market price Per Kg/ | Damage % |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
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|---|---|---|---|---|---|
| | | | | | |

8. Does other snails/birds/parasites/ organism increase or decline after arrival of this species?

Increase: Yes ☐ No ☐

Decline: Yes ☐ No ☐

If yes, what may be the cause for this? ----------

---

---

**CONTROL MEASURES**

9. Do any animals, bird, insect etc. eat this land snail? a. Yes ☐ b. No ☐

If yes, give the animal name(s) ----------

---

10. What methods do people apply to control it?

| | | | |
|---|---|---|---|
| Hand picking and destroy | | Use of chemical pesticide (*Give the name*) | |
| Pack in the polythene and through in the road | | Other local techniques (if any) | |
| Use of any plant products i.e. leaves, roots, bark and extraction against it | | | |
| Note: | | | |

11. Which is the most effective method to control it?

---

12. Is it possible to eradicate? a. Yes ☐ b. No ☐

If yes how (write suggestions of respondent)----------

---

a. Does any organization working to control the population of this species? Yes /No

If yes, write the name and ways of controlling methods

b. ----------

c. ----------

d. ----------

13. What kind of impacts do you notice in the environment after its arrival?

    For e.g.: Transmit disease, irritation, leave the slime trails and good impact if any.

    a. ---------- b. ---------- c. ----------

    d.---------- e. ----------

14. Is it used by people for any purposes? Such as meat, poultry diet, pig diet, fish diet etc.

    ---

    ---

    Are there any incidents, proverb, folk lore's about this snail?

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Prepare the table of persons that you interviewed and place here. In Appendix 2.

Include your selected photographs