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Breeding of the Giant African Edible Snail (Achatina achatina Linnaeus, 1758) in Gbado-Lite city, Democratic Republic of the Congo

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Abstract:

The objective of this study was to evaluate the effect of the nature of the food ration on the size, weight, weight gain and ex situ reproduction of the snail (Achatina achatina) in Gbado-Lite. The results of this work show that variations in size [from 8.2±1.2 cm at feeding (D0) to 9.9±2.1 cm at day D84 (snail farm A) and from 8.4±1.1 cm to 10.2±1.8 cm (snail farm B)]; hatching rate [88.2% (snail house A) and 94.2% (snail house B)]; weight [460±18.5 g at loading (D0) to 760±26.3 g on day D84 (snail house A) and 475±10.9 g to 760±26.3 g (snail house B)]; mean absolute weight gain 84 days after loading [37.7±12.0 g (snail house A) and 36.5±9.6 g (snail house B)] were not statistically different between snail houses including mean daily weight gain (0.450±0.1 g/d vs. 0.363±0.1 g/d) and survival rate (90% vs. 100%). Both formulations have the same effect on the reproduction of Achatina achatina in captivity. It is therefore desirable that more in-depth studies be conducted with the aim of popularizing this non-conventional breeding in the city of Gbado-Lite. Thus, in the current context of biodiversity erosion linked to human activities as well as environmental factors, snail farming can contribute to empowerment, improved socio-economic conditions and household resilience to climate change.

Keywords:
mini-rearing; mollusks; ubangi ecoregion; breeding; captivity

I. Introduction

In Africa in general and in the Democratic Republic of Congo (DRC) in particular, the forest constitutes an important source of animal protein for the local population, which makes it possible to fight against malnutrition and protein deficiency [FAO, 1994; Okangola, 2016; Ngbolua, 2017]. However, the anarchic and uncontrolled exploitation of forest resources due to the galloping demographic growth is currently raising questions about the long-term availability of wild animals. In addition, nowadays, the degradation of natural ecosystems, shifting agriculture and the reduction of forest areas constitute a permanent threat to the survival and sustainability of wildlife in their natural habitat (Kpula, 2021).

Among these animal resources is the land snail Achatina achatina which is an excellent source of animal protein, iron and calcium, substances often deficient in the diet in tropical regions. Its protein content is 74.6% and it is also very rich in essential amino acids such as lysine, leucine and phenylamine (Kouassi, 2007). These biochemical characteristics make this gastropod an animal of choice in Africa to fight malnutrition, especially among children. This non-timber forest product (NTFP) is only available on the market in Gbado-Lite during the period from June to August and the main source of supply of these animals remains the collection. In this regard, the population's renewed interest in snail meat is being challenged by the significant reduction in natural stocks, which are highly threatened due to strong collection pressure and the destruction of their natural habitat. Also, gastropod mollusks are known for their great capacity to accumulate the elements of transition indispensable for the anaemic subjects (Udofia, 2009). The present study was initiated with the hypothesis that a ration based on papaya leaves, maize flour, cassava leaves, cassava flour and enriched with calcium (eggshell or bone), plays a fundamental role in the physiology, growth and reproduction of snails in captivity. The general objective is to evaluate the ex-situ reproductive performance of the snail (Achatina achatina) under the bioclimatic conditions of Gbado-Lite. The specific objectives are to study the influence of two formulated feed rations on absolute weight gain, daily weight gain, hatching rate and survival of snails. To the best of our knowledge, this is the first time that snail mini-rearing has been carried out in the North Ubangi province of the Democratic Republic of Congo.

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II. Research Methods

2.1. Description of the Study Area

The present study was conducted in the town of Gbado-Lite (Latitude: 4° 16' 41" North; Longitude: 21° 00' 18" East; Altitude: 300-500 m above the Sea). The town of Gbado-Lite (Figure 1) is located in the Umbrian ecoregion, a subset of the Northeastern Congolian lowland forests. This ecoregion is one of the 200 global priority terrestrial ecoregions known as the « G200 » [Ngbolua, 2018; Ngbolua, 2019a; Ngbolua, 2019b; Ngbolua, 2019c; Ngbolua, 2020a; Ngbolua, 2020b].

