Off-season Mortality of Golden Apple Snail, *Pomacea canaliculata* (Lamarck) and its Management Implications

Abstract

RANEE ENRIQUEZ JOSHI, University Science High School, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, April 2005, **OFF-SEASON MORTALITY OF GOLDEN APPLE SNAIL, *POMACEA CANALICULATA* (LAMARCK) AND ITS MANAGEMENT IMPLICATIONS.**

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The study was conducted to determine whether GAS size and GAS sex has any relation with the off-season mortality of GAS and to provide management implications in accordance to the results obtained. The experiments for GAS size and sex were conducted in netbags and plastic trays with soil. Results showed that generally, GAS have low mortality rates but increased with their size. With GAS sex, no consistent mortality trends were observed. Mortality rates in plastic trays proved higher than those in netbags. It could be due to lack of aeration and low air exchange. Proper management implications have been derived by giving a rice cropping calendar which would help sustain yields and reduce GAS damage.

Introduction

The golden apple snail (GAS), *Pomacea canaliculata* (Lamarck), originating from South America, has increased its invasiveness and damage to rice plants in Asia and North America where it was introduced. It is known by an array of common names such as: golden miracle snail, golden snail, jumbo snail, Argentinian apple snail, *bisocol* and *golden kuhol*. The term “golden” refers not to their color, but to the amount of money snail wranglers could make raising them. However, GAS is its frequently used common name. It is listed as one of the World’s Worst

Invasive Alien Species (IAS) as its invasion ability is based on unique morphological and biological characteristics that support their capacity to survive in adverse environmental conditions and still reproduce fast.

GAS has become a major pest of rice in all the rice-growing countries where it was either intentionally or accidentally introduced (Joshi et al., 2003a). The most recent serious invasions are reported from Republic of Dominica, Papua New Guinea and South Korea. GAS continues to be a problem in Japan, Thailand, Vietnam, Cambodia and Malaysia. In Asia, distribution continues to expand westward. Large rice-growing regions of India, Bangladesh, China and Australia are the probable next targets of GAS invasions. From the information gathered in the given countries, it could be generalized that: (1) four years after its introduction in a country, it attains the pest status; (2) local establishment is a key feature of invasion; (3) establishment is stochastic; (4) once established, it will typically persist; and (5) invasion-resistance increases during assembly.

In the Philippines, the government promoted GAS production in 1982 and 1984, as a national livelihood program to increase the protein intake of low-income Filipino rice farmers and as an additional source of their income (Ang, 1984; Adalla and Rejesus, 1989). Due to improper rearing, GAS escaped into the rice paddies and infested 425.862 ha (11% of the total rice cropped area) in the Philippines (Rondon and Callo, 1989). The losses to Philippine rice crops from GAS in 1980 are tuned to US$ 1 billion in 1980's. Annual global agricultural economic losses from GAS range from 55-248 billion/year. By 1990, GAS infected area increased to more than 600,000 ha. Surveys conducted in 1991, showed that the infestation increased to 900,000 ha (Bayer, 1992). At present, it is a major biotic constraint in all regions and rice ecosystems of the Philippines (Alviola et al., 2000), including the Ifugao Rice Terraces (Dancel and Joshi, 2000; Joshi et al., 2001). In addition, to GAS being ranked as a pest of national importance, it is blamed for the decline of edible native apple snail, *Pila conica* (Gray) and the 'jojo' or 'yoyo' (*Mirgurnus anguillicaudatus*) in the Ifugao Rice Terraces. This is probably because of the competition for common habitat and resources (Halwart, 1994).

GAS being a highly voracious nocturnal herbivore destroys newly transplanted rice (Saxena et al., 1987). GAS damage is characterized by missing hills and floating leaf fragments in the rice field (Joshi et al., 2002). GAS cuts the base of young seedlings with its layered tooth (radula) and eats the succulent, tender rice leaves. The extent of damage to the rice crop depends on snail size, snail density, and growth stage of the rice plant. A density of three GAS per square meter causes significant yield loss, with much greater damage to direct-seeded rice and young seedlings transplanted at 18-21 days (Litsinger and Estaño 1993). GAS with 40-mm is generally the most destructive size, irrespective of the rice establishment method. It causes 100% destruction of the rice seedlings in the germinating stage and at least 20% in transplanted seedlings. At 30 days after transplanting, medium-sized snail (2-3 cm shell height) at a density of one and eight snails per square meter reduced the number of rice tillers by 19% and 98%, respectively (Basilio, 1991). GAS of 10-mm size was capable of causing damage to direct-seeded rice even after 1 day. However, 5-mm sized GAS did not damage rice seedlings; instead, they fed on algae and other organic matter at the field water surface. GAS adults also feed on azolla, morning glory, sweet potato, taro and other aquatic plants. Adults measuring 22-26 mm consume up to 15 grams of azolla in 12-24 hr (Saxena et al., 1987). GAS damage is severe in lower portions of the fields where water stagnates.

Hence, because of the undeniable significance and hazard of GAS to rice plants, this study investigated the natural mortality rates of GAS, after rice harvesting but before rice planting (off-season). This baseline information is necessary to tackle GAS and facilitate its size prediction during rice growing periods and developing environment-friendly and socially acceptable management options.

The study determined the mortality rates of various GAS sizes and sexes during off-season. Off-season is the time interval between the last harvesting and the succeeding planting season. During these periods, GAS aestivates in soil or crop residues in rice fields. GAS stores nutrients and minerals prior to aestivation. During aestivation, GAS closes its lid with its mucous and buries inside the soil and remains immobile until the rains have arrived. A lot of GAS probably die in the process of hibernation. Hence, this study quantified the mortality rates and patterns on various GAS sizes and sexes. From this information, the study also advised the proper management implications.

The knowledge gained in this study is essential for GAS management in rice farming. It will guide the farmers and extension workers as to which GAS sizes they would have to deal with during rice planting time (either in direct-seeded or transplanted rice systems). In addition, this study established information on managing dominant GAS sizes and sexes for paddy weeding in lowland transplanted irrigated rice farming.

Statement of the Problem

The following were the problems of the study:

1. What are the mortality rates of GAS during off-season in relation with their size?
2. What are the mortality rates of GAS during off-season in relation with their sex?
3. What are the management implications in relation with the various GAS sizes and sexes?

Objectives of the Study

The following were the objectives of the study:

1. To determine the mortality rates of GAS during off-season in relation with their size.
2. To determine the mortality rates of GAS during off-season in relation with their sex.
3. To determine the management implications in relation with the various GAS sizes and sexes.

Hypothesis of the Study

The hypothesis of the study was that the mortality rates were based on the variables; sex and size cannot contribute to any management implications.

Significance of the Study

Research on the mortality of GAS suggests a more comprehensive approach. Since there are very limited studies that employ the off-season mortality of GAS, this exploratory study contributed information to the growing body of the knowledge relevant to the rice researchers and farmers. Moreover, it contributed to proper GAS management implications and development of research methodology and procedures useful in the field problems.

Until September 2004, the different agencies of the Department of Agriculture, Philippines have not conducted a research on this aspect. The study filled the knowledge and information gaps relative to the off-season GAS mortality, particularly to the rice farm management extension staff and rice farmers. It would also give proper GAS management options to reduce the use of synthetic molluscicides.

Scope and Limitations of the Study

The study is confined itself in observing the off-season mortality rate of GAS. It only considered two variables, namely: size and sex. The study was completed in two months. The samples were collected in Maligaya, Science City of Muñoz, Nueva Ecija. The management implications were based on previously studied management options.

The only major limitation that may have affected the validity and accuracy of the study is the condition in which the samples were retained not in their natural habitat/environment.

Operational Definition of Terms

1. Mortality

   It refers to the population decrease factor or death rate of GAS.

2. Size

   It is the parameter was used to classify the samples. There were 8 definite sizes used ranging from 0 mm to 40 mm namely: 5 mm, 10 mm, 15 mm, 20 mm, 25 mm, 30 mm, 35 mm and 40 mm. Each range had a less than 1mm span.

3. Sex

   It refers to the gender of each snail, male or female.

4. Management Implications

   These are the different GAS management options suggested based on the gathered data from the study of the mortality rate of GAS.

Review of Related Literature

This chapter includes related readings, researches and references to this study which would help understand the topic of the research paper.

GAS Mortality

Snails larger than 6 mm exhibit higher cold tolerance than small snails as observed in Japan. Temperature is a practical and effective parameter in estimating mortality of field snails (Syobu et al., 2001). The apple snails are proven susceptible to low temperatures. They die within 35 days at 0°C, 3 days at –3°C and 1 day at –6°C (Oya et al., 1987). Unlike in Japan, the Philippines is a tropical country which makes the environment more favorable to GAS. The information about the mortality rate of GAS in the Philippines during the off-season is not thoroughly established, and this is what this study sought to provide.

Agrochemicals for GAS Management

Different agencies have developed and recommended integrated management methods for GAS, but Filipino farmers use commercially available synthetic molluscicides as their first-line of defense, without considering the toxic hazards to themselves and non-target organisms.

Result surveys in the Philippines support this, the survey showed that 75-100% of the rice farmers consider GAS to be the most serious pest problem in rice, with more than 40% applying pesticides (Revilla et al., 1001; Ketelaar, 1993). In 1988, the synthetic molluscicide expenditure was estimated at US$ 2.4 million (Halwart, 1994). In 1993, farmers spent about US$ 9 ha^{-1} for pest management (Medrano et al., 1993). This figure swelled to US$ 23 ha^{-1} despite the proper use of registered commercial molluscicides. In other parts of Asia, like Taiwan, they have spent more than US$ 1 million per year on molluscicides for treatment of 100,000 ha of rice fields (Cheng, 1989).

The chemical approach is unsuitable for the resource-poor rice farmers. Aside from the impracticality of using synthetic molluscicides, the use of organo-tin compounds further caused several human health risks, such as skin peeling in fingers and toes, head aches, skin disorders, blindness and even casualties (Anderson, 1993). These compounds caused high toxicities on fish especially in rice-fish farming systems (Hausen, 1993). Eventually, organo-tin compounds were banned. In addition, the use of pesticides for GAS control is difficult as GAS bury themselves in the soil to avoid exposure from the pesticide sprays (Dela Cruz et al., 2000; Dela Cruz and Joshi, 2001a).

Plant Molluscicides

Neem, *Azadirachta indica*, has come under close scientific scrutiny as a source of unique natural products for integrated pest management (Jacobson, 1989; Saxena, 1898; Schmutter, 1990, 2002a; Ascher, 1993). Schmutter (2002b) has reviewed the effectiveness of various neem materials against mollusks. Muley (1978) has stated that 100% mortality of the snail *Melania scabra* occurred in 20 minutes when treated with 0.5% tap water extract of dried neem seed powder. Neem seed extract was likewise toxic to *Biomphalaria glabrata* (Jacobson, 1989). Dried leaves were treated with *Lymnea luteola* and *Gyraulus convexiusculus* that caused them to die within 24 hours (Bali and Pati, 1985). Its leaf, bark and fruit were also tested on other mollusks and had successful results. Eventually, Maini and Rejesus (1993) tested aqueous neem leaf and seed extracts, neem oil and “Bioblitz” against GAS. Leaf and seed extracts were the most toxic causing 100% snail mortality at 100 ppm after 48 hours. Effects of neem treatments on the ecology of the snails are still to be investigated. Aqueous Neem Seed Kernel Extract (NSKE) was tested against non-operculated and operculated freshwater snails (Mossalam et al., 1994). Treatment with 2.5% NSKE killed four non-operculated snail species after 24 hours while the operculated species died in 24 hours when under 5% NSKE.

Vulgarone-B is another plant molluscicide isolated from crude oil by silica gel column chromatography of *Artemisia douglasiana* Besser aerial parts. The study of Joshi et al. (unpublished) has stated that Vulgarone-B has activity as molluscicide is comparable to that of metaldehyde (commercial molluscicide) in a laboratory bioassay indicating 100% mortality of GAS in 24 hours.

Naturally-Occurring Control Agents

Red ants and long-horned grasshopper predate on GAS egg masses, while ducks and rats consume their shells and meat (www.knowledgebank.irri.org/tropRice). Herding ducks into the rice fields during final land preparation or after crop establishment is therefore advised. Duck herding together with feed supplementation during their confinement can enhance egg production from 60 to 70% egg (Tacio, 1987). In rice-fish-duck-azolla farming system, duck-laying percentage was at an average of 60% (Cagauan, 1999).

Cultural and Physical Management

The shift from transplanted rice to direct-seeded rice culture even cause bigger GAS nuisance in the later crop establishment method. This is labor-intensive because missing hills should be replanted. Good field leveling and shallow water management practices are key options to reduce the GAS damage in lowland irrigated transplanted rice systems, but this practice is extremely difficult to adopt in direct-seeded and upland rice ecosystems and in flood-prone areas.

Installing metal screens at water inlets has been recommended to minimize the entry of large-sized GAS into the rice fields and to facilitate hand-collection, but small GAS can still enter undetected. Hand-picking GAS and crushing GAS egg masses by using hand-operated smashing devices are highly labor-intensive practices and unfeasible in large paddy fields. Mechanical control of GAS by rotary cultivator is efficient, as it can decrease their density drastically (Takahashi et al., 2002a). In submerged direct sown field, the GAS damaged 48.1 % of its area. However in the field where rotary cultivation was practiced it was only 2.3% (Takahashi et al., 2002b). Mochida (1988) also reported that the use of roto-tiller during land preparation is beneficial as it resulted to about 27% GAS mortality as compared to the unploughed fields.

