

# Management of the Golden Apple Snail, *Pomacea canaliculata* (Lamarck) in Irrigated Rice in Sabah

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## Abstract

The golden apple snail spread to Sabah in the 1990s' and became a major pest of rice a few years later. As soon as the snail was recognized as pest, the Department of Agriculture initiated a research program and launched a control operation, which employed an integrated approach comprising of cultural, biological and chemical components to combat the new invasive mollusc. Dialogue and briefing sessions were also conducted for the farmers to transfer technologies and to receive feedbacks from the end users. In general, the snail was damaging to rice seedlings only during the early stages of growth. Older seedlings with their culms already hardened became tolerant to the pest, which the snail could not rasp. For this reason, 40 day-old seedlings were used in transplanting with the water level maintained at 5 to 7 cm deep for the first few weeks and for direct seeding, the field was drained to saturated soil moisture condition to immobilize snail activities prior to broadcasting the pre-germinated seeds. These methods were widely practiced because they were simple and cost effective. Farmers also introduced ducks for biological control of snail in their rice fields at a density of 5 to 10 ducks/ha during the off and pre-planting seasons. The most common molluscicide used was tea seed powder, which was applied at 51kg/ha under a stagnant water of 5 to 7 cm deep in areas with high pest population density exceeding 5 snails/m<sup>2</sup>. A plant known as *Furcreae selloa* var. *marginata* was introduced to the farming community for the management of snail in rice. However, the use of molluscicide has been restricted to minimize environmental pollution and to conserve the natural enemies of golden apple snail. The control operation successfully contained the pest within two years. However, it was difficult to prevent the pest from spreading as it could spread by occasional floods and by human activities as well. Thus it is essential to continue to monitor its spread in the rice-growing districts.

**Keywords:** Golden apple snail, *Pomacea canaliculata*, rice pest, integrated pest control

## 1.0 Introduction

The golden apple snail (*Pomacea canaliculata*, Lamarck) is native to South America. It is a fresh water snail belonging to the Ampullaridae family (Cowie, 2002). In the 1980s' it was

introduced from Argentina to Taiwan for commercial production (Mochida, 1991). From here, the snail was distributed to the third world countries to improve the living conditions of the rural poor (Matienzo, 1984; Anderson, 1993). However, the introductions were done in haste with no prior studies on the economics and its impact to the new environments (Acosta and Pullin, 1989). When the demand for the snail was poor, farmers abandoned their snail-farming projects and in many instances, the snail escaped and ravaged the rice crop with losses running into millions of dollar (Naylor, 1996). The golden apple snail is now a major rice pest in Asia (Halwart, 1994). The estimated snail-infested areas were 171,425 ha in Taiwan in 1986, 16,195 ha in Japan in 1989 and 400,000 ha in the Philippines in 1989 (Mochida, 1991). In West Malaysia the snail was first reported in Kedah in 1991 in a place called Semeling, about 60km from Alor Setar (Anon., 1992). In East Malaysia, in Sabah, the snail was sighted in Keningau in 1992. Few years later, the snail spread to most rice-growing areas via floods and irrigation canals including human activities. As soon as the golden apple snail became a pest in Sabah, the Department of Agriculture immediately initiated a research program and launched a control operation to combat the new rice pest. This paper discusses the detail control operation program of the golden apple snail implemented in Sabah.

## **2.0 Biology and Ecology of the Golden Apple Snail**

In its native environment the golden apple snail inhabits swamps, marshes, ponds, lakes and riversides with shallow slow moving or stagnant water. The snail is extremely polyphagous, feeding on vegetal, detrital and animal matter with a voracious appetite. Temperature is the main growth-limiting factor, significantly influences many aspects of *Pomacea* biology (Cowie, 2002). But in Sabah, with no significant temperature fluctuation and an ecosystem quite similar to its natural habitat, the snail breeds continuously throughout the year. The only limiting factor for growth is the availability of water in sufficient quantity. Water is essential for feeding, growth and breeding. When the water level in the field is shallower than its shell height, the snail becomes less mobile and when the field is drying up the snails will creep into the mud to aestivate. Thus during dry weather conditions the snail is not visibly noticeable in the field. When the field is flooded again, the snail ceases hibernation and resumes its activities immediately. The snail could aestivate underground for more than 10 months (Teo, 2003a), therefore once infested the situation is seemingly irreversible. The most active period of the snail is during the wet rainy seasons. This is indicated by the pinkish colouration of the egg masses on the vegetations. Oviposition takes place at night. The eggs masses are laid on