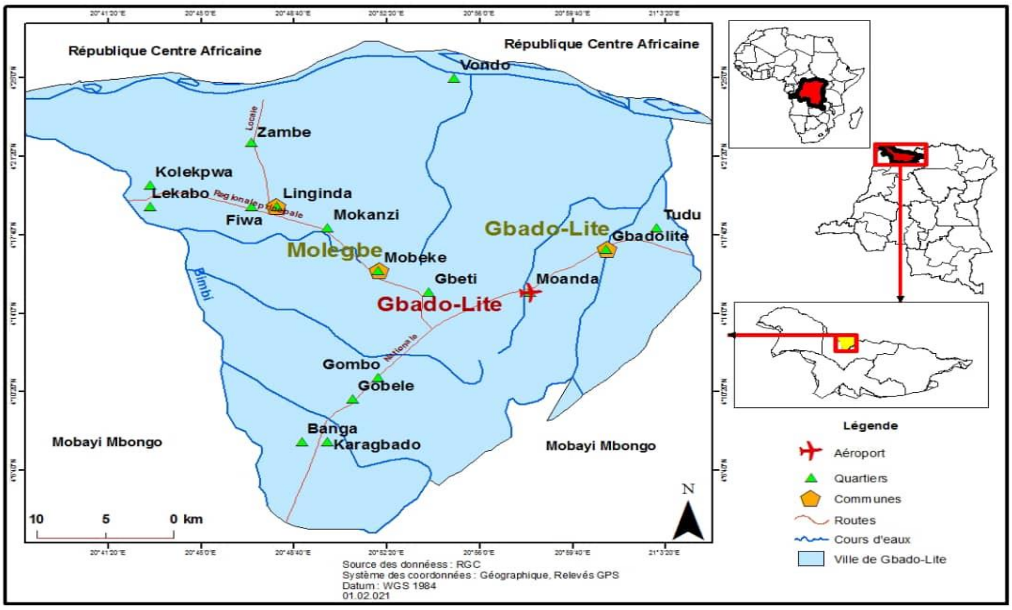

***Figure 1.** Geographical Location of the City of Gbado-Lite*

From a bioclimatic point of view, the city of Gbado-Lite belongs to the climatic type AW2 according to the classification of Köppen [Ngbolua, 2018; Ngbolua, 2019a; Ngbolua, 2019b; Ngbolua, 2019c; Ngbolua, 2020a; Ngbolua, 2020b]. Rainfall is relatively abundant with an average of more than 1600 mm, insolation is low, i.e., 45% of total radiation of tropical energy. Administratively, the city of Gbado-Lite is subdivided into three (3) communes including the urban commune of Gbado-Lite and the urban-rural communes of Nganza and Molegbe. The urban commune of Gbado-Lite is subdivided into five districts (Mowanda, Pangoma, Mbanza, Lite and Kaya).

The experimental device is set up in the commune of Gbado-Lite in the Pangoma district (latitude: N 4° 15' 42, 75"; longitude E 20° 59' 5,87"; altitude: 398,45 m above sea level).

2.2 Methodology

In order to carry out this study, the experimental method of rearing under shelter and inside the tank called snail house was adopted. The shelter was constructed with sticks and straws (Figure 2. A) to prevent the snails from direct contact with the sun and to maintain maximum humidity. As a safety measure, the base of the shelter was bypassed with a false cane entry device. Two snail bins (Figure 2. B-D) were constructed each with dimensions of 70 cm in length, 60 cm in width and 50 cm in height. These bins were constructed using clay bricks with a removable closing device on the upper part consisting of a wooden frame and a mesh to allow aeration and good ventilation of the enclosure. The bottom of the tanks was filled to a height of 2 cm with gravel followed by 7 cm of unamended soil and covered with dead leaves and tree branches to allow snails to climb. The loading was of ten broodstock (snails) in each snail tank. The nature of the food brought to the snails constituted the treatments of this experiment. Thus, the snails in tank A (T1) were fed a ration composed of papaya leaves and wet corn flour enriched with powdered charred eggshells, while those in tank B (T2) were fed a ration composed of cassava leaves and wet cassava flour enriched with charred bone powder. A container of water was placed in each tank to maintain humidity and temperature favorable to snail development. Daily watering of the outside walls of the tanks was carried out.

Figure 2. *Experimental Device*

Observations were made of the physical parameters of the environment (temperature) and biological parameters (size, weight, snail production and survival, and egg hatching). The temperature of the snail tanks was taken with a thermometer.

