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Growth performance of juvenile snail (*Archachatina marginata*) fed different plant leaves

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Abstract: To assess the growth performance of juvenile snail (*Archachatina marginata*) fed different plant leaves, 180 juvenile snails of one month old were divided into 4 treatments (T_1, T_2, T_3 and T_4), of 15 snails and 3 replicates in pens equipped with feeders and drinkers. T_1 received pawpaw leaves, T_2 received cassava leaves, T_3 received sweet potato leaves and T_4 received blood root leaves. Feed and fresh leaves were measured and served daily, and the leftover also quantified, using an electronic weighing scale (0.01 g precision) to evaluate the feed intake. The results showed that the highest value of feed intake was recorded in animals that received blood root leaves, while the lowest value is registered in the treatment receiving pawpaw leaves. The highest value of leave intake was recorded in the treatment that received pawpaw leaves. The highest values for weight shell length, shell diameter, shell lip width, shell lip height and carcass characteristics of *Archachatina marginata* fed with different plant leaves were recorded for snails fed with blood root leaves. The lowest value of triglycerides (1.44±0.5) and total cholesterol (4.11±2.66) in the hemolymph was registered in animals receiving blood root leaves compared to other treatments. The lowest value of total protein (26.44±3.28) in the hemolymph was registered in the treatment receiving blood root leaves compared to the treatment that received pawpaw, cassava, and sweet potatoes leaves. In conclusion, blood root leaves can be used as staple diet to improve the productivity of *Archachatina marginata*.

Keywords: *Archachatina marginata*; growth; juveniles; leaves

INTRODUCTION

Snail flesh contains almost all the amino acids needed by human and has been consumed worldwide since prehistoric times, as an alternative source of animal protein (Cobbinah et al., 2008). The high iron content of the meat is considered important for treating anemia (Fagbohunka et al., 2021), and the most vulnerable sections of the population suffering from iron deficiency are the infants of the weaning age, young children, and women of childbearing age (Baghele et al., 2023). However, due to the nutritional value of the species, the demand of snail flesh consumption is increasing with an increasing of populations. Snail consumption constitutes a serious problem for the survival and sustainability of the species, if we do not associate its breeding as a possibility of sustainable supply (Tchowan et al., 2017). For effective performance, nutrition in snail production cannot be underestimated. In order to improve the level of productivity of giant African snails in captivity, farming techniques have been employed on determining the nutritional needs of these animals (Otchoumou et al., 2004, Tchowan et al., 2018) at each stage of growth. The formulation of concentrated feed or supplements based on the results of previous work is necessary to optimize the growth and productivity of the snail farm. Furthermore, giant African land snails (*Archachatina marginata*) are also phytophagous, and they feed mostly during the night, because they are nocturnal animals and during the day depending on temperature and relative humidity of the environment. In captivity, study has shown that they can eat at any time of the day if served with their delicacy in a cool, humid environment. Their conventional feed comprises of fresh leaves/shoots (pawpaw, lettuce, cabbage, cassava, cocoyam, African spinach, waterleaf), ripe fresh fruits (pawpaw, banana, plantain, mango) and household/agro-wastes (poultry litter, rice bran, palm kernel meal), etc. (Ayodele and Asimalowo, 1999, Babalola and Owolabi, 2014). However, there is paucity of information on quality feedstuffs for large-scale production of snail. Indeed, Babalola (Babalola, 2018) studied the comparative evaluation of Lettuce Wastes, Pawpaw Leaves, Whole Lettuce and Cabbage Wastes as a sole feed ingredient for growing *Archachatina marginata* and revealed that lettuce waste, as well as cabbage waste can be utilized as sole feed for growing snails. Nevertheless, no study has yet been carried out on the effect of papaw (*Carica papaya*) leaves, cassava (*Manihot esculenta*) leaves, potatoes (*Ipomoeo batatas*) leaves and blood root (*Justicia secunda*) leaves on *Archachatina marginata*, but the chemical and phytochemical composition of these different plants have revealed that they are rich in calcium, phosphorus, water (Ugo et al., 2019) and flavoids, as Tchowan et al. (Tchowan et al., 2017) have shown that these elements are essential for snails during the growth phase. It would be judicious to determine the feeds that could significantly improve the productivity of juvenile snails (*Archachatina marginata*) in captivity. The general objective of the study is to get a better knowledge on the effect of the different plant leaves on the production performance of juvenile Giant African Land snail and to evaluate the effect of *Carica papaya* (pawpaw) leaves, *Manihot esculenta* (cassava) leaves, sweet potato (*Ipomoeo batatas*) leaves and *Justicia secunda* (blood root) leaves on the growth performance of the juvenile African land snails *(Archachatina marginata).*

MATERIALS AND METHODS

Period and study area

The study took place from May to July, 2023, at University of Buea Substation (figure 1), Southwest Region, Cameroon. The annual temperatures oscillate between 20 and 29°C. The prevailing climate is equatorial, characterized by a short dry season (mid-November to mid-March) and a long rainy season (mid-March to mid-November). Rainfall ranges from 2000 to 4000 mm per year and relative humidity from 85 - 95% with rain forest vegetation and volcanic soils.

