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Interaction on the diet and substrate on the growth of *Archachatina marginata* in breeding

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Abstract

Nine hundred juveniles of *Archachatina marginata* aged about two weeks, with an average live weight of 2.25 g with an average shell length of 20.12mm were monitored in culture for six (6) months on five types of substrates [S_1 (soil collected in a cassava plantation: *Manihot* sp.), S_2 (S_1 with 10% oyster shell meal), S_3 (S_1 with 10% sawdust), S_4 (S_1 with 5% oyster shell meal and 5% sawdust) and S_5 (uncultivated forest soil). Four diets including two industrial (D_1 and D_2 of 12% and 16% calcium respectively) and two based on fodder (D_3 and D_4 based on leaves and fruit of the papaya (*Carica papaya*) on the one hand and a mixture of papaya leaves and taro (*Xanthosoma maffafa*) on the other hand, were used. In order to determine the best combinations inducing the best growth performance, 20 combinations were formed at the rate of 45 spat for each combination; three replicas of 15 spat each. This study showed that the combination of diet and livestock substrate influences the growth of *Archachatina marginata*. Although the best feed is D_1 (74.68 g and 7.94cm) and the best substrate is S_2 (77.12 g and 7.79cm), the best combinations are D_2S_3 (69.37 g and 7.47cm), D_1S_4 (74.68 g and 7.94cm and D_4S_2 (77.12 g and 7.79cm). The combined effect of the high level of dietary calcium and that of the culture substrate does not promote good growth of snails. This work will help improve the production of African giant snails and provide important data for anyone wishing to engage in the breeding of these animals.

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Introduction

Naturally available food resources play a fairly substantial role in populations (Sodjinou *et al.*, 2002). Among these resources, African giant snails (or Achatines) belonging to the family Achatinidae are found there. These snails are highly valued by many African populations (Zongo 1995). For example, Achatine meat is the most consumed meat in South Benin ahead of aulacode, chicken, sheep or goats, beef and pork (Sodjinou *et al.*, 2002). It is estimated that in Côte d'Ivoire, the population eats 7.9 million kg of snails per year, while in Ghana; demand clearly exceeds production capacity (Cobbinah *et al.,* 2008).

Unfortunately, these protein resources are becoming scarce in their natural environment. To compensate for these deficits, heliculture is one of the alternatives to diversify the sources of animal protein of populations. It is therefore right that initiatives to breed these animals should be carried out in order to satisfy the ever-increasing demand for their consumption, but also to ensure the sustainability of the resource. Thus, several research initiatives on the pace of activity, growth (Ejidike *et al.*, Otchoumou *et al.*, 2004; Kouassi *et al.*, 2016), on reproduction (Otchoumou *et al.*, 2005, Kouassi, 2008) as well as on snail farming substrate were supported (Kouassi *et al.*, 2016; Awohouedji *et al.*, 2017). Indeed, the success of such breeding goes beyond the control of the feed, the breeding substrate, the pathology of these animals, but also and above all by a healthy appreciation of the food according to the different types of breeding substrate. Thus, the substrate is a key element for snails as it is both a source of mineral nutrients and a refuge.

In terms of snail production, several studies have shown the effect of feeding (Kouassi *et al.*, 2007, Kouassi, 2002) or farming substrate on the growth and reproduction of these animals by a variation in calcium levels. However, to our knowledge, no studies have yet been devoted to the combined effect of diet and substrate. The objective of this study is to highlight the combined effect of diet and culture substrate on the live weight and growth of the shell of *Archachatina marginata* in order to optimize its rearing. It was therefore necessary to evaluate the combined effect of food and substrate on the weight and shell growth of snails.

Material and method

Study site and animals

This study took place at the school-farm of Jean Lorougnon Guedé University, Côte d'Ivoire from September 2021 to February 2022; i.e a duration of 24 weeks. The average temperature and relative humidity of the rearing environment are respectively 25.5 ± 2.2°C and 90.7 ± 3.8%.

The biological material used in this study consists of snails belonging to a single species (Fig. 1): *Archachatina marginata* (Swainson, 1821). They were born at the farm-school of Jean Lorougnon Guedé University from breeders collected in the South Comoé region, Ivory Coast. About two weeks old, they are free of trauma (shell well formed, well filled and without breakage) and have an average live weight of 2.25 ± 0.1 g for an average shell length of 20.12 ± 0.5mm.

Fig. 1. *Archachatina marginata.*

Breeding substrates

Five types of substrates were used for this study. The first, S1 is the superficial layer (from 0 to 40cm deep) of the soil of a cassava plantation (*Manihot* sp.), a tuber widely cultivated in Côte d'Ivoire. The choice of this soil is linked to the fact that the breeding of snails will only be done on soils already exploited and certainly by the practice of cassava cultivation. The second substrate (S_2) is a mixture of 90% of the S_1 substrate and 10% of oyster shell flour (Table 1). The third, (S_3) is a mixture of 90% S_1 and 10% sawdust of wood. The fourth, (S_4) is a mixture of 90% S_1 with 5% oyster shell flour and 5% sawdust of wood. Substrate S_5 is the superficial layer (from 0 to 40cm deep) of the soil of a fallow forest at Jean Lorougnon Guedé University, control soil.