aerial substrates such as paddy stalks, weeds, fences, bunds, etc. A study on the biology of the pest at Agriculture Research Centre, Tuaran showed that the number of eggs oviposited per clutch ranged from 92 to 592, with a mean of 272 eggs. Most egg masses had more than 200 eggs, and egg masses with fewer than 100 eggs were rare. Egg masses with 500 to 600 eggs were not uncommon. The eggs took about eight to twelve days to hatch under laboratory conditions. The hatchlings were about 2mm in diameter. Hatching success was high, ranging from 87 to 100%. Hatching rate was not dependent on clutch size; clutches of 127, 140, 148, 477, 512 and 540 eggs produced 89.4, 98.6, 99.3, 97.2, 99.4 and 94.9% hatchlings respectively. Females were more numerous than males, with an overall male to female ratio of 1:4.6. The snails matured 82 days after hatching indicated by signs of matings (Teo, 2004). Mating could last 10 to 20 hours (Andrews, 1964; Albrecht *et al.*, 1996) and females could store sperm up to 140days (Estebenet and Cazzaniga, 1993). Growth was affected by population density, at a density of at least 20 snails 30cm<sup>2</sup>, growth was slower and no mating was observed at day 82 than when the density was 10 snails 2m<sup>2</sup>. Population density could also affect the number of egg masses, eggs per cluster and survivorships (Tanaka *et al.*, 1999; Cazzaniga and Estebenet, 1988; Lacanilao, 1988, 1990). Growth was also limited by certain environmental factors such as peat soils. An experiment conducted at Agriculture Research Centre, Tuaran showed that the number of egg masses oviposited was significantly reduced when peat soils was introduced into the experimental plots. Furthermore, peat soils had poor water retentive capacity. It could not hold water in a flooded condition for long; therefore it could not support the activities of the snail. The submersion of the egg masses under water by occasional floods could also be harmful. However, the submersion was detrimental only if the duration was longer than a week. If the egg masses were submerged for 14 days, there was a significant reduction in the percentage of eggs hatched (Teo, 2004).

### **3.0 Damage Potential of the Golden Apple Snail in Rice Seedlings**

In general, the younger the seedlings the more susceptible are they to snail, and the deeper the water level, the greater the damage. Direct seeded rice is therefore the most vulnerable to snail damage. The seedlings become tolerant to snail at the age of 40 days old if the water level is about 5 to 7cm depth or within the height of the hardened culms where the snail cannot rasp. At a deeper water level, the 40 day-old seedlings become susceptible to the pest when the upper tender tissues are submerged in water. The golden apple snail is destructive to rice seedlings for as long as water is not limiting. Thus, water is the most important factor for

determining the extent of damage. The damage potential of the golden apple snail in rice depends on water depth > seedling age > pest density in the decreasing order. At a water depth > 5 cm, the damage in direct seeded rice and transplanted 21, 30 and 40 day-old seedlings is 100, 89.2, 59.7 and 46% respectively. At a water depth of  $\leq 5$  cm, the damage in the 30 and 40 day-old seedlings is insignificant. The damage is also insignificant in direct seeded rice and 21 day-old seedlings when the water is drained to saturated soil moisture condition. Limiting the water depth reduces the damage significantly even when pest density is as high as 5 snails  $m^{-2}$ . Dry direct seeding which utilizes minimal amount of water in the early stages of growth receives 0% damage (Teo, 2003b). The conventional rice planting methods consisting of transplanting 21 day-old seedlings and direct seeding without water depth control are not recommended under snail-infested conditions because the pest density, which can inflict damages above the economic threshold level in transplanting is 0.3 snail  $m^{-2}$  while for direct seeding a lower pest density is expected (Teo, 2003c).

