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Effect of hen's egg shell in breeding substratum on growth meat yield of African giant snail Archachatina marginata (Swaison, 1821)

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ABSTRACT

In order to contribute to growth performances of the African giant snail *Archachatina marginata* in breeding stock, a study was carried out to determine the effect of hen egg shells on the growth and the meat yield of this snail species. Thus, juvenils of approximately one week old were bred during 80 weeks over six different substratums. These substratums were differentiated according to their content in hen's egg shell powder (0; 5; 10; 20; 30 and 40 %). The results indicate an improvement of the ponderal and shelly growths with the importance of the concentration of floured egg shells in the breeding substratum. Best average live weights (318.3 g, 322.g and 319.6 g) and average lengths of shells (147.1 mm, 148.3 and 152.9 mm) at the end of 80 breeding weeks were obtained respectively at substratum amendment rates of 20%, 30%, and 40%. The increase in the amendment rate of the substratum in this calcic source has also involved an increase in the total quantity of meat from 61.3 g on the compost not amended to 88.2 g on the substratum containing 30% of the calcic source. However, it should be noted a reduction in the proportion of consumable flesh from 28.8 to 26.96%.

Keywords: *Archachatina marginata*; calcium; egg shell; growth performance; substratum.

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1 - INTRODUCTION

Snails are appreciated a lot for the quality of meat they get. The generally consumed part of the body is the pedal mass (Otchoumou *et al*., 2010). The shell and the visceral mass can be revalued in animal nutrition (Otchoumou, 2005). If the meat of the snail is so much estimated and more and more consumed by the Ivory Coast populations, it is partially due to its perfume and taste (Ashaye *et al*., 2001). Moreover, this meat contains important nutritional values, being an important source of protein, amino acids (lysin, phenylalanine and leucine), energy, and minerals according to Heymans *et al*., (1972), Ayayi *et al*., (1978), Diomandé *et al*., (2008) and Otchoumou, *et al*., (2010). In addition, flesh of mollusks is very poor in lipid (Aboua, 1995). That is why it is recommended in for the poor diets in lipid (Saldanha *et al*., 2001). The portion of flesh consumed in West Africa represents only a third of the live weight of the giant snail. The shell and the visceral mass hold near half of the live weight (Otchoumou, 2005; Stievenart, 1996). We can so recover from a kilogram of giant snails intended for the human consumption, near a half-kilogram of valuable tissues for the animal feeding (calcium and protein). In Côte d'Ivoire, Ghana and in Nigeria, where the flesh of snail is highly appreciated and consumed, these animals are mostly collected during the wet season. However, during this decade, the populations of wild snails have decreased considerably because of an overexploitation, the deforestation, the use of pesticides, the slash-and-burn for vegetable cultivation and the accidental forest fire (Cobbinah *et al*., 2008). Thus, it seems important and urgent to finalize techniques of breeding stock for a long-term conservation of snails, and in particular *Archachatina marginata*. Herein, this paper presents the content of floured egg shells of hen on the growth and yield meat of this mollusk species.

2 - MATERIAL AND METHODS

2.1 - Breeding substrata

Basic compost has been taken away from the ground of a rain forest from which six different breeding substrata have been made. These substrata were settled adding to the compost powder of hen's egg shell at rates of 0 %, 5 %, 10 %, 20 %, 30 % and 40 % giving respectively substrata S_0, $S_{Œ5}$, $S_{Œ10}$, $S_{Œ20}$, $S_{Œ30}$ and $S_{Œ40}$. The chemical compositions of these substrata were determined by the company PETROCI, according to the method of Energy Diffusion Spectrometry (EDS).

Three samples were analyzed per substratum and the results were then transferred on an Excel file.

