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Alberto A Silva
Fisheries and Marine Sciences Department, Northern Negros State College of Science and Technology, Old Sagay, Sagay City, Philippines

Ernesto S Suay
Fisheries and Marine Sciences Department, Northern Negros State College of Science and Technology, Old Sagay, Sagay City, Philippines

Wynne S Silva
Fisheries and Marine Sciences Department, Northern Negros State College of Science and Technology, Old Sagay, Sagay City, Philippines

Frank Paolo Jay B Albarico
Fisheries and Marine Sciences Department, Northern Negros State College of Science and Technology, Old Sagay, Sagay City, Philippines

Corresponding Author:
Frank Paolo Jay B Albarico
Fisheries and Marine Sciences Department, Northern Negros State College of Science and Technology, Old Sagay, Sagay City, Philippines

Notes on freshwater clam and land snail as alternative food for rice paddy eel, *Monopterus albus*

Alberto A Silva, Ernesto S Suay, Wynne S Silva and Frank Paolo Jay B Albarico

Abstract
This research was conducted to determine the growth performance of rice paddy eel *Monopterus albus* using freshwater clams *Batissa violacea*, land snail *Achatina* sp. and golden apple snail *Pomacea caniculata* as natural foods. Specifically, the study aimed to ascertain the food type that yielded the best result in terms of absolute growth. A simple cost and return analysis were also presented. Nine 100-liter plastic tanks were stocked each with five pieces *M. albus*, installed in a Completely Randomized Design. Ten grams of azolla were placed in each tank to serve as biofilter. *M. albus* were fed daily rations of 10%, 8%, and 6% of their body weight during the 1st, 2nd and 3rd fifteen days of culture, respectively. Feeding was done once a day between 05:00 and 06:00 o'clock in the afternoon. Findings showed significant difference among treatments in terms of absolute growth, but no significant difference in feed conversion ratio. All treatments got 100% survival rate. The highest absolute growth were obtained using golden apple snail as food followed by freshwater clam and land snail, respectively. This study revealed that all the natural foods tested could be used as feed for *M. albus* culture. The potential of freshwater clam as alternative food in addition to golden apple snail as the common natural food of *M. albus* in the wild was demonstrated.

Keywords: Aquaculture, *Monopterus albus*, feed conversion ratio, golden apple snail, freshwater clam, land snails

1. Introduction
Monopterus albus Zuiew, 1793 are among the aquatic species introduced in the Philippines without any permit [1]. This species has become invasive in the rice fields which obstructed farmer's operations [1-3]. It has also become invasive in other countries such as the United States [4-5]. On the contrary, due to increasing demand of eels in many Asian countries, the species become eventually an export potential for the Philippines [6].
With the increasing demand of eels, exploitation for some species has increased and historical decline in stocks have been observed [7-9]. Therefore, there is a need for aquaculture of other eel species such as *M. albus*, which has become commercially accepted. This species have evidently caused problems in rice farms by burrowing on the dikes [2], however, findings showed that in other countries, the species have not caused decline in native species which have been previously thought [10]. This species is also used in traditional medicine [11] which supports its wide use and importance.
Researches on the breeding of *M. albus* were conducted by various authors to improve productivity in hatchery conditions [12-14]. Culture practices are also developed in other countries like Vietnam where they evaluated and observed that home-made natural food such as golden snail have gained positive results compared to commercial feeds [14]. This suggests that locally available natural foods could be utilized in the absence of commercial feeds.
With the increasing demand in the Philippines, eels need to be promoted for aquaculture to avoid depending on wild caught. However, despite its aquaculture potential, only few are involved in aquaculture of the species [15]. It may be due to few markets of eels in the Philippines, but more importantly, eels have export potential. Moreover, freshwater eels are potential as protein source for upland areas. Culture does not require large areas unlike other cultured species such as milkfish. It is also rich in essential nutrients, hence, become a healthy food [16]. The fish decreases cholesterol and lowers blood pressure; also reduces the risk of developing arthritis.

