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Research Article

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Effectiveness of Plant-Based Attractants in Preventing the Escape of Golden Apple Snails (*Pomacea canaliculata*) into the Ecosystem

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Abstract

The effectiveness of plant-based attractants was studied using large traps, which attracted relatively more snails in agricultural water drainage ditches and rice-cultivating environments, although their effectiveness in rice fields and lakes was limited. The rate began to rise after three hours of observation. Watermelon peel exhibited the highest apple snail attraction rate (13.8%), followed by potatoes (10.0%), and apple peel (8.8%). These values significantly differed from the attraction rate attributed to papaya leaves (F=3.84; P=0.0387). After 24 h, watermelon peel and apple peel indicated a higher rate of attraction (23.4% and 21.7%, respectively), which were significantly different compared with those of papaya leaves and potatoes (F=9.94; P=0.00455). Large bait traps outperformed funnel traps in capturing golden apple snails and trapped a significant number of snails measuring over 1 cm in size. Watermelon peel was the most effective attractant for a large bait trap, followed by apple peel, potatoes, and papaya leaves. On average, 110 snails were captured in the lure net. However, potatoes, apple peels, and papaya leaves caught an average of 93, 80, and 79 snails, respectively. Among the attractants, the lure effect of the snails was not significantly different. The efficiency of

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large bait traps in capturing snails, regardless of the plant attractant employed, followed the order: apple peel > watermelon peel and potatoes > papaya leaves > melon > Korean melon. Watermelon peel is highly recommended for farmer use, as well as apple peel and potatoes. Utilizing these snail attractants may contribute positively to developing a safe and environment-friendly integrated pest management strategy.

Key words: Golden apple snails (GAS), Integrated pest management, Large bait trap, Plant-attractants

Introduction

The Golden apple snails (GAS) *Pomacea canaliculata* (Lamarck) was a recently introduced rice pest in Asian countries as a source of high-protein food and agricultural income in 1980, and were introduced for consumption purposes in Korea in 1983. GAS have been utilized since 1992 in Korea to control weed growth in rice fields, exploiting their feeding behaviors. However, these snails have recently begun overwintering in the southern parts of Korea due to climate change, causing harm. In 2007, the Ministry of Environment categorized the GAS as a second-class organism for ecological control. Its management is based on preventative and corrective methods emphasizing cultural and mechanical practices, with molluscicide as a measure of last resort [1-3]. The planting method greatly influences the period of susceptibility to snail [3,4]. The species of GAS introduced in Korea is *P. canaliculata*, which is native to South America and has significant differences in appearance, food, and reproduction compared to the native snails in Korea. Unlike native snails that reproduce as larvae, GAS reproduce through eggs. In their original tropical regions, From 1992, they began to be used as a weed control agent in eco-friendly rice farms by utilizing their feeding habits. Using GAS as organic material for rice farming, a weed control rate of 96% was confirmed immediately after radiation and a 98% control rate was confirmed on the 7th day after radiation, proving its effectiveness [5-7]. Experiments in water tank also demonstrated that the GAS can cause the loss of macrophytes and increase the EC (Electric conductivity), COD (Chemical oxygen demand), T-N (Total nitrogen) and T-P (Total phosphorus) in water [8]. In 2007, the potential of fish trap was studied to control GAS and the number of attracted snail per week was 216 in the big fish trap (Φ 15 cm) with menthol paste that is rice cake for carp fishing [8]. However, due to climate change, GAS are now able to overwinter in Korea, causing damage to crops in the southern region. Lot of study have been performed on physiological and ecological research on preventing of overwintering and crop damage caused by GAS in the field of eco-friendly agriculture [3,5,6,8, 9,11-13]. Therefore, the Korean Ministry of Environment has classified GAS as a grade 2 organism for legal ecosystem management since 2007, and debates surrounding the regulation of GAS continue [9]. GAS are considered a pest of rice, causing serious damage to rice crops in countries such as the Philippines, Taiwan, Southeast Asia, and Japan, which is why they are classified as one of the world's top 100 invasive alien species by the IUCN (International Union for Conservation of Nature) [10]. As a result, regarding eco-friendly agriculture, the management of overwintering GAS has become a hot topic, as they have become a major eco-friendly agriculture in Korea, occupying 89% of the eco-friendly rice farming area as of 2018. In this regard, physical control through installation of luring and blocking nets and chemical control using chemicals are included in the methods for controlling overwintering GAS, but research is needed on biological control using plant extracts and native microorganisms that have effects on pest control, considering the eco-friendly aspect of pest control [8,12,14,15]. A study revealed that the extract of *Zingiber officinale* contains higher molluscicidal activity than the extract of Carica Papaya [9]. Therefore, it has the potential to be commercialized as a biomolluscicide to control the population of GAS specifically at the egg stage in order to minimize environmental impacts caused by GAS and to achieve sustainable agricultural development, research on preventing the leakage and control of the ecosystem, as well as ecological studies on the interaction between GAS and native organisms, should be conducted. One recommended method to facilitate the manual handpicking process is the utilization of herbage or plant attractants. The adverse effects of molluscicides, used to control invasive GAS, have prompted the exploration of eco-friendly methods such as cultural, mechanical and biological controls. In a field study assessing the efficacy of locally available and cost-effective plant-based traps against the snails, jackfruit peel and damaged pomelo emerged as more effective than tapioca leaves, water spinach leaves [16, 17]. Incorporating these findings into rice fields during the early susceptible growth stage is recommended, as it facilitates the collection and destruction of snails [18, 19]. Another study in the Philippines was conducted and found that taro leaves (*Colocasia esculenta*), commonly known as keladi in Malaysia, have the potential to attract apple snails [20]. Incorporating attractant materials not only enhances the efficiency of manual hand-picking but also nables farmers to perform targeted molluscicide spot praying, thereby preventing unnecesary and indiscriminate over-application. In this study, the fruit-based attractants include papaya leaves, apple peel, watermelon and potatoes as an apple snail attractant were tested and evaluated to determine their effectiveness in attracting apple snails. In determining the effectiveness of these materials as attractants, series of tests were performed under lab conditions, agricultural reservoirs, freshwater lake and rice cultivation environment. This study aims to enhance the existing physical management techniques and offer alternative methods for apple snail control. Additionally, it is anticipated that the study will propose an interim environmentally friendly solution, suggesting the use of plants as attractants to effectively address the GAS infestations in rice fields. [21] reported that only 23% of the farmers had previously received training in GAS management. They found that training neither had positive nor negative effects on the number of sustainable methods applied, molluscicide avoidance, concern about using molluscicides, or on the farmers' knowledge about GAS. As much as 74% of the respondents applied molluscicides. Contrary to recommendations, farmers applied only few sustainable control methods. All farmers had clear knowledge gaps about GAS, especially in species identification, which can even further the ongoing decline of native mollusks in rice landscapes. [21,22] demonstrated that growing azolla could help increase the survival of newly-planted rice, specifically on newly transplanted (TPR), against the potential damage of invasive apple snail (IAS) [22]. The study aims to understand how different attractant materials, including apple peel, watermelon peel, potatoes, and papaya leaves, influenced the attraction and capture of GAS as well as to develop an efficient trapping technique employing baited traps to eradicate the snails released into the surrounding ecosystems.

