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Pest Incidence, Mortality, Aestivation, Feed Intake and Growth in West African Giant Snails (*Achatina Achatina*) Reared Under Different Housing Systems

Nyameasem, J. K.[1] and Borketey-La, E. B.[2]

[1]Animal Research Institute, Council for Scientific and Industrial Research, P.O. Box AH 20, Achimota, Ghana

[2] Faculty of Agricultural Education, University of Education, Winneba, , P.O. Box 40, Asante Mampong, Ghana

ABSTRACT

A study was conducted to evaluate the performance of *Achatina achatina* snails reared under an indoor system (snail village complex) and two other systems (trench pen and hutch box). Snails were stocked at the rate of 1.33 kg/m^2 and fed unripe pawpaw fruit as basal diet supplemented with either cocoyam leaves or pawpaw leaves using a completely randomized 3x2 factorial arrangement with three replications. Temperature, humidity, dry matter intake, weight changes, incidence of aestivation, pest and mortality were monitored in the housing systems during the study. The snail village recorded reduced cases of aestivation, mortality and pest incidence when compared with the trench pen and hutch box systems. The effect of housing type was significant ($P<0.05$) for total dry matter intake, total crude protein intake, total weight gain and weekly weight gain, with snails in the snail village recording best performances. The effect of feed supplement type was not significant ($P>0.05$) for all parameters measured. The snail village complex seemed to offer more favourable conditions for feed intake, weight gain and better protection against mortality, aestivation and pest incidence.

***Keywords**: Pawpaw leaf, Cocoyam leaf, Hutch boxes, Snail village, Trench pen*

1. INTRODUCTION

Snails are the largest group of molluscs constituting the largest animal group next to arthropods. Snail meat is tasty, tender and highly nutritional; and it is particularly rich in protein (12-16%) and all the essential amino acids (Cobbinah 1994; Eruvbetine *et al.* 1997). The protein in snails is of good quality with high levels of lysine, leucine, isoleucine and phenylalacine (Imevbore and Ademosum 1988). It is rich in iron (45-50mg/kg) and calcium, but low in fat (0.5-0.8%) and cholesterol compared to other protein sources like poultry and pigs and contains almost all the amino acids needed for human nutrition (Cobbinah 1994). The high iron content is considered important in the treatment of anaemia. In addition, it is believed that, the glandular substances from edible snails cause agglutination of certain bacteria; thus snails could be of value against a variety of ailments. In Ghana, the bluish liquid obtained from the shell when the snail is removed is believed to be good for infant development. The snail meat is also believed to contain aphrodisiac properties (Addae-Kagyah 1996). It serves as a ready source of meat to the rural communities where majority cannot afford the high cost of meat (Fagbuaro *et al.* 2005).

In West Africa, people gather snails, eat them and sell the remaining as a way of making money. Snail meat has, traditionally, been a major ingredient in the diet of people living in the high forest belts of West Africa. In Cote d'Ivoire for example, an estimated 7.9 million kg of snails are eaten annually (Cobbinah 1994). In Ghana, although consumption figures are not available, it is clear that, demand outstrips supply (Etchu *et al.* 2008). In recent years, however, wild snail populations have declined considerably primarily because of the impact of human activities such as deforestation, pesticide use, slash-and-burn agriculture, spontaneous bush fires and the collection of snails before they have reached maturity (Ngenwi *et al*. 2010). Snail supply from the wild would be further affected by issues of climate variability and change. Therefore, calls for domestication and intensive management of the edible land snail cannot be overemphasized.

There has been attempts to farm snails for local consumption and especially, for export, particularly in Ghana, Nigeria and Benin (Monney 1998; Gomot 1998). Earlier reports (Cobbinah 1994; Baba and Adeleke 2006; Ngenwi *et al.* 2010) have vividly expressed the advantages of snail farming. Like all wild species, snails are better adapted to their natural environment than to farming, so if local climatic conditions suit snails, they are best farmed outside. Most West African snail farmers, however, copy European methods, which are largely outdoor and thus expose snails to vagaries of the weather, pests and disease attacks. Improved housing and good management practices are, therefore, crucial for increased productivity and supply of snails all year round. This is particularly important as climate change is already having a negative impact on Africa through extremely high outdoor temperatures (IPCC 2007), which are not favourable to snail growth and development. Production losses due to escape, pest as well as problems of aestivation would also be reduced with improved housing. It was hypothesized that indoor systems could offer better conditions for growth and development of snails in tropical environments.