Foods

Four types of food were used in this study. The first two (D_1 and D_2) are industrial foods formulated in the form of flour with varying levels of calcium (Table 2). The D_3 and D_4 diets are composed of chlorophyllous foods. They are the result of a mixture of papaya leaves and fruits (*Carica papaya*) on the one hand (D_3) and a mixture of papaya leaves and *Xanthosoma maffafa* leaves on the other hand (diet D_4).

Methodology

A total of 900 *A. marginata* juveniles were used in this study which lasted 24 weeks; from September 2020 to February 2021. Sixty batches of 15 snails each were formed for all 20 combinations (4 diets x 5 substrates), i.e three repetitions per combination. These batches are placed in brick bins witch area is 1 m² for 0.5 m³ of volume (Fig. 2) to assess zootechnical performance related to food and/or rearing substrate. Fitted with a mosquito net-type lid constituting the anti-leakage device and allowing the animals to ventilate, the interior of the bins is made up of various substrates prepared for this purpose at a thickness of 10cm. The animals are regularly watered and fed ad libitum every two days. Every two weeks, they are weighed using an electronic pocket scale of 0.01 g precision. Shell length is determined using a 0.01mm precision electronic caliper and mortality is also noted.

Fig. 2. Breeding pen.

Chemical analysis

The substrates used in this study were the subject of a chemical analysis by SODEMI (Société pour le Développement Minier de la Côte d'Ivoire). Minerals such as iron, aluminum, calcium and magnesium were determined by the method of chemical determination of oxides of major elements. Copper and zinc were determined by the determination of base metals using an atomic absorption spectrophotometer. The organic matter of the substrates was dissolved in 50% hydrogen peroxide and the different proportions were determined according to the formula [(Pi-Pf) x100/Pi].

with:

Pi= weight in grams of the dry sample before treatment with hydrogen peroxide.

Pf= weight in grams of the dry sample after treatment with hydrogen peroxide

Statistical analyzes and expression of results

The R software and Microsoft Excel 2007 made it possible to carry out the various statistical treatments. Descriptive statistics were used to characterize the value of foods and substrates. As for the R software, it was used to discriminate between the different combinations of rearing substrates and food. The weight and shellfish growths are estimated from the average daily growth every two weeks and expressed by the average weight growth (g/d), the average shellfish growth (mm/d). Cumulative mortality is also calculated according to the formulas:

Average weight gain (CP)

$$CP = \frac{Pf - Pi}{Tf - Ti} \quad (1)$$

Pi: Initial average live weight
Pf: Final average live weight

Ti: Initial time in days

Tf: Final time in days

Average shellfish growth (CC)

$$CC = \frac{Lf - Li}{Tf - Ti} \qquad (2)$$

Li: Mean initial shell length

Lf: Mean final shell length

The cumulative mortality rate (MC) is obtained according to the formula

$$MC = \frac{Nam}{Nta} x100 \qquad (3)$$

Nam: Total number of dead animals

Nta: Total number of animals experimented

Results

Composition of rearing substrates and nutritional value of feed

The chemical analysis of the different substrates (Table 1) indicates that the substrates are rich in aluminum oxide (3.43-4.57%) and iron oxide (2.68-3.31%). On the other hand, the substrates are poor in copper (trace), in zinc (0.003-0.004%) and in magnesium oxide (0.03-0.09%). The rates of calcium oxide and organic matter are variable respectively between 0.04 and 4.6% and between 1.21 and 10.81%. The S_2 substrate is the richest in calcium oxide while the S3 substrate is the richest in organic matter.

Table 1. Composition of substrates Tableau.

Component	Substrate 1 (S_1)	S_2	S_3	S_4	S5
Cultivated ground	100	90	90	90	0
Forest ground	0	0	0	0	100
Powder of oyster	0	10	0	5	0
Sawdust	0	0	10	5	0
Chimic analysis					
AlO3	4,57	4,32	4,3	4,26	3,43
Fe2O3	3,31	2,82	3,32	2,92	2,68
CaO	0,08	4,6	0,12	2,48	0,04
MgO	0,04	0,09	0,04	0,07	0,03
Zn	0,003	0,004	0,004	0,004	0,004
Cu	Trace	Trace	Trace	Trace	Trace
Organic matter	1,22	1,21	10,81	5,68	6,04

The nutritional value of the foods used in this study (Table 2) reveals that the D_1 and D_2 foods produced in the laboratory have a high rate of minerals (38.43 and 43.35%) than the D_3 and D_4 foods composed of leaves and fruits (2.37 & 11.15%). The levels of phosphorus (0.1 to 1.2%), potassium (0.82 to 1.08%), sodium (0.34 to 0.52) and cellulose (2.41 to 4.76) are more or less of the same order in all foods. On the other hand, the levels of calcium (0.33 to 16.01%), protein (4.67 to 17.48%) and fat (1.5 to 4.71%) vary greatly from one food to the other.