Materials and Methods

Location and period of investigation

This study was carried out at a plastic house in research institute of Dong Yang Chemical Co., Ltd. and at a rice cultivation field in Gokseong, Jeonnam, Korea from the first of March to the end of October, 2023.

Effect experiment of four fruit based–attractants to capture the snails

An experiment was conducted to evaluate the effectiveness of four plant-based attractants in capturing snails. Apple peel, watermelon peel, potatoes and papaya leaves were tested as GAS attractants under free-choice conditions (Fig. 1). Each of the four materials was reduced to a uniform size and placed at each corner of the trough (800 cm × 984 cm × 300 cm). Each experimental condition was duplicated four times, following a randomized complete block design. The troughs were filled with rice field mud, and the surface was leveled. Tap water was then added to a depth of 3 cm. Apple snails, collected from the field and measuring approximately 15 mm in width and 20 mm in height, were introduced into the center of each trough at a density of 20 individuals for each replication. The count of snails drawn to each attractant material was documented at intervals of 10, 20, 30, 40, 50, and 60 minutes after release, as well as at 3, 6, 24 and 48 hours after release of the snails. The investigation was

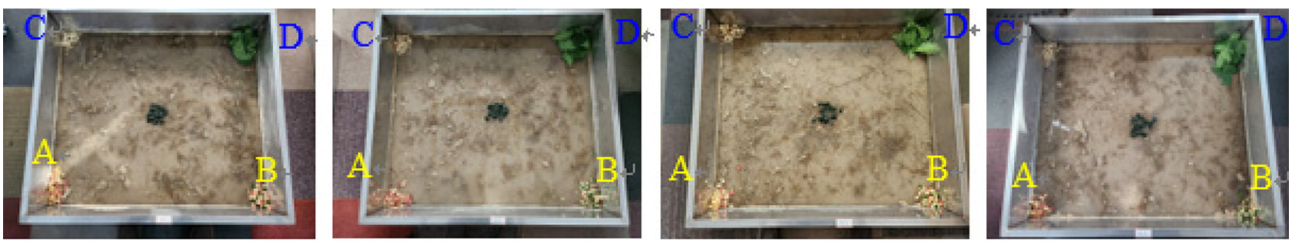

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Fig. 1. Experiment on the effect of four fruit-based snail bait with the fruit-based attractant materials in the troughs (800 cm × 984 cm × 300 cm). A; Apple peel, B; Watermelon peel, C; Potatoes, D: Papaya leaves.