2.2 - Breeding technique and growth control

Snails *Archachatina marginata of* approximately one week old with an average live weight of 1.45 ± 0.13 g and a shell average length of 18.9 ± 0.17 mm were used for this experiment. They were bred at a density of 25 snails/m^2 in wooden containers of dimensions 0.14 x 0.17 x 0.21 m. Breeding occurred in a room in which containers were disposed on shelves. Experiments were carried out in triplicate. Containers were hosed twice a day (morning and evening) with pump water. Water quantity was 0.25 litres / substratum. Each container was covered with a plastic mesh.

The animals were nourished at satiety every two days with cereal. The substratums were regularly cleaned to get the substrata rid of resting food and animal faeces. Snails were weighed every two weeks with a Sartorius scale of 0.1 g precision and their shell length measured, using a slide calliper of 0.1 millimetre precision.

The daily average ponderal growth, daily average shell growth and the survival rate were calculated as follow:

- Daily average weight growth (DAWG): DAWG = (Pf - Pi) / NS x ΔT

- Daily average shell growth (DASG): DASG = (Lf-Li) / NS x DT

- Rate of survival (RS): RS = (NS - DS) x 100 / NS

With: Pi = initial total weight; Pf = final total weight; Li = initial length; Lf = final length; ΔT = duration in days, NS = total number of snail and DS = number of dead snails.

2.3 - Determination of the meat yield

After 80 weeks of breeding, 30 snails were taken randomly on each substratum to estimate the meat production efficiency. After 24 hours of fast, the selected snails were marked, measured in length and weighed before being scalded during 15 min.

After cooling, soft tissues were removed from shells, and then placed on metal mesh to be drained. Empty shells were also drained. The pedal mass was then separated from the visceral mass. For each specimen, the total flesh mass, the empty shell, the pedal and visceral mass were weighed.

The proportions of the different parts of the snails body produced on each type of substratum were given according to following formulas':

- Percentage of empty shell = Weight of empty shell x 100 / Live weight of snail;
- Percentage of visceral mass = visceral mass weight x 100 / Live weight of snail;
- Percentage of flesh mass = flesh mass weight x 100 / Live weight of snail;
- Percentage of pedal mass = pedal mass weight x 100 / Live weight of snail.

2.4 – Statistical analysis

The homogeneity of various of starting batches was checked according to Bartlett's test. Statistica 7.1 software was used to assess the effect by the factorial analysis of mean values. One way ANOVA was used to test the effect of the substrata treatment. LSD test was also applied to compare the means when no difference was detected by ANOVA.

2.5 – Ethical Statement

All experiments were carried out in accordance with the Ivorian laws and University guide line for the care experimental animals. All procedures of the current experiment have been approved by the committee of Environment Department of Jean Lorougnon Guede University, Côte d'Ivoire.

3 - RESULTS

3.1 - Chemical composition of the breeding substrata

The chemical composition of the different substrata is presented in Table I. Among the six minerals tested, only two (calcium and silicon) showed significant differences between substrata. The compositions of substrata in aluminium, magnesium, potassium and iron were similar. The calcium content increased regularly with the substrata content in egg shell so that the highest proportion (15.36%) of calcium was obtained with S_{OE40}. Concerning the silicon composition, it decreases when the egg shell content in the substratum increases. The lowest proportion in silicon (8.36%) was obtained in substratum S_{OE40} and the highest (13.9%) in S_0. These results suggest the existence of an interaction between the minerals of the litter.

3.2 - Ponderal and shelly growth

The growth performances recorded on the different substrata are summarized in table II. From similar initial live weights (1.43g to 1.48g), snails reached final weights ranging from 214.1g (S_0) to 322.4g (S_{OE40}) after 80 breeding weeks. The final weight increased proportionally with egg shell content in the substrata from S_0 to S_{OE20} (214.1g to 318.3g). From then the growth becomes more or less steady (Test LSD, $p>0.05$). The daily growth rate follows the same tendency as the final weight ranging from 0.38g/day (S_0) to 0.57g/day (S_{OE40})

The snails final shell length varied from 112 mm (S_0) to 152.9 (S_{OE40}) mm with a daily growth rate ranging between 0.17 and 0.24 mm/day. These final lengths were statistically different (LSD, $p<0.05$) and increased with proportions of hen's egg shell in the breeding substrata. However, there is no significant difference between the daily shelly growths with the substrata except between those of S_0 and S_{OE40} that showed respectively the lowest and the highest values of this parameter.