Integrated Management Options

Despite GAS being classified as invasive, it can still be managed. GAS can be utilized as an animal feed and human food. It is now considered as a replacement for meat or fish meal in animal diets. The protein content (62.5%) is comparable to the CP value of Peruvian Fish meal (61.2%) but a little lower than the meat meal (66%) (Gerpacio and Castillo, 1979). Uncooked GAS meal in swine diets can be used up to 15% (Catalma et al., 1991a) and up to 10% in the diet of native chicks (Catalma et al., 1991b).

Nile Tilapia in aquaria when fed with GAS meat meal at 75-100% of the diet mixed with rice bran was beneficial and cost-effective (Cagauan and Doria, 1989). Similarly, in cage culture of Nile tilapia, snail-meal based diet was superior over the fish fed with fishmeal-based diet (Reazo, 1988). In the freshwater prawn larvae (*Macrobrachium rosenbergii*), 60% GAS meal in dried form mixed with rice bran, shrimp meal and fish meal gave good growth results (Lansangan et al., 2002).

As human food, GAS is cooked with coconut milk or made into 'kropeck'. One major hindrance in the feasibility of GAS recipes is their short shelf life. Moreover, the latest GAS recipe is the "chicharon kuhol" (cracker) which is devoid of water, odorless and has a longer shelf life (Dela Cruz and Joshi, 2001b).

GAS can also be used as bioweeder in transplanted rice systems. Paddy weeding is practiced by some organic and inorganic farmers in

Japan, Philippines and South Korea (Okuma et al., 1994; Wada et al., 2002, Yusa et al., 2003; Joshi et al., 2003a). GAS is employed to feed on aquatic weeds. Utilizing GAS for weeding is less laborious, more economical and “care-free” when compared with ducks, carp or tadpole shrimps (Yusa et al., 2003). In areas, not invaded by GAS, paddy weeding should be strictly prohibited.

Methodology

This chapter contains the different materials and methods used in the different experiments and explain how the management implications were derived.

GAS Mortalities

The study was conducted in Maligaya, Science City of Muñoz, Nueva Ecija. With the help and support of Department of Agriculture-Philippine Rice Research Institute (DA-PhilRice), the proponent had access to the CPD headhouse No.6 and other equipment. The experiments utilized various sizes and sexes of Golden Apple Snail, *Pomacea canaliculata* (Lamarck) from October 30, 2004 to December 31, 2004.

Experiment 1. GAS Mortality of Different GAS Sizes in Netbag Treatment

GAS were collected from water-logged rice fields, irrigation canals and fish ponds. They were sorted for standard sizes using a Mitutoyo digital caliper (range of ±1mm) (Plate 1). The GAS sizes were 10, 15, 20, 25, 30, 35 and 40-mm. The GAS were then colored white with an OFFICE correction fluid and numbered individually for proper identification using a N60 Pentel Pen permanent marker (Plate 2 & 3). GAS were weighed individually in a Mettler AE 240 digital balance (Plate 4).

Plate 1. Sorting of GAS sizes and sex.

Plate 2. Drying the marked shell of the GAS.

Plate 3. Assigning numbers to GAS.

Plate 4. Weighing marked GAS individually in the Metler AE 240 digital balance.

One hundred individuals per size were put in each netbag with the dimensions 24” x 12” (Plate 5). The netbags were labeled to avoid misidentification. Every two weeks, ten GAS were taken out from each netbag. They were weighed again using a Mettler AE 240 digital balance and were submerged in water for 2h in order to determine if they were alive or dead. On the eighth week, the remaining 70 GAS were weighed individually and submerged in water together to make the final assessment of mortality.

Plate 5. GAS sizes and sexes in netbags.

Experiment 2. GAS Mortality of Different GAS Sizes in Plastic Tray with Soil Treatment

The same procedure on GAS was followed except that in Experiment 2 where GAS were placed in 6” x 6” plastic trays in which one inch of paddy field soil was placed (Plate 6). After the soil has been levelled, 300 ml water was added to each tray. Ten plastic trays were used for each GAS size. In each plastic tray, five snails were buried into the soil. Following this, dried soil was added until the plastic tray was filled (Plate 7). The trays were then covered with a plastic lid having 64 holes for proper ventilation. Gypsum blocks were put in one plastic tray of each size, to get the soil moisture readings. Moisture readings were taken every two weeks. The mortality of the GAS were checked on the 56th day after treatment. The GAS were not weighed as it was impossible to remove the soil sticking on the shell.

Plate 6. The plastic trays used for the experiment were filled with one-inch paddy field soil.

Plate 7. GAS in plastic tray with water and paddy soil.

Experiment 3. GAS Mortality of Different GAS Sexes in Netbag Treatment

The same procedure was done to the GAS as in Experiment 1. The GAS were further classified according to their sex. GAS of 10 mm and 15 mm were not included in this experiment as their sex could not be determined. Twenty-five GAS per sex were put for each netbag. GAS were individually weighted after 56 days and then submerged in water to confirm if they were dead or alive.

Experiment 4. GAS Mortality of Different GAS Sexes in Plastic Tray with Soil Treatment

The same method in Experiment 3 was followed except that they were put in 6” x 6” plastic trays with paddy field soil (Plate 8). Twenty- five

GAS per sex were used, with 5 GAS per tray. The mortality was checked on the 56th day as done in the earlier experiments (Plate 9).

Management Implications

From the results of the four experiments, management implications were arrived at and presented as the second phase of this study. These management implications are recommendations to manage GAS.

Plate 8. The set-up of the plastic tray experiments.

Plate 9. Observations for GAS mortality.

Results and Discussion

This chapter presents the results based on the experiments conducted. This also includes discussions on suggested management implications.

GAS Mortalities

In all four experiments, GAS mortalities of all sizes and sexes showed that small-sized GAS took longer time to become active. This is probably because in small–sized GAS the operculum was tightly sealed with the mucus (saliva) (Plate 10). No relationships were observed for either sex.

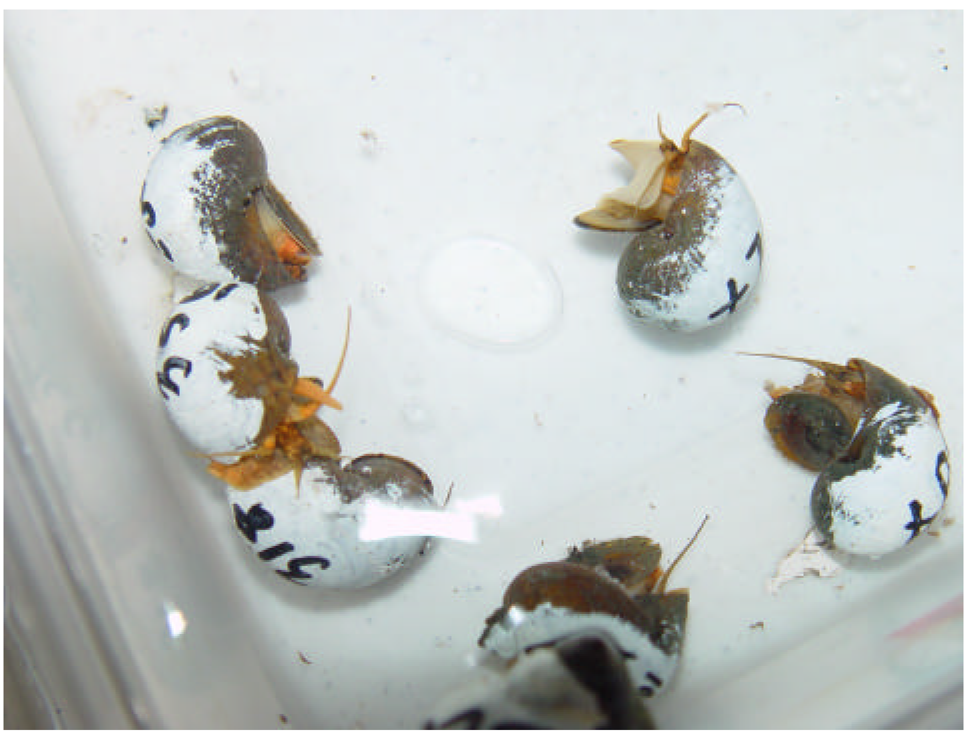

Plate 10. GAS observations on mortality after one hour.

Experiment 1. GAS Mortality of Different GAS Sizes in Netbag Treatment

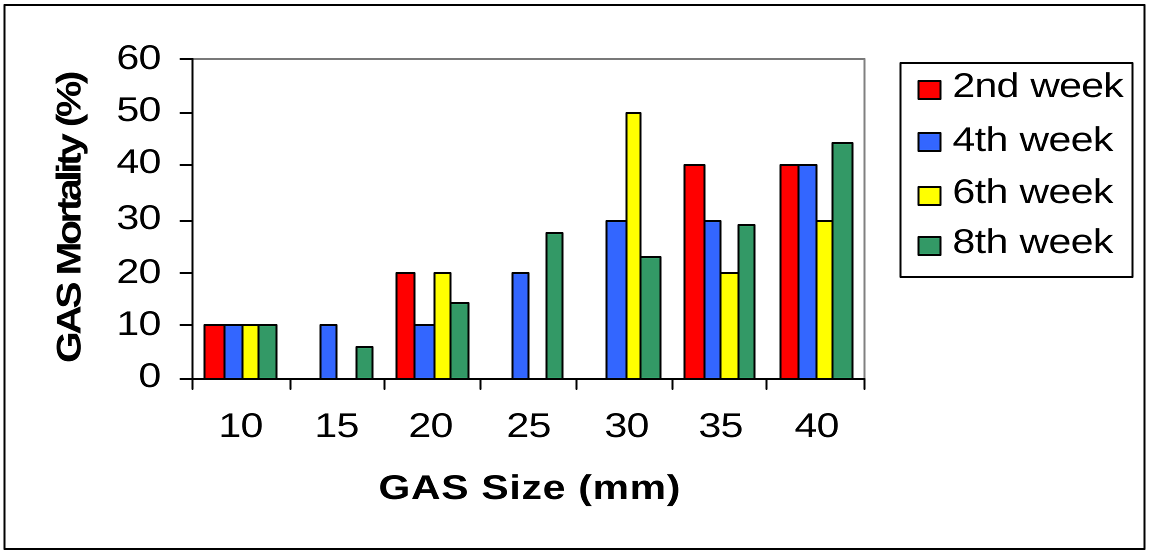

Figure 1. GAS mortality (%) at 2nd, 4th, 6th and 8th week after storage in netbags, October 30-December 31, 2004 (N=10 for 2nd, 4th and 6th week and N=70 for 8th week).

GAS mortality (%) increased as the size of the GAS increased (Figure 1). During the conduct of this experiment, it was observed that the large-sized GAS were more susceptible to the larvae of parasitic flies (Plate 11). This would have caused greater loss of body fluids and thus induced death. The 10-mm GAS mortality remained stagnant throughout the period of observation.

The distinct patterns in mortality were not observed in the 15-mm and 25-mm GAS which could not be explained fully. This could be possibly because there were some dead GAS individuals in the netbags that would have triggered death of other remaining GAS.

Plate 11. GAS with the parasitic fly larva.
(Note: white larva protruding out of the GAS operculum)

Table 1. GAS weight loss (%) in the netbags on the final day of observation.

GAS Size (mm)*	Alive			Dead		
	Initial Wt. (g) (X ± S.D.)	Final Wt. (g) (X ± S.D.)	Weight Loss (%) (X ± S.D.)	Initial Wt. (g) (X ± S.D.)	Final Wt. (g) (X ± S.D.)	Weight Loss (%) (X ± S.D.)
10	0.3 ± 0.1	0.2 ± 0.1	29.0 ± 8.2	0.3 ± 0.1	0.1 ± 0.1	53.6 ± 18.0
15	0.7 ± 0.2	0.5 ± 0.2	23.9 ± 8.1	0.6 ± 0.2	0.3 ± 0.1	52.7 ± 15.1
20	1.6 ± 0.2	1.3 ± 0.2	20.4 ± 3.5	1.4 ± 0.3	0.8 ± 0.2	40.5 ± 14.3
25	3.0 ± 0.3	2.5 ± 0.4	18.2 ± 7.7	2.7 ± 0.5	1.2 ± 0.4	54.7 ± 13.6
30	5.1 ± 0.6	4.2 ± 0.7	18.3 ± 6.7	4.7 ± 0.4	2.1 ± 0.5	55.0 ± 13.0
35	6.7 ± 1.0	5.4 ± 1.2	19.8 ± 10.2	6.2 ± 1.0	2.8 ± 0.9	55.3 ± 12.6
40	9.4 ± 1.6	7.3 ± 1.7	22.5 ± 8.3	8.0 ± 1.2	3.7 ± 1.2	53.7 ± 14.1

* N=70 per size.