Table 2. Composition of the experimental diet.

Ingredients	Diet 1 (D1)	Diet 2 (D2)	Diet 3 (D3)	Diet 4 (D4)
Fresh pawpaw leaves	0	0	50	50
Fresh xanthosoma leaves	0	0	50	0
Fruit of pawpaw	0	0	0	50
maïze	19,3	9,7	0	0
Coton	16	15,7	0	0
Soja graine	16	15,7	0	0
Blé tendre	15	14,7	0	0
Phosphate of calcium	4	4	0	0
Complexe of vitamins	0,5	0,5	0	0
Powder of shell oyster	28,7	39,2	0	0
NaCl	0,1	0,1	0	0
Oligot-elements	0,4	0,4	0	0
Total (g)	100	100	100	100
Analysis content				
Ash	38,43	43,35	2,37	11,15
Ca	12,02	16,01	0,33	0,84
Phosphore	1,2	1,19	0,71	0,1
Potassium	1,02	1,04	0,82	1,08
Sodium	0,37	0,34	0,47	0,52
Crude cellulose	4,76	4,67	2,41	2,53
Protein	17,48	17,14	4,67	5,67
Fat	4,71	4,61	1,5	1,83

Feeding and growth of A. marginata

The Figures of plate 1: a_1, b_1, c_1, d_1, and e_1 on the one hand and a_2, b_2, c_2, d_2 and e_2 on the other hand, show respectively the weight growth and the shell growth of the snail *Archachatina marginata* submitted to four types of food according to the different substrates. The effect induced by food on the weight and shell growth of *A. marginata* snails is revealing and variable from one substrate to another.

The analysis of these graphs shows that on substrates poor in calcium (S_1, S_3 and S_5), the best foods are those which are rich in calcium (D_1 and D_2). On the other hand, on S_2 and S_4 substrates, rich in calcium, the best foods are D_1. & D_4.

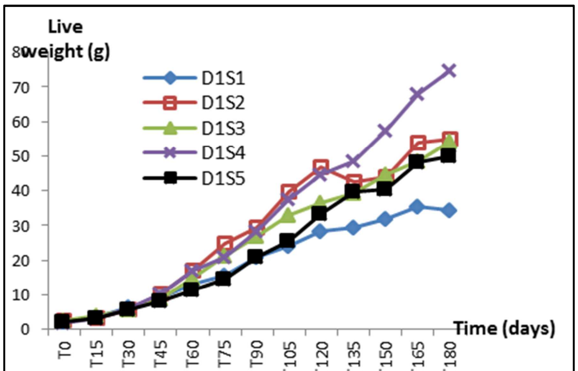
Basic statistics reveal that the best food among those tested is food D_1 (Table 3). Food D_1 induced the best average weight and shell growth (26.03 g and 4.83cm) followed by D_2 (21.07 g and 4.63cm), D_4 (18.84 g and 4.01cm) and D_3 (15.87 g and 4.07cm).

Statistical analysis by comparing the average weight and shell growths induced reveals a significant difference between food D_1 and foods D_3 and D_4. There is, however, no statistical difference between D_1 and D_2, as well as between D_3 and D_4. The average mortality is relatively low and is between 0.48% (food D_3) and 0.18% (food D_1). Animals subjected to D_3 recorded the highest mortality rate (0.48%).

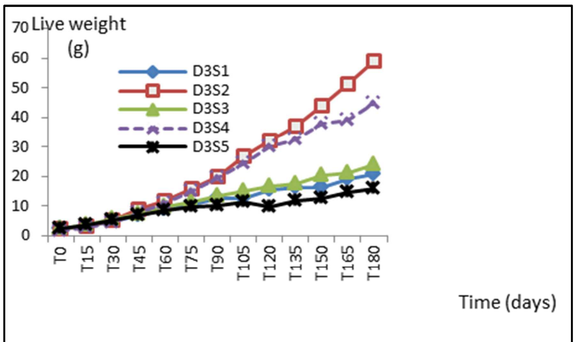
Table 3. Elementary statistics relating to the diet.