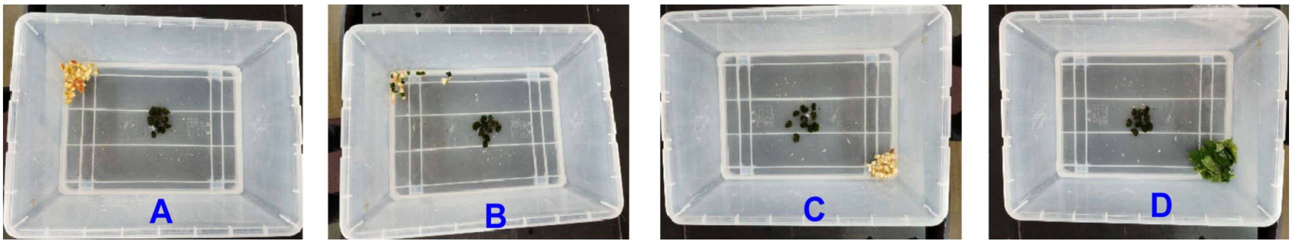

Fig. 2. Experiment on the effect of single snail bait with the fruit-based attractant materials in the living box (33 cm × 48 cm× 20.5 cm). A; Apple peel, B; Watermelon peel, C; Potatoes, D: Papaya leaves.

conducted in two phases, encompassing the initial batch and the second batch of 20 GAS. Likely, the other trial was carried out under no-choice conditions. Apple peel, watermelon peel, potatoes, and papaya leaves served as attractant materials. Each plant material was placed individually within the left end of an open living box measuring 33 cm × 48 cm × 20.5 cm (Fig. 2). No rice field mud was introduced into each box; instead, rice field water was added to a depth of 3 cm. Ten field-collected GAS, each measuring 15 mm in width and 20 mm in height, were placed inside the right end of the living box. The experimental treatments were replicated three times in a randomized complete block design. The count of individuals engaging with or attaching to the attractants was documented at specific time intervals: 10, 20, 30, 40, 50, and 60 minutes, as well as 3, 6, 24 and 48 hours following the release of the snails.

Trapping experiment of catch net for snails inhabiting rice paddy drainage

Experiment conducted to assess the effectiveness of catch nets in capturing snails inhabiting rice paddy drainage and to study the attraction and capture of snails using different attractant materials within a controlled and ecologically conscious agricultural setting. An experiment designed to evaluate the efficiency of catch nets in capturing snails within a rice paddy drainage. The shrimp nets, fish traps and large trap bait net were used to perform trapping survey for collecting GAS with four plant-based attractants such as apple peel, watermelon peel, potatoes and papaya leaves the irrigation water beside the environment-friendly rice paddy test field that was located at Gokseong in Jeonnam of Korea (Fig. 3).

Density observation of captured snails in the rice paddy field

An investigation was conducted on the population density of freshwater snails inhabiting a rice cultivation paddy. This was done by introducing four types of attractants into large bait traps, six days after the administration of 4 kg of GAS (measuring 15 mm in width and 20 mm in height) into the rice paddy test plot (2,310 m^2). The density observation of captured snails utilized a large trap bait net with four plant-based attractants, namely, apple peel, watermelon peel, potatoes, and papaya leaves. The study took place in an environmentally friendly rice paddy test field located in Gokseong, Jeonnam province (Fig. 4).

Fig. 3. Trapping survey for golden apple snails using shrimp nets, fish traps and large trap bait net with four plant-based attractants such as apple peel, watermelon peel, potatoes and papaya leaves in the environment-friendly rice paddy test field (Gokseong, Jeonnam, Korea). A; shrimp trap net, B; fish trap net, C: large trap bait net.