Initial weights of dead and alive GAS were similar at the start of the experiment (Table 1). The standard deviation (S.D.) values were very small, suggesting variation within weights were negligible to cause experimental errors. Weight loss (%) in alive GAS ranged from 18.2 to 29.0 with a maximum standard deviation of 10.2. On contrary, GAS that were dead on the eighth week of storage lost weight (40.5-55.3) with a much higher standard deviation value. This loss in weight is probably related to the loss of body fluids during the storage as it is known that GAS utilize stored foods for their metabolism during dormancy. The weight loss (%) is a reliable indicator to determine if the GAS is dead or alive, rather than deciding the status solely on the initial and final weights or by immersing GAS in water. Hence in the future, this indicator can be used by researchers to study the long-term GAS mortality patterns. This is because even though the shell size was same (as measured by digital caliper); they differed significantly in their body weights.

Experiment 2. GAS Mortality of Different GAS Sizes in Plastic Tray with Soil Treatment

GAS mortality across all sizes was clearly higher in plastic trays compared with those in netbags (Figure 2). The mortality gradient in netbag was ascending as the size of the GAS increased. However, in plastic trays the mortality patterns were erratic (inconsistent trends). This is probably because there was less air flow in plastic trays that hindered their respiration even though GAS has both gills and lungs.

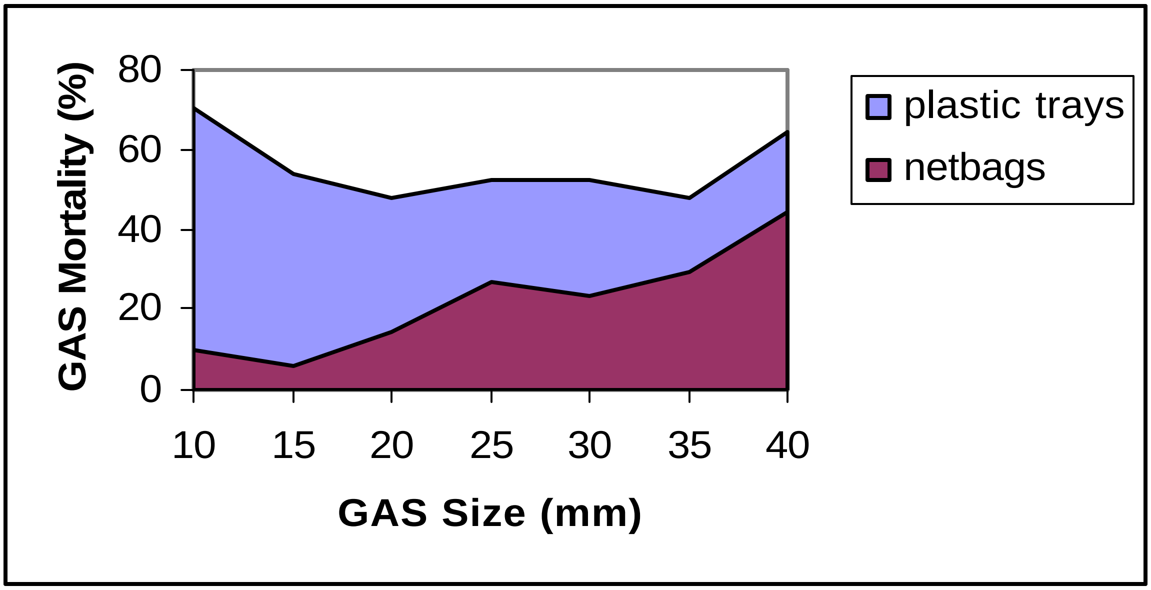

Figure 2. GAS mortality (%) observed in plastic trays and netbags at the end of the 8th week of storage (N=50 for plastic trays and N=70 for netbags).

Experiment 3. GAS Mortality of Different GAS Sexes in Netbag Treatment

There were no significant patterns of initial weight, final weight and weight loss (%) in relation with GAS sex that could be established (Table 2). Alive GAS were similar to the results of Experiment 1 although with a much lower weight loss (range of 16.2-25.9 %) and standard deviation (9.3). The weight loss (%) for the dead GAS ranged from 49.7 to 64.7 with a maximum standard deviation of 21. This experiment verifies the findings in Experiment 1 that showed that weight loss (%) is a more reliable indicator rather than weight, to know whether the GAS is alive or dead.

Table 2. GAS weight loss (%) in males and females of various sizes in netbags on the last sampling date.

GAS Size (mm)*	Sex	Alive			Dead		
		Initial Wt. (g) (X ± S.D.)	Final Wt. (g) (X ± S.D.)	Weight Loss (%) (X ± S.D.)	Initial Wt. (g) (X ± S.D.)	Final Wt. (g) (X ± S.D.)	Weight Loss (%) (X ± S.D.)
20	M	2.1 ± 0.2	1.6 ± 0.2	25.9 ± 4.2	2.3 ± 0.1	1.1 ± 0.1	53.1 ± 0.6
	F	1.5 ± 0.2	1.2 ± 0.2	22.3 ± 5.2	1.4 ± 0.2	0.5 ± 0.2	64.7 ± 8.7
25	M	3.0 ± 0.4	2.3 ± 0.4	23.3 ± 6.4	2.4 ± 0.2	1.2 ± 0.3	50.1 ± 12.5
	F	2.9 ± 0.4	2.3 ± 0.4	19.9 ± 4.1	2.6 ± 0.3	1.3 ± 0.2	49.7 ± 8.4
30	M	5.1 ± 0.6	4.1 ± 0.7	19.9 ± 5.6	4.0 ± 0.8	1.7 ± 0.1	55.9 ± 11.7
	F	5.1 ± 0.5	4.1 ± 0.6	19.1 ± 5.9	4.1 ± 0.8	1.6 ± 0.4	59.1 ± 12.3
35	M	6.4 ± 1.2	5.2 ± 1.4	20.0 ± 9.3	6.6 ± 0.7	3.2 ± 0.9	57.4 ± 21.0
	F	6.8 ± 1.0	5.1 ± 1.0	24.1 ± 8.0	6.3 ± 1.4	3.0 ± 0.1	52.4 ± 12.7
40	M	9.4 ± 2.0	7.9 ± 2.0	16.2 ± 4.5	8.2 ± 1.7	3.6 ± 1.0	54.6 ± 14.9
	F	9.0 ± 1.0	6.9 ± 1.3	23.6 ± 7.7	7.8 ± 0.8	3.0 ± 1.1	61.0 ± 12.4

*N=25 for each sex and size.

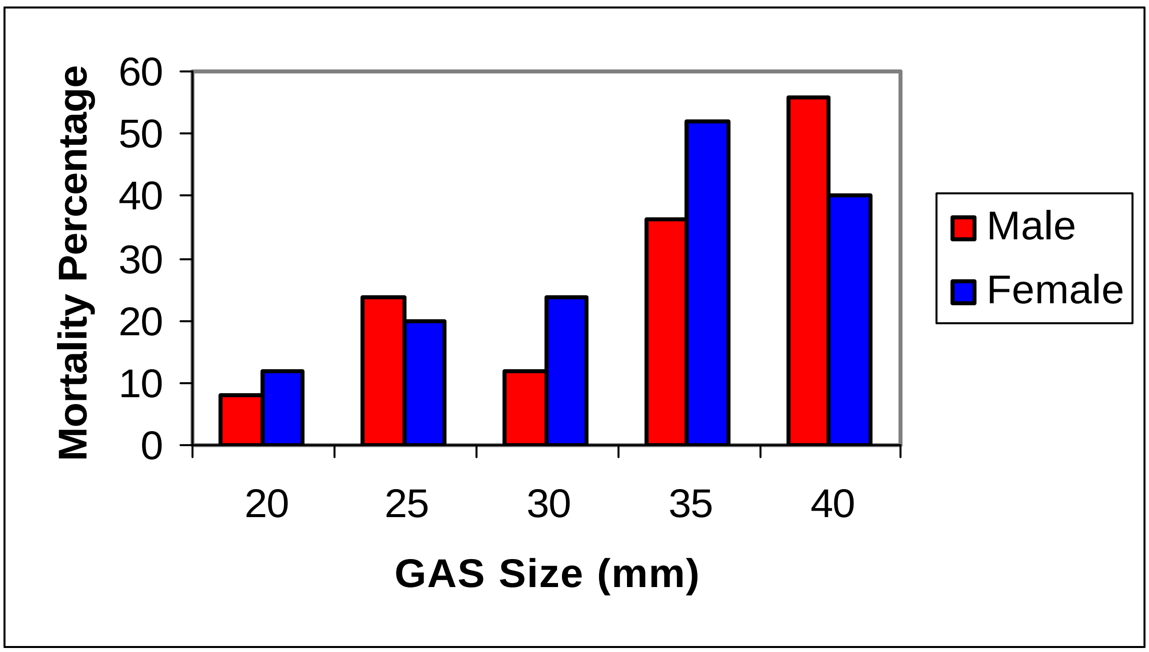

Figure 3. GAS mortality (%) at 8th week after storage in netbags, October 30-December 31, 2004 (N=25 for each sex and size).

The GAS mortality levels in relation to its sex were extremely variable (Figure 3). No consistent patterns were observed. It could only be observed that the mortality rate of the female GAS increased as the size increased, but suddenly decreased at 40-mm. In males, morality percentage increased except in 30-mm GAS. Therefore, there is no relationship between GAS sex and mortality percentage under netbag experiment.

Experiment 4. GAS Mortality of Different GAS Sexes in Plastic Tray with Soil Treatment

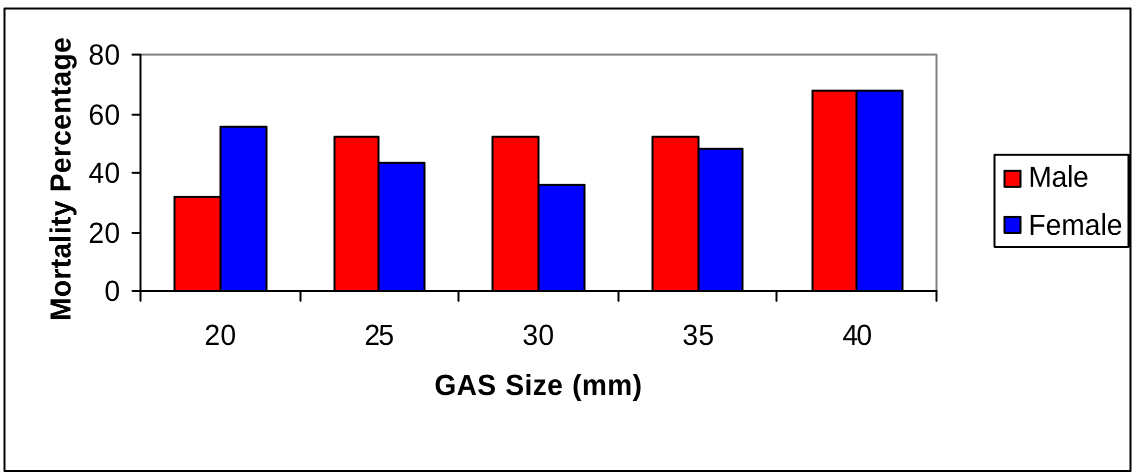

Figure 4. GAS mortality (%) at 8th week after storage in plastic trays, October 30-December 31, 2004 (N=25 for each sex and size).

The mortality patterns of the males and females GAS varied. The mortality percentages of the males increased as their size increased just as it was observed in Experiment 1. However, mortality in females was inconsistent. Very different from the previous experiments, the mortality in 40-mm were similar for both sexes (Figure 4).

Management Implications

In rice farming, integrated crop management practices are necessary to sustain high yields. GAS being one of the major rice pest needs to be properly managed. Based on this study, the best way to increase natural mortality of GAS prior to rice farming is to increase the per cent of weight loss by enhancing the loss of body fluids. There are several options which need to be integrated with the rice cropping calendar. Briefly, they are as follows (Table 3):

> The GAS mortalities and GAS sizes were interdependent. Small-sized GAS (10-15 mm) had the lowest mortality in the netbags (not including in plastic trays), which means that during land preparation, exposing GAS to sunlight by deep ploughing would enhance desiccation and thus produce size-related mortalities. Once the GAS were exposed, they could also be predated by birds and rats. The GAS egg masses also serve as food for the long-horned grasshopper and red ants.

After flooding, but prior to harrowing, releasing ducks would again accelerate size-related reduction. Ducks are known to feed on GAS up to 15-mm.

Table 3. Farmers' activities, possible options, their effects and possible farmers' acceptance.

Farmers' Activities	Management Implications	Possible Effects	Farmers' Possible Acceptance/Practice
Land Soaking	Duck Herding	Itching Food for Ducks	Highly Variable
	Manual Collection	Labor-Intensive Income-generating	Extremely High
	Harrowing	Labor-Intensive	Already Practiced
Land Preparation	Manual Collection	Labor-Intensive Income-generating	Extremely High
	Installation of Screens in Water Inlets	Labor-Intensive Expensive Not effective	Low
Crop Pest Management	Manual Collection	Labor-Intensive Income-generating	Extremely High
	Application of Agrochemicals and Botanicals	Expensive Fatal to Non-Target Organisms	High
	Proper Water Management	Labor-Intensive	Extremely High
Harvesting	Manual Collection	Labor-Intensive Income-generating	Extremely High
After Harvest	Deep Ploughing	Increase Mortality	Extremely High

After duck herding, the use of old newspapers to attract GAS, can make the manual picking of GAS easier and faster. Leaves of gabi, banana, papaya, trumpet flower, kangkong and sweet potato could be used as attractants in areas were they are readily available. Manual collection should be done during the early morning and late afternoon, as GAS are highly active during those times. Manual collection is an attractive option for farm workers as they can use GAS for food, as well as feed for farm animals (ducks, pigs, prawns and fishes).