#### **4.0 Golden Apple Snail Research Program**

The Department of Agriculture initiated a research program to develop control techniques against the golden apple snail as soon as it was spotted in the rice field. The research program adopted a user sensitive approach to enhance the transfer of technology to the farmers. Initial studies focused on the ecology and biology of the pest including its damage potential to rice seedlings. The objective was to acquire knowledge of the pest in the rice ecosystem with a view to develop control techniques. The studies also covered a trial on the selection and evaluation of molluscicides from marketed products and biopesticides from plants. Later studies emphasized on environment-friendly control measures such as cultural and biological controls. Research findings were pooled to form an integrated pest management (IPM) package, which consisted of cultural, biological and chemical components. The package was applied in the snail control operation launched by the Department of Agriculture, which was implemented statewide (Teo, 1999a).

#### **5.0 Control Measures Developed for Golden Apple Snail**

**5.1. Cultural Controls.** The most common cultural controls practised by farmers are handpicking and transplanting of 40-day-old seedlings with the water depth maintained at 5 cm for the first few weeks. At booting, the plants become tolerant to the pest so the water level can be raised to more than 10 cm at this stage. For direct seeding, the water in the field is drained to saturated soil moisture condition followed by broadcasting the pre-germinated

seeds. The seeds are prepared by soaking in water inside a gunny-sack for two nights and on the third day; the sack is lifted from the water and hung to drain off excess water. On the fourth day, the seeds are broadcast onto the field. If machine is used to broadcast the pre-germinated seeds, soaking for one night is sufficient because longer soaking time will produce longer roots that are prone to damage during broadcasting. At day 28, water is introduced to a depth of 5 cm only and to a deeper depth when the crop reaches the booting stage. These methods are widely used by farmers because they are simple and cheap to apply. Handpicking is carried out occasionally through a community effort known as 'gotong royong'. Handpicking is now easier with the use of herbage attractants. Leaves of Papaya (*Carica papaya*), Sweet Potato (*Ipomea batatas*), Tapioca (*Manihot esculenta*) and Gliricidia (*Gliricidia sepium*) are potent snail attractants (Teo, 1999b). A small bundle of the leaves are submerged in stagnant water at the edge of the field. A significant number of snails are attracted to the leaves after 24 hours. The snails are collected and destroyed the following day. This method significantly reduced time and labour required in the normal handpicking operation.

While controlling snails in the field, filters such as wire mesh screens were set up at the water inlet points to prevent re-infestation through the flow of snail-infested water. However, the smallest snail size is 2mm and only meshes size smaller than 2mm is 100% snail proof. So this measure was not widely used because the filters were clogged by dirt or rubbish too soon. Once the filters are blocked by rubbish, water will not flow and flood will soon build up and overflows the banks of the irrigation canal. Unless manpower is available for cleaning the filters at regular intervals, it is not practical to set up filters at the irrigation inlets.

During off-planting seasons farmers were encouraged to keep the field dry to stop snail from breeding. Dry ploughing and rotovating were carried out just before the pre-planting season to kill snails aestivating underground by exposing them to heat and dryness. During wet ploughing, farm machineries were required to go through a sanitation procedure. Tractors and combine harvesters after operating in an infested area were required to wash thoroughly at the washing pavement prepared by the District's Agriculture Extension before embarking onto their next destination. This protocol was enforced to curb the spread of golden apple snail by farm machinery.

**5.2. Biological Control.** Duck was recommended to the farmers for biological control of snail in rice fields at a density of 5 to 10 ducks ha<sup>-1</sup>. At these densities the duck could reduce the pest population from 5 snails m<sup>-2</sup> to less than 1 snail m<sup>-2</sup> after 1 month. The recommended varieties of duck include William Siam > Taiwan > Mallard > Peking > Khaki

Campbell in the decreasing order (Teo, 2001). Ducks are damaging to young rice seedlings too. So it cannot be released when the seedlings are still young. For transplanted rice, the ducks can be released after 4 weeks and for direct seeding, after 6 weeks. The ducks can also damage the crop at the ripening stage, so they are kept in captivity during this period. Biological control of snail with ducks is highly effective and consistent. Snails and their egg masses could hardly be spotted in some rice fields introduced with duck herding.