Snail size (total shell length) was determined using a caliper (Figure 3. B & C). Snail weight was taken using a 1 g precision scale (Figure 3. A). For reproduction, the number of eggs laid (Figure 3. D & E) and the number of eggs hatched (Figure 3. F) were counted.

Figure 3. *A Balance; B & C Vernier calipers; D & E Laid eggs; F Hatching eggs*

The analyses concerned:

1) Absolute Weight Gain (AWG): is used to evaluate the weight growth of snails during a given time and is obtained by the difference between the final average weight and the initial average weight.
2) Daily weight gain (DWG): is used to evaluate the weight growth of snails related to the rearing time. It is calculated from the formula: $DWG = \frac{\text{Final Average Weight} - \text{Initial average weight}}{\text{Duration of breeding}}$
3) Hatching rate (OER): is used to assess snail reproduction by the number of eggs hatched relative to the rearing time. It is calculated from the formula: $OER\ (\%) = \frac{\text{Number of eggs hatched}}{\text{Number of eggs hatched}} \times 100$
4) Snail survival (SS) was assessed using the formula: $SS\ (\%) = \frac{\text{Number of live snails}}{\text{Number of snails in charge}} \times 100$.

2.3. Statistical Analysis

ANOVA was used to assess the effect of the nature of the feed ration on snail size, weight and weight gain at the 0.05 significance level.

III. Results and Discussion

3.1 Results

Temperatures of the snail bins were taken before the snails were loaded and the results are shown in Figure 4.

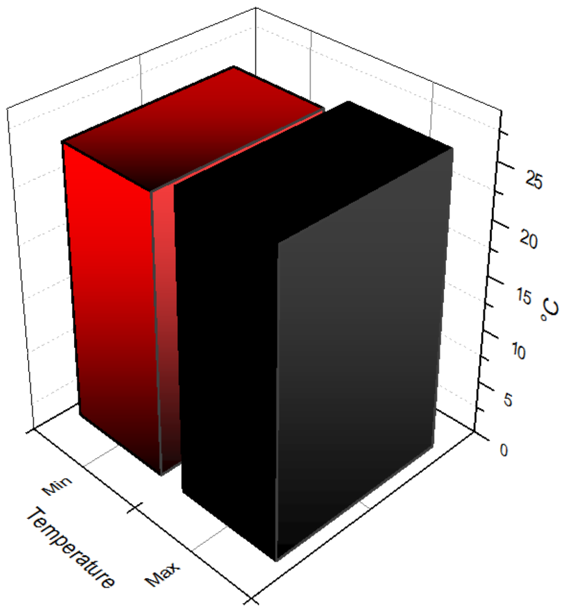

Figure 4. *Temperatures of Snail Farms*

From this figure, it can be seen that in the snail farms, temperatures varied between 25.5 and 27.0°C with an average of 26.3°C.

This corresponds to the conditions under which snails develop in the dense evergreen forest and secondary scrubland of West Africa south of the Sahara (Hodasi, 1984). The results of the measurements on the size of the breeding snails are given in Table 1.

Table 1. Influence of the Ration on the Size (in Centimeters) of the Breeding Snails during Rearing

Variables	**A (T_1)**	**B (T_2)**	**F_C**	**Probability**	**$F_{0,05}$**
Size on loading (D_0)	*8.2*±1.2	*8.4*±1.1	0.105	0.75	4.414
Size on D_{21}	*8.4*±1.2	*8.6*±1.0	0.146	0.707	4.414
Size on D_{42}	*8.6*±1.2	*8.9*±1.0	0.284	0.601	4.451
Size on D_{63}	*8.8*±1.1	*9.2*±0.9	0.787	0.388	4.451
Size on D_{84}	*9.9*±2.1	*10.2*±1.8	0.118	0.736	4.451

From this table, it can be seen that the size in snail house A increased from 8.2±1.2 cm at loading (D0) to 9.9±2.1 cm at day D84 while in snail house B, it increased from 8.4±1.1 cm to 10.2±1.8 cm. Statistical analysis according to Fisher Snedecor revealed no difference between snail sizes in the two treatments (calculated F is less than critical F at the 5% alpha threshold). This shows that both diets have the same effect on the increase in snail size during the rearing period.