During harrowing, the use of rotary weeder can further enhance GAS mortality, Takahashi et. at (2002b).

In the past, use of metal screens in the water inlets and manual/mechanical collection of GAS egg masses has been suggested, but farmers' found these methods labor-intensive and impractical (Joshi). It is recommended that when the soil is harrowed, the seedbeds should be raised to avoid GAS feeding on the seedlings.

During transplanting, shallow paddy water must be maintained at 1-2 cm deep starting three days after transplanting. This is the most destructive stage of GAS; therefore water management is the key to GAS management.

Application of agrochemicals and botanicals are not advised because they could also harm and kill non-target organisms. Aside from that they are beyond the reach of resource-poor farmers.

By following this cropping calendar GAS mortalities could be increased and rice yields could be sustained and improved. This calendar (Table 3) was designed based from the results obtained in this study. It also aims to help rice technicians, extension workers and farmers, to have an integrated approach to GAS management that is socially-acceptable, economical, sustainable and environmental-friendly.

Summary, Conclusions and Recommendation

Summary

GAS is a major rice pest in all rice-growing countries. Its damage could range from 20-100% from the germinating to the transplanting stage. The extent of the damage can be determined by snail size, snail density and rice crop stage. Hence, it is highly significant to study the mortality rates of GAS before the planting season to be able to predict the GAS size dominant in the rice field.

The study aimed to determine if there is a relationship between GAS off-season mortality and GAS size and sex. The experiments were conducted in netbags and plastic trays with soil. GAS in netbags represent the GAS exposed while GAS in plastic trays were the GAS that aestivated. From the baseline information of the conducted experiments management implications were suggested.

Results showed that there is a highly positive relationship between GAS size and its mortality. Generally, GAS mortality increased as it increased in size. This could be clearly observed in netbags than in the plastic trays. In the plastic trays, there was a very high mortality for the small-sized GAS, which was probably due to the lack of aeration and low air exchange. No consistent patterns were observed between GAS mortality and its sex. A rice cropping calendar was suggested in order to sustain high yields and reduce GAS damage.

Conclusions

GAS mortality in terms of their size and sex ranged from 5-60%, over the observation periods. These values are very low conforming their fast reproductive potentials and growth. Thus, it is advised to initiate GAS management options even before land preparation, rather than during transplanting only. In addition, it is much harder to manage GAS once rice seedlings are already planted. A well-leveled field with proper water management is the key to reduce GAS damage to rice.

Recommendations

GAS mortality rates should be studied in terms of its weight, weight loss and other factors related over a longer period. These studies would then help to fill the knowledge gaps on GAS management and provide refinement to the GAS management systems in rice ecosystems.

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Web Links

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ISSG Website: http://www.issg.org/
http://www.issg.org/database/welcome/

Database on Introductions of Aquatic Species (DIAS)
http://www.fao.org/waicent/faoinfo/fishery/statist/fisoft/dias/mainpage.htm

The golden apple snail in the rice fields of Asia
http://www.fao.org/NEWS/1998/RIFILI-E.HTM

Sarawak Warns Of Snail Threat
http://agrolink.moa.my/moa1/newspaper/pertanian/ra981123c.html

No. 1 GOLDEN APPLE SNAIL IN PAPUA NEW GUINEA Papua New Guinea has ... (PDF) http://www.spc.int/pps/PestAlerts/AgAlertNo01.pdf view as html

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http://www.cphst.org/npag/Molamppc598.pdf

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http://www.agnet.org/library/article/pt2002041.html

Eco-Jobs & Eco-Entrepreneurship A Global Data base on such Initiatives & Opportunities http://www.mssrf.org/ecojobs/sard/175b.html

HALTING THE SNAIL TRAIL OF DESTRUCTION
http://www.csiro.au/news/mediarel/mr1998/mr98241.html
http://www.gsmfc.org/nis/nis/*Pomacea* _canaliculata.html

The Florida (USA) link to golden apple snail is as follows:
http://www.floridaaquaculture.com/Pub/Pub.htm

The apple snail technical bulletin
http://www.floridaaquaculture.com/Pub/Apple%20Snails.pdf

Apple Snails in Wetland Taro Production
http://agrss.sherman.hawaii.edu/onfarm/pest/pest0008.html

Aquatic Species Introductions Database from FAO
http://www.fao.org/scripts/acqintro/query/retrive.idc

MISSISSIPPI EMERGENCY APPLE SNAIL REGULATION
http://doacs.state.fl.us/~pi/plantinsp/AppleSnailMainx.html

Some Hawaii pests arrived by invitation
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Appendices

Experiment 1. GAS Mortality of Different GAS Sizes in Netbag Treatment

Appendix 1. Weekly observation on the mortality of 10-mm GAS (November 21, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
22	0.34	0.17	0.07	Dead	20.59
138	0.33	0.29	0.04	Alive	12.12
20	0.37	0.32	0.05	Alive	13.51
288	0.32	0.27	0.05	Alive	15.63
161	0.31	0.26	0.05	Alive	16.13
124	0.27	0.24	0.03	Alive	11.11
260	0.39	0.34	0.05	Alive	12.82
306	0.25	0.19	0.06	Alive	24.00
293	0.38	0.33	0.05	Alive	13.16
319	0.4	0.34	0.06	Alive	15.00

Appendix 2. Weekly observation on the mortality of 10-mm GAS (December 4, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
19	0.21	0.19	0.02	Dead	9.52
335	0.3	0.22	0.08	Alive	26.67
278	0.37	0.25	0.12	Alive	32.43
43	0.47	0.34	0.13	Alive	27.66
27	0.38	0.27	0.11	Alive	28.95
336	0.23	0.11	0.12	Alive	52.17
147	0.33	0.31	0.02	Alive	6.06
33	0.38	0.32	0.06	Alive	15.79
109	0.33	0.19	0.14	Alive	42.42
65	0.38	0.24	0.14	Alive	36.84

Appendix 3. Weekly observation on the mortality of 10-mm GAS (December 19, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
299	0.11	0.09	0.02	Dead	18.18
229	0.26	0.17	0.09	Alive	34.62
10	0.48	0.38	0.1	Alive	20.83
99	0.24	0.22	0.02	Alive	8.33
218	0.33	0.25	0.08	Alive	24.24
268	0.37	0.26	0.11	Alive	29.73
56	0.35	0.26	0.09	Alive	25.71
228	0.47	0.37	0.1	Alive	21.28
281	0.25	0.17	0.08	Alive	32.00
311a	0.29	0.23	0.06	Alive	20.69

Appendix 4. Final observation on the mortality of 10-mm GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
116	0.25	0.12	0.13	Dead	52.00
142	0.15	0.11	0.04	Dead	26.67
198	0.31	0.19	0.12	Dead	38.71
267	0.24	0.11	0.13	Dead	54.17
283	0.36	0.08	0.28	Dead	77.78
313	0.19	0.05	0.14	Dead	73.68
318	0.4	0.19	0.21	Dead	52.50
25	0.36	0.29	0.07	Alive	19.44
39	0.32	0.25	0.07	Alive	21.88
41	0.38	0.16	0.22	Alive	57.89
42	0.36	0.27	0.09	Alive	25.00
52	0.37	0.28	0.09	Alive	24.32
57	0.33	0.25	0.08	Alive	24.24
60	0.39	0.27	0.12	Alive	30.77
62	0.27	0.18	0.09	Alive	33.33
68	0.33	0.27	0.06	Alive	18.18
74	0.36	0.28	0.08	Alive	22.22
76	0.41	0.3	0.11	Alive	26.83
81	0.32	0.24	0.08	Alive	25.00
85	0.4	0.29	0.11	Alive	27.50
87	0.38	0.27	0.11	Alive	28.95
91	0.37	0.26	0.11	Alive	29.73
94	0.34	0.26	0.08	Alive	23.53
95	0.27	0.21	0.06	Alive	22.22
99	0.24	0.16	0.08	Alive	33.33
100	0.33	0.2	0.13	Alive	39.39
111	0.33	0.23	0.1	Alive	30.30

112	0.46	0.35	0.11	Alive	23.91
113	0.27	0.17	0.1	Alive	37.04
118	0.32	0.22	0.1	Alive	31.25
119	0.37	0.28	0.09	Alive	24.32
123	0.36	0.28	0.08	Alive	22.22
152	0.27	0.19	0.08	Alive	29.63
154	0.44	0.37	0.07	Alive	15.91
166	0.32	0.22	0.1	Alive	31.25
167	0.2	0.13	0.07	Alive	35.00
170	0.36	0.27	0.09	Alive	25.00
173	0.36	0.25	0.11	Alive	30.56
177	0.37	0.25	0.12	Alive	32.43
179	0.31	0.2	0.11	Alive	35.48
186	0.31	0.2	0.11	Alive	35.48
192	0.38	0.3	0.08	Alive	21.05
201	0.35	0.25	0.1	Alive	28.57
204	0.42	0.33	0.09	Alive	21.43
206	0.33	0.23	0.1	Alive	30.30
216	0.32	0.23	0.09	Alive	28.13
217	0.35	0.27	0.08	Alive	22.86
219	0.25	0.17	0.08	Alive	32.00
224	0.4	0.27	0.13	Alive	32.50
236	0.29	0.21	0.08	Alive	27.59
238	0.3	0.22	0.08	Alive	26.67
242	0.44	0.25	0.19	Alive	43.18
252	0.34	0.25	0.09	Alive	26.47
270	0.27	0.16	0.11	Alive	40.74
271	0.29	0.21	0.08	Alive	27.59
282	0.31	0.21	0.1	Alive	32.26
289	0.32	0.24	0.08	Alive	25.00
290	0.35	0.28	0.07	Alive	20.00
291	0.28	0.19	0.09	Alive	32.14
295	0.35	0.21	0.14	Alive	40.00
298	0.33	0.24	0.09	Alive	27.27
303	0.32	0.22	0.1	Alive	31.25
312	0.25	0.15	0.1	Alive	40.00
316	0.36	0.28	0.08	Alive	22.22
324	0.25	0.19	0.06	Alive	24.00
330	0.26	0.17	0.09	Alive	34.62
337	0.22	0.1	0.12	Alive	54.55
311b	0.24	0.22	0.02	Alive	8.33
51a	0.45	0.36	0.09	Alive	20.00
51b	0.35	0.23	0.12	Alive	34.29

Appendix 5. Weekly observation on the mortality of 15-mm GAS (November 21, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
315	0.83	0.75	0.08	Alive	9.64
94	0.61	0.55	0.06	Alive	9.84
186	0.47	0.41	0.06	Alive	12.77
46	1	0.94	0.06	Alive	6.00
63	0.59	0.53	0.06	Alive	10.17
141	0.74	0.67	0.07	Alive	9.46
382	0.77	0.7	0.07	Alive	9.09
237	0.64	0.56	0.08	Alive	12.50
139	0.47	0.42	0.05	Alive	10.64
168	0.63	0.58	0.05	Alive	7.94

Appendix 6. Weekly observation on the mortality of 15-mm GAS (December 4, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
28	0.67	0.33	0.34	Dead	50.75
170	0.77	0.65	0.12	Alive	15.58
346	0.67	0.55	0.12	Alive	17.91
234	0.64	0.58	0.06	Alive	9.38
12	0.61	0.47	0.14	Alive	22.95
316	0.85	0.7	0.15	Alive	17.65
78	0.85	0.82	0.03	Alive	3.53
393	0.74	0.58	0.16	Alive	21.62
61	0.82	0.72	0.1	Alive	12.20
68	0.79	0.74	0.05	Alive	6.33

Appendix 7. Weekly observation on the mortality of 15-mm GAS (December 19, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
198	0.43	0.34	0.09	Alive	20.93
199	0.48	0.36	0.12	Alive	25.00
383	0.78	0.63	0.15	Alive	19.23
9	0.9	0.75	0.15	Alive	16.67
311	0.8	0.69	0.11	Alive	13.75
225	0.88	0.75	0.13	Alive	14.77
83	0.91	0.75	0.16	Alive	17.58
92	0.72	0.62	0.1	Alive	13.89
365	0.63	0.5	0.13	Alive	20.63
7	0.75	0.61	0.14	Alive	18.67