Blay *et al*. (2004) reported the availability of compounded feeds for enhancing the fattening process of snails; however, the taste of the meat is less preferred by consumers. Kalio and Etela (2011) reported that the meat of snails fed waterleaf, centro and pawpaw leaves were of comparable quality and preferred by consumers to those fed with a commercial broiler starter mash. Adequate fresh natural feeding materials are, therefore, required in large scale production systems (Okonta and Agbogidi 2011). Cocoyam (*Xanthosoma spp*.) leaves, an important leafy vegetable, is a common feed resource fed to captive snails in Ghana. The high competition for this resource has hampered its availability for farming of snails, thus the search for alternative feed resources is inevitable. The current study was conducted to evaluate the performance of *A. achatina* snails reared under an indoor system (snail village complex) and two outdoor systems (trench pen and hutch box) when fed pawpaw (*Carica papaya*) fruit as basal diet supplemented with either cocoyam leaves or pawpaw leaves. Temperature, humidity, dry matter intake, weight changes, incidence of aestivation, pest and mortality were monitored in the housing systems during the study.

2. MATERIALS AND METHODS

2.1 Location of study

The study was undertaken at the Non-traditional Animal Production Unit of University of Education, Winneba-Mampong Campus in Ashanti Mampong (Latitude 07^0, 04^0N; longitude 01^0, 24^0W; annual mean rainfall is 1094.2mm), which is located within the transitional zone of Ghana. The soil used for the experiment was topsoil collected from dumpsites.

2.2 Housing for snails

The Hutch box system, Trench pen system as described by Cobbinah (1994) and the snail village complex were used for the studies. Hutch boxes were square or rectangular, single-chamber wooden boxes with lids, placed on wooden stilts above the ground at a suitable height for easy handling. The stilts were fitted with metal conical protectors or aprons, to prevent vermin from crawling or climbing up the stilts to attack the snails in the boxes. In the middle of the lid is an opening covered with wire netting and nylon mesh. In the floor of the box are a few holes through which excess water could drain out. The boxes were filled with sieved organic matter rich soil to a depth of 18-25 cm. The boxes were placed under trees to protect snails from scorching sun or torrential rain.

The Trench pens were adjoining snail pens of 0.6 × 0.6 m to 1 × 1 m, raised 40-50 cm above the ground. Outside walls and inner partitions consisted of sandcrete blocks. The pens were filled with sieved organic matter rich soil to a depth of 10-15 cm. Pens were covered with wooden frame lids with chicken wire and nylon mesh. A thatched shed was erected over the pens to protect snails against the fierce heat of the sun and heavy rain.

The snail village complex, an indoor system, consisted of pens each measuring 100 cm x 100 cm x 50 cm, located in an enclosure built with sandcrete walls and roofed with thatch. **(a)**

The housing unit had a floor dimension of 5.21 m × 4.21 m providing an area of 21.9 $m^{2.}$ The floor of the housing unit was cemented and divided into cubicles. Each cubicle of the snail village complex was equipped with perforated PVC pipe for easy watering. The cubicles in all housing systems were filled with loamy soil at a depth of 0.14m.

Dried cocoa leaves were put on top of the soil as litter. Cubicles were fitted with wooden frame lids covered with chicken wire and nylon mesh.

2.3 Experimental design and management

A. achatina snails, after rinsing in water, were stocked at the rate of 1.33kg/m^2 in a completely randomized 3x2 factorial arrangement with three replications. The basal diet was unripe pawpaw fruit offered at 10% of live weight (as fed basis). Powdered oyster shells was supplied every month at the rate of 15% (w/w). The factors were:

Type of housing:

TPS: Trench pen system

SVC: Snail village complex

HBS: Hutch box system

Source of supplementary feed:

CYL: Cocoyam leaves

PPL: Pawpaw leaves

2.4 Measurements

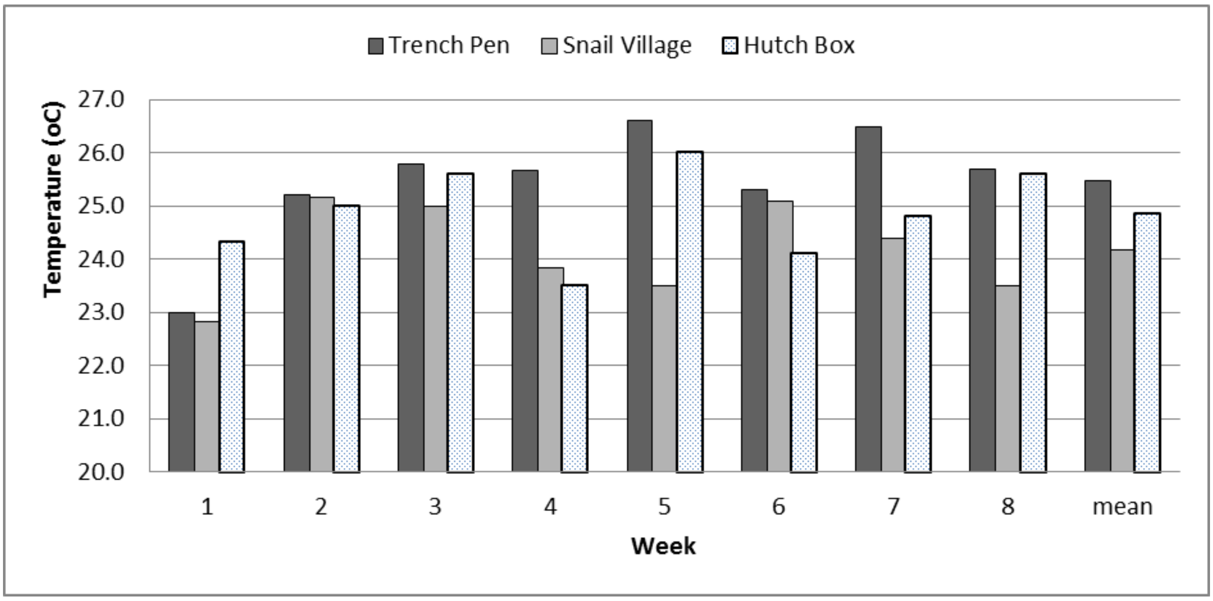
The experiment lasted for 8 weeks. Five snails, marked with oil paint, were weighed at the start of the experiment and then weekly, on the same day of the week and before feeding in the morning. Feeds offered and refusals were recorded. Incidence of pest, mortality and aestivation in snails was studied by direct observation. Temperature and humidity in housing systems were monitored each day. Snails were kept moist by use of a water sprinkler system during times of low humidity. The proximate analysis of the experimental diets was carried out according to the method of AOAC (1990)

2.5 Data analysis

Data were analysed using the Generalised Linear Model (GLM) procedure of R (R 2012). Differences between means of a trait for factors were tested using Tukey's Test (Steel and Torrie, 1980).

3. RESULTS

Figure 1 shows the mean weekly temperature and relative humidity values recorded in the housing systems during the study period.



(b)