Tables 2 and 3 show the weight evolution and weight gain of the breeding snails, respectively.

Table 2. Evolution of Weight (in grams) of Snails during Rearing

Variables	**A (T_1)**	**B (T_2)**	**F_C**	**Probability**	**$F_{0.05}$**
Weight on loading	460±18.5	475±10.9	0.049	0.828	4.414

(D_0)					
Weight on D_{21}	635±26.5	610±11.7	0.075	0.788	4.414
Weight on D_{42}	635±26.5	630±12.3	0.658	0.428	4.451
Weight on D_{63}	715±27.2	685±12.0	1.335	0.264	4.451
Weight on D_{84}	760±26.3	780±16.9	0.414	0.529	4.451

From the point of view of weight gain and weight growth, the weight increased from 460±18.5 g at loading (D0) to 760±26.3 g at day D84 in escargotière A while in escargotière B it increased from 475±10.9 g to 760±26.3 g. The mean absolute weight gain 84 days after loading (g) is 37.7±12.0 g in snail house A and 36.5±9.6 g in snail house B. Regarding the average daily weight gain, it was 0.450±0.1 g/d and 0.363±0.1 g/d in snail farms A and B, respectively.

Table 2 indicates that from loading to the end of the experiment, individuals in T_2 showed a higher average weight than those in T_1.

Table 3. Weight Gain during Rearing

Variables	**A (T_1)**	**B (T_2)**	**F_C**	**Probability**	**$F_{0,05}$**
Average absolute weight gain 84 days after loading (g)	37.7±12.0	36.5±9.6	2.156	0.160	4.451
Average daily weight gain (g/d)	0.450±0.1	0.363±0.1	2.156	0.160	4.451

From Table 3, it can be seen that snails in T1 showed a higher absolute weight gain than those in T2 i.e., 37.7 > 363 g for a duration of 84 days of rearing. However, individuals in snail house A (fed papaya leaves and wet maize meal) showed greater daily weight gain than those in snail house B (fed cassava leaves and wet cassava meal), i.e., 0.450 g/d > 0.363 g/d. However, statistical analysis indicates that there is no significant difference between the two diets used in their effects on snail ecophysiology.

Figure 4 shows the snail egg hatch rate for the two treatments.

Table 4. Hatching Rates of Snail Eggs

Frequency of collection	**A (T_1)**			**B (T_2)**		
	Number of eggs/ laying	**Hatchings**	**Hatching rate**	**Number of eggs/ laying**	**Hatchings**	**Hatching rate**
1	105	100	95.2	110	104	94.6
2	182	180	98.9	80	77	96.3
3	52	0	0	78	72	92.3
4	95	91	95.8	105	99	94.3
5	108	100	92.5	117	111	94.9
6	109	103	94.5	97	88	90.7
7	0	0	0.0	152	141	92.8
8	0	0	0.0	120	117	97.5
Total	651	574	88,2	859	809	94.2

It appears from this table 4 that out of a total of 651 eggs laid by the individuals of snail farm A (T1), 574 hatched, corresponding to a hatching rate of about 88.2%; on the other hand, out of a total of 859 eggs laid by the individuals of snail farm B (T2), 809 hatched, corresponding to a hatching rate of about 94.2%.

This result shows that the hatching rate of the individuals from T2 is higher than those from T1, i.e., 94.2% > 88.2%. It can be noted that the number of eggs per clutch depends on the weight and size of the snail; for example, a snail weighing 130 grams and measuring 10.8 cm laid 182 eggs and another weighing 55 grams and 8.7 cm laid 105 eggs. Moreover, the eggs have ovoid forms which vary between 6 to 7 mm length and 5 to 6 mm broad; the small snails have a size of 4 to 5 mm length at the first day of the hatching.

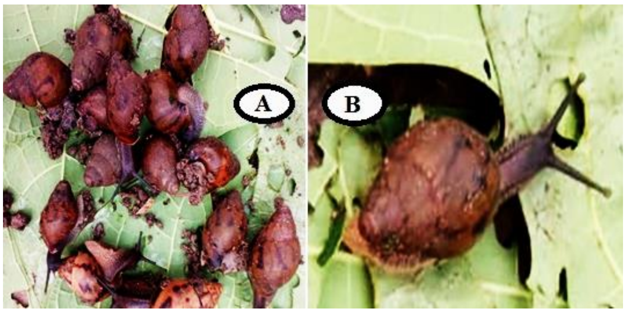

***Figure* 5.** *Juvenile Snails Produced*

The table 5 shows the survival of snails during the experiment.