Animal material

A total of 180 juvenile snails (figure 2) aged one month, weighing 1.5-2g, shell length of

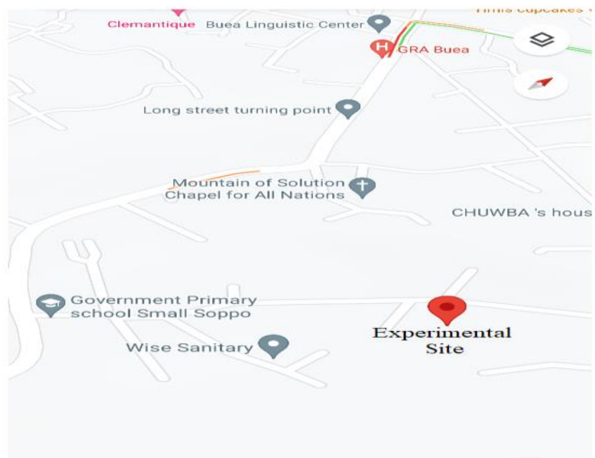


Figure 1. Experimental site

Figure 2. Juvenile snails

20mm-25mm, shell diameter 15-20 mm, shell lip height 12-18, shell lip width 7-11mm, spire height 6-10mm and body whorl length 15-20 mm free of injury and broken shells were used for the study.

Housing and equipment

The snails were placed in a pen (1 ×0.5 × 0.5m) constructed with cement blocks (figure 3), planks, and mosquito netting type mesh (1mm). The bottom of each pen was filled with loamy soils to a depth of 10cm. The soil was disinfected with virunet (0.5g/L/substrate), two weeks before the animals were introduced. The pens were constructed in a house, built with cement block of 4x4x3 m. The temperature of the room ranges from 25-29°C and natural lighting (12 hours of light and 12hours of darkness). The relative humidity within each replicate of pens was maintained between 85-95%. Each pen was equipped with a plastic feeder and a drinker of 5cm in diameter.

Figure 3. Experimental housing

Plant material

The plant materials consisted of pawpaw leaves (figure 4a), sweet potatoes leaves (figure 4b), cassava leaves (figure 4c) and blood root leaves (figure 4d). These leaves were harvested from the local community, allowed for 24hours to wither. The nutritional values of the different plant leaves are presented in table 1.

Experimental diets

Diets was formulated every two weeks and stored in airtight container to avoid rancidity. The different ingredient was purchased from market, and the nutritional values of the snail diet are presented on table 2.

Conduct of the experiment

A total of 180 juvenile snails of one month old were divided into 4 treatments (T_1, T_2, T_3 and T_4) of 15 snails and 3 replicates in pens equipped with feeders and drinkers. T_1 received pawpaw leaves, T_2 received cassava leaves, T_3 received sweet potato leaves and T_4 received blood root leaves. All treatments also received the diet as described in table 1. Feed and fresh leaves were measured and

Table 1. Nutritional values of the different plant leaves

Nutritional values	Pawpaw	Sweet potatoes	Cassava	Blood root
Moisture (%)	57.01	28.17	64-88	12.80
Fat (%)	2.01	0.51	3.63	8.10
Ash (%)	2.18%	1.36g	0.7-4.50	19.59
Protein (%)	6.50	7.96%	1.0-10.0	18.09
Crude fibre (%)	3.10	5.3	0.50-10.0	0.60
Carbohydrate (%)	29.20	8.82	7-18.3	40.81
Phosphorus (mg/100g)	1971.17	81	27-211	1.775
Sodium (mg/100g)	30.42	6	25.60-85.0	24.7
Potassium (mg/100g)	80.13	508	350-1230	58.5
Calcium (mg/100g)	1086.53	78	34-708	9.47

Source: (Arogbodo, 2020, Haytowitz et al., 2011, Popoola et al., 2019, Raimi and Temitayo, 2020, Salvador et al., 2014, Ugo et al., 2019).

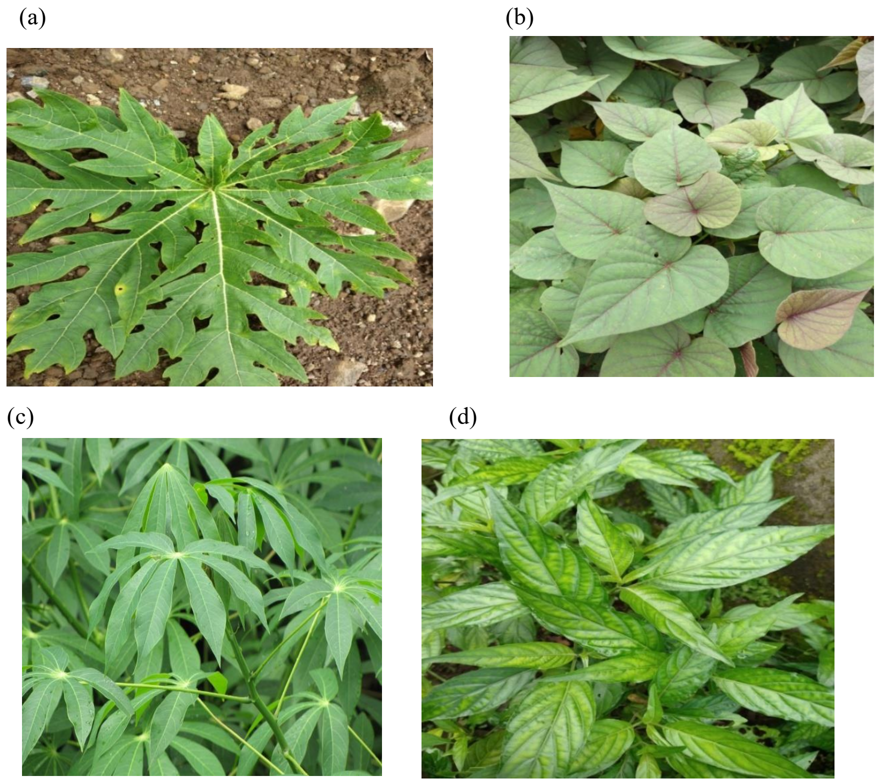


Figure 4. Pawpaw leaves (a), sweet potatoes leaves (b), cassava leaves (c), blood root Leaves (d)