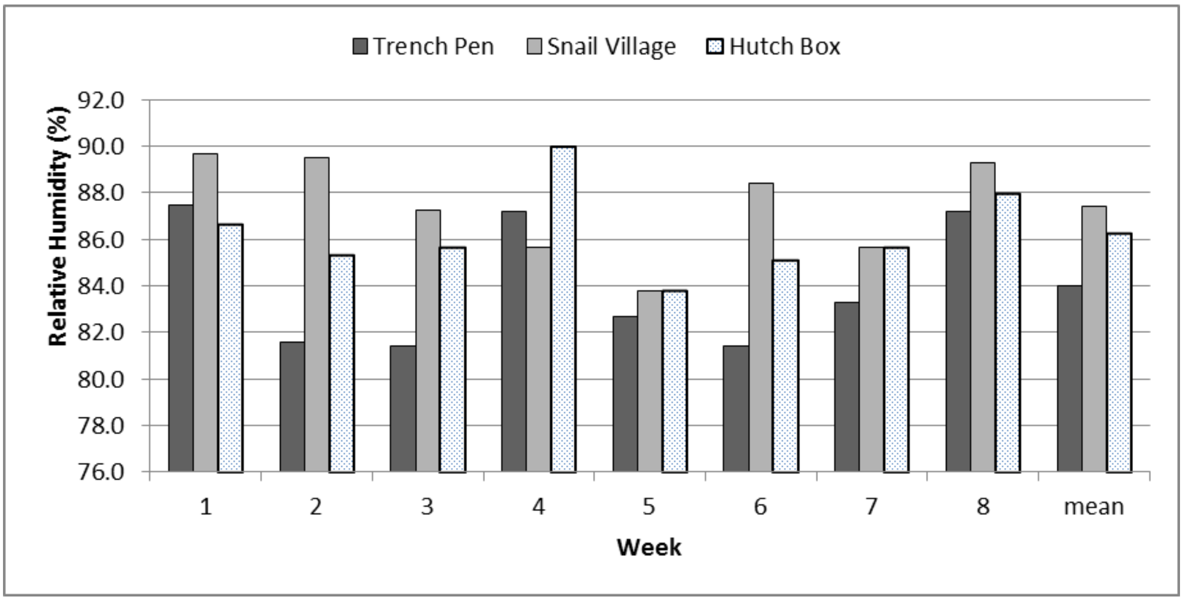


Figure 1, Environmental conditions in housing systems during the study (a) Mean weekly temperature (ºC) (b) Mean weekly Relative Humidity (%)

The snail village recorded the lowest mean weekly temperature (24.2±0.88), followed by the hutch box (24.9±0.86 ºC) and then trench pen (25.5±1.12ºC) (Fig. 1a). The mean weekly temperature in the snail village was 1.3ºC and 0.7ºC lower than the trench pen and hutch box systems, respectively. Mean weekly relative humidity (Fig. 1b) was highest in the snail village (84±2%), followed by the hutch box system (86±2%) and then the trench pen (84±3%). Relative humidity was 3.4% and 1.1% higher in the snail village than in the trench pen and hutch box systems, respectively.Figure 2 shows the incidence of pest, mortality and aestivation observed in the housing systems.

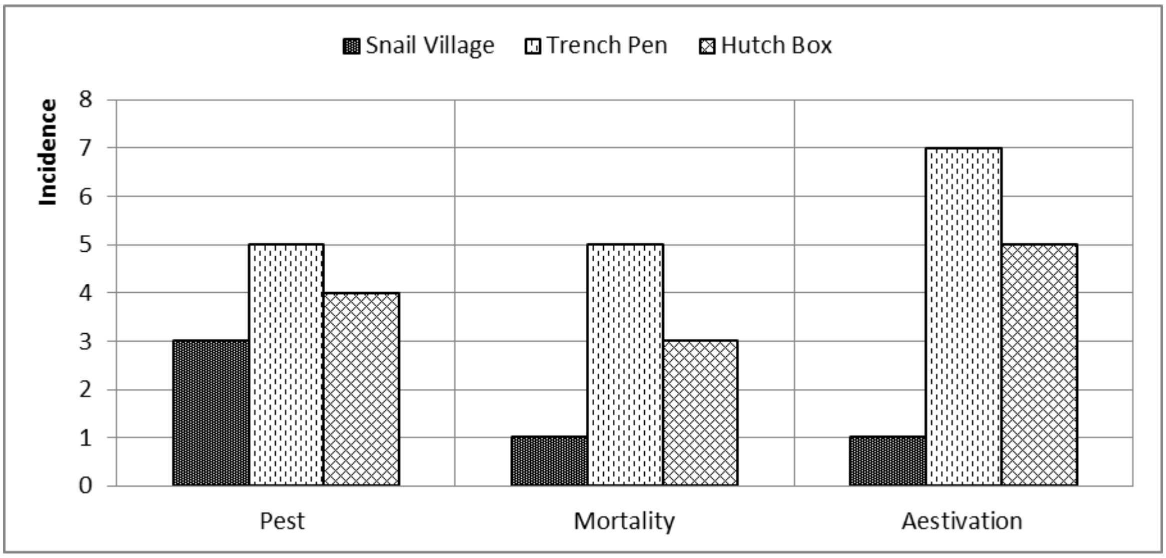


Figure 2: Incidence of pest, mortality and aestivation in housing systems

The snail village recorded reduced cases of aestivation, mortality and pest incidence when compared with the trench pen (150%, 133% and 50%, respectively) and hutch box systems (133%, 100% and 28%, respectively). Pests observed during the study (see table 1) included lizards, tree frogs, millipedes and *Alluaudihella flavicorni*, termites and red ants. The termites were mainly found in the trench pens and the snail village, whereas the ants were found in the hutch boxes. The dead snails, in each case, were observed, and maggots were seen in the decaying flesh inside the shell.