It promotes healthy eyesight, nervous system function and normal brain development. Though many people are hesitant to eat eels, this species is evidently nutritious [17]. This study was undertaken to utilize locally available natural foods especially those that are considered pests (i.e. *Pomacea caniculata* Lamarck, 1818 and *Achatina* sp.) and abundant in the locality (i.e. *Batissa violacea* Lamarck, 1818) for *M. albus* culture. This aims to determine growth and survival of *M. albus* fed with said food and to provide a simple cost analysis of its culture in plastic tanks.

2. Materials and Methods

2.1 Experimental design

This study used an experimental method in determining the growth responses of rice paddy eel in tanks fed with the different locally available feeds. Locally available feeds tested are freshwater clams, land snails and golden apple snail. The Completely Randomized Design was used having three treatments with three replicates; installed indoor at the Northern Negros State College of Science and Technology, Multi-species Hatchery, Old Sagay, Sagay City. The experimental set-up was composed of three treatments: Treatment I – freshwater clam (*B. violacea*), Treatment II – land snail (*Achatina* sp.) and Treatment III – golden apple snail (*P. caniculata*), also used as control. Rice paddy eel is the natural predator of golden apple snail; hence, it was used as control in this experiment.

2.2 Experimental set-up

Nine 100L capacity plastic containers were used in the 45-day culture period. Each container was filled with 10 cm clay soil as substrates and 5-inch water depth to mimic the natural habitat of the eels. The substrate used was collected from a nearby rice farm with *M. albus* citing. A total of 45 pieces rice paddy eels were used in this study, purchased from a local market in Cadiz City, Province of Negros Occidental. The species were identified as *M. albus* consistent with that described by Bricking, E. M. (2002) [18]. Five pieces rice paddy eels with an average size of 15.1 grams were stocked in each tank. Ten grams of azolla were placed inside the tanks to serve as biofilter, no aeration was provided.

2.3 Stocking, feeding and management

Stocking of rice paddy eels were done early in the morning. The experimental organism was fed once a day between 05:00 to 06:00 o'clock in the afternoon. The experimental animals were given daily rations of 10%, 8% and 6% of their body weight during the 1st, 2nd and 3rd fifteen days of culture, respectively. Fifty per cent water change was done every other day to avoid pollution caused by unconsumed feeds and feces. Total fish sampling on weight gained was done every 15 days until harvest.

2.4 Data analysis

Experimental animals were harvested after 45 days of culture. Absolute growth rate was determined by subtracting the initial weight from the final weight of the harvested rice paddy eel. A simple cost and return analysis was done by dividing the net income over the total expenses, multiplied by 100. Feed conversion ratio (FCR) was determined by dividing the average biomass to the feed consumed, multiplied by 100. Mean (weight and length) and percentage (survival) were subjected to Analysis of Variance to determine the differences among feed types in terms of growth and feed conversion ratio. Data were also subjected to post hoc analysis to compare values between treatments.

3. Results and Discussion

The experiment was carried over for 45 days which resulted to 100% survival in all treatments. High survival rate may be due to a low stocking density which provided larger area for the species [19]. Table 1 presents the survival rate, mean weight and absolute growth of rice paddy eel for forty-five (45) days culture period.

Table 1: Survival Rate, Mean Weight and Absolute Growth of Rice Paddy Eel (*M. albus*) after 45 Days of Culture.

Treatments	Survival Rate	Mean Weight (g) Initial	Final	Absolute Growth
I (Freshwater clam)	100%	15.1	74.8	59.7[a]
II (Land Snail)	100%	15.0	70.4	55.4[b]
III (Golden Apple Snail, Control)	100%	15.1	77.2	62.1[c]

*****Absolute growth rates were significantly different from each treatment ($p<0.05$)

Statistical analysis showed significant difference among treatments in terms of their absolute growth at $p<0.05$. Among the natural foods given, golden apple snail yielded the highest absolute growth rate. Based on literatures, golden apple snail is the food preference of the cultured species [20]. Moreover, golden apple snail has protein content of 62% [20], higher than freshwater clam and land snail, respectively. Yang *et al.* [21] suggested that the optimum protein percentage for *M. albus* is 35.7%; the value has been exceeded by the protein content present in golden apple nails resulting to highest absolute growth. This suggests that golden apple snail is better to be used as natural food, consistent with the common culture practices in Vietnam [14] where eels cultured in rice paddies are fed with golden apple snail. The two other treatments, freshwater clam and golden apple snail although were significantly different, have the potential as alternative foods due to near absolute growth values of 59.7 and 55.4 g, respectively, compared to golden apple snail with 62.1 g. The 100% survival observed in all treatments suggests that food were sufficient, thus, their cannibalistic behaviour [22] did not manifest throughout the culture period.

