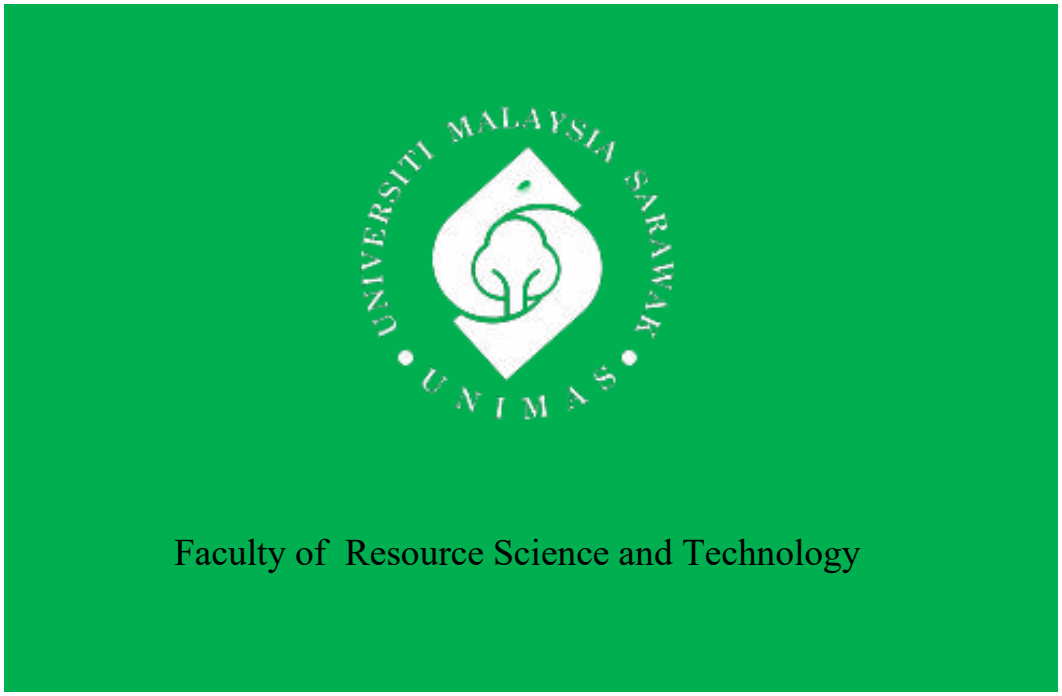

Faculty of Resource Science and Technology

Effect of Different Diets on Juvenile *Achatina fulica* Growth

Ellcy Usun Seling (69562)

Bachelor of Science with Honours

(Resource Biotechnology)

2022

Effect of Different Diets on Juvenile *Achatina fulica* Growth

Ellcy Usun Seling

A thesis submitted
In fulfillment of the requirements for the degree of Bachelor of Science
(Resource Biotechnology)

Faculty of Resource Science and Technology
UNIVERSITI MALAYSIA SARAWAK
2022

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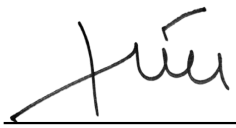
Supervisor's signature:  (Date: 11/7/2022)

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Effect of Different Diets on Juvenile *Achatina fulica* Growth

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ABSTRACT

Achatina fulica is a pest of agricultural and ornamental plants in the tropics for over a century, there are still limited information about its biology. The aim of this research is to study the effect of different diet on juvenile *A. fulica* growth and to determine the best diet formulation for juvenile *A. fulica* growth performances. In this study, 16 number of juvenile *A. fulica* collected around the Kuching area were examined for 2 months. There were two distinct diet treatments : Diet 1 (cucumber only) and Diet 2 (mixture of layer poultry fed with cucumber) were provided and physical measurement was taken every seven days to examine the impact of the diets. Physical measurement included the following: body weight, body length, shell length, and shell diameter. There were 8 number of juvenile *A. fulica* that survive at the end of this study period. The findings indicated that base on the survival *A. fulica,* shows that *A. fulica* fed with extra with supplement show more obvious growth performance as compared to individuals fed only with vegetable.