Appendix 8. Final observation on the mortality of 15-mm GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
37	0.82	0.3	0.52	Dead	63.41
45	0.71	0.38	0.33	Dead	46.48
96	0.69	0.23	0.46	Dead	66.67
299	0.32	0.21	0.11	Dead	34.38
3	1.12	0.79	0.33	Alive	29.46
4	0.91	0.79	0.12	Alive	13.19
8	0.62	0.5	0.12	Alive	19.35
14	0.71	0.6	0.11	Alive	15.49
16	1.12	0.83	0.29	Alive	25.89
20	0.48	0.38	0.1	Alive	20.83
31	0.64	0.52	0.12	Alive	18.75
33	0.55	0.4	0.15	Alive	27.27
38	0.71	0.58	0.13	Alive	18.31
39	0.74	0.62	0.12	Alive	16.22
58	0.89	0.79	0.1	Alive	11.24
65	0.85	0.64	0.21	Alive	24.71
72	0.7	0.47	0.23	Alive	32.86
87	0.81	0.6	0.21	Alive	25.93
108	0.8	0.73	0.07	Alive	8.75
110	0.65	0.43	0.22	Alive	33.85
111	0.77	0.59	0.18	Alive	23.38
134	0.5	0.36	0.14	Alive	28.00
136	0.62	0.51	0.11	Alive	17.74
144	0.7	0.52	0.18	Alive	25.71
145	0.95	0.77	0.18	Alive	18.95
146	0.85	0.62	0.23	Alive	27.06
149	0.6	0.41	0.19	Alive	31.67
151	0.72	0.55	0.17	Alive	23.61
159	0.7	0.55	0.15	Alive	21.43
165	0.66	0.46	0.2	Alive	30.30
166	0.78	0.62	0.16	Alive	20.51
177	0.45	0.35	0.1	Alive	22.22
182	0.62	0.48	0.14	Alive	22.58
183	0.82	0.68	0.14	Alive	17.07
188	0.64	0.5	0.14	Alive	21.88
197	0.81	0.67	0.14	Alive	17.28
200	0.43	0.28	0.15	Alive	34.88
202	0.5	0.3	0.2	Alive	40.00
206	0.54	0.43	0.11	Alive	20.37
212	0.55	0.45	0.1	Alive	18.18
216	0.53	0.43	0.1	Alive	18.87
219	0.43	0.28	0.15	Alive	34.88
222	0.61	0.47	0.14	Alive	22.95

250	0.54	0.46	0.08	Alive	14.81
252	0.82	0.66	0.16	Alive	19.51
261	0.81	0.63	0.18	Alive	22.22
277	0.58	0.42	0.16	Alive	27.59
281	0.39	0.27	0.12	Alive	30.77
290	0.77	0.65	0.12	Alive	15.58
292	0.62	0.24	0.38	Alive	61.29
293	0.81	0.64	0.17	Alive	20.99
302	0.81	0.64	0.17	Alive	20.99
317	0.81	0.63	0.18	Alive	22.22
322	0.63	0.51	0.12	Alive	19.05
325	0.77	0.64	0.13	Alive	16.88
330	0.37	0.29	0.08	Alive	21.62
338	0.8	0.62	0.18	Alive	22.50
340	0.58	0.37	0.21	Alive	36.21
357	0.49	0.38	0.11	Alive	22.45
364	0.63	0.49	0.14	Alive	22.22
374	0.79	0.66	0.13	Alive	16.46
378	0.87	0.67	0.2	Alive	22.99
379	0.71	0.54	0.17	Alive	23.94
396	0.48	0.35	0.13	Alive	27.08
407	0.52	0.37	0.15	Alive	28.85
411	0.75	0.61	0.14	Alive	18.67
416	0.6	0.41	0.19	Alive	31.67
419	0.68	0.56	0.12	Alive	17.65
446	0.39	0.26	0.13	Alive	33.33
447	0.34	0.21	0.13	Alive	38.24

Appendix 9. Weekly observation on the mortality of 20-mm GAS (November 21, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
264	f	1.43	1.29	0.14	Dead	9.79
127	f	1.58	0.98	0.6	Dead	37.97
149	f	1.32	1.17	0.15	Alive	11.36
221	f	1.43	1.35	0.08	Alive	5.59
216	f	1.55	1.4	0.15	Alive	9.68
307	f	1.39	1.27	0.12	Alive	8.63
296	f	1.66	1.52	0.14	Alive	8.43
130	f	1.36	1.23	0.13	Alive	9.56
180	f	1.44	1.3	0.14	Alive	9.72
155	m	1.86	1.73	0.13	Alive	6.99

Appendix 10. Weekly observation on the mortality of 20-mm GAS (December 4, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
193	f	1.7	1.41	0.29	Dead	17.06
270	f	1.28	1.24	0.04	Alive	3.13
47	f	1.33	1.2	0.13	Alive	9.77
220	f	1.6	1.29	0.31	Alive	19.38
73	f	1.71	1.52	0.19	Alive	11.11
231	f	1.45	1.17	0.28	Alive	19.31
135	f	1.54	1.39	0.15	Alive	9.74
271	f	1.5	1.35	0.15	Alive	10.00
215	f	2.06	1.61	0.45	Alive	21.84
308	m	1.52	1.11	0.41	Alive	26.97

Appendix 11. Weekly observation on the mortality of 20-mm GAS (December 19, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
41	f	1.58	0.61	0.97	Dead	61.39
19	f	1.67	0.72	0.95	Dead	56.89
260	f	1.31	1.08	0.23	Alive	17.56
43	f	1.54	1.26	0.28	Alive	18.18
61	f	1.5	1.2	0.3	Alive	20.00
69	f	1.62	1.26	0.36	Alive	22.22
28	f	1.45	1.18	0.27	Alive	18.62
32	f	1.38	1.18	0.2	Alive	14.49
304	f	1.36	1.09	0.27	Alive	19.85
30	m	1.65	1.42	0.23	Alive	13.94

Appendix 12. Final observation on the mortality of 20-mm GAS (December 31, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
123	f	1.07	0.61	0.46	Dead	42.99
145	f	1.7	0.78	0.92	Dead	54.12
146	f	1.74	1.4	0.34	Dead	19.54
188	f	1.17	0.87	0.3	Dead	25.64
211	f	1.35	0.98	0.37	Dead	27.41
244	f	1.2	0.6	0.6	Dead	50.00
253	f	1.62	0.84	0.78	Dead	48.15
263	f	1.3	0.77	0.53	Dead	40.77
283	f	1.88	0.66	1.22	Dead	64.89

289	f	1.02	0.7	0.32	Dead	31.37
2	f	1.58	1.26	0.32	Alive	20.25
5	f	1.28	1.04	0.24	Alive	18.75
10	f	1.91	1.53	0.38	Alive	19.90
13	f	1.69	1.31	0.38	Alive	22.49
24	f	1.49	1.15	0.34	Alive	22.82
25	f	1.5	1.13	0.37	Alive	24.67
33	f	2	1.6	0.4	Alive	20.00
44	f	1.42	1.14	0.28	Alive	19.72
49	f	1.49	1.21	0.28	Alive	18.79
53	f	1.6	1.23	0.37	Alive	23.13
68	f	1.61	1.38	0.23	Alive	14.29
72	f	1.82	1.56	0.26	Alive	14.29
77	f	1.81	1.55	0.26	Alive	14.36
78	f	1.26	1.03	0.23	Alive	18.25
79	f	1.44	1.16	0.28	Alive	19.44
80	f	1.18	0.91	0.27	Alive	22.88
119	f	1.28	0.95	0.33	Alive	25.78
120	f	1.64	1.14	0.5	Alive	30.49
121	f	1.24	1	0.24	Alive	19.35
122	f	2.06	1.72	0.34	Alive	16.50
125	f	1.7	1.26	0.44	Alive	25.88
134	f	1.55	1.2	0.35	Alive	22.58
144	f	1.21	0.95	0.26	Alive	21.49
147	f	1.56	1.22	0.34	Alive	21.79
151	f	1.91	1.52	0.39	Alive	20.42
156	f	1.54	1.22	0.32	Alive	20.78
163	f	1.8	1.43	0.37	Alive	20.56
166	f	1.71	1.37	0.34	Alive	19.88
169	f	2.03	1.62	0.41	Alive	20.20
177	f	1.25	0.93	0.32	Alive	25.60
178	f	1.35	1.11	0.24	Alive	17.78
181	f	1.41	1.14	0.27	Alive	19.15
185	f	1.36	1.01	0.35	Alive	25.74
186	f	1.35	1.11	0.24	Alive	17.78
197	f	1.26	1.04	0.22	Alive	17.46
198	f	1.73	1.42	0.31	Alive	17.92
199	f	1.46	1.18	0.28	Alive	19.18
212	f	1.29	1.05	0.24	Alive	18.60
213	f	1.6	1.27	0.33	Alive	20.63
226	f	1.66	1.29	0.37	Alive	22.29
233	f	1.15	0.89	0.26	Alive	22.61
242	f	1.64	1.16	0.48	Alive	29.27
250	f	1.69	1.41	0.28	Alive	16.57
254	f	1.64	1.39	0.25	Alive	15.24
257	f	2.14	1.78	0.36	Alive	16.82
273	f	1.4	1.07	0.33	Alive	23.57

277	f	1.63	1.33	0.3	Alive	18.40
284	f	1.47	1.2	0.27	Alive	18.37
288	f	1.63	1.33	0.3	Alive	18.40
302	f	1.92	1.41	0.51	Alive	26.56
305	f	1.65	1.37	0.28	Alive	16.97
317	f	1.39	1.13	0.26	Alive	18.71
318	f	1.42	1.16	0.26	Alive	18.31
319	f	1.37	1.12	0.25	Alive	18.25
322	f	1.53	1.19	0.34	Alive	22.22
18	m	1.93	1.58	0.35	Alive	18.13
34	m	1.73	1.44	0.29	Alive	16.76
179	m	1.43	1.1	0.33	Alive	23.08
195	m	1.98	1.6	0.38	Alive	19.19
219	m	1.73	1.32	0.41	Alive	23.70

Appendix 13. Weekly observation on the mortality of 25-mm GAS
(November 21, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
323	f	2.36	2.09	0.27	Alive	11.44
341	f	2.57	2.35	0.22	Alive	8.56
334	f	3.18	2.82	0.36	Alive	11.32
206	f	3.19	2.89	0.3	Alive	9.40
235	f	3	2.52	0.48	Alive	16.00
173	m	2.57	2.1	0.47	Alive	18.29
405	m	2.8	2.58	0.22	Alive	7.86
177	m	3.78	3.42	0.36	Alive	9.52
424	m	2.6	2.44	0.16	Alive	6.15
373	m	3.09	2.85	0.24	Alive	7.77

Appendix 14. Weekly observation on the mortality of 25-mm GAS
(December 4, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
277	f	1.7	0.99	0.71	Dead	41.76
295	f	3.68	1.79	1.89	Dead	51.36
27	f	3.01	2.61	0.4	Alive	13.29
318	f	2.92	2.61	0.31	Alive	10.62
269	f	2.94	2.56	0.38	Alive	12.93
165	f	3.25	2.87	0.38	Alive	11.69
356	f	3.29	2.79	0.5	Alive	15.20
384	f	3	2.72	0.28	Alive	9.33
246	f	2.33	1.83	0.5	Alive	21.46
409	m	2.29	1.52	0.77	Alive	33.62

Appendix 15. Weekly observation on the mortality of 25-mm GAS (December 19, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
168	f	3.05	2.64	0.41	Alive	13.44
262	f	2.94	2.59	0.35	Alive	11.90
44	f	3.2	2.85	0.35	Alive	10.94
121	f	3.54	3.11	0.43	Alive	12.15
123	f	4.15	3.3	0.85	Alive	20.48
303	f	2.58	2.17	0.41	Alive	15.89
394	f	2.75	2.38	0.37	Alive	13.45
313	m	2.87	2.24	0.63	Alive	21.95
61	m	3.56	3.14	0.42	Alive	11.80
407	m	3.3	2.84	0.46	Alive	13.94

Appendix 16. Final observation on the mortality of 25-mm GAS (December 31, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
34	f	2.45	0.87	1.58	Dead	64.49
59	f	3.09	1.01	2.08	Dead	67.31
92	f	2.54	1.03	1.51	Dead	59.45
155	f	3.15	2.67	0.48	Dead	15.24
223	f	3.36	1.11	2.25	Dead	66.96
254	f	3.37	1.7	1.67	Dead	49.55
282	f	3.2	1.01	2.19	Dead	68.44
316	f	2.81	1.38	1.43	Dead	50.89
332	f	3.27	0.93	2.34	Dead	71.56
333	f	2.94	1	1.94	Dead	65.99
362	f	2.71	1.17	1.54	Dead	56.83
363	f	1.27	0.78	0.49	Dead	38.58
371	f	2.62	1.4	1.22	Dead	46.56
78	m	2.74	1.22	1.52	Dead	55.47
98	m	2.9	0.96	1.94	Dead	66.90
149	m	2.58	1.27	1.31	Dead	50.78
320	m	2.43	1.34	1.09	Dead	44.86
421	m	2.38	1.03	1.35	Dead	56.72
427	m	2.18	1.22	0.96	Dead	44.04
1	f	3.61	3.15	0.46	Alive	12.74
26	f	3.37	2.71	0.66	Alive	19.58
29	f	3.37	2.94	0.43	Alive	12.76
47	f	2.63	2.07	0.56	Alive	21.29
51	f	3.21	2.36	0.85	Alive	26.48
52	f	3.05	2.56	0.49	Alive	16.07
63	f	3.42	2.94	0.48	Alive	14.04
65	f	3.2	2.48	0.72	Alive	22.50