Table 1, Pests encountered in housing systems

Housing unit	Pest
Snail Village	Frogs, termites,
Trench Pen	Toads, millipedes, *Alluaudihella flavicornis*, termites
Hutch Box	Red ants, millipedes,

The proximate composition of the feed materials fed to snails is presented in Table 2. Though all feed materials were plant-based, crude protein and mineral contents varied (see table 2). Cocoyam leaf feed was 33% richer in crude protein than pawpaw leaf feed, but with similar crude fibre content. Cocoyam and pawpaw leaves also contained important mineral elements such as calcium and phosphorus in higher concentrations than pawpaw fruit.

Table 2, Proximate Composition of Feed Materials Fed the Snails

	Pawpaw Leaf	Cocoyam Leaf	Unripe Pawpaw Fruit
Dry matter % as fed	23.2	16.7	88.4
Crude protein %DM	22.8	28.4	0.8
Crude fibre %DM	13.3	14.3	17.8
Ether extract % DM	0.4	5.5	0.7
Ash % DM	9.7	13.9	9.2
Calcium g/kg	35.8	18.7	2.4
Phosphorus g/kg	3.8	2.3	1.8
Nitrogen free extract, % DM	53.8	37.9	71.5

Table 3, Effect of type of housing and type of supplement on feed intake and live weight gain (main effects)[1,2]

	Housing System				Diet			
Parameters	**TPS**	**SVC**	**HBS**	**Prob.**	**CYL**	**PPL**	**Prob.**	**SEM**
Total DM intake, *g*	22.9^{b}	61.4^{a}	37.3^{b}	**	36.8	44.2	(*)	6.98
Total CP intake, *g*	5.87^{b}	15.4^{a}	9.52^{b}	**	10.5	10.1	(*)	1.81
Initial weight, g	103	101	102	(*)	102	101	(*)	1.98
Final weight, *g*	118.2^{ab}	125^{a}	117.8^{b}	*	119.9	120.8	(*)	2.77
Total weight gain, g	15.7^{b}	23.9^{a}	16.2^{b}	**	17.6	19.6	(*)	1.32
Weekly weight gain, *g*	3.15^{b}	4.77^{a}	3.23^{b}	**	3.52	3.91	(*)	0.265

[1] Results are presented as Mean ± SEM. Significance: (*), P≥0.05; *, P≤ 0.05; **, P≤ 0.001. [2]Weight measurements (n=5)

[a,b]Means within rows with different superscripts are significantly different

The effect of type of housing was significant for total dry matter intake (P<0.05), total crude protein intake (P<0.05), final weight (P<0.05), total weight gain (P<0.05) and weekly weight gain (P<0.05) (table 3), with snails in the snail village recording best performances. These parameters were, however, similar (P>0.05) for trench pen and hutch box systems. Snails in the snail village complex gained 32% and 34% more weight when compared with snails of the hutch box and trench pen systems, respectively.

The effect of supplement type was not significant (P>0.05) for all parameters measured (see table 3), however, the highest growth (5.4 g/week) was obtained with snails fed pawpaw leaf supplement in the snail village. This was closely followed by snails fed cocoyam leaves (4.2 g/week) also in the snail village. Growth of snails under trench pen and hutch box systems was, however, similar. Snails fed pawpaw leaves in the snail village grew 25% faster than their counterparts fed on cocoyam leaf supplement. Interaction effects were, however, insignificant (P>0.05) for all parameters tested.

Table 4 shows the correlation analyses between temperature, humidity, dry matter intake and weight gain.