Table 5. Survival Rate of Snails as a Function of Rearing Time

Treatments	Loading		21 DAL		42 DAL		63 DAL		84 DAL		Total	%
	n	%	n	%	n	%	n	%	n	%		
T_1	10	100	10	100	9	90	9	90	9	90	9	90
T_2	10	100	10	100	10	100	10	100	10	100	10	100

Legend: n Numbers; DAL days after loading.

3.2 Discussion

According to the Voluntary National Review of the Sustainable Development Goals (SDGs) published by the Ministry of Planning (2020), the DRC is the second largest country in Africa with an area of about 2,345,409 km^2.

Its socio-demographic situation is worrisome since 44.5% of the population (approximately 37.3 million inhabitants) live in urban areas with a very low human development index. Indeed, more than 49% of households (i.e., one in two) are affected by food insecurity, 16.4% of which are severely so. More than half of the households in the DRC are economically vulnerable because they spend nearly 65% of their monthly expenses on food. Thus, in order to achieve the MDGs such as poverty eradication (MDG1), hunger alleviation (MDG2) and good health and well-being (MDG3), the domestication of snails can facilitate socio-economic development through a community-based agro-industrial initiative. Indeed, edible snails constitute a food with high nutritional value due to their richness in calcium, iron, essential acids, vitamins A, D3 and E. Moreover, in addition to its food value, the snail can be used c in the pharmacopoeia to treat certain diseases. Indeed, its high iron content is used in the treatment of anaemia in traditional medicine (Cobbannah, 1994). In addition, snails play an important role in the ecological balance of forests, fallow lands and wetlands and their breeding is not harmful to the urban environment as is the case with poultry or large cattle for example.

In addition to raising snails for family consumption, the marketing of surplus snail production can contribute to the empowerment and improvement of socio-economic conditions of poor households in Gbado-Lite and its surroundings. In terms of resilience to climate change, snail farming can be practiced throughout the year without any seasonal influence, as is also the case with mushroom farming in the Great Lakes region of Africa (Kiyuku, 2020) Agro-ecology defined as the science of natural resource management for the benefit of the poorest faced with an unfavourable environment constitutes (through mini-snail farming) a discipline to be developed and popularized in North Ubangi province in order to reduce pressure on wildlife [Altieri, 1996; Triplet, 2016].

From this table it can be seen that the conditions of the study environment were favourable for the rearing of snails because during the entire experimental period, the survival rate was 90% for T1 and 100% for T2.

IV. Conclusions

The objective of this study was to evaluate the effect of the nature of the food ration on the size, weight, weight gain and ex situ reproduction of the snail (Achatina achatina) in the bioclimatic conditions of Gbado-Lite. The results of this work show that:

1) Size increased from 8.2±1.2 cm at loading (D0) to 9.9±2.1 cm at day D84 (snail house A) and from 8.4±1.1 cm to 10.2±1.8 cm (snail house B);
2) Hatching rate was 88.2% (snail house A) and 94.2% (snail house B) respectively;
3) Weight increased from 460±18.5 g at loading (D0) to 760±26.3 g on day D84 (snail house A) and from 475±10.9 g to 760±26.3 g (snail house B);
4) Mean absolute weight gain 84 days after loading was 37.7±12.0 g (snail house A) and 36.5±9.6 g (snail house B), respectively. In contrast, the average daily weight gain was 0.450±0.1 g/d and 0.363±0.1 g/d in snail farms A and B, respectively;
5) Survival rate was 90% for T1 and 100% for T2.

The Fisher Snedecor analysis of variance showed no significant differences between the two diets (calculated F < 5% critical F) indicating that the two formulations have the same effects on the ex-situ reproduction of Achatina achatina under the bioclimatic conditions of Gbado-Lite. Thus, the environmental conditions were favourable for snail rearing. It is therefore desirable that more in-depth studies be conducted with the aim of popularizing this non-conventional breeding in the city of Gbado-Lite. Thus, in the current context of biodiversity erosion linked to human activities as well as to environmental factors such as climate change, etc., the safeguarding of natural resources must necessarily involve the implementation of effective management and conservation strategies.

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