Key words: *Achatina fulica*, snail, growth performance, dietary treatments, achatinidae

ABSTRAK

Achatina fulica dikenali sebagai makhluk perosak tumbuhan pertanian dan tanaman di kawasan tropika selama lebih dari satu abad, namun masih terdapat maklumat terhad tentang aspek biologinya. Matlamat penyelidikan ini dilakukan adalah untuk mengkaji kesan diet yang berbeza terhadap pertumbuhan A. fulica dan untuk menentukan formulasi diet terbaik untuk prestasi pertumbuhan A. fulica. Dalam kajian ini, 16 ekor bilangan A. fulica yang didapati di sekitar kawasan Kuching telah dikaji selama 2 bulan. Terdapat dua diet yang berbeza disediakan: Diet 1 (timun sahaja) dan Diet 2 (campuran timun dan dedak ayam) dan pengukuran fizikal diambil setiap tujuh hari untuk mengkaji kesan diet tersebut. Pengukuran fizikal termasuklah yang berikut: berat badan, panjang badan, panjang cangkerang dan diameter cangkerang. Pada akhir kajian, hanya terdapat 8 ekor A. fulica yang masih hidup. Daripada penemuan berdasarkan A. fulica yang masih hidup, menunjukkan bahawa A. fulica yang diberi makan dengan suplemen tambahan menunjukkan prestasi pertumbuhan yang lebih jelas berbanding individu yang diberi makan hanya dengan sayur-sayuran.

***Kata kunci**: Achatina fulica, siput, prestasi pertumbuhan, rawatan pemakanan, achatinidae*

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AF	anti fungal
A. fulica	*Achatina fulica*
$CaCo_3$	calcium carbonate
cm	centimeters
℃	degree celsius
mm	millimeters

CHAPTER 1

INTRODUCTION

Achatina fulica, or the common garden snail, belongs to the phylum Mollusca that makes the biggest group in the Gastropoda class (Stroke, 2006). Molluscs occupy a wide range of aquatic and terrestrial habitats, making them one of the most diverse and prolific animal groups. Among all land snails, *A. fulica* is the largest edible gastropods that is documented to originate from East Africa (Rowson *et al*., 2010). *A. fulica* and their species relatives have a shell within which their main body may normally withdraw and to store their vital organs. It also closely related to slugs, however, the latter have shells that have been reduced to an internal fragment or totally lost over the time period (Solem, 2020). Among all snails land, *A. fulica* is an important food source in many part of the world including in the European countries, Africa and Asia. This is due to the fact that snail flesh is high in protein and vital minerals such as iron, calcium, magnesium, and zinc (Ghosh *et al*., 2017). Besides its meat, the slime or mucin secreted by *A. fulica* is also a highly valued product from this mollusk. *A. fulica* mucin possesses important biological components which include antibacterial, antimicrobial, and antioxidant properties (Santana *et al*., 2012). The active antimicrobial component in snail mucin is a protein called achacin that cause cell membrane damage, interfere with cell metabolism, and destroy cytoplasmic cell components. In a study by Iguchi *et al.* (1982), *A. fulica* mucin was shown to inhibit *Pseudomonas aeruginosa* growth and propagation.

A. fulica is also recognised as a severe agricultural pest and an intermediate vector for a wide range of parasites responsible for human illness (Miranda & Pecora, 2017). Despite being a major nuisance, this species offers significant economic advantages due

to its beneficial characteristics. Scientists have discovered that the body and shell of *A. fulica* are beneficial in medical treatment, wastewater treatment, bioabsorbant in water treatment, and as reinforcing materials for composites used in automobile components (Ferguson *et al*., 2018; Ibrahim *et al*., 2021). Due to its beneficial properties in thriving industries and invasive pests worldwide, *A. fulica* is believed to be highly potential economically as demands are expected to rise in the near future.

Like other animals, the growth performances of *A. fulica* are influenced greatly by their dietary consumption and their surroundings, such as their habitat (Kehinde *et al*., 2004). According to Okonkwo *et al*. (2000), the nutritive contents of snail feeds influence growth tissues, shell markings, and weight. Most reports available on snail feeds and feeding behaviors are very general and unspecific. These reports are often generated by local farmers and lack scientific merits and do not address the effects of different types of diets on the growth performances of *A. fulica*. Therefore, this study is performed to determine the effects of two types of diets on the growth of *A. fulica*. The diets choosen included vegetable only and a mixture of vegetable supplemented with poultry feed. To assess the effects of the different diets, several physical readings was taken like body weight, body length, shell length, shell diameter and sexual maturity via egg production.