Table 4, Correlation (r) between Environmental factors, weekly weight gain and weekly dry matter intake in *Achatina achatina* snails

	Trench pen		Snail village		Hutch box	
	DM intake	Weight gain	DM intake	Weight gain	DM intake	Weight gain
Temperature	-0.918	-0.995	-0.849	-0.697	-0.900	-0.936
Humidity	0.479	0.645	0.270	0.369	0.767	0.879

4. DISCUSSION

Berill (1977) observed that snails thrive best in areas with moderate temperature and humidity. Thompson and Cheney (1996) reported a temperature of 15 – 24^{o}C and humidity of 75 – 95% as conducive for snail farming. The humidity values recorded over the period (81.2 – 90%) were found to be favourable; however, temperature values fluctuated and went well above 24^{o}C. According to Cobbinah (1994), fluctuations in humidity and temperature could have pronounced effect on *Achatina achatina*. The trench pen and hutch box systems, per their positioning, allowed the rising and setting sunrays into pens. This might have caused heat stress in snails and encouraged evaporation, thus hastening dehydration in the snails (Hickman *et al.* 1988; Klein-Rollais and Daguzen 1990; Cobbinah 1994). These factors might be responsible for the high incidence of aestivation in the trench pens and hutch boxes. The giant land snail prefers high humid cool areas (Awuku *et al.* 1994), therefore, the snail village, which is an indoor system, might have provided favourable conditions against aestivation in snails.

Pests and predators observed during the study period confirmed the findings of Cobbinah (1994) and Thompson and Cheney (1996). Termites mostly ruined feed materials in the pens they infested. The termites were mainly found in the trench pens and the snail village, whereas red ants were only found in hutch boxes. The termites might have come from the ground, since the bottom of the pens was not cemented. It could not be ascertained, however, whether the red ants and termites had any direct parasitic effects on *Achatina achatina.* The tree frogs found in some of the pens might have come in with the dry cocoa leaves used as litter cover. Awuku *et al.* (1994) opined that snails may have pests that feed on it in the wilderness but in captivity, pests can be reduced. The snail village seemed to offer a better protection against pests.

The choice of pawpaw leaf was based on earlier observations (Imevbore 1990; Omole *et al*. 2004) that snails preferred the leaf and the fruit of pawpaw to other feeds. The low protein content in pawpaw fruit does not make it a good source of protein but rather a carbohydrate and starch-rich source (Bello *et al.* 2008), thus it served as source of energy for the snails. Crude protein concentration of pawpaw leaves were comparable to the 23.9% reported by Omole *et al.* (2004) but lower than the 32.6% reported by Imran *et al.* (2009). This variation may be due to differences in age and soil composition. Imran *et al.* (2009) reported that pawpaw leaves contained mineral elements such as sodium, calcium, magnesium, phosphorus and iron in higher concentrations than pawpaw fruit. Differences in calcium were, however, corrected by supplying oyster shell meal to snails every month (Dauda 1993).

Earlier studies (Omole *et al.* 2004; Imran *et al*. 2009) reported differences in dry matter intake and weight gain when snails were offered different diets. In the present study, snails under the snail village system consumed more dry matter and grew faster accordingly; whereas trench pen and hutch box systems had similar dry matter intake and weight gain. This is an indication that, conditions in the housing units might have affected performance of the snails (Thompson and Cheney 1996). Several factors can greatly influence the growth of snails including feed, temperature and moisture. According to Cobbinah (1994), snails thrive best in areas with moderate temperature and high humidity. The snail village system must have provided a more favourable environmental condition for optimum performance of snails. Dryness inhibits growth and stops activity in snails (Thompson and Cheney 1996), therefore, the relatively low dry matter intakes and performances observed in the trench pen and hutch box systems could be partly explained by the, relatively, high incidence of mortalities and aestivation among snails. The weekly weight gains of 3 - 4 g observed in this study compares favourably with values reported for *Archatina marginata* fed different single plant diets (Omole *et al.* 2004), but relatively higher than 1 - 3 *g* reported for *Achatina achatina* fed single diets including pawpaw leaves and pawpaw fruit (Imran *et al.* 2009).

According to Hickman *et al.* (1988), temperature has profound effect on the rate of biochemical reactions, and consequently, on the metabolism and activity of animals. A negative and strong correlation existed between temperature and weekly weight gain and weekly dry matter intake in this study. This observation agrees with Tra Bi Koe (1994), Thompson and Cheney (1996) and Manning and Dawkins (1998) who indicated that temperature is critical in the growth and feeding of snails.

5. CONCLUSIONS

The three housing systems were found to support appreciable level of growth of *A. achatina*; however, the snail village complex seemed to offer more favourable conditions for feed intake, weight gain and better protection against mortality, aestivation and pest incidence. The consumption of pawpaw leaf and cocoyam leaf diets was similar among snails; therefore, pawpaw leaves could replace cocoyam leaves in snail diets.

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