70	f	3	2.4	0.6	Alive	20.00
97	f	2.89	2.44	0.45	Alive	15.57
100	f	2.67	2.05	0.62	Alive	23.22
103	f	3.17	2.45	0.72	Alive	22.71
131	f	2.81	2.35	0.46	Alive	16.37
134	f	2.89	2.51	0.38	Alive	13.15
136	f	2.76	2.1	0.66	Alive	23.91
137	f	3.1	2.36	0.74	Alive	23.87
140	f	3.27	2.87	0.4	Alive	12.23
154	f	2.52	2.03	0.49	Alive	19.44
161	f	2.6	2.27	0.33	Alive	12.69
164	f	2.45	1.88	0.57	Alive	23.27
166	f	3.35	2.82	0.53	Alive	15.82
175	f	2.86	2.35	0.51	Alive	17.83
181	f	2.88	3.49	-0.61	Alive	-21.18
187	f	2.46	1.92	0.54	Alive	21.95
195	f	3	2.46	0.54	Alive	18.00
205	f	3.1	2.69	0.41	Alive	13.23
208	f	3.24	2.72	0.52	Alive	16.05
219	f	3.49	2.84	0.65	Alive	18.62
226	f	3.17	2.43	0.74	Alive	23.34
253	f	2.88	2.01	0.87	Alive	30.21
263	f	2.93	2.56	0.37	Alive	12.63
265	f	2.43	1.9	0.53	Alive	21.81
267	f	2.95	2.18	0.77	Alive	26.10
270	f	3.06	2.65	0.41	Alive	13.40
272	f	2.85	2.41	0.44	Alive	15.44
298	f	2.74	2.12	0.62	Alive	22.63
338	f	3.24	2.72	0.52	Alive	16.05
339	f	3.15	2.44	0.71	Alive	22.54
340	f	3.07	1.9	1.17	Alive	38.11
344	f	2.47	1.93	0.54	Alive	21.86
359	f	2.39	1.92	0.47	Alive	19.67
379	f	3.03	2.61	0.42	Alive	13.86
381	f	3.4	2.76	0.64	Alive	18.82
388	f	3.44	2.95	0.49	Alive	14.24
236	f	2.9	2.32	0.58	Alive	20.00
17	m	2.7	1.98	0.72	Alive	26.67
122	m	3.59	3	0.59	Alive	16.43
151	m	3.25	2.68	0.57	Alive	17.54
264	m	3.08	2.56	0.52	Alive	16.88
288	m	2.97	2.49	0.48	Alive	16.16
428	m	2.69	2.41	0.28	Alive	10.41

Appendix 17. Weekly observation on the mortality of 30-mm GAS (November 21, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
271	f	7.31	4.71	2.6	Alive	35.57
360	f	7.73	3.37	4.36	Alive	56.40
404	f	8.03	3.48	4.55	Alive	56.66
42	f	5.75	4.99	0.76	Alive	13.22
14	f	7.14	3.65	3.49	Alive	48.88
16	f	5.69	3.67	2.02	Alive	35.50
239	m	7.29	5.08	2.21	Alive	30.32
285	m	7.04	3.83	3.21	Alive	45.60
65	m	6.32	4.23	2.09	Alive	33.07
354	m	6.91	4.27	2.64	Alive	38.21

Appendix 18. Weekly observation on the mortality of 30-mm GAS (December 4, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
259	f	4.35	2.47	1.88	Dead	43.22
170	f	4.42	2.92	1.5	Dead	33.94
305	m	4.01	2.18	1.83	Dead	45.64
72	f	5.62	5.21	0.41	Alive	7.30
215	f	6.4	5.52	0.88	Alive	13.75
312	f	5.16	4.72	0.44	Alive	8.53
338	f	4.05	3.28	0.77	Alive	19.01
335	f	4.59	4.07	0.52	Alive	11.33
81	m	6.13	5.79	0.34	Alive	5.55
384	m	3.72	3.17	0.55	Alive	14.78

Appendix 19. Weekly observation on the mortality of 30-mm GAS (December 19, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
361	f	4.62	4.12	0.5	Dead	10.82
257	m	4.71	2.13	2.58	Dead	54.78
189	m	5.72	2.21	3.51	Dead	61.36
235	m	5.64	1.94	3.7	Dead	65.60
50	m	4.25	1.92	2.33	Dead	54.82
11	f	5.31	4.8	0.51	Alive	9.60
33	f	5.34	5.05	0.29	Alive	5.43
191	f	4.42	3.55	0.87	Alive	19.68
266	f	4.87	4.29	0.58	Alive	11.91
64	f	4.83	4.23	0.6	Alive	12.42

Appendix 20. Final observation on the mortality of 30-mm GAS (December 31, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
15	f	4.78	1.9	2.88	Dead	60.25
86	f	4.13	1.33	2.8	Dead	67.80
126	f	4.98	1.5	3.48	Dead	69.88
134	f	4.32	3.23	1.09	Dead	25.23
139	f	5.33	2.51	2.82	Dead	52.91
145	f	5.27	2.51	2.76	Dead	52.37
226	f	3.87	2.36	1.51	Dead	39.02
332	f	4.46	1.92	2.54	Dead	56.95
341	f	5.18	1.64	3.54	Dead	68.34
365	f	4.72	2.54	2.18	Dead	46.19
132	m	4.99	1.66	3.33	Dead	66.73
137	m	4.91	2.82	2.09	Dead	42.57
159	m	4.41	1.63	2.78	Dead	63.04
252	m	4.26	1.82	2.44	Dead	57.28
396	m	4.59	1.6	2.99	Dead	65.14
407	m	4.57	2.49	2.08	Dead	45.51
6	f	4.9	3.61	1.29	Alive	26.33
17	f	4.49	3.62	0.87	Alive	19.38
20	f	5.17	4.43	0.74	Alive	14.31
22	f	4.2	3.4	0.8	Alive	19.05
24	f	5.56	4.54	1.02	Alive	18.35
27	f	5.48	4.69	0.79	Alive	14.42
35	f	4.89	3.99	0.9	Alive	18.40
37	f	4.95	4.2	0.75	Alive	15.15
40	f	5.54	4.43	1.11	Alive	20.04
47	f	4.5	3.79	0.71	Alive	15.78
48	f	5.15	4.35	0.8	Alive	15.53
49	f	4.97	3.09	1.88	Alive	37.83
67	f	4.84	4.12	0.72	Alive	14.88
88	f	5.26	4.47	0.79	Alive	15.02
111	f	4.91	4.26	0.65	Alive	13.24
115	f	5.12	4.48	0.64	Alive	12.50
118	f	5.18	3.56	1.62	Alive	31.27
143	f	4.05	3.48	0.57	Alive	14.07
155	f	4.13	3.07	1.06	Alive	25.67
188	f	5.51	4.59	0.92	Alive	16.70
197	f	6.36	5.65	0.71	Alive	11.16
209	f	5.12	4.22	0.9	Alive	17.58
213	f	4.48	3.68	0.8	Alive	17.86
222	f	4.58	3.73	0.85	Alive	18.56
241	f	5.22	4.65	0.57	Alive	10.92
258	f	6.8	5.6	1.2	Alive	17.65

272	f	5.32	4.67	0.65	Alive	12.22
278	f	5.12	4.09	1.03	Alive	20.12
283	f	5.52	4.6	0.92	Alive	16.67
286	f	6.3	5.56	0.74	Alive	11.75
290	f	4.95	4.08	0.87	Alive	17.58
310	f	5.86	5.34	0.52	Alive	8.87
348	f	4.98	3.57	1.41	Alive	28.31
359	f	5.51	4.67	0.84	Alive	15.25
368	f	4.52	3.6	0.92	Alive	20.35
371	f	4.99	3.92	1.07	Alive	21.44
375	f	6.15	5.44	0.71	Alive	11.54
376	f	5.36	4.67	0.69	Alive	12.87
1	m	5.88	4.96	0.92	Alive	15.65
92	m	5.66	4.91	0.75	Alive	13.25
108	m	5.04	3.76	1.28	Alive	25.40
135	m	4.3	3.14	1.16	Alive	26.98
148	m	4.84	3.68	1.16	Alive	23.97
167	m	5.39	4.7	0.69	Alive	12.80
202	m	4.37	3.26	1.11	Alive	25.40
214	m	4.36	2.81	1.55	Alive	35.55
244	m	4.47	3.87	0.6	Alive	13.42
248	m	4.2	2.93	1.27	Alive	30.24
254	m	4.59	3.22	1.37	Alive	29.85
284	m	4.87	4.28	0.59	Alive	12.11
299	m	5.19	4.67	0.52	Alive	10.02
316	m	4.5	3.55	0.95	Alive	21.11
387	m	5.61	4.66	0.95	Alive	16.93
403	m	4.99	4.52	0.47	Alive	9.42

Appendix 21. Weekly observation on the mortality of 35-mm GAS (November 21, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
46	f	6.66	5.85	0.81	Dead	12.16
380	f	6.9	4.73	2.17	Dead	31.45
413	f	5.35	3.95	1.4	Dead	26.17
170	f	6.39	5.81	0.58	Dead	9.08
144	f	8.5	8.07	0.43	Alive	5.06
381	f	7.7	7.02	0.68	Alive	8.83
342	m	7.56	7.16	0.4	Alive	5.29
388	m	5.82	5.34	0.48	Alive	8.25
82	m	6.68	6.23	0.45	Alive	6.74
450	m	7.05	6.32	0.73	Alive	10.35

Appendix 22. Weekly observation on the mortality of 35-mm GAS (December 4, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
303	f	4.71	3.21	1.5	Dead	31.85
301	f	5.4	2.9	2.5	Dead	46.30
215	m	5.89	2.02	3.87	Dead	65.70
437	f	8.41	7.31	1.1	Alive	13.08
210	f	8.01	7.52	0.49	Alive	6.12
10	f	7.71	6.93	0.78	Alive	10.12
423	f	6.36	5.18	1.18	Alive	18.55
53	f	9.07	8.62	0.45	Alive	4.96
203	m	6.36	5.91	0.45	Alive	7.08
221	m	5.64	4.67	0.97	Alive	17.20

Appendix 23. Weekly observation on the mortality of 35-mm GAS (December 19, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
246	m	6	2.12	3.88	Dead	64.67
427	m	5.22	1.65	3.57	Dead	68.39
325	f	5.53	4.44	1.09	Alive	19.71
392	f	7.12	5.72	1.4	Alive	19.66
412	f	6.13	4.29	1.84	Alive	30.02
176	f	5.39	4.49	0.9	Alive	16.70
434	m	4.76	3.51	1.25	Alive	26.26
288	m	5.22	4.18	1.04	Alive	19.92
452	m	7.24	5.93	1.31	Alive	18.09
321	m	5.86	4.75	1.11	Alive	18.94

Appendix 24. Final observation on the mortality of 35-mm GAS (December 31, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
23	f	5.31	1.2	4.11	Dead	77.40
76	f	7.12	2.84	4.28	Dead	60.11
80	f	7.14	3.49	3.65	Dead	51.12
105	f	7.07	4.29	2.78	Dead	39.32
212	f	4.44	2.27	2.17	Dead	48.87
226	f	6.49	2.33	4.16	Dead	64.10
230	f	6	3.49	2.51	Dead	41.83
355	f	6.25	3.3	2.95	Dead	47.20
365	f	6.68	3.75	2.93	Dead	43.86
438	f	5.59	1.47	4.12	Dead	73.70

31	m	7.18	3.68	3.5	Dead	48.75
156	m	6.71	2.08	4.63	Dead	69.00
169	m	8.19	3.26	4.93	Dead	60.20
205	m	5.55	3.46	2.09	Dead	37.66
235	m	4.91	1.59	3.32	Dead	67.62
253	m	5.9	1.86	4.04	Dead	68.47
352	m	4.73	2.64	2.09	Dead	44.19
367	m	5.4	1.61	3.79	Dead	70.19
396	m	7.98	4.16	3.82	Dead	47.87
422	m	6.14	3.32	2.82	Dead	45.93
8	f	7.21	6.15	1.06	Alive	14.70
22	f	8.76	8	0.76	Alive	8.68
51	f	5.36	4.32	1.04	Alive	19.40
100	f	6.65	5.29	1.36	Alive	20.45
146	f	5.87	5.03	0.84	Alive	14.31
183	f	5.74	4.68	1.06	Alive	18.47
264	f	5.88	4.97	0.91	Alive	15.48
290	f	6.95	6.27	0.68	Alive	9.78
291	f	6.94	5.01	1.93	Alive	27.81
318	f	5.37	4.33	1.04	Alive	19.37
330	f	7.96	7.09	0.87	Alive	10.93
335	f	6.14	4.55	1.59	Alive	25.90
347	f	7.74	6.86	0.88	Alive	11.37
348	f	6.4	4.25	2.15	Alive	33.59
361	f	6.72	6.1	0.62	Alive	9.23
401	f	6.83	5.14	1.69	Alive	24.74
26	m	7.05	5.71	1.34	Alive	19.01
47	m	6.25	5.04	1.21	Alive	19.36
48	m	6.16	5.12	1.04	Alive	16.88
59	m	7.89	7.37	0.52	Alive	6.59
60	m	6.28	5.33	0.95	Alive	15.13
74	m	7.31	6.42	0.89	Alive	12.18
93	m	7.05	5.86	1.19	Alive	16.88
96	m	6.82	5.78	1.04	Alive	15.25
107	m	6.95	5.22	1.73	Alive	24.89
141	m	5.89	4.35	1.54	Alive	26.15
149	m	7.56	4.36	3.2	Alive	42.33
167	m	9.68	8.92	0.76	Alive	7.85
202	m	6.46	5.32	1.14	Alive	17.65
204	m	5.73	3.73	2	Alive	34.90
207	m	5.82	4.81	1.01	Alive	17.35
213	m	6.35	5.35	1	Alive	15.75
249	m	6.3	4.99	1.31	Alive	20.79
250	m	6.99	5.67	1.32	Alive	18.88
286	m	7.1	5.36	1.74	Alive	24.51
314	m	6.27	5.11	1.16	Alive	18.50
334	m	5.59	4.1	1.49	Alive	26.65
350	m	6.5	5.03	1.47	Alive	22.62