	Live weight				Shell length				Mortality			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
Number of data	65	65	65	65	65	65	65	65	65	65	65	65
Mean	26,03[a]	21,07[ab]	15,87[b]	18,05[b]	4,83[a]	4,63[a]	4,07[b]	4,01[b]	0,18[b]	0,22[b]	0,48[a]	0,2[b]
Standar deviation	18,74	14,76	12,76	18,84	1,61	1,35	1,24	1,51	0,43	0,48	0,85	0,51
Minimum	1,76	1,78	1,8	1,67	2,01	2	2	1,97	0	0	0	0
Maximum	74,68	69,37	59,23	77,12	7,94	7,47	7,06	7,79	2	2	3	2

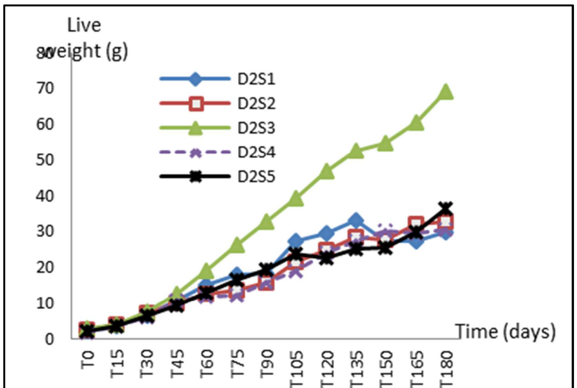
The mean of the same growth parameter indexed by the same letter are not statistically different (p<0,05)



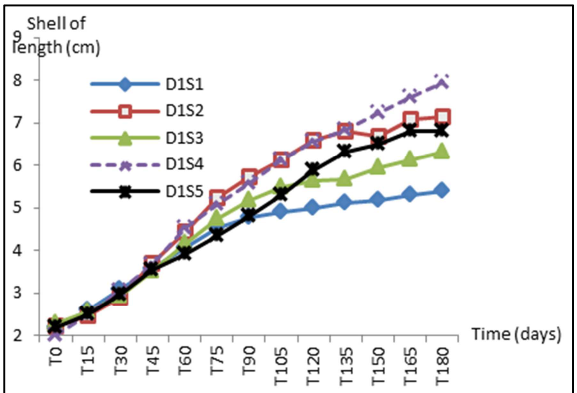
a3: Ponderal growth of *A. marginata* bred with D1 according to the substrate



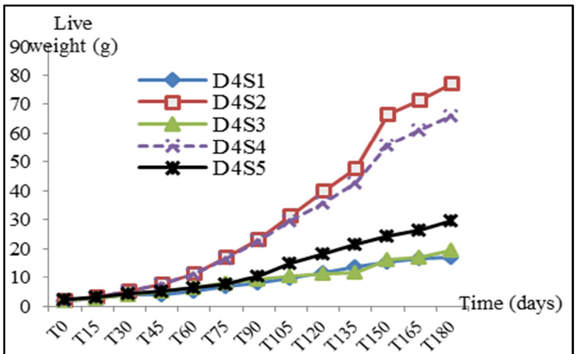
c3: Ponderal growth *of A. marginata* bred with D3 according to the substrae



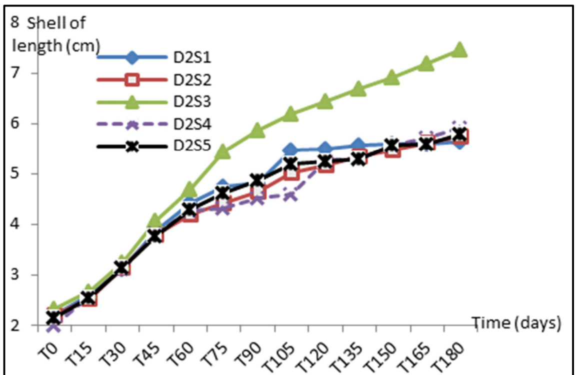
b3: Ponderal growth *of A. marginata* bred with D2 according to the substrate



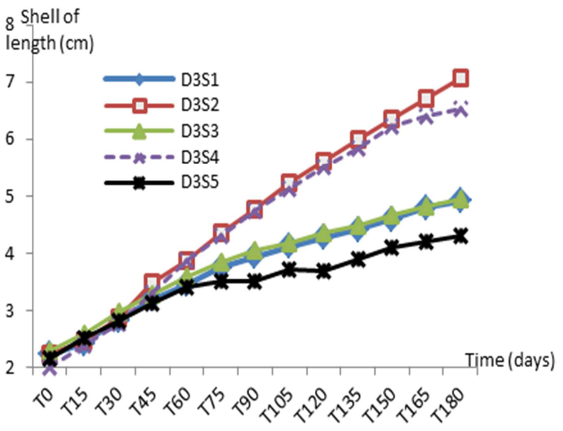
a4: Shell growth of A. *marginata* bred with D1 according to the substrate