3.3 - Rate of survival

The survival rates obtained on substrata S_0; S_{OE5}; S_{OE10}; S_{OE20}; S_{OE30} and S_{OE40} are respectively 86.08 %; 79.29%; 77.19%; 76.02%; 71.11% and 64.55% (Table II). These results indicates a decrease of the survival rate of snails with the increase in the rate of the floured of egg shells rate in the breeding substrata.

3.4 - Meat yield

The mean live weights checked randomly on substrata ranged from 212.76g to 322. 72 g. Their empty shell weights evolved between 78.78g (S_0) to 144.28g (S_{OE40}). Then, the highest shell weight is obtained on S_{OE40} and the lowest on S_0. Concerning the tissues extracted from these shells, the lowest tissue weight was obtained with S_0 (115g) and the highest S_{OE20} (167g). From these tissues, the pedal mass weighted between 61g (S_0) and 90.96 g (S_{OE20}).

The effect of the content in egg shells powder of the breeding substratum on the different parts of the body of the animals is summarized in table III. The weight of shell produced by snails increases with the content of the calcic source of the breeding substratum. Likewise, the quantities of soft fabrics, pedal and visceral mass, decrease not significantly, with the increases of the rate of this calcic source in the substratum. The quantities of soft fabrics, pedal mass and visceral mass on the substratum's are statistically identical ($P > 0.05$) at all he substrata.

The proportions of the different body parts of these snails are indexed in table IV. The proportions of shells produced on the substrata, vary from 37.10(S_0) to 45.30% (S_{OE40}) and those of tissues from 48.64% (S_{OE40} to 54.20% (S_0). Concerning the percentages of pedal and visceral masses, they range respectively between 26.96% (S_{OE40}) and 28.80% (S_0) and between 21.68% (S_{OE40}) and 25.60% (S_0). The snails present a proportion of tissues statistically higher than that of their shell on the substrata. In addition, these animals present a proportion of pedal mass higher than that of visceral mass whatever the breeding substratum.

The statistical analysis of the results indicates an increase in the shelly proportion of the animals with the content of the calcic source in the breeding substratum. On the other hand, the increase in the content of this calcic source of the substratum, involves a reduction in the percentage of tissue. The statistical analysis does not indicate any difference, between the proportions of soft fabrics generated by snails on all the substrata. Nevertheless, the animals bred on the substratum S_{OE40} have a proportion of tissue (48.64%) weaker than those on the other substrata. The results also show that proportion of pedal mass decreases when the content of the substratum in egg shell powder increases.

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Tableau I: Chemical composition of the substrata used for experiments.

	Minerals (%)						
Substrata	Magnesium	Aluminium	Calcium	Iron	Potassium	Silicon	Organic matter (%)
S_0 (100% compost)	0.12^{a} ± 0.01	2.41^{a} ± 0.20	0.17^{f} ± 0.03	1.68^{a} ± 0.06	0.05^{a} ± 0.02	13.9^{a} ± 2.31	79.4^{a} ± 4.92
$S_{Œ5}$ (S_{0+} 5% egg shells)	0.13^{a} ± 0.01	2.96^{a} ± 0.33	2.07^{e} ± 0.5	1.69^{a} ± 0.2	0.047^{a} ± 0.01	13.24^{a} ± 2.17	78.25^{a} ± 7.23
$S_{Œ10}$ (S_{0+} 10% egg shells)	0.14^{a} ± 0.05	2.18^{a} ± 0.21	3.97^{d} ± 0.91	1.61^{a} ± 0.09	0.045^{a} ± 0.06	12.55^{a} ± 1.98	75.75^{a} ± 11.09
$S_{Œ20}$ (S_{0+} 20% egg shells)	0.15^{a} ± 0.03	1.93^{a} ± 0.7	7.77^{c} ± 1.24	1.43^{a} ± 0.3	0.04^{a} ± 0.03	11.15^{ab} ± 2.11	74.96^{a} ± 5.96
$S_{Œ30}$ (S_{0+} 30% egg shells)	0.17^{a} ± 0.02	1.69^{a} ± 0.24	11.56^{b} ± 2.1	1.25^{a} ± 0.7	0.035^{a} ± 0.01	11.06^{bc} ± 1.93	74.1^{a} ± 9.05
$S_{Œ40}$ (S_{0+} 40% egg shells)	0.19^{a} ± 0.01	1.45^{a} ± 0.09	15.36^{a} ± 2.09	1.07^{a} ± 0.4	0.03^{a} ± 0.03	8.36^{c} ± 2.45	72.39^{a} ± 11.12