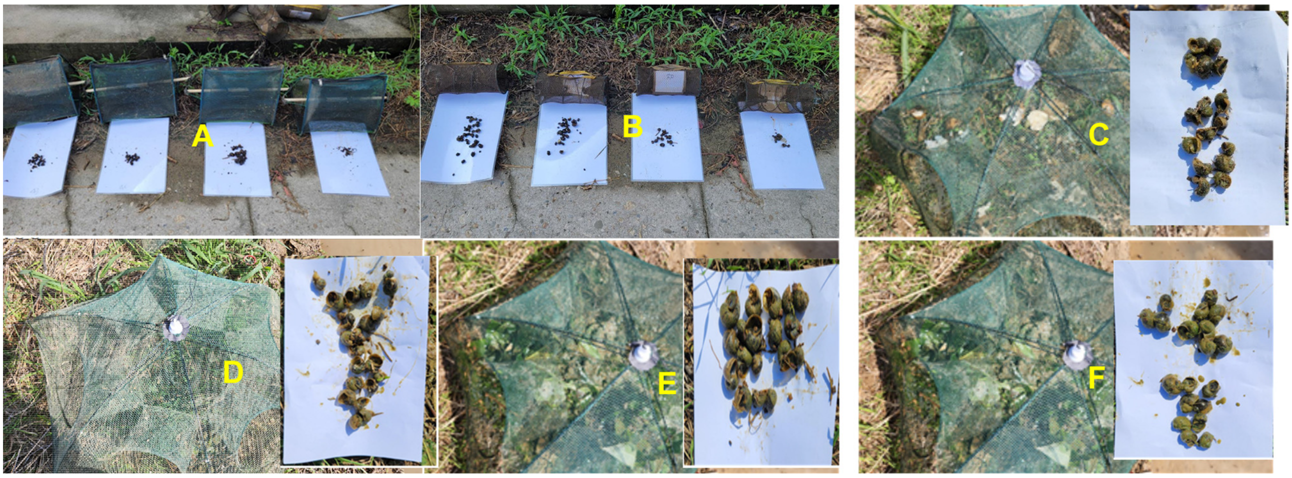

Fig. 4. Density observation of captured snails using the shrimp and fish trap, large trap bait net (large fish trap; base 90 cm, height 30 cm) with four plant-based attractants such as apple peel, watermelon peel, potatoes and papaya leaves in the environment-friendly rice paddy test field (Gokseong, Jeonnam, Korea). A; the snails captured into the shrimp trap net with four plant-based attractants, B; the snails captured into the fish trap net with four plant-based attractants, C; the snails captured into the large trap bait net with apple peel, D; the snails captured into the large trap bait net with potatoes, E; the snails captured into the large trap bait net with papaya leaves.

Statistical analysis

The information was processed using Statistical Analysis System version 9.4 from SAS Institute in 2022. Analysis of variance (ANOVA) was employed to assess the quantity of apple snails drawn to the attractants. Mean comparisons were conducted through the least significant difference (LSD) test at a significance level of $p<0.05$. SigmaPlot (version 12.5 from Systat Software Inc.) was utilized to evaluate the snails' attraction rate using polynomial linear analysis and quadratic curve.

Result and Discussion

Effectives of four fruit based–attractants to capture the snails

The average quantity of snails drawn to various attractant materials was assessed under free-choice conditions in laboratory test A, following the introduction of the initial batch of 20 GAS. Table 1 indicates that during the initial 20-minute period, no snails exhibited attraction to any of the attractant materials employed in this experiment. However, after a half-hour, a minimal number of snails were observed to be drawn to both watermelon peel and potatoes, and there was no

Table 1. Mean number of snails attracted to different attractant materials under the free-choice conditions in the lab test A after 1st input of Golden apple snails (20 snails)

Duration	Attractant Mean±SE (%)				
	Apple peel	Watermelon peel	Potatoes	Papaya leaves	LSD
10 mins	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0
20 mins	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0±0.0 a (0.0)	0.0
30 mins	0.0±0.0 a (0.0)	1.5±0.58 a (7.5)	1.25±0.5 a (6.3)	0.0±0.0 a (0.0)	0.588
40 mins	0.75±0.5 c (3.8)	1.75±0.5 b (8.8)	2.5±0.58 a (12.5)	0.0±0.0 a (0.0)	0.703
50 mins	2.25±0.5 a (11.3)	1.5±1.0 ab (7.5)	2.5±0.58 a (12.5)	0.75±0.96 b (3.8)	1.218
60 mins	1.5±0.57 b (7.5)	2.5±1.0 a (12.5)	1.75±0.5 ab (8.6)	0.75±0.96 b (3.8)	1.198
3 hrs	1.75±1.75 ab (8.8)	2.75±0.5 a (13.8)	2.0±0.8 ab (10.0)	1.25±0.5 b (6.3)	1.277
6 hrs	2.5±0.58 ab (12.5)	2.25±0.5 ab (11.3)	2.75±0.96 a (13.8)	1.5±0.58 b (7.5)	1.043
24 hrs	4.0±0.82 a (20.0)	4.5±0.58 a (22.5)	3.25±1.26 a (16.3)	2.75±1.71 a (13.8)	1.793
48 hrs	3.75±0.5 a (18.8)	3.5±1.29 ab (17.5)	2.5±0.58 ab (12.5)	2.25±0.96 b (11.3)	1.371

Means with same letters in the same column are not significantly different at LSD test (α=0.05)