1.1 OBJECTIVES

This research focused on the general effects of different diets on *A. fulica*. In specific, the objectives of this study are:

1. To study the effects of different diets on the growth performances of juvenile *A. fulica*.
2. To assess the best diet for juvenile *A. fulica* from the diets tested.

CHAPTER 2

LITERATURE REVIEW

2.1 *Achatina fulica*

Achatina fulica is a terrestrial invertebrate species. The common name of this species is "Giant African snail", as this species is a native to Africa (Global Invasive Species Database, 2021). Other than *A. fulica*, this species is also known as *Lissachatina fulica* (Bowdich, 1822). *A. fulica* belongs to the phylum mollusca and the family Achatinidae. The Achatinidae family is indigenous to Africa, where it is represented by around 200 species belonging to 13 genera of gastropods (Raut & Barker, 2002). The Achatina genus has many species, which include *A. fulica*, *A. achatina* and *A. marginata* (Elom & Okpara-Elom, 2021). A study by Wagh & Patil (2016) stated that the Achatina genus is a significant and destructive land snail pest throughout the world.

A. fulica has several unique physical attributes and is easily identifiable by its enormous size, long, and conical shell. Because of its large size, the *A. fulica* can be easily differentiated from other garden snails. Adult snails may develop to be up to 8 inches (30 cm) long and four inches in diameter (10 cm). *Achatina fulica* possesses a cone-shaped shell with light to dark brown shells and deeper brown vertical stripes. The colouration lightens as it approaches the shell's tip, which is nearly white. The shell functions to protect *A. fulica* from predators and physical dangers. It will also spend time within their shells if temperatures are too low for their comfort. The shell can grow to be up to 20 cm long, although it is more typically 5 to 10 cm long. When the snail is fully developed, the shell will typically have seven to nine whorls (Hoffman & Pirie,

2014). However, environmental factors and nutrition can affect the colour. On the head of *A. fulica*, two set of tentacles can be seen (Figure 2.1). The small and short lower (anterior) pair of tentacles are significant for detecting and taste to assist the *A. fulica* in finding food and avoiding potentially harmful situation, while the bigger upper (posterior) pair is where the eyes are situated (Cowie, 2010). In addition, *A. fulica* uses its tiny teeth to scrap their food before consuming it. For locomotory purposes, *A. fulica* has a muscular foot system that assists in movement that is lined with mucus to reduce impact and avoid tissue damage.

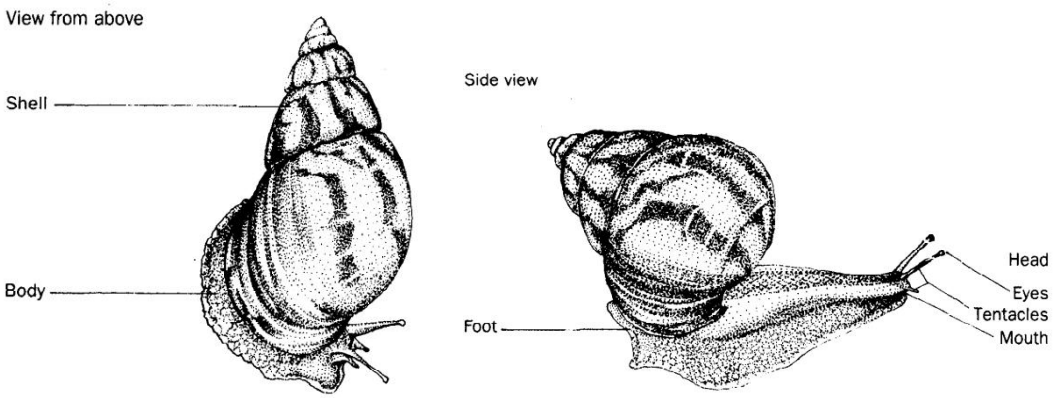

Figure 2.1 *A. fulica* main anatomy (Cobbinah, 2008).