The values in the same column indexed with at least one common letter are not different according to the test of Levene with $P < 0.05$

Table II: Growth performance and survival rate of snails reared on substrata with different egg shell contents.

	Substratums					
	S_0	$S_{Œ5}$	$S_{Œ10}$	$S_{Œ20}$	$S_{Œ30}$	$S_{Œ40}$
Initial live weight (g)	1.48^{a} ± 0.04	1.46^{a} ± 0.093	1.45^{a} ± 0.068	1.46^{a} ± 0.13	1.46^{a} ± 0.067	1.43^{a} ± 0.34
Final live weight (g)	214.1^{d} ± 22.3	269.7^{c} ± 7.24	293.1^{b} ± 15.22	318.3^{a} ± 11.74	322.4^{a} ± 22.1	319.6^{a} ± 14.18
Daily average ponderal growth (g/day)	0.38^{b} ± 0.28	0.48^{ab} ± 0.34	0.52^{ab} ± 0.41	0.57^{a} ± 0.42	0.57^{a} ± 0.42	0.57^{a} ± 0.44
Initial average length (mm)	18.9^{a} ± 1.0	18.8^{a} ± 1.3	18.9^{a} ± 1.3	19.0^{a} ± 0.72	18.8^{a} ± 1.1	19.1^{a} ± 1.2
Final Average length (mm)	112^{e} ± 4.2	132.7^{d} ± 3.6	135.6^{c} ± 1.9	147.1^{b} ± 4.2	148.3^{b} ± 2.9	152.9^{a} ± 5.4
Daily average shelly growth (mm/day)	0.17^{b} ± 0.1	0.2^{ab} ± 0.1	0.21^{ab} ± 0,1	0.23^{ab} ± 0,2	0.23^{ab} ± 0,2	0.24^{a} ± 0,1
Average rate of survival (%)	86.08^{a} ± 4.67	79.29^{b} ± 2.96	77.19^{b} ± 4,92	76.02^{b} ± 3,87	71.11^{c} ± 8,26	64.55^{d} ± 2,81

The mean values on the same line indexed with the same signs are not different (test LSD, P< 0.05)

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Table III: Weight of the various parts of the body of snails according to the content of floured of eggs shells of the substratum.