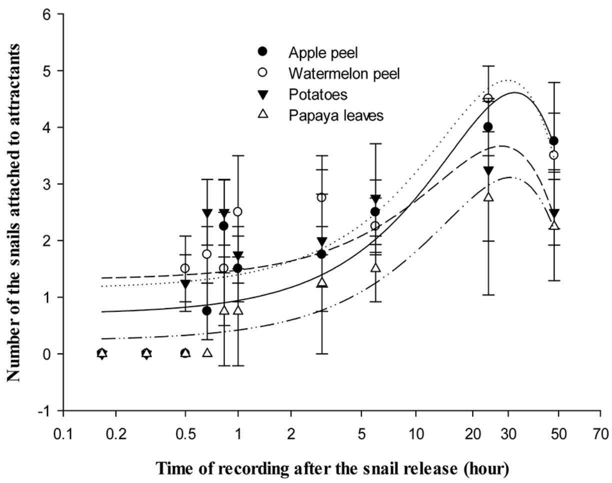

Fig. 5. Rate of attraction of the Golden apple snails over time to different attractant materials under the free-choice conditions in the lab test A after 1st input of Golden apple snails (20 snails).

notable distinction in the observed quantities between the two (F=0.67; P=0.5885). At the one-hour mark, all attractant materials successfully lured the snails, yet once again, there was no significant difference among them (F=0.34; P=0.7993). The snail attraction rate within the first hour was remarkably low, as illustrated in Fig. 5. The rate began to rise after three hours of observation. Watermelon peel exhibited the highest apple snail attraction rate (13.8%), followed by potatoes (10.0%), and apple peel (8.8%). These three materials showed a significant difference from the attraction rate attributed to papaya leaves (F=3.84; P=0.0387) (Table 1). Although the attraction rate increased after 6 hours, 24 hours and 48 hours all four materials did not exhibit a significant difference from one another in terms of the number of attracted snails (Table 1). In this experiment, the outcomes lacked strong support, as the percentage of snails attracted to each attractant did not exceed 20%.

Additionally, the average quantity of snails attracted to various attractant materials was measured under free-choice conditions in laboratory test A, following the introduction of a second batch of 20 golden apple snails. In the second free-choice test, the snails started to attach to all the attractant materials 10 minutes as showed in the Table 2. The snails exhibited changing preferences for the materials until the initial hour. Nevertheless, Table 2 indicates that there was no significant difference among all the treatments (F=0.26; P=0.8546), and the percentage of attracted snails remained as low as in the first free-choice test. After 6 hours, watermelon peel again attracted the highest number of snails (16.7%) and differed significantly from the other materials (F=0.74; P=0.5570). After 24 hours, somehow watermelon peel and apple peel had the higher rate of attraction (23.4%, 21.7%) and they were significantly different compared with papaya leaves and potatoes (F=9.94; P=0.00455) (Table 2).

Although watermelon peel and apple peel attracted more snails than potatoes and papaya leaves, the difference between them at 3 hours was not significant. At the end of 48 hours, although watermelon peel still recorded the highest percentage of attraction, it had no significant difference compared with apple peel and potatoes (F=4.07; P=0.0500). As shown in the Fig. 6, the attraction rate of GAS to various attractant materi-

Table 2. Mean number of snails attracted to different attractant materials under the free-choice conditions in the lab test A after 2nd input of Golden apple snails (20 snails)

Duration	Attractant Mean±SE (%)				
	Apple peel	Watermelon peel	Potatoes	Papaya leaves	LSD
10 mins	0.33±0.58 a (3.3)	0.67±0.58 a (3.4)	0.33±0.58 a (3.3)	0.00±0.00 a (0.0)	0.941
20 mins	0.70±1.15 a (3.5)	1.33±0.58 a (6.7)	0.33±0.58 a (3.3)	0.33±0.58 a (3.3)	1.438
30 mins	1.50±0.58 ab (15.2)	1.67±0.58 a (8.4)	0.33±0.58 b (3.3)	0.33±0.58 b (3.3)	1.087
40 mins	1.30±0.58 ab (6.5)	2.33±0.58 a (11.7)	0.67±0.58 b (8.4)	1.00±1.00 b (5.0)	1.331
50 mins	1.00±1.00 b (5.0)	3.00±1.00 a (15.0)	0.67±0.58 b (8.4)	0.33±0.58 b (3.3)	1.537
60 mins	2.00±1.00 a (10.0)	4.00±2.00 a (20.0)	3.00±1.73 a (15.0)	2.00±1.00 a (10.0)	2.824
3 hrs	2.67±0.58 a (3.4)	2.33±0.58 a (11.7)	2.67±0.58 a (13.4)	2.00±1.00 a (10.0)	1.331
6 hrs	3.00±1.00 a (15.0)	3.33±1.15 a (16.7)	2.33±0.58 a (11.7)	2.67±0.58 a (13.4)	1.631
24 hrs	4.33±0.58 a (21.7)	4.67±0.58 a (23.4)	2.67±0.58 b (13.4)	2.00±1.00 b (10.0)	1.331
48 hrs	6.00±1.00 a (30.0)	6.33±1.53 a (31.7)	5.33±1.53 ab (21.7)	3.00±1.00 b (15.0)	2.431