Table 2. Ingredients and calculated nutritional values of snail diet

Ingredients	Quantities/ kg
Corn Flour	15.50
Soybean meal	16.50
Remolding	8.50
Fish meal	10.50
Shell	23.50
Palm oil	9.5
Cotton meal	16.00
Total (%)	100
Nutritional values (g/Dry matter)	
Crude protein	24.32
Metabolizable energy(kcal/kg)	2812.45
Energy protein ratio	115.64
Fat	13.04
Calcium	10.07
Phosphorus	0.89
Phosphocalcic ratio	0.08
Lysine	1.32
Methionine	0.52

served daily, and the leftover also quantified using an electronic weighing scale (0.01 g precision) to evaluate the feed intake.

Data on weight, shell length, shell diameter, shell lip height, shell lip width, spire height and body whorl length, was measured at beginning of the experiment, and then monthly using a weighing scale (0.01g precision) and a digital vernier caliper (0.01mm sensitivity) to evaluate the growth characteristics. The substrate of each pen was watered with 250mls of water daily to maintain the humidity and animals were monitored for a period of 15 weeks.

At the end of the experiment, five average snails were taken from each replicate and sacrificed. The bluish fluids (haemolymph) were collected in ependolf tubes with the use of syringes around the pneumostome within the aperture as described by Naresh et al. (Naresh et al., 2013) and taken to the Agroecology Laboratory at the University of Buea to determine the biochemical characteristics using a commercial kit. The live weight, shell weight, visceral mass, pedal mass, head, heart, gonads, and stomach weight were recorded using a weighing scale (0.01g precision) to evaluate the carcass characteristics (Apata et al., 2015).

The samples of the pedal mass were removed from the shell, washed separately with distilled water to remove any adhere contaminants and was taken to Laboratories of Animal Nutrition and Feeding and Soil Sciences of the Faculty of Agronomy and agricultural science of the University of Dschang-Cameroon, to evaluate, respectively, the proximate composition (AOAC, 1990) and mineral content (Pauwels et al., 1992).

Statistical data analysis

Data collected for growth characteristics, carcass characteristics, hemolymph biochemical characteristics and proximate composition was submitted to one-way analysis of variance to compare the means. Significantly different means were separated using Waller Duncan Test Procedure. Statistical Package for Social Science (SPSS) version 25.0 was used.

RESULTS

Evolution of feed intake of *Archachatina marginata* fed with different plant leaves

The evolution of feed intake of *Archachatina marginata* fed with different plant leaves is illustrated in figure 5. It is revealed that:

Irrespective of the period of the experiment, the trend, profile, and shape of the curve are comparable among treatments.

When they consider the period of the experiment, at the second week of the experiment, animals that received cassava leaves (T_2) recorded the lowest value ($p<0.05$) of feed intake while animals that received sweet potatoes leaves (T_3) recorded highest value of feed intake compared to other treatments.

At the end of the experiment, animals receiving sweet potatoes leaves (T_3) recorded the highest value ($p<0.05$) of feed intake followed by animal receiving blood root leaves (T_4). The lowest value was registered in animal receiving pawpaw leaves (T_1).

Evolution of leave intake of *Archachatina marginata* fed with different plant leaves

The evolution of leave intake of *Archachatina marginata* fed with different plant leaves is illustrated in figure 6. We can observe that:

Irrespective of the period of the experiment, the trend, profile, and shape of the curve are comparable among treatments during the period of trial.

When consider the period of the experiment, at the second and fourteen week of the experiment, animals that received cassava leaves (T_2) registered the lowest value of leave intake while animals that received pawpaw leaves (T_1) recorded highest value of leave intake during the period of experiment except the first and eight weeks compared to other treatments.

At the end of the experiment, animals receiving pawpaw leaves (T_1) and animals receiving cassava leaves (T_2) obtained the highest value of

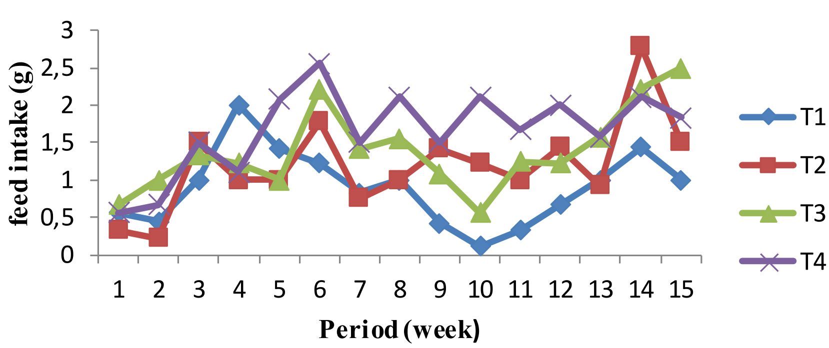


Figure 5. Evolution of feed intake of *Archachatina margina*ta fed with different plant leaves

feed intake. The lowest value was recorded in animal that received blood root leaves.

Evolution of weight of *Archachatina marginata* fed different types of plant leaves

The evolution of weight of *Archachatina marginata* fed with different plant leaves is shown in figure 7. It reveals that, the weight of the snail increases with age in a linear pattern. From the first to the third period of the experiment, animals receiving cassava leaves (T_2) recorded the highest value of weight compared to other treatments.