Variables	Substratums					
	S_0 (0% egg shells)	$S_{\text{Œ5}}$ (5% egg shells)	$S_{\text{Œ10}}$ (10% egg shells)	$S_{\text{Œ20}}$ (20% egg shells)	$S_{\text{Œ30}}$ (30% egg shells)	$S_{\text{Œ40}}$ (40% egg shells)
Cockles weight (g)	$78.78^{b\,\text{¤}} \pm 8.01$	$102.88^{ba\,\wedge} \pm 9.58$	$118.68^{ba\,\times} \pm 14.98$	$134.92^{a\,*} \pm 9.78$	$138.48^{a\,+\,*} \pm 12.69$	$144.28^{a\,+} \pm 7.86$
Tissue weight (g)	$115.52^{a\,\text{¤}} \pm 14.51$	$145.72^{a\,\wedge} \pm 6.66$	$156.40^{a\,*} \pm 6.16$	$167.84^{a\,+} \pm 14.78$	$158.96^{a\,*} \pm 16.04$	$155.04^{a\,*} \pm 10.29$
Loss related to the preparation (g)	$18.46^{e\,*} \pm 4.43$	$20.44^{e\,*} \pm 6.97$	$18.04^{e\,*} \pm 6.55$	$19.96^{e\,*} \pm 8.77$	$19.12^{e\,*} \pm 6.78$	$19.24^{e\,*} \pm 5.61$
Pedal mass (g)	$61.28^{c\,\wedge} \pm 8.80$	$77.36^{c\,\times} \pm 5.84$	$83.40^{c\,*} \pm 3.42$	$90.96^{c\,+} \pm 9.91$	$87.76^{c\,+\,*} \pm 9.72$	$85.88^{c\,*} \pm 13.09$
Visceral mass (g)	$54.24^{d\,+} \pm 9.45$	$68.36^{d\,*} \pm 7.10$	$73.00^{d\,*} \pm 5.1$	$76.88^{d\,*} \pm 13.96$	$71.2^{d\,*} \pm 9.29$	$69.16^{d\,*} \pm 13.89$
Mean live weight (g)	$212.76^{d} \pm 23.51$	$269.04^{c} \pm 7.17$	$293.12^{b} \pm 14.45$	$322.72^{a} \pm 10.99$	$316.56^{a} \pm 22$	$318.6^{a} \pm 13.64$

The average values of the same line indexed of the same letters are not different with the test LSD ($P < 0.05$)

The average values of the same column indexed of the same signs are not different with test LSD ($P < 0.05$)

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Table IV : Body proportions of snails according to the content of powder of egg shell of the breeding substratum

Variables	S_0 (0% egg shells)	$S_{\text{Œ}5}$ (5% egg shells)	$S_{\text{Œ}10}$ (10% egg shells)	$S_{\text{Œ}20}$ (20% egg shells)	$S_{\text{Œ}30}$ (30% egg shells)	$S_{\text{Œ}40}$ (40% egg shells)
Shells Producer (%)	$37.10^{b\text{¤}} \pm 1.6$	$38.21^{b\text{¤}} \pm 3.09$	$40.38^{b\wedge} \pm 3.6$	$41,86^{b\wedge} \pm 3,37$	$43,71^{b*} \pm 1,92$	$45,30^{b+} \pm 1,9$
Soft fabrics (%)	$54.20^{a+} \pm 2.2$	$54.17^{a+} \pm 2.22$	$53.42^{a+*} \pm 2.18$	$51,99^{a*} \pm 3,93$	$50,21^{a\wedge} \pm 3,61$	$48,64^{a\text{¤}} \pm 1,67$
Loss related to the preparation (%)	$8.66^{e+} \pm 1.6$	$7.61^{e+} \pm 2.62$	$6.19^{e*} \pm 2.37$	$6,16^{e*} \pm 2,6$	$6,09^{e*} \pm 2,29$	$6,06^{e*} \pm 1,86$
Pedal mass (%)	$28.80^{c+} \pm 2.7$	$28.75^{c+} \pm 2.05$	$28.49^{c+} \pm 1.40$	$28,19^{c+*} \pm 2,96$	$27,71^{c+*} \pm 2,30$	$26,96^{c*} \pm 3,86$
Visceral mass (%)	$25.60^{d+} \pm 3.1$	$25.42^{d+} \pm 2.62$	$24.93^{d\text{¤}} \pm 1.62$	$23,79^{d+*} \pm 4,05$	$22,50^{d*} \pm 2,62$	$21,68^{d*} \pm 4,04$

The average values of the same line indexed of the same letters are not different with the test LSD ($P < 0.05$)

The average values of the same column indexed of the same signs are not different with test LSD ($P < 0.05$)