Means with same letters in the same column are not significantly different at LSD test (α=0.05)

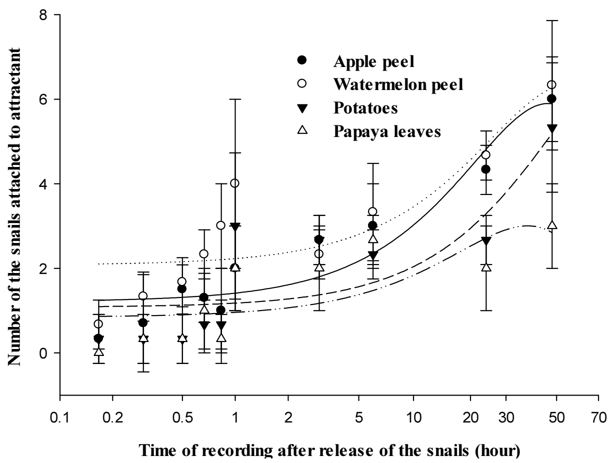

Fig. 6. Rate of attraction of the Golden apple snails over time to different attractant materials under the free-choice conditions in the lab test A after 2nd input of Golden apple snails (20 snails).

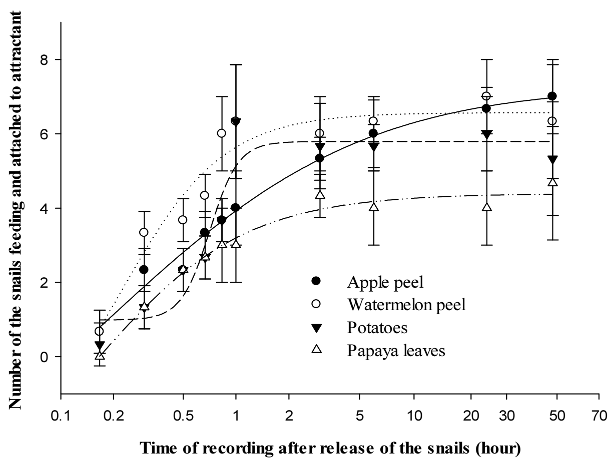

Fig. 7. Change tendency of number for snails feeding and attached to the different attractants over time under no-choice conditions in the lab test B after input of Golden apple snails (10 snails).

als was monitored over time in laboratory test A, following the introduction of a second batch of 20 snails under free-choice conditions. The rate had decreased in watermelon peel and apple peel but for potatoes and papaya leaves, the rate of attraction had increased (Fig. 6). The rate in potatoes also increased but showed no significant difference compared with the previous two (Fig. 5 and Table 1).

Basically, the apple snail number did not differ significantly among the attractant materials under no-choice conditions from 15 until 60 min after release although watermelon and potatoes seemed to be the most preferred (Table 3). Indeed, the snails started to feed and attach to the materials after 10 minutes and the rate showed an increasing trend in general after 1-3 hours (Fig. 7). At 2, 4, and 6 hours after release, all the attractant materials showed no significant difference from one another (F=0.89; P=0.4872, F=0.76; P=0.5464, F=6.25; P=0.0172, F=6.44; P=0.0158, F=5.70; P=0.0219, F=6.02; P=0.0190, F=2.07; P=0.1821, F=4.83; P=0.0332, F=10.79; P=0.0035, F=1.61; P=0.2619) (Table 3) in attracting the snails. Apple and watermelon fruit attracted the highest percentage of snails at 4 hours, but the rate went down at 6 and 24 hours after release (Fig. 7). As shown in the figure, the trend in the variation of the number of snails feeding on and adhering to different attractants was observed over time in laboratory test B, following the introduction of a group of 10 golden apple snails under no-choice conditions. At 6 hours, the percentage of snails attracted to water-

Table 3. Mean number of snails attracted to different attractant materials under the no-choice conditions in the lab test A after input of Golden apple snails (10 snails)