At the end of the experiment, animals that received blood root leaves (T_4) recorded the highest value followed by animals receiving sweet potatoes leaves (T_3).

Evolution of shell length, shell diameter, shell lip width, shell lip height of *Archachatina marginata* fed with different plant leaves

The monthly evolution of shell length, shell diameter, shell lip width, shell lip height, spire

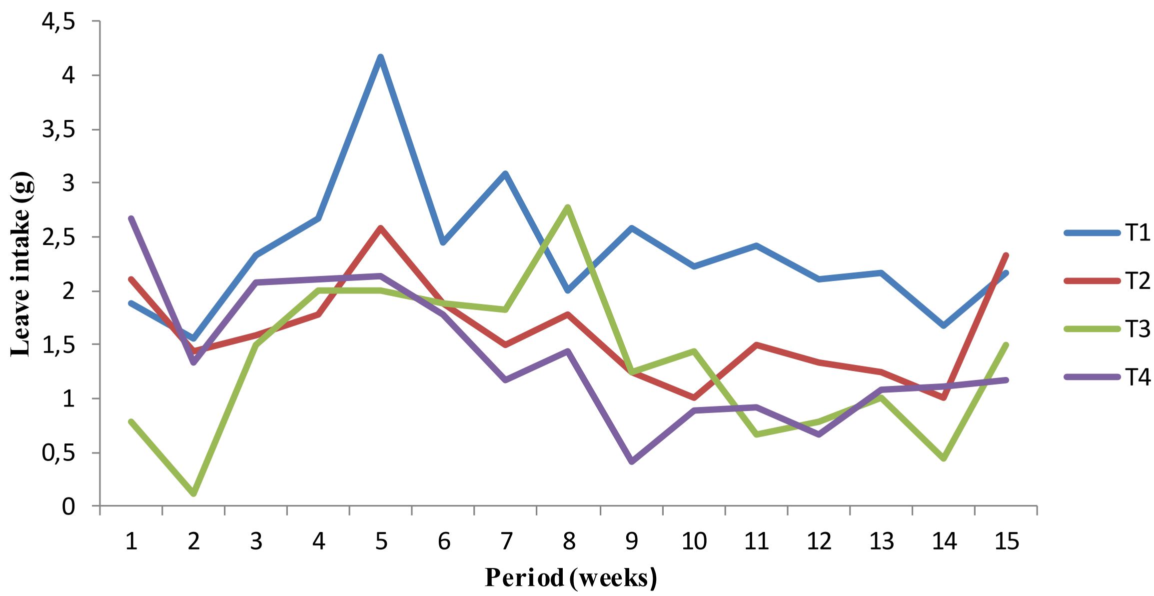


Figure 6. Evolution of leave intake of *Archachatina marginata* fed with different plant leaves

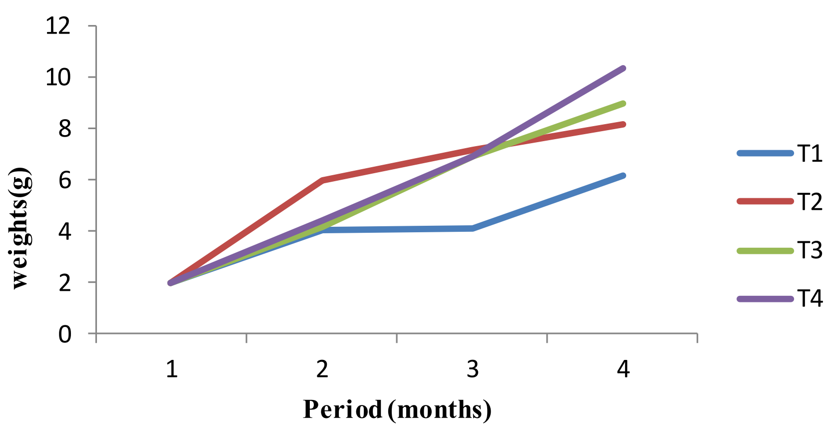


Figure 7. Evolution of weight of *Archachatina marginata* fed different types of plant leaves

height of *Archachatina marginata* fed with different plant leaves is presented in figure 8.

We can realize that shell length, shell diameter, shell lip width, shell lip height, spire height increases with the period of trial. Irrespective of period of the experiment, the lowest value is registered in the treatment that received pawpaw leave.