**5.3. Chemical Control.** Although chemical control is included in the IPM package, the Department of Agriculture discouraged farmers from using chemicals because they are hazardous to the environment, and may also endanger public health. Chemical control is preferable only when the pest population density exceeded 5 snails m<sup>-2</sup> and when there is manpower shortage or when time is a constraint for other means of control. The chemicals recommended for snail control include tea seed powder, pellets of metaldehyde 5% and niclosamide. Tea seed powder is recommended at 51kg/ha under a stagnant water of depth 5 – 7 cm. Tea seed powder is a by-product of oil extraction from tea seeds. It contains 5.2 to 7.2% saponin, which causes hemolysis in animals (Minsalan and Chiu, 1988). It is toxic to most aquatic organisms such as fish and frog. However, its residual period lasts for 4 days only. Pellets of metaldehyde 5% is used when tea seed powder is not available. The recommended rate is 15kg/ha but usually a smaller quantity is used because it is spot-applied in waterlogged areas or small ponds following field draining in the rice plots.

A trial on the screening of plants with molluscicidal properties managed to identify a plant species known as Yellow Furcraea or Wild Sisal (*Furcraea selloa* var. *marginata*), which is highly effective against golden apple snail. Dry leaf powder of Yellow Furcraea is recommended for golden apple snail control at 45kg/ha (Teo, 2002), much lower than the recommended rate for tea seed powder.

## **6.0 Management Strategy**

In the beginning when the golden apple snail became a pest, awareness campaign consisting of briefing/dialogue sessions were organized repeatedly by the Extension's staff and research personnel to disseminate information on the new rice pest to the farming community. The main objectives were to motivate farmers to participate in the control operation and to enhance transfer of technology. Farmers are the source of manpower; they are the users and the implementers of research findings. Without farmers' involvement, the control operation would not be successful. In the meet-the-farmer sessions, farmers were taught how to control

the snail pest. A control program was formulated for the area where the meeting was held and usually consisted of water depth management, transplanting of older seedlings, handpicking by the community with or without herbage attractants, tea seed powder applications, snail filters and duck herding. For a start, resource-poor farmers were provided with the materials they were lacking, for example tea seed powder was given free to those farmers whose rice fields were heavily infested by the pest. The meeting sessions also served as a place for the exchange of ideas and for receiving feedbacks from the farmers. It was the venue to rectify mistakes and to clarify confusions. For example in the beginning many farmers mistook the golden apple snail as the local snail (*Pila* spp.). They could not differentiate between the new rice pest and the local snail. After a series of briefings and field visits they were convinced and willing to participate in the control operation.

A Pest Surveillance Committee was set up at the Department of Agriculture Headquarters, in all districts and villages with the objectives to supervise and to monitor the control operation. The committee consisted of Research-Extension personnel and the farmers. The committees called for a meeting monthly at the initial stage to determine the progress of the control operation. A leader would be picked from among the farmers and one Extension staff was assigned to supervise the control program for each location. The Extension staff would report the progress of control to the District Agriculture Officer who would in turn report to the chairperson of the Pest Surveillance Committee at the Headquarters. A census was conducted during the following pre-planting season to assess the effectiveness of the control operation by estimating snail population density. Snail density was estimated by throwing at random a 1m-quadrat at 15 throws/ha. As a backup support, mass media, flyers, posters and signboards were set up at strategic locations to caution the public not to spread the snail.

## **7.0 Management of the Breeding Grounds of the Golden Apple Snail**

Ponds, lakes, swamplands, marshes, drains, streams are breeding grounds of the golden apple snail. If these places are linked with the source of water for irrigation or nearby the rice field, it is important that control measures be implemented to curb the spread of the pest. If the breeding areas are located outside the agriculture zone or non-agriculture areas such as urban areas, then control measures may not be necessary. If the snail is breeding in a pond, the water should be drained off to stop the activities of the snail. If draining is not possible, then other means of control should be implemented to maintain the pest population density at a tolerable level. Application of molluscicides should not be given the priorities, as this approach may endanger public health and is harmful to beneficial organisms or natural