Duration	Attractant Mean±SE (%)				
	Apple peel	Watermelon peel	Potatoes	Papaya leaves	LSD
10 mins	0.33±0.58 a (3.3)	0.67±0.58 a (6.7)	0.33±0.58 a (3.3)	0.00±0.00 a (0.0)	0.941
20 mins	0.68±1.15 a (6.8)	1.33±0.58 a (13.0)	0.33±0.58 a (3.3)	0.33±0.58 a (3.3)	1.438
30 mins	1.33±0.58 ab (13.3)	1.67±0.58 a (16.7)	0.33±0.58 b (3.3)	0.33±0.58 b (3.3)	1.087
40 mins	1.33±0.58 bc (13.3)	2.33±0.58 ab (23.3)	0.67±0.58 c (6.7)	1.00±1.00 a (10.0)	1.331
50 mins	1.00±1.00 b (10.0)	3.00±1.00 a (30.0)	0.67±0.58 b (6.7)	0.33±0.58 b (3.3)	1.719
60 mins	2.00±1.00 b (20.0)	4.00±2.00 a (40.0)	3.00±1.73 a (30.0)	2.00±1.00 b (20.0)	2.241
3 hrs	2.67±0.58 ab (26.7)	2.33±0.58 a (23.3)	2.67±0.58 ab (26.7)	2.00±1.00 b (20.0)	1.631
6 hrs	3.00±1.00 a (30.0)	3.33±1.15 a (33.3)	2.33±0.58 a (23.3)	2.67±0.58 b (26.7)	1.537
24 hrs	4.33±0.58 ab (43.0)	4.67±0.58 a (46.7)	2.67±0.58 b (26.7)	2.00±1.00 c (20.0)	1.537
48 hrs	6.00±1.00 a (60.0)	6.33±1.53 a (63.3)	5.33±1.53 a (53.3)	3.00±1.00 a (30.0)	2.663

Means with same letters in the same column are not significantly different at LSD test (α=0.05)

melon and apple were higher than the previous two materials, but increased after 6 hours, and was among the highest at the end of 24 hours (Fig. 7). At 48 hours, more than 60% of the released snails in the treatments with watermelon and apple were attracted while only about 40% were attracted to the other two treatments (Fig. 7). Even though mortality was not recorded, the percentages were low and the differences were not significant. Generally, all the test materials were capable of attracting apple snails but they differed in the degree of attraction. Each of the plant materials including the apple peel and watermelon peel had their own advantages and disadvantages because they are possible to prevent the escape of the GAS into the rice-cultivating environment b using easily applicable the lure substances like apple peels, potatoes and watermelon kinds.

In the free-choice tests (Test A and Test B), the reason for the very low percentage of attracted snails was probably due to the use of tap water for the trials. The presence of chlorine in tap water may have adversely impacted the snails' behavior. During the investigation, the snails exhibited reduced activity, with many remaining stationary inside their shells and some even burying themselves in the mud. This behavior had a minor impact on the accuracy of the results obtained. Another study demonstrated a greater attraction percentage by utilizing rice field water in natural conditions instead of tap water [23]. It is suggested that future experiments consider using rice field water under conditions that allow for free choice. In this study, the third test under no-choice conditions proved that the snails became more active when placed in the rice field water. The percentage of active individuals was higher than those of individuals observed in Tests A and B. The reaction of the snails towards the attractants in Test 3 also was quicker than Tests A and B.

The majority of the snails were discovered attached to the attractants, likely seeking shelter or sustenance. Based on observations from Tests A and B, apple and watermelon were identified as the most appealing materials, probably due to their potent and fragrant odors capturing the snails' attention. Potatoes were the next favored attractant, while papaya leaves were the least preferred, serving mainly as a hiding place rather than a food source. All plant-based attractants have the potential to serve as attractants for gathering snails, particularly during rice field preparation and crop establishment. Farmers have the flexibility to choose based on attractants availability. To provide robust recommendations for the physical control of apple snails, additional trials in natural or field conditions are necessary to obtain compelling data.

Trapping effect of catch net for snails inhabiting rice paddy drainage

The research took place in an eco-friendly rice paddy test field located in Gokseong, Jeonnam, Korea, as shown in the Fig. 3. The concentration of the four attractants in the rice paddy irrigation channel was measured using three types of catch nets over a 48-hour period. Effect of attractant net on rice fields was conducted at agricultural waterways and small rivers. The concentration of the four attractants in the rice paddy irrigation channel was measured using three types of catch nets over a 48-hour period. Table 4 indicates the result of an experiment to capture GAS in a bait net using four types of attractants, the size of snail snails was relatively higher in the large trap net and shrimp nets than in the general fish traps. Larger numbers were caught, and relatively large snails larger than 1 cm were also caught. The order were watermelon > apple > potatoes > papaya leaves in the three type of bait trap (Table 4). The attracting effect of the golden

Table 4. Density of the three types of catch net with four attractants in the rice paddy irrigation channel during 48 hrs.