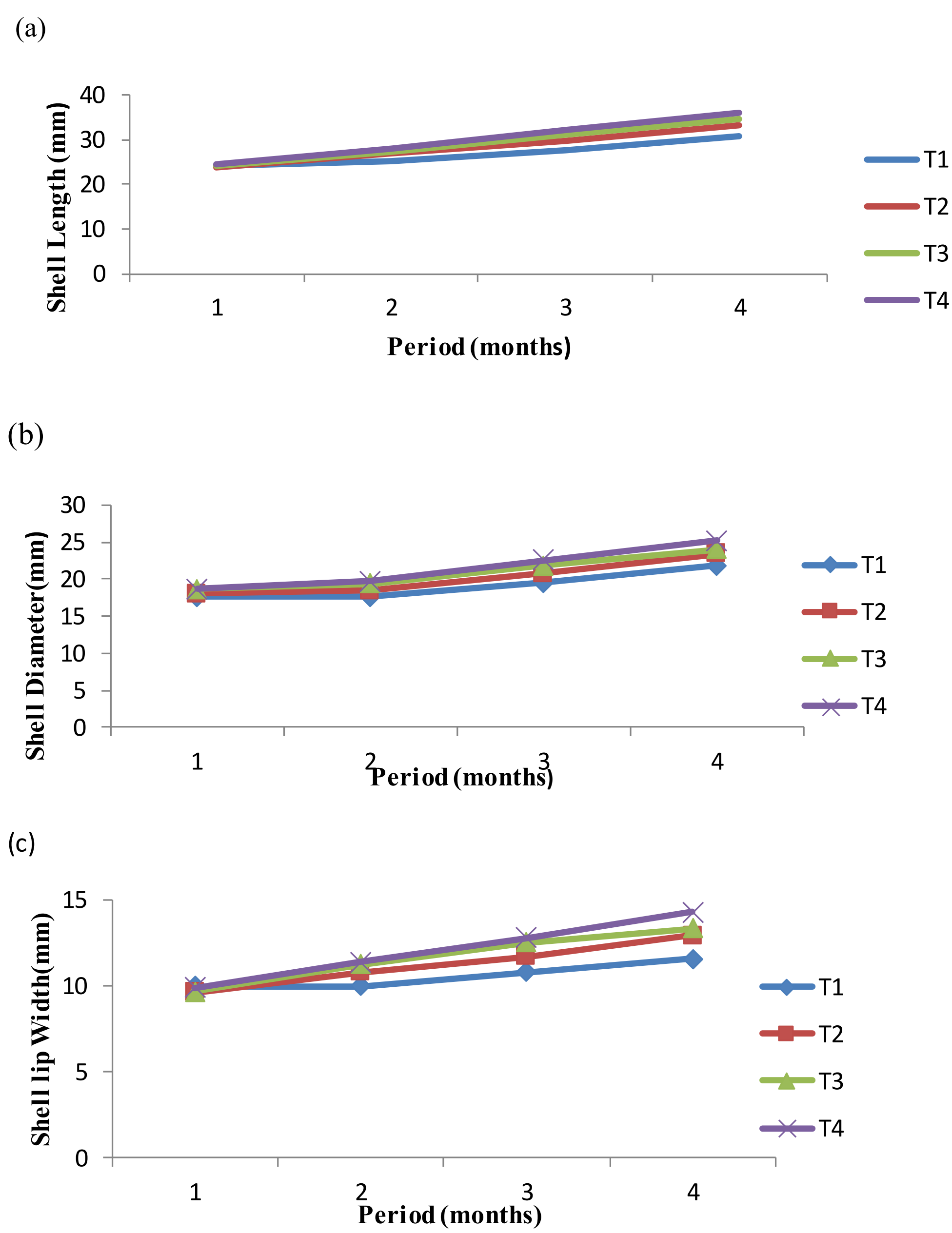
The highest value was recorded in the treatment that received blood root leaves.

Biochemical characteristics of hemolymph of *Archachatina marginata* fed with different plant leaves

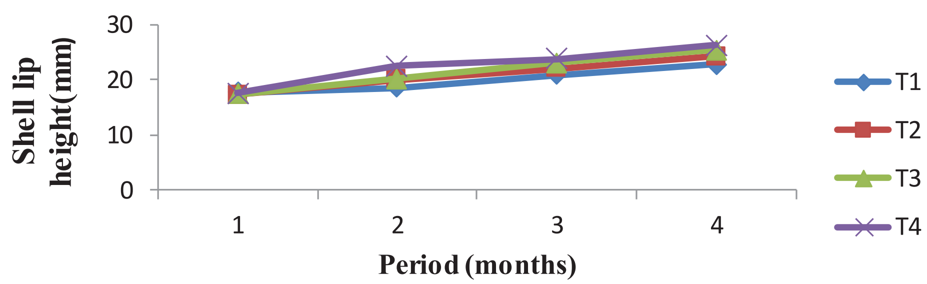
The biochemical characteristics of hemolymph of *Archachatina marginata* fed with different plant leave is illustrated in figure 9 to 11.

- **Triglyceride**

The values of triglycerides (figure 8) in the snail hemolymph were influenced in animals fed



(d)



(e)

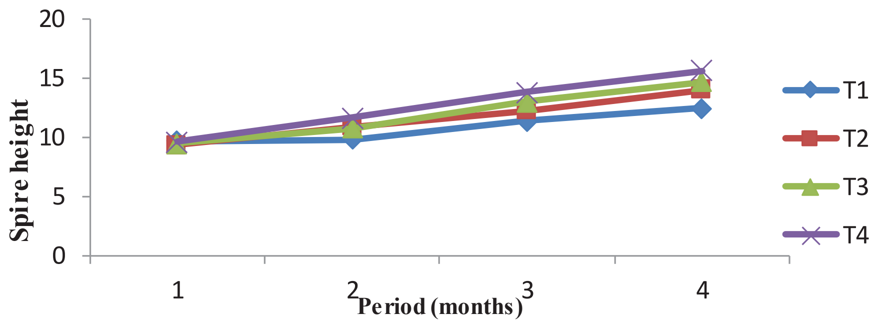


Figure 8. Evolution of shell length (a), shell diameter (b), shell lip width (c), shell lip height (d), spire height (e) of *Archachatina marginata* fed with different plant leaves