366	m	7.56	6.66	0.9	Alive	11.90
370	m	5.8	1.69	4.11	Alive	70.86
371	m	7.28	6.18	1.1	Alive	15.11
373	m	8.46	7.26	1.2	Alive	14.18
382	m	5.39	4.28	1.11	Alive	20.59
385	m	4.99	3.99	1	Alive	20.04
395	m	8.12	6.86	1.26	Alive	15.52
405	m	7.94	6.17	1.77	Alive	22.29
425	m	6.6	4.85	1.75	Alive	26.52
426	m	6.48	5.7	0.78	Alive	12.04
431	m	5.67	4.79	0.88	Alive	15.52
435	m	6.48	5.56	0.92	Alive	14.20
453	m	5.04	3.73	1.31	Alive	25.99

Appendix 25. Weekly observation on the mortality of 40-mm GAS (November 21, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
254	f	9.04	7.86	1.18	Dead	13.05
191	f	7.35	4.93	2.42	Dead	32.93
255	f	8.32	6.82	1.5	Dead	18.03
279	m	10.71	9.46	1.25	Dead	11.67
259	f	9.65	8.95	0.7	Alive	7.25
235	f	9.25	8.27	0.98	Alive	10.59
88	m	7.33	6.78	0.55	Alive	7.50
267	m	9.42	9	0.42	Alive	4.46
269	m	11.24	7.65	3.59	Alive	31.94
223	m	9.65	8.81	0.84	Alive	8.70

Appendix 26. Weekly observation on the mortality of 40-mm GAS (December 4, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
17	f	8.87	3.42	5.45	Dead	61.44
86	f	6.56	2.96	3.6	Dead	54.88
159	f	7.69	6.21	1.48	Dead	19.25
210	m	7.99	3.07	4.92	Dead	61.58
202	f	8.63	6.91	1.72	Alive	19.93
12	f	7.78	6.32	1.46	Alive	18.77
263	m	7.73	6.56	1.17	Alive	15.14
212	m	10.03	8.65	1.38	Alive	13.76
315	m	14.25	13.24	1.01	Alive	7.09
242	m	9.36	8.6	0.76	Alive	8.12

Appendix 27. Weekly observation on the mortality of 40-mm GAS (December 19, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
222	f	7.11	3.56	3.55	Dead	49.93
239	f	6.88	5.96	0.92	Dead	13.37
220	m	7.48	2.55	4.93	Dead	65.91
75	f	9.68	8.86	0.82	Alive	8.47
175	f	10.99	9.71	1.28	Alive	11.65
167	f	10.1	8.4	1.7	Alive	16.83
158	f	9.65	7.72	1.93	Alive	20.00
313	m	7.6	5.52	2.08	Alive	27.37
217	m	11.32	9.96	1.36	Alive	12.01
81	m	8.58	7.44	1.14	Alive	13.29

Appendix 28. Final observation on the mortality of 40-mm GAS (December 31, 2004).

Snail No.	Sex	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
3	f	8.12	2.52	5.6	Dead	68.97
11	f	9.08	2.67	6.41	Dead	70.59
25	f	9.1	2.77	6.33	Dead	69.56
45	f	7.94	4.37	3.57	Dead	44.96
56	f	6.41	3.09	3.32	Dead	51.79
60	f	9.99	3.63	6.36	Dead	63.66
64	f	5.83	2.94	2.89	Dead	49.57
83	f	8.12	4.29	3.83	Dead	47.17
84	f	8.39	2.42	5.97	Dead	71.16
87	f	7.12	4.48	2.64	Dead	37.08
166	f	8.43	5.42	3.01	Dead	35.71
206	f	10.12	2.77	7.35	Dead	72.63
224	f	6.7	3.11	3.59	Dead	53.58
239	f	6.88	3.14	3.74	Dead	54.36
247	f	8.75	5.64	3.11	Dead	35.54
258	f	7.38	2.78	4.6	Dead	62.33
5	m	9.73	6.43	3.3	Dead	33.92
16	m	7.08	4.36	2.72	Dead	38.42
37	m	7.17	2.11	5.06	Dead	70.57
52	m	7.7	5.29	2.41	Dead	31.30
62	m	6.8	3.63	3.17	Dead	46.62
215	m	6.82	2.94	3.88	Dead	56.89
219	m	7.46	4.13	3.33	Dead	44.64
248	m	10.61	3.23	7.38	Dead	69.56
250	m	8.87	6.06	2.81	Dead	31.68
273	m	8.95	3.19	5.76	Dead	64.36
276	m	8.28	2.9	5.38	Dead	64.98

280	m	6.8	3.29	3.51	Dead	51.62
297	m	6.96	2.13	4.83	Dead	69.40
298	m	9.05	5.84	3.21	Dead	35.47
317	m	7.48	2.43	5.05	Dead	67.51
7	f	9.5	8.23	1.27	Alive	13.37
18	f	9.25	6.04	3.21	Alive	34.70
22	f	6.56	5.86	0.7	Alive	10.67
34	f	10.44	8.44	2	Alive	19.16
46	f	13.26	11.12	2.14	Alive	16.14
57	f	11.55	9.79	1.76	Alive	15.24
67	f	9.87	8.44	1.43	Alive	14.49
85	f	11.18	9.39	1.79	Alive	16.01
156	f	9.8	9.01	0.79	Alive	8.06
162	f	10.36	8.18	2.18	Alive	21.04
173	f	7.73	5.71	2.02	Alive	26.13
180	f	8.28	5.24	3.04	Alive	36.71
184	f	8.75	5.31	3.44	Alive	39.31
192	f	11.76	10.23	1.53	Alive	13.01
209	f	11.51	9.2	2.31	Alive	20.07
227	f	6.86	5.82	1.04	Alive	15.16
234	f	7.81	5.57	2.24	Alive	28.68
246	f	8.86	7.51	1.35	Alive	15.24
252	f	9.71	6.28	3.43	Alive	35.32
253	f	8.96	7.12	1.84	Alive	20.54
257	f	11.82	9.46	2.36	Alive	19.97
73	m	9.09	6.93	2.16	Alive	23.76
78	m	6.9	5.36	1.54	Alive	22.32
211	m	9.47	8.1	1.37	Alive	14.47
216	m	10.43	8.85	1.58	Alive	15.15
218	m	8.22	5.64	2.58	Alive	31.39
229	m	8.97	7.14	1.83	Alive	20.40
231	m	9.35	7.06	2.29	Alive	24.49
236	m	7.32	4.67	2.65	Alive	36.20
237	m	8.42	7.02	1.4	Alive	16.63
243	m	8.15	5.51	2.64	Alive	32.39
260	m	7.71	6.01	1.7	Alive	22.05
281	m	8.74	6.41	2.33	Alive	26.66
286	m	9.36	7.37	1.99	Alive	21.26
287	m	11.16	8.57	2.59	Alive	23.21
292	m	10.59	8.33	2.26	Alive	21.34
293	m	8.29	5.01	3.28	Alive	39.57
294	m	11.17	9.26	1.91	Alive	17.10
316	m	8.16	5.68	2.48	Alive	30.39

Experiment 2. GAS Mortality of Different GAS Sizes in Plastic Tray with Soil Treatment

Appendix 29. Final observation on the mortality of various GAS sizes in plastic trays (December 31, 2004).

S. No	10 mm	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm
1	Dead	Dead	Dead	Dead	Dead	Dead	Dead
2	Dead	Dead	Dead	Dead	Dead	Dead	Dead
3	Dead	Dead	Dead	Dead	Dead	Dead	Dead
4	Dead	Dead	Dead	Dead	Dead	Dead	Dead
5	Dead	Dead	Dead	Dead	Dead	Dead	Dead
6	Dead	Dead	Dead	Dead	Dead	Dead	Dead
7	Dead	Dead	Dead	Dead	Dead	Dead	Dead
8	Dead	Dead	Dead	Dead	Dead	Dead	Dead
9	Dead	Dead	Dead	Dead	Dead	Dead	Dead
10	Dead	Dead	Dead	Dead	Dead	Dead	Dead
11	Dead	Dead	Dead	Dead	Dead	Dead	Dead
12	Dead	Dead	Dead	Dead	Dead	Dead	Dead
13	Dead	Dead	Dead	Dead	Dead	Dead	Dead
14	Dead	Dead	Dead	Dead	Dead	Dead	Dead
15	Dead	Dead	Dead	Dead	Dead	Dead	Dead
16	Dead	Dead	Dead	Dead	Dead	Dead	Dead
17	Dead	Dead	Dead	Dead	Dead	Dead	Dead
18	Dead	Dead	Dead	Dead	Dead	Dead	Dead
19	Dead	Dead	Dead	Dead	Dead	Dead	Dead
20	Dead	Dead	Dead	Dead	Dead	Dead	Dead
21	Dead	Dead	Dead	Dead	Dead	Dead	Dead
22	Dead	Dead	Dead	Dead	Dead	Dead	Dead
23	Dead	Dead	Dead	Dead	Dead	Dead	Dead
24	Dead	Dead	Dead	Dead	Dead	Dead	Dead
25	Dead	Dead	Alive	Dead	Dead	Alive	Dead
26	Dead	Dead	Alive	Dead	Dead	Alive	Dead
27	Dead	Dead	Alive	Alive	Alive	Alive	Dead
28	Dead	Alive	Alive	Alive	Alive	Alive	Dead
29	Dead	Alive	Alive	Alive	Alive	Alive	Dead
30	Dead	Alive	Alive	Alive	Alive	Alive	Dead
31	Dead	Alive	Alive	Alive	Alive	Alive	Dead
32	Dead	Alive	Alive	Alive	Alive	Alive	Dead
33	Dead	Alive	Alive	Alive	Alive	Alive	Alive
34	Dead	Alive	Alive	Alive	Alive	Alive	Alive
35	Dead	Alive	Alive	Alive	Alive	Alive	Alive
36	Alive	Alive	Alive	Alive	Alive	Alive	Alive
37	Alive	Alive	Alive	Alive	Alive	Alive	Alive
38	Alive	Alive	Alive	Alive	Alive	Alive	Alive
39	Alive	Alive	Alive	Alive	Alive	Alive	Alive
40	Alive	Alive	Alive	Alive	Alive	Alive	Alive

41	Alive	Alive	Alive	Alive	Alive	Alive	Alive
42	Alive	Alive	Alive	Alive	Alive	Alive	Alive
43	Alive	Alive	Alive	Alive	Alive	Alive	Alive
44	Alive	Alive	Alive	Alive	Alive	Alive	Alive
45	Alive	Alive	Alive	Alive	Alive	Alive	Alive
46	Alive	Alive	Alive	Alive	Alive	Alive	Alive
47	Alive	Alive	Alive	Alive	Alive	Alive	Alive
48	Alive	Alive	Alive	Alive	Alive	Alive	Alive
49	Alive	Alive	Alive	Alive	Alive	Alive	Alive
50	Alive	Alive	Alive	Alive	Alive	Alive	Alive
% Mortality	**70**	**54**	**48**	**52**	**52**	**48**	**64**

Experiment 3. GAS Mortality of Different GAS Sexes in Netbag Treatment

Appendix 30. Final observation on the mortality of 25-mm male GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
14	2.61	1.58	1.03	Dead	39.46
68	2.21	1.35	0.86	Dead	38.91
109	2.38	1.05	1.33	Dead	55.88
304	2.32	1.42	0.9	Dead	38.79
408	2.7	1	1.7	Dead	62.96
420	2.16	0.76	1.4	Dead	64.81
15	3.54	2.85	0.69	Alive	19.49
19	3.29	2.67	0.62	Alive	18.84
105	3.2	2.43	0.77	Alive	24.06
124	2.54	1.91	0.63	Alive	24.80
179	3.02	2.17	0.85	Alive	28.15
189	3.18	2.43	0.75	Alive	23.58
212	3	2.6	0.4	Alive	13.33
241	3.09	2.23	0.86	Alive	27.83
244	2.59	2.13	0.46	Alive	17.76
261	3.25	2.02	1.23	Alive	37.85
271	4.03	3.49	0.54	Alive	13.40
283	2.95	2.35	0.6	Alive	20.34
291	2.91	2.44	0.47	Alive	16.15
296	3.27	2.37	0.9	Alive	27.52
319	2.63	1.76	0.87	Alive	33.08
343	2.85	2.16	0.69	Alive	24.21
399	3.04	2.25	0.79	Alive	25.99
418	2.75	2.22	0.53	Alive	19.27
425	2.54	1.87	0.67	Alive	26.38