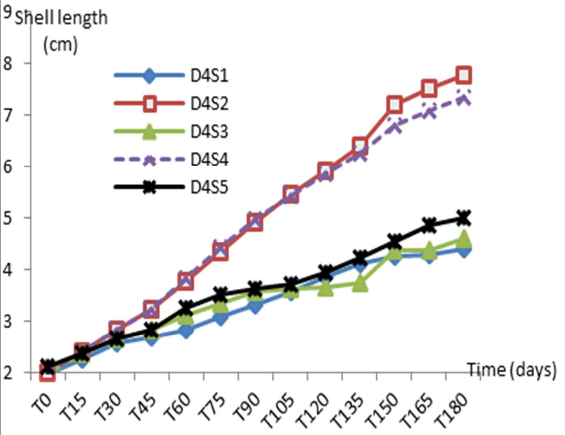
d3: Ponderal growth of *A. marginata* bred with D4 according to the substrate



b4: Shell growth of *A. marginata* bred with D2 according to the substrate



c4: Shell growth of *A. marginata* bred with D3 according to the substrate



d4: Shell growth of *A. marginata* bred with D4 according to the substrate

Fig. 2. Effect of the rearing substrate on the weight and shell growth of *A. marginata*.

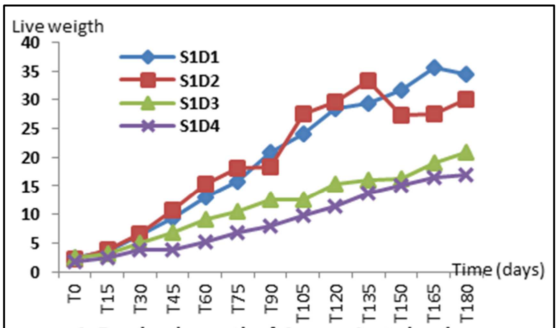
Breeding substrate and growth of A. marginata

In order to ensure the effect induced by the breeding substrate on the growth of snails, the weight and shell growth of *A. marginata* was evaluated according to five types of substrates (Plate 2). Weight growth (a_3, b_3, c_3 and d_3) and shell growth (Fig. a_4, b_4, c_4 and d_4) varies from one substrate to another. The temporal analysis of the different graphs indicates a clear demarcation between the substrates when the animals are subjected to vegetarian diets. The best substrates that emerge from this are S_2 and S_4. On the other hand, the S_3 substrate, rich in organic matter, appears to be the best when the snails are fed with the D_2 food having the highest calcium content.

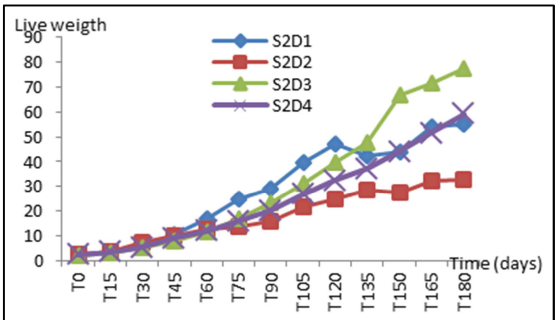
The best substrates are in the order of S_2 (25.59 g and 4.8cm) > S_4 (24.46 g and 4.76cm) > S_3 (20.41 g and 4.31cm) > S_5 (16 .03 g and 4.07cm) > S_1 (14.80 g and 3.99cm) (Table 4). The comparison of the means with the R software reveals a statistical difference between the growth of the snails reared on substrate S_2 and those reared on S_1 and S_5. However, there is no difference in growth between the animals of the S_2, S_3 and S_4 substrates. Also, the cumulative average mortality of snails reared on S_1 (0.5%) and S_5 (0.62%) substrates seems high compared to that of animals on S_4 (0%), S_3 (0.21%) substrates. and S_2 (0.02). The lowest mortality was recorded on the S_4 substrate (0%).

Table 4. Statistiques élémentaires relatives au substrat.