The total biomass after harvest was also determined, with the highest result of 0.385g observed in treatment fed with golden apple snail. This coincides with the result on the absolute growth where golden apple snail got the highest. The best FCR was obtained by Treatment I, however, the differences are not significantly different among treatments and the results were very close as showed in Table 2. Treatment II, fed with land snail got the highest FCR and lowest absolute growth which indicate that land snail should be the least feed type to be used if golden apple snail and clam are available. Lower FCR indicates better growth.

In terms of supply, although all feed types used were abundant and locally available, freshwater clams are consumed by the local community. The use as food for culture may compete with the local people. Contrary, land snails despite its low absolute growth and high FCR, is considered pest therefore ideal for collection and could be used also as alternative food if godel apple snail and freshwater clam are not available. *M. albus* was introduced in the Philippines [1] and abroad [4, 5, 23] which have affected rice farming systems [2]. However, it can be used to benefit the aquaculture sector and biodiversity as control for golden apple

snail and land snail. The latter food materials has also became pests in some areas of the country, therefore, utilizing them as food for *M. albus* culture can increase its control and management efforts.

Table 2: Average Biomass, Feed Consumption and FCR of Different Feed Types after 45 Days of Culture.

Treatments	Biomass (g)	Feed Consumed (g)	FCR
I (Freshwater clam)	374.0	746.3	2.00[a]
II (Land Snail)	352.0	721.5	2.05[a]
III (Golden Apple Snail, Control)	385.7	778.5	2.02[a]

*****FCR were not significantly different from each treatment (p<0.05).

Table 3: Sample Cost Analysis of Rice Paddy Eel Fed with Freshwater Clam, Golden Apple Snail and Land Snail after 45 Days of Culture.

	Treatment I	Treatment II	Treatment III
Input			
a. Tanks (rental)	10.00	10.00	10.00
b. Eels	20.00	20.00	20.00
c. Feeds	78.00	50.00	60.00
Total	108.00	80.00	90.00
Output			
a. Total production (kg)	1.12	1.06	1.16
b. Total sales (150/kg)	168.00	159.00	174.00
Net Income	60.00	79.00	84.00
Return of Investment	55.5%	98.8%	93.0%

A simple cost and return analysis was done to see which among the feed types used is economically viable. Results showed Treatments I, II and III got 55.5%, 98.8% and 93% return of investments, respectively (Table 3). Freshwater clam has the lowest return of investments due to a more expensive market value; since they are consumed by the local people. Land snail and golden apple snail on the other hand are considered pests and not usually consumed by the locals, thus, having a lesser expense. Nevertheless, all food types used are economically viable having more than 50% return of investments. Utilizing these locally available organisms as food source for aquaculture species is practical and economical.

The best growth of *M. albus* was observed using golden apple snail, followed by freshwater clam and land snail as natural food; with no significantly different results in FCR. These results corroborate studies in Vietnam [14] on the use of golden apple snails as primary natural food for *M. albus*. However, the use of freshwater clam as food was also promising due to its comparable growths from golden apple snail. Economically, the use of land snail may prosper especially for small farmers due to its cheaper price. Many natural foods have been used as alternative protein sources for *M. albus* culture such as other types of snails and silkworms [24], earth worms [24, 25] and maggot meals [25]. This research demonstrates additional locally available foods like freshwater clam (good growths) and land snail (high return of investments) as potential alternatives to golden apple snails in *M. albus* culture.

4. Conclusion

All natural food used in this study were able to yield growth for *M. albus.* Freshwater clam has comparable absolute growth to golden apple snail, while land snail despite of the lower growth rate, can be economically beneficial due to its cheaper price. This suggests that both freshwater clam and land snail are potential as alternative food for rice paddy eel, *M. albus* in the absence of golden apple snail.

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