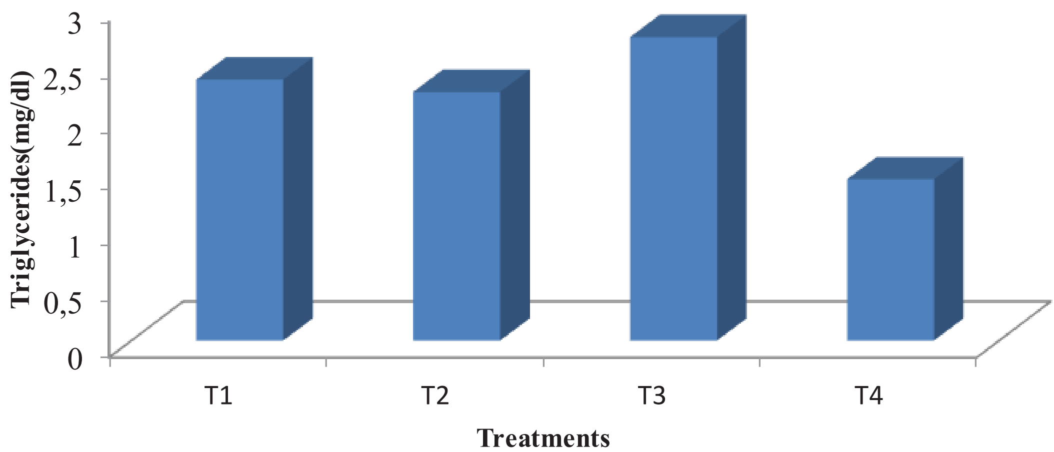


Figure 9. Evolution of Triglycerides in *Archachatina marginata* fed with four types of plant leaves

with different plant leaves. The lowest value was recorded in the treatment that received blood root leaves (T_4) compared to other treatments.

The highest value was registered in the treatment that received sweet potatoes leaves (T_3). However, no significant differences ($p>0.05$) were registered among the treatments.

- **Total Cholesterol**

The values of total cholesterol (figure 10) registered in animals fed with cassava leaves (T_2), sweet potato (T_3) leaves and blood root leaves (T_4) were lower compared to animals that received pawpaw leaves. However, no significant differences were registered among the treatments ($p>0.05$).

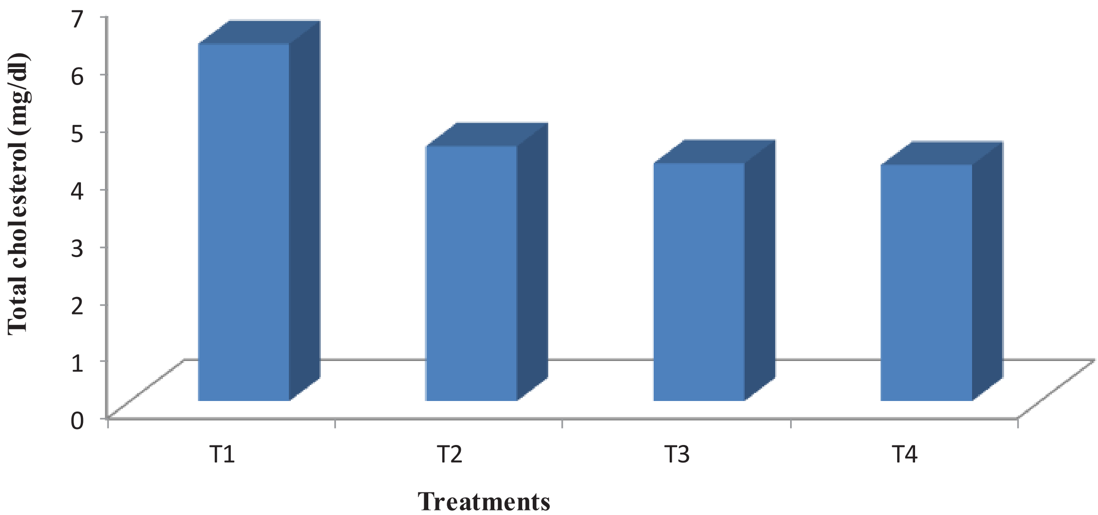


Figure 10. Evolution of cholesterol in the hemolymph in *Archachatina marginata* fed with different plant leaves

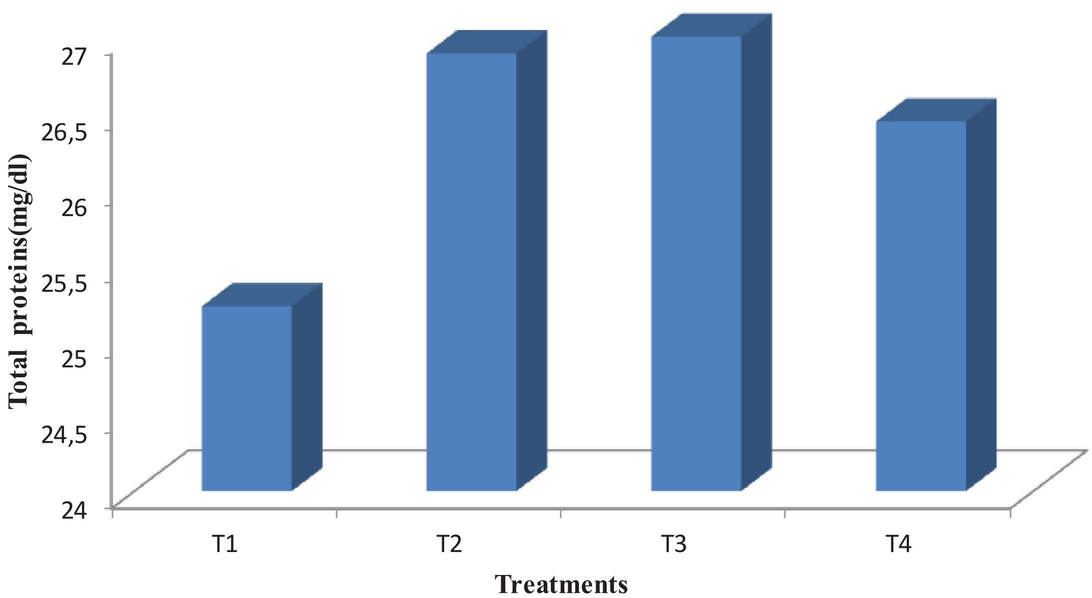


Figure 11. Total proteins in the hemolymph in *Archachatina marginata* fed with different plant leaves

- **Total proteins**

The highest value of total protein in the hemolymph (figure 11) was recorded in treatments that received sweet potatoes leaves (T_3), followed by treatments that received cassava leaves (T_2) and blood root leaves (T_4). The lowest value was registered in the treatment that received pawpaw leaves (T_1). However, no significant differences were registered among the treatments (p>0.05).