Attractants	Number of snails captured in the three type of catch net											
	Shrimp trap				Fish trap				Large trap bait			
	1	2	3	Mean±SD	1	2	3	Mean±SD	1	2	3	Mean±SD
Apple peel	71	76	80	75.7±3.11	68	50	57	58.3±6.44	88	72	80	80.0±5.33
Watermelon peel	92	79	90	87.0±5.33	59	59	56	58.0±1.33	127	92	112	110.3±12.22
Potatoes	79	74	65	72.7±5.11	60	74	72	68.7±5.78	111	60	108	93.0±22.00
Papaya leaves	57	75	98	76.7±14.2	67	48	67	60.7±8.44	75	79	85	79.7±3.56
Total	299	304	333	(936)	254	231	252	(737)	401	303	(305)	(1,009)

A: Shrimp trap net, B: Fish trap net, C; Large trap bait net.

apple snails was highest in the large trap that was applied with watermelon. The 110 snails were averagely captured in the lure net. However, potatoes, apple peels and papaya leaves caught an average of 93, 80 and 79 snails, respectively. There was no significant difference in the lure effect of the snails according to the attractants. It was found that the attracting effect of large snails was about twice as large, but the effect of attracting large snails using a trap and shrimp net in the first year. Compared to the experiments performed mainly on agricultural waterways and small rivers, the capture of golden apple snails living in rice paddy fields was performed. [1] reported that submerged funnel trap used with the assistance of attracting agents (fish meal and chemical light) was designed as an easy, objective and quantitative tool for collecting aquatic organisms in the rice paddy fields. As shown the Fig. 4, the large trap (Φ 90 cm) was effective to catch the snails that were submerged in the rice paddy. The effect of attracting large traps increased in the order of watermelon, papaya leaf, and melon (Table 4).

Density observation of captured snails in the rice paddy field

A test of trapping nets for control of GAS in rice cultivation environment. The total 301 snails including juveniles were caught in the large bait trap with apple peel, watermelon peel, potatoes, papaya leaves, melon and Korean melon in seven days after administration of snails (middle size, 10-20 mm) in 2023 (Table 5). That was similar with the result of attracting snail that was done in 2022. Meanwhile, the 19-20 snails were averagely captured in the traps with apple peel, watermelon peel and potatoes. the 15-17 snails were averagely in the traps with papaya leaves, melon and Korean melon. However, only averaged 15 snails were caught in the traps with Korean melon. There was no significant difference in the lure effect of the snails according to the attractants except Korean melon. The experiments were conducted in rice fields, agricultural reservoirs and freshwater lakes to establish a method to prevent spillage of the GAS in rice-paddy fields. A study was conducted to evaluate the efficiency of catch nets in capturing snails within a controlled and environmentally sustainable rice paddy test field. The golden apple snails in rice growing environment so that it can be applied to efficient farming. Suggested installation of large pots such as agricultural irrigation and drainage in the rice cultivation environment. Potatoes, apple and watermelons that are easy to use for farms are recommended as attractants. After administering bait to the entire rice field on April 24, 2023, attractant nets had been installed on May 3. After 6 days (on May 9), the attractant effect increased in the order of apple peel, potatoes, watermelon peel, papaya leaves, melons and Korean melons for large bait trap. We found that the efficiency of large bait trap in capturing snails, regardless of the pant attractant employed, followed this order of increased catch rates: apple peel > watermelon peel and potatoes > papaya leaves > melon > Korean melon.

Conclusion

Based on this study, several plant materials such apple peel, watermelon peel, potatoes and papaya leaves have potential for use as attractants to facilitate the collection of apple snails in the field, or to make it easier for spot spraying of molluscicides. Watermelon

Table 5. Investigation of catch amount of the snail by four attractants in paddy fields using large trap bait nets in a rice paddy

Attractants	Number of snails captured in the nets					
	1	2	3	Sum	Average±SD	CV (%)
Apple peel	20	22	18	60	20.0±1.33	6.65
Watermelon peel	17	19	21	57	19.0±1.33	7.00
Potatoes	22	20	17	59	19.7±1.78	9.03
Papaya leaves	19	18	16	53	17.7±1.11	6.27
Melon	17	16	13	46	15.3±1.56	10.20
Korean melon	9	10	7	26	8.7±1.11	12.76
Total	104	105	92	301		

* Six days after administration of snail shellfish (10-20 mm), ** Rice paddy test plot (2,310 m^2).

peel is highly recommended to be used by farmers as well as apple peel and potatoes. The utilization of these snail attractants may contribute positively to the development of an integrated pest management strategy which is safe and environmental friendly. To be applied through efficient agricultural utilization, large bait trap are installed in rice cultivation environments, such as irrigation and drainage channels. By using easily applicable lure substances like apple peels, potatoes and watermelon, it is possible to prevent the escape of the GAS into the rice fields.

Note

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