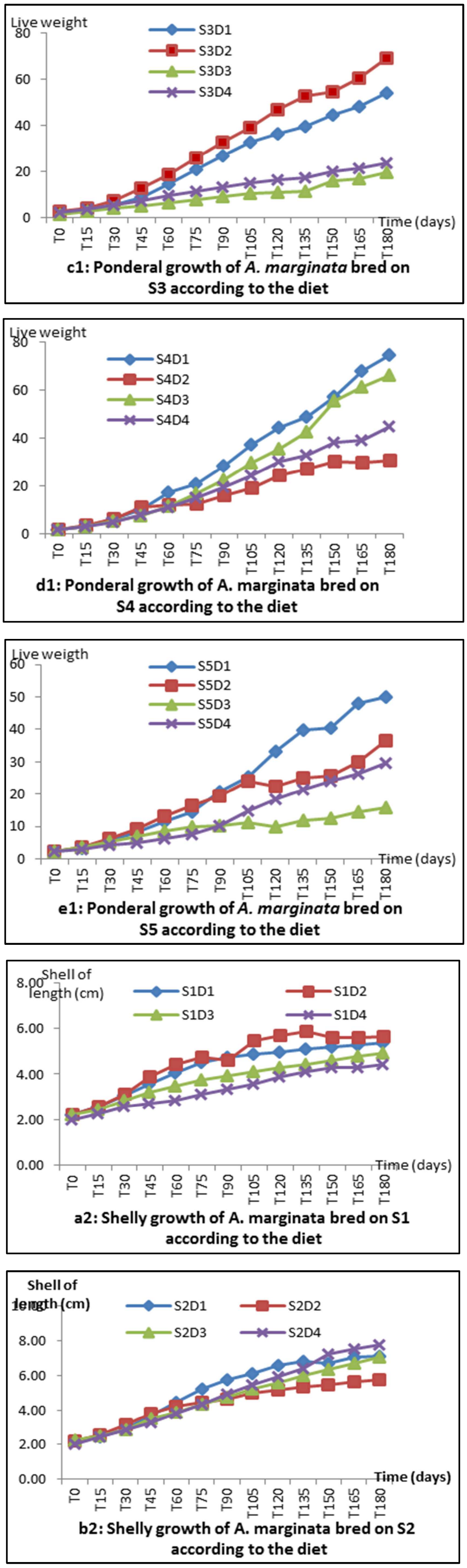
	Live weight					Shell length					Mortality				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Number of data	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
Mean	14,8^{b}	25,59^{a}	20,41^{ab}	24,46^{a}	16,03^{b}	3,99^{b}	4,8^{a}	4,31^{ab}	4,76^{a}	4,07^{b}	0,5^{a}	0,02^{bc}	0,21^{b}	0c	0,62^{a}
Standar deviation	9,94	20	17,6	19,6	12,3	1,11	1,7	1,44	1,7	1,26	0,8	0,14	0,6	0	0,79
Minimum	1,77	1,77	1,67	1,98	2,24	1,98	2	1,97	2	2;11	0	0	0	0	0
Maximum	35,6	77,12	69,47	74,7	49,9	5,88	7,8	7,47	7,9	6,81	3	1	2	0	3



a1: Ponderal growth of *A. marginata* bred on S1 according to the diet



b1: Ponderal growth of *A. marginata* bred on S2 according to the diet



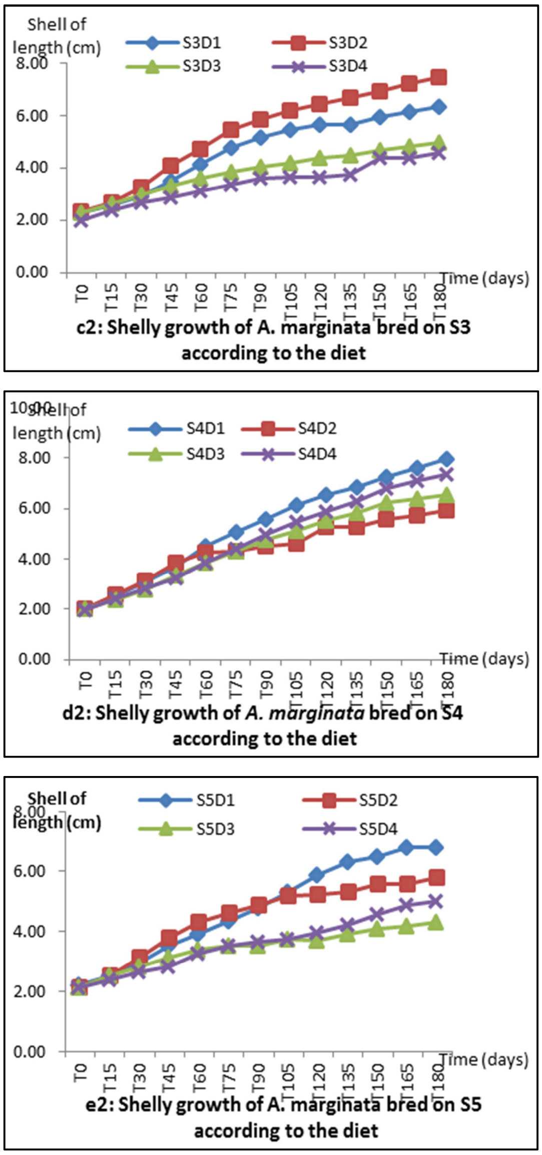
c1: Ponderal growth of *A. marginata* bred on S3 according to the diet

d1: Ponderal growth of A. marginata bred on S4 according to the diet

e1: Ponderal growth of *A. marginata* bred on S5 according to the diet

a2: Shelly growth of A. marginata bred on S1 according to the diet

b2: Shelly growth of A. marginata bred on S2 according to the diet



c2: Shelly growth of A. marginata bred on S3 according to the diet

d2: Shelly growth of *A. marginata* bred on S4 according to the diet

e2: Shelly growth of A. marginata bred on S5 according to the diet

Fig. 1. Effect of the diet on the weight and shell growth of *A. marginata*.

Interaction between food and rearing substrates on the growth of A. marginata

The characteristics of the growth of *Archahchatina marginata* under the combined effect of food and rearing substrate are recorded in Table 5.