Carcass characteristics of *Archachatina marginata* fed with different plant leaves

The carcass characteristic of snail (table 3) is affected by different plant leaves. The values of live weight, shell weight, heart, foot, stomach was highest (p<0.05) in animal fed with blood root leaves (T_4), followed by animals that received cassava leaves (T_2) except stomach. The lowest value of gonad was registered in animals receiving pawpaw leaves (T_1) and blood root leaves (T_4) compared to other treatments, however, no significant differences were registered among the treatments (p>0.05).

Proximate composition of snail flesh fed with four types of plant leaves

The proximate composition of snail flesh fed with different plant leaves are summarized in table 4.

It is revealed that the significantly highest value of dry weight, ash, organic matter was recorded in animal that received blood root leaves (T_4), while the highest value of crude protein was registered in animals receiving sweet potatoes leaves (T_3). The lowest value of lipids was registered in animals receiving pawpaw leaves (T_1).

Table 3. Carcass characteristics of *Archachatina marginata* fed with different plant leaves

Carcass characteristics(g)	Treatments			
	T1 (Pawpaw)	T2 (Cassava)	T3 (Sweet potatoes)	T4 (Bloot root)
Live weight	6.67±1.93^{a}	8.33±3.64^{a}	7.67±2.34^{ab}	11.78±3.73^{b}
Shell weight	1.22±0.44^{a}	1.78±0.66^{ab}	1.78±0.66^{ab}	2.11±0.92^{c}
Intestine	1.00±0.00^{a}	1.44±0.52^{a}	1.11±0.33^{a}	2.00±0.70^{b}
Head	0.11±0.33^{a}	0.33±0.50a ^{ab}	0.22±0.44^{ab}	0.67±0.50^{c}
Heart	0.06±0.07^{a}	0.12±0.06^{a}	0.11±0.06^{a}	0.14±0.04^{a}
Pedal mass	1.11±0.33^{a}	1.33±0.70^{a}	1.11±0.60^{a}	1.78±0.83^{b}
Stomach	0.25±0.01^{a}	0.20±0.0 ^{a}	0.21±0.00^{a}	0.31±0.01^{a}
Gonad	0.01±0.01^{a}	0.02±0.01^{a}	0.02±0.01^{a}	0.01±0.01^{a}

a, b and c mean along the same row having different superscript are significantly different (p<0.05).

Table 4. Proximate composition of snail meat fed with different plant leaves

Characteristics	Treatments			
	T1 (Pawpaw)	T2 (Cassava)	T3 (Sweet potatoes)	T4 (Blood root)
Dry weight (g)	1.63	2.58	2.40	3.06
Ash (%DM)	3.99	3.79	4.26	4.63
Organic matter (%DM)	96.01	96.20	95.73	95.37
Crude protein (%DM)	52.20	54.01	54.92	51.7
Lipids (%DM)	4.02	3.67	3.86	3.46

Mortality rate of *Archachatina marginata* fed with different plant leaves.

The mortality rate (figure 12) was influenced in juvenile snails fed with different plant leaves. The treatment that received pawpaw leaves has not received any mortalities compared to others that the mortality evolved in irregular manner.

DISCUSSION

The study aimed to compare the growth performance, carcass characteristics, biochemical characteristics of the hemolymph and proximate composition of the giant African land snail (*Archachatina marginata*) fed with different plant leaves, shows that the highest value of feed intake was recorded in animals that received blood root leaves while the lowest value is registered in the treatment receiving pawpaw leaves. These results are similar with those obtained by Tchowan et al. (Tchowan et al., 2017) and Tchowan et al. (Tchowan et al., 2018), who evaluated the effects of protein and energy level in the diet in snails, but in contrast with those reported by Ademolu et al. (Ademolu et al., 2004) on the performance, proximate analysis and mineral analysis of *Archachatina marginata* fed different nitrogen sources. These results may be justified by differences in the nutrient content of pawpaw leaves and blood root leaves. Animals fed blood root leaves would have not found all the elements required to meet their needs in the plant, hence the high consumption of compounded feed. Indeed Ugo et al. (Ugo et al., 2019), showed that pawpaw leaves contain high levels of potassium (1971.17mg/100g) and calcium (1086.53mg/100g), but very low levels of protein (6.5%). On the other hand, Arogbodo (Arogbodo, 2020) in his studies revealed that blood root leaves have a low calcium (9.47mg/100g), potassium (58.50mg/100g), but high protein content. These nutrients are essential for the growth and development of juvenile snails, as calcium and phosphorus are needed to build the snail's shell, while proteins contribute to the formation of tissues, cells, organs, and organ systems. The results of the work carried out by Tchowan et al. (Tchowan et al., 2017) on snails reinforce these hypotheses.