enemies of the snail. The natural enemies found in Sabah include Collared Kingfisher (*Todirhamphus chloris chloroptera*), rodents (*Rattus* spp.), Stink Bug (*Scotinophora cinera* Le Guill), frog (*Rana rugulosa*), fishes: Common Carp (*Cyprinus carpio*), African Catfish (*Clarias gariepinus*), Tilapia (*Oreochromis niloticus*), Kerok (*Abas testudineus*) and Jalak (*Ocephalus striatus*), fire ant (*Solenopsis geminata*), red ant (*Tridomyrmex myrmecodiae*), domestic ducks (*Anas platyrhynchos*), Fulvous Whistling-Duck, (*Dendrocygna bicolor*) and Purple Swampphen (*Porphyrio porphyrio*) (Teo, in press). There are also insect predators such as the small water bug, *Sphaerodema molestum* (Duf.), which could consume more than 1000 hatchlings throughout its lifetime (Chanpayate, 2004). The breeding of the golden apple snail in the wetlands would not continue to reach an alarming number because of reasons discussed earlier under the biology of the snail. Inhibitory substances produced under high population density could result detrimental effects on growth as well (Lacanihao, 1988; Schnorbach, 1995). Based on personal observation, the population density of the golden apple snail in the beginning in any new infested areas was usually very high, exceeding 5 snails m<sup>-2</sup> with numerous egg masses oviposited. After one or two years the pest population density would drop to as low as less than one snail m<sup>-2</sup>. Molluscicides should not be applied in haste. However, if chemical control couldn't be avoided, a safer product like tea seed powder or *Furcreae* leaves should be used instead. Biological control of snails with ducks is a good option in the wetlands if there are facilities to house the predator. Fish is another potential biocontrol agent against snails in the bodies of water. A trial conducted at Agriculture Research Centre, Tuaran showed that African Catfish (*Clarias gariepinus*) and Common Carp (*Cyprinus carpio*) were the most effective predators of golden apple snail but African Catfish was not adaptable to the rice field conditions (Teo, 2006). Most fish species preyed on *Pomacea* snail. The number of snail consumed by fish depended on the fish species and the size of the snail. Ponds and lakes with larger area and deeper water level may be more suitable for the African Catfish. The African Catfish is a carnivorous fish species, which probably could withstand attacks better than the Common Carp from other carnivorous fish species such as Jalak (*Ocephalus striatus*). Since all the beneficial species help to reduce the snail population in one way or another, pesticides should not be applied indiscriminately so as to preserve the natural predators of the golden apple snail.

## **8.0 Problems and Constraint**

The control operation encountered several social problems. In the beginning many farmers mistook the golden apple snail as the local snail *Pila* spp. and refused to believe that it was an exotic pest until they experienced damages in their crop. In fact, man was the principle agent

of dispersal of the pest. The snail spread to most of the districts by man. Farmers brought home the snail for culinary purposes, which at the same time scattered some into their paddy field or backyard to allow it to multiply for future food sources. The control operation could contain the pest in the field but it couldn't stop man from spreading it to another place despite the repeated warnings issued during the control operation. Response from farmers was poor in some districts. Not many farmers turned up in a briefing/dialogue session or in a handpicking operation. Many chose to use tea seed powder in preference to other control measures. Farmers were also slow in adopting innovations such as duck herding for snail control. As an incentive, ducks were given free to some farmers in the beginning. However, when something was given free, the neighbours and the rest of the community hoped to receive the same treatment. Also, not all farmers implemented control measures in their own field. Nearby fields with no control measures carried out became a source for re-infestation to adjacent fields with the pest already under control.

## **9.0 Conclusions**

The golden apple snail invaded Sabah in the 1990s' and is now a major pest of rice. How it got into this country remains a mystery. As soon as the snail was spotted in the rice field, the Department of Agriculture immediately formulated a research programme to study the pest and at the same time initiated a control operation to combat the new rice pest. An integrated approach was adopted consisting of cultural, biological and chemical components. The control operation with the cooperation of farmers, Extension agents and researchers managed to contain the pest within two years. The total infested area in Sabah now stands at 8,000ha. Because of its prolific nature and its ability to aestivate underground for a considerable period, it is impossible to eradicate it once it has established in an area. The golden apple snail invasion is an irreversible phenomenon. Chemical control should not be emphasized in any control operation because it is not environment-friendly and toxic to non-target organisms particularly to the natural enemies of the golden apple snail. In Japan, endosulfan, niclosamide and tea seed cake were not registered for golden apple snail control (Wada, 2004). This approach enhances the survival of beneficial species and organisms released for biological control of the snail. Most of the pest population densities in the infested areas now are below 1 snail per m<sup>2</sup>. Nowadays the Pest Surveillance Committee does not hold its meeting anymore because the pest has been contained. However, the Extension Office in the districts continues to monitor the pest particularly in the direct seeding areas, which are the high-risk zones.

## 10.0 References

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