4 - DISCUSSION

The results of this study show that the composition of the substratum on which lives the snails, has a real influence on its growth performances. These results corroborate those of Jess, (1989) who showed that the snail draws approximately 40% of its nutriments on the ground. Compost amended with powder of hen's egg shell is a breeding substratum that can improve the growth performances of *Archachatina marginata* during this experiment. The increase of the concentration of the powder of egg shell in the substratum involved the improvement of the ponderal and shelly growth of this snail. Egg shell of hen is a significant source of calcium, a mineral used by snail for the production of its shell (Crowell, 1973; Ireland, 1991). It is rightly that these animals are mostly encountered on grounds rich in calcium (Hotopp, 2002; Memel *et al.,* 2011). The results of this study show that calcium present in hen egg's shell is bio-available for *A. marginata*. Indeed, according to Cuif (2008), there are two principal forms of limestone with the same chemical composition ($CaCO_3$) but of different crystalline organizations: calcite and aragonite. This author thinks that the crystalline organization of hen egg shell is calcite.

The optimal rate of powder of egg shells in the substratum having supported a better growth is 20% with a calcium content of 7, 77 %. Beyond 20%, the increase in this calcic source up to 40% in the breeding substratum did not present any significant additive effect on the growth of this snail. Calcium is certainly, an element essential for the growth of snails but, it would not be the only responsible for the growth observed on the substrata. Indeed, according to Gomot *et al.* (1986), some minerals in particular magnesium and other substances present in the organic matter, can also be factors of stimulation of snails growth.

Although the increase in the rate of amendment of the substratum in powder of egg shells made it possible to improve the performances of growth of *A. marginata,* this amendment seems to be harmful for the survival of the young snails.

The mortality of these snails would be caused by the thin membrane which papers the interior of the egg shell. Indeed, this membrane would be toxic for snails because after its decomposition in the substratum, mortalities decrease.

The snail is a significant source of protein appreciated by the African populations for the quality of meat they get. The part of the body generally consumed is the pedal mass that involves the head, the foot and the coat.

The shell and the visceral mass (digestive gland, gonads, gland of albumin, liver, pancreas, genital apparatus, heart and kidney) can be according to Otchoumou (2005), revalorized in animal nutrition.

The investigation carried out on the quantity of meat produced by snails according to their breeding substratum, revealed a variation of the body proportions of these animals according to the content of the substratum in calcium. Thus, the increase in the powder rate of hen's egg shells in the breeding substratum involved an increase in the shelly proportion. That suggests that an excess of bio-available calcium in breeding *of Archachatina marginata* has as consequence, an excessive production of shell as detriments to flesh production. These results corroborate those of Otchoumou and *al*. (2011) who reported that an increase in food calcium has as a consequence the increase in the shelly proportion as detriments to pedal and visceral mass for *Achatina achatina* and *Archachatina ventricosa*. Indeed, according to Brisson, (1968), at the moment of the laying, the embryo of *Archachatina* or *achatina* presents already a shell spiral but extremely very fragile. This shell is then fattened by development of péristracum under which are dropped gradually the limestone's layers of ostracum and mother-of-pearl. Although the proportions of flesh decrease with the increase in the rate of calcium in the substratum, the most significant quantities of meat were presented by snails having the highest live weights.

The proportions of meat obtained starting from snails produced during this experiment (26.96 to 28.8%) remain lower than that *of Achatina achatina* presented by Otchoumou (2010) who found 33% in a similar experiment. This difference between our results suggests that the body proportions of snails vary not only according to the species but also according to the conditions of breeding.

5 - CONCLUSION

The egg shells of the hen (Gallus gallus), products of human consumption, have been found to be important in African giant snails breeding. Thus, the revalorization of this source of calcium would be a contribution to the maintenance of our environment because these elements belong to urban garbage. The optimal rate of amendment of the substratum in this source of calcium adapted to the breeding of *A.marginata* nourished with concentrated food (12.5% of calcium) is 20%. However, to avoid the high mortality that is observed during this experiment another study would be necessary on the conditions of amendment of the substrata.

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