The highest values for weight, shell length, shell diameter, shell lip width, shell lip height and carcass characteristics of *Archachatina marginata* fed with different plant leaves were recorded for snails fed with blood root leaves. These results are consistent with previous studies performed in snails (Tchowan et al., 2017) and poultry (Zhang et al., 2007). The results are also similar with those reported by Oko *et al.* (Oko et al., 2022), who studied the effect of *Justicia secunda*, as a phytogenic growth promoter in broilers. Previous

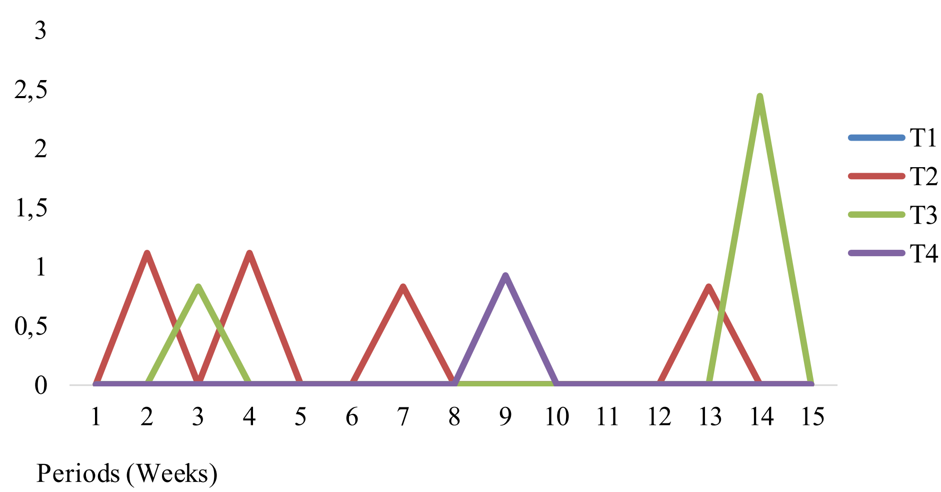


Figure 12. Mortalities rate of snail (*Archachatina marginata*) fed with different plant leaves

and our results indicated that increasing feed consumption had a positive effect on characteristics in all species. The results could be justified by the high consumption of the compounded feed observed in animals in this treatment, which would result in an increase in weight and morphometric characteristics of the shell and carcass. The result could also be justified by the presence of flavonoids, which contribute for anti inflamatory, antioxidant and nociceptive properties of *Justicia secunda* (Onoja et al., 2017). Indeed, *Justicia secunda* is very rich in phytochemicals, proximate constituents, macro elements (Calcium, phosphorus, potassium, sodium and magnesium and micro elements like Iron and Zinc. These properties may improve on the growth performance of the animals. Furthermore, Onoja et al. (Onoja et al., 2017) revealed in his study the presence of flavonoids, which the major contributor for the anti-inflammatory, anti-oxydant anti-nociceptive properties of *Justicia secunda* (Onoja et al., 2017). Wani et al.(Wani et al., 2021) demonstrated that flavonoids have been associated with possible roles in the prevention of several chronic diseases involving oxidative stress in poultry and other animals. Recent studies showed that increasing the levels of flavonoids in broiler diet leads to an improvement in growth performance, blood constituents, carcass composition and small intestinal morphology (Prihambodo et al., 2021). Kamboo et al. (Kamboh et al., 2016) concluded in their study that supplementation of plant flavonoids generally improves the immunity and antioxidant status of growing broilers. Gheisar et al. (Gheisar et al., 2015) showed that feeding broiler chickens with diet containing phytogenic blend leads to improvement in body weight gain.

The lowest value of triglycerides and total cholesterol was registered in animals receiving blood root leaves compared to other treatments. The results are in contrast with those obtained by Onochie et al. (Onochie et al., 2020), who studied the phamacobiochemical effects of ethanol extract of *Justicia secunda* Valhl leaves *Rattus norvegicus* and showed that the extract increased the lipid profile values in a dose-dependent manner. It increased the blood levels of low-density lipoprotein (LDL), cholesterol and triglycerides. However, high levels of these substances increase the risk for developing heart disease. Our results could be due to the fact the consumption of blood root leaves in that treatment, would have decrease intracellulear calcium concentration as demonstrated by Onochie et al. (Onochie et al., 2020). The same authors showed in his study that the hyperlipidemic effect observed may be due to an increase in the intracellular calcium concentrations, then the proximate analysis confirmed the calcium content of the extract and increased intracellular calcium concentrations are associated with hyperlipidaemia and lipid abnormalities. The mortalities rate recorded during this study could be due to environmental factors.

CONCLUSION

At the end of the study on growth performance of juvenile snail (*Archachatina marginata*) fed different plant leaves, we can conclude that blood root leaves improve feed intake, body weight, morphometric characteristics the shell and carcass in snails. Blood root leaves can be used as staple diet to improve the productivity of *Archachatina marginata*.

Consent of publication

Not applicable.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Interest

The authors declare that they have no conflicts of interest.

Funding

There was no funding for this study.

CREDIT Author statement

Tchowan Guy Merlin designed the study and carried out the experimental protocol. Also, he has Analyzed and interpreted the results, wrote the first draft. Njodzeka Amabel Ghakanyuy participated in data collection and data analysis. Ferdinand Ngoula analyzed and interpreted the results. Tchoumboué Joseph conceptualized the study and supervised the field. All authors read and approved the final manuscript.

Ethics Committee Approval

The study was approved by the Ethical Committee of the Department of Animal Science of the University of Dschang (ECDAS-UDS 20/03/2017/UDS/FASA/DSAES) and was in conformity with the internationally accepted standard ethical guidelines for Laboratory animal use and care as described in the European community guidelines; EEC Directive 86/609/EEC, of the 24th of November 1986.

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