2.2 Importance of *A. fulica*

A. *fulica* is relatively a species that is insignifant to the general public interest. However, *A. fulica* is an important source of cheap protein in many African and Asian nations (Fagbouro *et al*., 2006). Their meat is reported to be high in protein and low in fat. Other studies also claimed that snail meat is high in vital minerals such as zinc, iron, calcium, and magnesium Ademolu *et al*. (2004). The four species of giant land snails in Nigeria is also shown to contain other minerals such as phosphorus, potassium, and sodium (Fagbuoro *et al.,* 2006)**.** In addition to being food for human needs, *A. fulica* is

also being utilized as a protein source for Nile tilapia (Prasad & Chaudhary, 2019). The same study further revealed that this species can be used as a partial or total replacement for soybean as a protein source for the fish.

Parameter	Meat (mean ± SD)			Shell (mean ± SD)		
	A. marginata	*A. achatina*	*A. fulica*	*A. marginata*	*A. achatina*	*A. fulica*
Moisture (%)	5.2 ± 0.05	6.1 ± 0.01	4.88 ± 0.01	0.27 ± 0.04	0.43 ± 0.13	0.21 ± 0.01
Fat (%)	4.37 ± 0.06	5.06 ± 0.14	2.27 ± 0.16	0.68 ± 0.05	0.59 ± 0.03	0.62 ± 0.13
Protein (%)	85.12 ± 2.14	71.66 ± 1.24	62.56 ± 1.23	2.1 ± 0.41	3.18 ± 0.58	2.06 ± 0.25
Fibre (%)	1.32 ± 0.15	1.21 ± 0.03	0.03 ± 0.01	0.5 ± 0.05	0.63 ± 0.02	0.36 ± 0.04
Ash (%)	3.06 ± 0.02	3.49 ± 0.01	3 ± 0.01	96.31 ± 0.01	94.85 ± 0.11	95.85 ± 0.08
Carbohydrate (%)	2.25 ± 0.11	13.69 ± 0.15	27.29 ± 1.21	0.64 ± 0.03	0.95 ± 0.01	1.26 ± 0.02
Energy (KJ/100g)	1646.98 ± 8.68	1638.17 ± 6.53	1611.44 ± 8.6	71.74 ± 1.49	92.04 ± 1.57	79.38 ± 1.4

SD - Standard deviation.

Table 2.1 The proximate and energy content of the dried snail meat and shell samples (Nkansah *et al*., 2021).

A. *fulica* is also a significant member of the ecosystem, where it helps in the decomposition and consumption of dead plant materials. *A. fulica* contributes to the recycling of nutrients and building blocks necessary for life (Cowie, 2010). As several species are restricted to unaltered natural environments and have limited dispersion capacities, land snails are useful indicators of the long-term stability of natural ecosystem (Nurinsiyah *et al*., 2016).

A. fulica products are also economically beneficial because of the popular used of snail mucus in skin care products prevalent in the Korean beauty industry (Baumann, 2020). *A. fulica* mucin is also reportedly useful as a pharmacological material that can be used to treat various types of epidermal diseases. According to Nantarat *et al*. (2019), *A. fulica* mucus contains achacin and mytimacin AF Achacin which are said to have

antimicrobial properties. In addition, both compounds are effective antimicrobial protein that defence agents with specific structural features that allow penetration and disruption of target membranes. According to Noothuan *et al*. (2021), snails release several types of mucus with different function. Some of these properties are claimed to be beneficial to skin health, especially for wound healing, antimicrobial, anticancer and for skin regenerative purposes (Tachapuripunya *et al*., 2021). The shell waste from this species is also a valuable material for used in the industries. Chitosan-derived glucosamine, found in crustacean shells and snail, has been studied as a dietary supplement for osteoarthritis (Vaz, 1982; Maya *et al*., 2017). An osteochondral defect in living joints can be filled with a viscous liquid and then solidified using a chitosan-based medium that attaches to bone and cartilage (Hoeman *et al*., 2004). Another study by Peter *et al*. (2019) has confirmed that copper ion removal from wastewater using chitosan is technically viable, ecologically benign, and advantageous since the presence of an amine functional group on the chitosan improved copper ion adsorption. Apart from these applications, *A. fulica* shell is also beneficial as an alternative organic filler for biocomposite to strengthen the polymer composite. This was demonstrated in a recent study on nano-$CaCO_3$ generated from the shell of *A. fulica* using mechanochemical methods (Gbadeyan *et al*., 2021). Synthetic filler materials like nano clay and nano-silica may contain hazardous components that will affect human health and the environment if used as reinforcements (Marrot *et al*., 2014). Therefore, organic materials from *A. fulica* were considered a replacement component for composites to alleviate the problem above.