A careful analysis of this table reveals that after six months, the final weight and shell length of the snails vary respectively between 15.7 g (D_3S_5) and 77.12 g (D_4S_2) and between 4.3cm (D_3S_5) and 7.94cm (D_1S_4) for an average mass between 8.86 g (D_4S_1) and 32.96 g (D_2S_3). Daily weight gain fluctuates between 0.08 g/d (D_3S_5) and 0.49 g/d (D_4S_2). As for shellfish growth, it fluctuates between 0.013cm/d (D_3S_5) and

0.035cm/d D_1S_4). The four best weight increases were obtained in order with the combinations: D_4S_2 (0.449 g/d), D_1S_4 (0.434 g/d), D_2S_3 (0.397 g/d), and D_4S_4 (0.384 g/d). On the other hand, the best shell growth was obtained in the order of the combinations D_1S_4 (0.035cm/d), D_4S_2 (0.034cm/d), D_4S_4 (0.032cm/d) and D_2S_3 (0.031cm/d). Thus, out of a total of 20 combinations, four turn out to be more favorable for good snail growth. The combinations not favorable to good snail growth are in the order of D_3S_5 (0.080 g/d and 0.013cm/d), D_4S_1 (0.090 g/d and 0.015cm/d), D_4S_3 (0.106 g/d and 0.016cm/d), D_3S_1 (0.110 g/d and 0.016cm/d) and D_3S_3 (0.127 g/d and 0.016cm/d). These combinations are characterized by an absence of minerals, in particular calcium, both in the feed and in the substrate.

Table 5. Parameters of growth according to combinations diet & substrate.

	Parameters								
	Initial weight (g)	Final weight (g)	Average weight (g)	Daily average ponderal growth (g/day)	Initial length of shell (cm)	Final length of shell (cm)	Average length of shell (cm)	Daily average shell growth (cm/day)	Avarage mortality (%)
D1S1	2.33^{a}	34.33^{gh}	19.58^{cdef}	0.190^{fghi}	2.20^{a}	5.38^{efgh}	4.28^{abcdef}	0.019^{bcdef}	0.154^{cd}
D1S2	2.47^{a}	54.93^{de}	28.85^{abc}	0.312^{bcde}	2.23^{a}	7.14^{abcd}	5.16^{a}	0.029^{abcde}	0.000^{d}
D1S3	2.50^{a}	54.13^{de}	26.17^{abc}	0.307^{cde}	2.29^{a}	6.33^{bcdef}	4.66^{abcd}	0.024^{abcdef}	0.154^{cd}
D1S4	1.76^{a}	74.68^{ab}	32.18^{a}	0.434^{ab}	2.01^{a}	7.94^{a}	5.29^{a}	0.035^{a}	0.000^{d}
D1S5	2.25^{a}	49.90e^{f}	23.37^{abcde}	0.284^{def}	2.20^{a}	6.81^{abcde}	4.76^{abc}	0.027^{abcdef}	0.615^{b}
D2S1	2.25^{a}	30.08^{h}	19.24^{cdef}	0.166^{ghij}	2.20^{a}	5.65^{defgh}	4.54^{abcd}	0.021^{abcdef}	0.462^{bc}
D2S2	2.40^{a}	32.78^{gh}	14.94^{def}	0.181^{fghi}	2.20^{a}	5.75^{defgh}	4.41^{abcde}	0.021^{abcdef}	0.077^{cd}
D2S3	2.73^{a}	69.37^{bc}	32.96^{a}	0.397^{abc}	2.33^{a}	7.47^{ab}	5.32^{a}	0.031^{abcd}	0.231^{bcd}
D2S4	1.78^{a}	30.68^{h}	17.20^{def}	0.172^{ghij}	2.00^{a}	5.93^{cdefg}	4.39^{abcdef}	0.023^{abcdef}	0.000^{d}
D2S5	2.25^{a}	36.53^{g}	18.02^{def}	0.204^{fgh}	2.15^{a}	5.80^{defgh}	4.47^{abcde}	0.022^{abcdef}	0.308^{bcd}
D3S1	2.38^{a}	20.80^{ij}	11.52^{f}	0.110^{hij}	2.23^{a}	4.92^{fgh}	3.77^{cdef}	0.016^{def}	1.077^{a}
D3S2	2.50^{a}	59.23^{d}	24.57^{abcd}	0.338^{bcde}	2.25^{a}	7.06^{abcd}	4.7^{abc}	0.029^{abcde}	0.000^{d}
D3S3	2.50^{a}	23.83^{i}	12.99^{ef}	0.127^{hij}	2.30^{a}	4.95^{fgh}	3.86^{bcdef}	0.016^{def}	0.154^{cd}
D3S4	1.80^{a}	44.85^{f}	20.86^{bcdef}	0.256^{efg}	2.00^{a}	6.54^{abcde}	4.54^{abcd}	0.027^{abcdef}	0.000^{d}
D3S5	2.33^{a}	15.70^{j}	9.43^{f}	0.080^{j}	2.15^{a}	4.30^{h}	3.47^{ef}	0.013^{f}	1.154^{a}
D4S1	1.77^{a}	16.86^{j}	8.86^{f}	0.090^{ij}	1.98^{a}	4.42^{h}	3.34^{f}	0.015^{def}	0.308b^{cd}
D4S2	1.77^{a}	77.12^{a}	30.98^{ab}	0.449^{a}	2.02^{a}	7.79^{ab}	4.92^{ab}	0.034^{ab}	0.000^{d}
D4S3	1.74^{a}	19.57^{ij}	9.51^{f}	0.106^{ij}	1.97^{a}	4.6^{gh}	3.41^{ef}	0.016^{def}	0.308^{bcd}
D4S4	1.75^{a}	66.22^{c}	27.61^{abc}	0.384^{abcd}	1.98^{a}	7.35^{abc}	4.81^{abc}	0.032^{abc}	0.000^{d}
D4S5	2.24^{a}	29.52^{h}	13.31^{def}	0.162^{ghij}	2.11^{a}	5.02^{fgh}	3.60^{def}	0.017^{cdef}	0.385^{bcd}