Appendix 31. Final observation on the mortality of 25-mm female GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
115	2.63	1.63	1	Dead	38.02
194	2.29	1.26	1.03	Dead	44.98
211	2.37	1.08	1.29	Dead	54.43
273	3.13	1.27	1.86	Dead	59.42
326	2.63	1.27	1.36	Dead	51.71
6	3.06	2.58	0.48	Alive	15.69
11	2.88	2.32	0.56	Alive	19.44
13	2.97	2.46	0.51	Alive	17.17
30	2.65	1.82	0.83	Alive	31.32
67	2.89	2.34	0.55	Alive	19.03
69	3.54	2.81	0.73	Alive	20.62
86	2.37	1.88	0.49	Alive	20.68
117	2.27	1.69	0.58	Alive	25.55
141	3.15	2.74	0.41	Alive	13.02
142	2.99	2.43	0.56	Alive	18.73
183	3.1	2.6	0.5	Alive	16.13
186	3.19	2.52	0.67	Alive	21.00
250	3.5	2.96	0.54	Alive	15.43
275	3.2	2.64	0.56	Alive	17.50
346	2.6	2.07	0.53	Alive	20.38
347	2.92	2.25	0.67	Alive	22.95
355	2.56	1.95	0.61	Alive	23.83
378	1.99	1.63	0.36	Alive	18.09
389	3.34	2.54	0.8	Alive	23.95
393	3.2	2.61	0.59	Alive	18.44

Appendix 32. Final observation on the mortality of 30-mm male GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
70	4.59	1.66	2.93	Dead	63.83
251	4.26	1.64	2.62	Dead	61.50
398	3.04	1.75	1.29	Dead	42.43
54	4.9	3.97	0.93	Alive	18.98
66	4.86	4.11	0.75	Alive	15.43
76	4.57	3.72	0.85	Alive	18.60
110	5.68	4.87	0.81	Alive	14.26
142	4.92	3.85	1.07	Alive	21.75
144	4.81	3.69	1.12	Alive	23.28
151	5.43	4.76	0.67	Alive	12.34
163	5.4	3.69	1.71	Alive	31.67
174	4.92	4.2	0.72	Alive	14.63
208	5.42	4.46	0.96	Alive	17.71
247	4.18	3.12	1.06	Alive	25.36
249	4.63	3.32	1.31	Alive	28.29
276	5.97	4.88	1.09	Alive	18.26
279	5.54	4.27	1.27	Alive	22.92
291	4.46	3.14	1.32	Alive	29.60
303	5.49	4.8	0.69	Alive	12.57
320	5.54	4.63	0.91	Alive	16.43
321	6.39	5.5	0.89	Alive	13.93
322	4.28	3.4	0.88	Alive	20.56
381	4.41	3.59	0.82	Alive	18.59
394	5.02	3.75	1.27	Alive	25.30
399	6.26	5.22	1.04	Alive	16.61

Appendix 33. Final observation on the mortality of 30-mm female GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
2	4.62	1.37	3.25	Dead	70.35
52	4.49	1.74	2.75	Dead	61.25
277	2.43	1.25	1.18	Dead	48.56
340	3.94	2.38	1.56	Dead	39.59
349	4.72	1.61	3.11	Dead	65.89
353	4.09	1.28	2.81	Dead	68.70
12	5.13	4.04	1.09	Alive	21.25
59	4.81	4.12	0.69	Alive	14.35
62	5.66	4.46	1.2	Alive	21.20
68	4.25	3.34	0.91	Alive	21.41
101	5.26	4.46	0.8	Alive	15.21
105	5.32	4.44	0.88	Alive	16.54
114	5.1	3.63	1.47	Alive	28.82
123	5.27	4.24	1.03	Alive	19.54
149	5.29	4.51	0.78	Alive	14.74
184	5.35	4.39	0.96	Alive	17.94
198	3.93	3.27	0.66	Alive	16.79
201	4.57	2.93	1.64	Alive	35.89
216	5.88	4.7	1.18	Alive	20.07
225	4.41	3.26	1.15	Alive	26.08
273	5.53	4.57	0.96	Alive	17.36
326	4.99	4.26	0.73	Alive	14.63
327	5.05	4.38	0.67	Alive	13.27
350	5.34	4.55	0.79	Alive	14.79
351	5.38	4.72	0.66	Alive	12.27

Appendix 34. Final observation on the mortality of 35-mm male GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
12	6.63	3.45	6.63	Dead	100.00
65	6.32	2.18	4.14	Dead	65.51
87	6.91	3.42	3.49	Dead	50.51
108	7.06	5.17	1.89	Dead	26.77
111	7.59	2.99	4.6	Dead	60.61
145	7.03	3.12	3.91	Dead	55.62
211	5.5	2.75	2.75	Dead	50.00
341	5.65	3.57	2.08	Dead	36.81
448	6.86	2.01	4.85	Dead	70.70
21	5.4	3.65	1.75	Alive	32.41
49	5.24	4.18	1.06	Alive	20.23
130	8.02	6.47	1.55	Alive	19.33
138	7.78	7.04	0.74	Alive	9.51
149	7.56	6.35	1.21	Alive	16.01
153	8.82	7.67	1.15	Alive	13.04
162	7.33	6.24	1.09	Alive	14.87
179	6.1	5.94	0.16	Alive	2.62
189	5.77	4	1.77	Alive	30.68
190	5.89	4.52	1.37	Alive	23.26
216	4.82	3.47	1.35	Alive	28.01
261	6.62	5.27	1.35	Alive	20.39
272	7.39	6.46	0.93	Alive	12.58
274	4.75	3.03	1.72	Alive	36.21
327	5.69	3.96	1.73	Alive	30.40
411	5.83	4.97	0.86	Alive	14.75

Appendix 35. Final observation on the mortality of 35-mm female GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
39	4.19	1.9	2.29	Dead	54.65
58	9.17	3.09	6.08	Dead	66.30
72	4.7	2.48	2.22	Dead	47.23
77	6.65	4.12	2.53	Dead	38.05
94	6.39	4.62	1.77	Dead	27.70
113	8.12	3.5	4.62	Dead	56.90
211	5.5	3.01	2.49	Dead	45.27
227	5.24	1.51	3.73	Dead	71.18
307	6.61	2.49	4.12	Dead	62.33
357	6.09	3.53	2.56	Dead	42.04
362	6.92	3.72	3.2	Dead	46.24
420	5.65	2.48	3.17	Dead	56.11
446	7.03	2.35	4.68	Dead	66.57
9	6.21	5.23	0.98	Alive	15.78
13	7.29	6.25	1.04	Alive	14.27
116	8.12	5.5	2.62	Alive	32.27
157	5.52	4.19	1.33	Alive	24.09
168	8.02	6.85	1.17	Alive	14.59
180	5.77	3.73	2.04	Alive	35.36
181	6.12	4.42	1.7	Alive	27.78
267	6.4	4.89	1.51	Alive	23.59
296	8.65	6.37	2.28	Alive	26.36
311	6.87	5.06	1.81	Alive	26.35
419	6.15	5.33	0.82	Alive	13.33
451	5.98	3.88	2.1	Alive	35.12

Appendix 36. Final observation on the mortality of 40-mm male GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
24	7.55	2.25	5.3	Dead	70.20
33	7.26	4.9	2.36	Dead	32.51
40	8.93	3.04	5.89	Dead	65.96
59	6.69	4.22	2.47	Dead	36.92
68	4.83	2.16	2.67	Dead	55.28
69	8.89	3.22	5.67	Dead	63.78
77	8.52	4.41	4.11	Dead	48.24
266	7.86	2.4	5.46	Dead	69.47
288	10.01	4	6.01	Dead	60.04
289	7.09	4.31	2.78	Dead	39.21
291	8.95	4.86	4.09	Dead	45.70
300	8.49	2.55	5.94	Dead	69.96
301	7.96	5.27	2.69	Dead	33.79
311	12.13	3.18	8.95	Dead	73.78
15	8.7	7.4	1.3	Alive	14.94
20	8.27	6.53	1.74	Alive	21.04
28	8.74	7.37	1.37	Alive	15.68
36	7.94	5.97	1.97	Alive	24.81
44	9.2	7.8	1.4	Alive	15.22
49	5.91	4.7	1.21	Alive	20.47
271	11.57	10.28	1.29	Alive	11.15
274	10.07	9.07	1	Alive	9.93
275	9.62	8.13	1.49	Alive	15.49
304	13.56	11.98	1.58	Alive	11.65
314	9.61	7.93	1.68	Alive	17.48

Appendix 37. Final observation on the mortality of 40-mm female GAS (December 31, 2004).

Snail No.	Initial Weight	Present Weight	Total Weight Loss	Status	Weight Loss %
1	7.42	4.77	2.65	Dead	35.71
8	8.36	2.63	5.73	Dead	68.54
10	8.32	3.46	4.86	Dead	58.41
23	9.24	3.23	6.01	Dead	65.04
29	7.78	4.54	3.24	Dead	41.65
72	7.72	2.44	5.28	Dead	68.39
161	8.31	2.33	5.98	Dead	71.96
171	6.69	2.35	4.34	Dead	64.87
188	7.63	2.62	5.01	Dead	65.66
201	6.7	2.04	4.66	Dead	69.55
4	8.72	7.73	0.99	Alive	11.35
21	10.63	8.24	2.39	Alive	22.48
30	8.42	6.18	2.24	Alive	26.60
47	8.42	6.67	1.75	Alive	20.78
66	9.29	7.41	1.88	Alive	20.24
163	10.51	8.83	1.68	Alive	15.98
178	7.21	5.26	1.95	Alive	27.05
186	8.38	5.42	2.96	Alive	35.32
190	8.82	6.49	2.33	Alive	26.42
194	10.31	9.14	1.17	Alive	11.35
195	9.28	7.83	1.45	Alive	15.63
198	8.22	5.28	2.94	Alive	35.77
200	9.5	6.83	2.67	Alive	28.11
204	9	6.5	2.5	Alive	27.78
207	8.03	5.7	2.33	Alive	29.02

Experiment 4. GAS Mortality of Different GAS Sexes in Plastic Tray with Soil Treatment

Appendix 38. Final observation on the mortality of male GAS of various sizes (December 31, 2004).

S. No	20 mm	25 mm	30 mm	35 mm	40 mm
1	Dead	Dead	Dead	Dead	Dead
2	Dead	Dead	Dead	Dead	Dead
3	Dead	Dead	Dead	Dead	Dead
4	Dead	Dead	Dead	Dead	Dead
5	Dead	Dead	Dead	Dead	Dead
6	Dead	Dead	Dead	Dead	Dead
7	Dead	Dead	Dead	Dead	Dead
8	Dead	Dead	Dead	Dead	Dead
9	Alive	Dead	Dead	Dead	Dead
10	Alive	Dead	Dead	Dead	Dead
11	Alive	Dead	Dead	Dead	Dead
12	Alive	Dead	Dead	Dead	Dead
13	Alive	Dead	Dead	Dead	Dead
14	Alive	Alive	Alive	Alive	Dead
15	Alive	Alive	Alive	Alive	Dead
16	Alive	Alive	Alive	Alive	Dead
17	Alive	Alive	Alive	Alive	Dead
18	Alive	Alive	Alive	Alive	Alive
19	Alive	Alive	Alive	Alive	Alive
20	Alive	Alive	Alive	Alive	Alive
21	Alive	Alive	Alive	Alive	Alive
22	Alive	Alive	Alive	Alive	Alive
23	Alive	Alive	Alive	Alive	Alive
24	Alive	Alive	Alive	Alive	Alive
25	Alive	Alive	Alive	Alive	Alive
% Mortality	**32**	**52**	**52**	**52**	**68**

Appendix 39. Final observation on the mortality of female GAS of various sizes. (December 31, 2004).

S. No	20 mm	25 mm	30 mm	35 mm	40 mm
1	Dead	Dead	Dead	Dead	Dead
2	Dead	Dead	Dead	Dead	Dead
3	Dead	Dead	Dead	Dead	Dead
4	Dead	Dead	Dead	Dead	Dead
5	Dead	Dead	Dead	Dead	Dead
6	Dead	Dead	Dead	Dead	Dead
7	Dead	Dead	Dead	Dead	Dead
8	Dead	Dead	Dead	Dead	Dead
9	Dead	Dead	Dead	Dead	Dead
10	Dead	Dead	Alive	Dead	Dead
11	Dead	Dead	Alive	Dead	Dead
12	Dead	Alive	Alive	Dead	Dead
13	Dead	Alive	Alive	Alive	Dead
14	Dead	Alive	Alive	Alive	Dead
15	Alive	Alive	Alive	Alive	Dead
16	Alive	Alive	Alive	Alive	Dead
17	Alive	Alive	Alive	Alive	Dead
18	Alive	Alive	Alive	Alive	Alive
19	Alive	Alive	Alive	Alive	Alive
20	Alive	Alive	Alive	Alive	Alive
21	Alive	Alive	Alive	Alive	Alive
22	Alive	Alive	Alive	Alive	Alive
23	Alive	Alive	Alive	Alive	Alive
24	Alive	Alive	Alive	Alive	Alive
25	Alive	Alive	Alive	Alive	Alive
% Mortality	**56**	**52**	**52**	**52**	**68**

Appendix 40. Moisture observations in plastic trays throughout the whole observation period.

Moisture readings	Nov. 6, 2004	Nov.20,2004	Dec.4,2004	Dec.19,2004	Dec.31,2004
10mm	97.7	96.7	96.7	96.8	96.8
15mm	97.6	96.9	96.7	96.9	96.9
20mm	97.5	96.5	96.4	96.5	96.5
25mm	97.7	96.5	95.9	95.8	96.9
30mm	97.6	96.6	96.4	96.5	96.5
35mm	97.6	96.3	96	96.6	96.7
40mm	97.7	96.6	96.5	96.8	96.9
control1	97.5	97.1	97.2	97.3	97.3
control2	97.6	96.7	96.5	96.7	96.9
control3	97.7	96.8	96.9	97.1	97.1