2.3 *A. fulica* Growth Pattern and Life Cycle

A. fulica development stage starts from the eggs, followed the juvenile and finally the adult phase, as shown in (Figure 2.2). The growth patterns of *A. fulica* can be defined into three stages: exponential – the most lengthy phase, stable with a preponderance of varying juvenile and adult shell sizes, and decline (Pointer & Blanc, 1985). *A. fulica* is very much dependent on nutritional availability for the optimal growth of its body and shell (length, size, weight, and diameter). According to Vázquez *et al*. (2018), *A. fulica* can attain full reproductive size of 75 to 80 mm of shell length after 35 weeks of cultivation. However, according to another study published by Fisher *et al*. (2014), this contrasts to field-gathered data in Brazil, where snails are reported to attain a comparable size only after a year and a half of age.

Figure 2.2 Life cycle of *Achatina fulica* (Kumar *et al*., 2021).

Compared to other livestock, land snails have a high rate of prolific fecundity and are capable of continuous egg laying numerous times over a period following a single

mating event (Okon *et al*., 2013). *A. fulica* will begin to lay eggs when they reach sexual maturity, which occurs between the ages of 8 and 12 months, or when their body weight reaches between 110 and 125 g in weight. In around two weeks, the eggs will hatch (Capinera, 2020). After hatchling from the egg, the young snail continue to feed and grow. It was reported that the most crucial stage when snail reach young stage because they have a high mortality rate during this period (Upatham *et al*., 1987). Shell growth ends in the late stages of young adult. In the first year of growth, snail shells will reach a diameter of approximately 16 to 20 mm. The shells will continue to grow to between 26 to 33 mm after the second year. *A. fulica* growth performance is usually examined based on the maximum shell length, particularly in bivalves (Ridgway *et al*., 2021). When it reaches adult stage, *A. fulica* can reach up to 3 or 4 inches to 11 inches shell length with the body stretch about 15 inches long (Mcleod, 2021). Rounded shell or body may come from negative allometric growth, impacting the individual maximum shell length (Ghara, 1990; Abertoni *et al*., 2003). Snail growth rate tends to diminish as snails become older. According to Raut & Barker, (2002), *A. fulica* lifespan is within nine years.

A. fulica are hermaphrodites, meaning they reproduce sexually (Dicken *et al*., 2018). Mate selection in hermaphrodites is likely to evolve in protandry young male adults. Protandry is known as development of male organ growth or maturity of their products prior to the emergence of the comparable female product. It is reported that snail require between 4 to 12 hours for mating (Capinera, 2020). Despite the fact that sexual activity occurs at night, snails are frequently spotted copulating in the morning due to the length of fertilizing. When two snails mate, there is a possibility of intertransmission of gametes between two mating individuals concurrently but this only occurs if the snails

are of similar sizes (Tomiyama, 1993). If there are differences in size, the larger snail will act as the female and gametes will only be transmitted from the smaller snail to the larger snail, resulting in a unilateral mating.

2.4 *A. fulica* Habitat

A. fulica was originally documented in Africa. *A. fulica* favours environments that are tropical, with warm temperatures all year round coupled with considerable humidity levels (Hoffman & Pirie, 2014). This species is prevalent at regions of low to mid elevation with temperatures ranging from 9 to 29 °C, such as agricultural, coastal, wetland and disturbed areas. Their habitat may include natural and cultivated woods, riparian zones, scrublands and urban environments. *A. fulica* can also live in less than optimal circumstances, such as 2 °C where they usually hibernate and 30 °C during which aestivation may occur (Raut & Barker, 2002). Besides that, this kind of species grow at temperatures ranging from 25 to 26 °C during the day and 21 to 23 °C at night (Pallet & O'Brien, 2020). As *A. fulica* is cold-blooded, they tend to live in locations with high humidity and mild temperatures.