The mean of the same growth parameter indexed by the same letter are not statistically different (p<0,05)

The average mortality of the different combinations varies little; between 0% and 1.15%. The highest mortalities were recorded on the D_3S_5 (1.15%) and D_3S_1 (1.08%) combinations

Discussion

Food influences the growth of snails, as evidenced by the results of this study. Also, it emerges from this study that the best foods inducing good growth of snails are industrial foods in the form of flour: D_1 with 12% calcium and D_2 composed of 16% calcium. Indeed, in order to optimize the growth performance of snails, several food preparation initiatives have been initiated (Zongo *et al.*, 1990). Thus, foods D_1 and D_2 have been enriched with nutrients, in particular dietary calcium, and induce good growth in snails. On the other hand, snails are vegetarians in the wild and must seek their nutrients necessary for their growth in several sources. This justifies the weak growth observed in animals fed with a reduced number of plants; here papaya leaves and fruits (*Carica papya*) and taro leaves (*Xanthosoma maffafa*). The results of this study also show that the growth of snails is influenced by the breeding substrate. These results are in agreement with those of Graham, (1978) and Jess and Mark, (1989), who report that the soil not only constitutes a real refuge for snails, but the latter draw about 40% of their nutrients from it. The performances observed seem to be strongly linked to the level of calcium and magnesium. Indeed, the best snail growth was obtained on S_2 and S_4 substrates, rich in calcium and magnesium.

These results agree with those of Chevalier, (1992) and Ebenso, (2003) who noted that snails like ferralitic and/or limestone soils rich in water. Also, magnesium is involved in several essential enzymatic reactions, in particular in the production of energy. It acts in balance with other minerals, such as calcium or potassium (Graham, 1978).

Although food D_1 and substrate S_2 are the best food and substrate in the present study, the best combinations inducing good growth of snails are D_1S_4, D_2S_3, D_4S_2 and D_4S_4 and not D_1S_2. This result suggests an interaction between the minerals of the substrate and those of the food in the sense of a complementation of the rate of dietary calcium and that of the substrate. Feed with high calcium content (16%) is compatible with a substrate rich in organic matter (D_2S_3) and feed with moderate calcium content (12%) is better suited to a substrate with moderate calcium content; witness the growth observed at the level of the D_1S_4 and D_4S_2 combinations. This complementation seems to admit a limit beyond which the calcium content proves to be toxic or inhibiting the growth of *A. marginata* (D_2S_2, combination rich in calcium but inducing weak growth 14.94g and 4.41cm). These results are in agreement with those of Aman, (2011) and Bouye, (2017), which limit the calcium level of substrate amendment to 6.23% for a diet of 12% calicum. In addition, our results indicate better daily growth performance in *A. marginanta* than conventional above-ground breeding in buildings or under shade without calcium amendment of the substrate. Indeed, after 24 weeks of experimentation, the D_1S_4, D_2S_3, D_4S_2 and D_4S_4 combinations gave better weight and shellfish growth than those obtained by Kouassi and Aman, (2014), certainly thanks to the combined effect of food nutrients and those of the rearing substrate. Also, daily weight and shellfish growths are better than those obtained by Otchoumou *et al.*, (2003) on substrates amended with different sources of calcium.

Conclusion

The study on the interaction of diet and culture substrate on the growth of *Archachatina marginata* snails in the rearing environment revealed that a calcium-rich feed is suitable for better growth of snails on a substrate rich in organic matter. On the other hand, on a substrate rich in calcium, a plant-based diet (low in calcium) is needed for good growth of snails. The accumulation of calcium in the feed and in the substrate is to be avoided in the case of the breeding of giant snails because inhibits the growth of these animals.

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