According to Sarma *et al*. (2015), humidity and temperature will influence *A. fulica* growth performance. In addition, habitat also influence the *A. fulica* egg production (Capinera, 2020). This kind of species will dig in loose soil and place their egg inside the hole in depths of 2 to 3 cm. The desire for certain diets is one of the most significant factors influencing *A. fulica* population dynamics, growth rate, survival, and fecundity. However, the temperature range can have an impact on body weight, especially during prolonged dry seasons or periods of significant temperature shift

(Asagba *et al*., 2018). As a result, stable climatic conditions are important to this snail's growth and well-being.

2.5 *A. fulica* Diet

A. fulica is a herbivorous species that feeds predominantly on vascular plant materials, making little distinction between live and dead matters. This snail species has sensitive sensory organs, which aids in sensing garden produce and other plant resources. *A. fulica* is known to travel to favoured food plant areas in the garden. This giant African land snail feeds on over 500 distinct plant species, making it a major agricultural invasive species (Centre for Agriculture &Bioscience, n.d.). According Cowie (2010), *A. fulica* also favour soft-textured fruits and tubers such as bananas, beets and marigolds. There are reports that not all plant is consumed in the same way, and snail species have different food preference (Capinera, 2020). There is no clear distinction between the diet of adult and juvenile *A. fulica*, however, it is documented that adult snails prefer living plants and vegetation.

A. fulica is also known to be phytophagous and omnivorous. It feeds on decaying organic materials, vegetation and fruits (Canpinera, 2020). According to Ruth & Barker (2002), juvenile *A. fulica* prefers decaying matter and unicellular algae, while more matured adult snails have a broader range of preference which includes lichens, fungi, and animal matters. In addition, *A. fulica* require calcium in order to maintain and build strong calcareous shells, and as a result, they devour more of certain types of plants in order to obtain the calcium they require. In comparison to adult snails, the hatchlings require higher calcium supplies in their diets until their shell is 5 mm in diameter (Mead,

1979). Individuals with shells ranging in height from 5 to 30 mm are reported to favor live plants over dead ones (Raut & Barker, 2002). When they are unable to obtain enough calcium from plants, they may resort to feeding on bones from corpses, sand, or tiny stones to supplement their diet. Calcium powder, cuttlebone, dead snail shells, natural limestone, bone meal, and wood ash are all good sources of calcium and are often used by snail farmers worldwide. An increase in calcium supplementation (from ground egg shell) in the snail bedding may assist in increasing shell thickness. Shell health can also also be enhanced by feeding snails specialized vegetables such as Carica papaya and pawpaw (Amobi & Ezewudo, 2019; Kant & Diarra, 2021).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials and Methods

The materials that were used in this research:

1) Juvenile *Achatina fulica* (3 months of age from the same brood)

2) Cucumbers

3) Layers poultry feed (Brand 105M Layer feed, Gold Coin)

4) Plastic containers

3.1.1 Sample collection

In this study, 16 juvenile *A. fulica* (3 months of age) from the same brood was kept in captivity at the Microbiology Laboratory 2 of the Faculty of Resource Science and Technology (University Malaysia Sarawak) for a two-month research period.

3.1.2 Housing of *A. fulica*

The *A. fulica* was kept in two rectangular clean plastic containers, which it was divided into eight *A. fulica* for each of the containers. Then, the lid was perforated with small holes to enable the snails to breathe and to prevent the snails from escaping. The lids are also provided to protect the snails from other predators. After that, the containers containing juveniles of *A. fulica* were kept at room temperature (24 to 26 °C) with a relative humidity of 40% to 50%.

3.1.3 Dietary Treatments

All *A. fulica* juveniles were acclimatized for two weeks within the containers before the feeding studies. Following this, the snails were fed with two diets for the duration of the two months study period. The two distinct diets were as follows:

i. Diet 1 : Cucumber only

ii. Diet 2 : Cucumber + Layers poultry feed

Achatina fulica were fed once a day with 20 g of cucumber for both diets and 5 g of layers poultry feed for Diet 2. The diet was fed in excess on daily basis, and any leftover food was removed to prevent the growth of unwanted microorganisms within the container from influencing the *A. fulica* juvenile growth.

3.1.4 Analysis and Data Collection

The physical measures of the juvenile *A. fulica* were taken every seven days to examine the impact of the diets. Physical measurement included the following: body weight, body length, shell length, and shell diameter. Then, the *A. fulica* juveniles were washed and dried on clean paper towels.