

# Growth Performance of *Archachatina Marginata* Bred on the Substrate Amended with Industrial Calcium: Mikhart

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**Abstract:** This study aims to improve growth and meat production of snail *Archachatina marginata* bred on substrates amended with Mikhart an industrial source of calcium. Spats of approximately one week old were reared for 80 weeks on six types of substrates amended with Mikhart at different doses (0, 5, 10, 20, 30 and 40%). During the rearing period, snails were individually weighed and measured every two weeks. At the end of the breeding period, proportions of the different parts (tissue and shell) have been determined. The best growth weight (0.64 g/d) and shell production (0.28 mm/d) were recorded on the substrate containing 30% of the calcium source (Mikhart). There is an improvement in the snails' growth rate with an increase in Mikhart rate in the culture substrate until a Mikhart incorporation 30% beyond which a decrease of both growth and meat production are observed. In addition, the mortality rate decreased with the augmentation on the calcium content of the substrate.

**Keywords:** *Archachatina marginata*, Calcium, Meat, Mikhart

## 1. Introduction

The expansion process of the snail shell is based on an organ of growth located in the parietal part of the bead [1]. Development of soft tissue occurs only if the shell grows. So, expansion of shell affects the development of the soft tissues of the snail [1]. The shell of this animal consists essentially of calcium carbonate crystals taken from the soil and the food [2]. The snail uses calcium to develop its shell and for the calcification of eggs. When reared, this mineral appears thus indispensable not only for making their diets but also in the preparation of farmed substrates [3], [4]. Indeed, the snail draws about 40% of his nutrients in the soil on which it lives; by foot sole [5]. However, to date, no comprehensive study has been conducted yet on the minimum calcium content of the substrate that would ensure the effective reduction of the development cycle of African giant snails in captivity.

If the snail meat is valued and increasingly consumed by Ivoirians, it is partly because of its fragrance and its flavor [6]. Moreover, this meat contains some important nutritional qualities. Indeed, it is an important source of protein, amino acids (lysine, phenylalanine and leucine), energy and minerals [2], [7]. However, the flesh of these mollusks contains very low quantities of lipid. It is rightly recommended in dietary poor in lipid [8]. The portion of meat traditionally consumed in West Africa accounts for only about one third of the slaughter weight of the giant snail [3], [1]. The breeding of African giant snails stayed little practiced in Ivory Coast, the challenge for research nowadays is to determine techniques and processes not only to produce large animals sizes in few time but also animals with a high proportion of meat.

## 2. Material and Method

### 2.1 Site of the study and breeding substrates

This study was conducted at Achatina farm of Nangui Abrogoua University.

Six types of breeding substrates were formed by varying the proportion of Mikhart (industrial source of calcium) in a control substrate ( $S_0$ ) that is the soil collected in the forest of the University (a rainforest). Soil samples were taken between the surface soil and 12 cm depth. Breeding substrates were constituted as follows:

- $S_0$  : 15kg of raw soil only
- $S_{Ca5}$  :  $S_0$  + 5% of Mikhart
- $S_{Ca10}$  :  $S_0$  + 10% of Mikhart
- $S_{Ca20}$  :  $S_0$  + 20% of Mikhart
- $S_{Ca30}$  :  $S_0$  + 30% of Mikhart
- $S_{Ca40}$  :  $S_0$  + 40% of Mikhart

### 2.2 Determination of Chemical Composition of Substrates

The chemical composition of livestock substrates was determined by PETROCI company (Ivory Coast Oil Company), using the method of the Broadcast Energy Spectrometry (BSE). Three samples of each substrate were collected and then finely ground and uniformly spread on a carbon pad adhesive. These samples were subsequently observed under the electron microscope equipped with an X-ray detector. This latter is calibrated to a probe diameter from 30 to 120 mm and a power sensor 20 to 25 kilo-electron

volts. To identify the chemical composition of the elements, the device performs a measurement of the transition energy of the electrons in the electron clouds of the K series; L and M atoms of the sample. The results are then transferred to a usable Excel file. The acquisition of the chemical composition is performed on several different areas of the sample and the result is given with a standard deviation.

### 2.3 Breeding Techniques and Growth Control

One week old specimens of *Archachatina marginata* with an average live weight of  $1.44 \pm 0.23$  g and an average shell length of  $19.1 \pm 1.9$  mm were divided randomly into the six groups and reared on the six different types of substrates. There were three replicates per substrate. These snails were reared at a density of 25 individuals / m<sup>2</sup>.

The tanks of livestock are randomly arranged on shelves in a breeding room at a mean temperature of  $28 \pm 2^\circ\text{C}$  and a humidity of  $82 \% \pm 5$ . They were watered twice a day (morning and evening) and fed daily with a composite food containing mainly cereal flour. Characteristics of this food are presented in Table I [3]. The substrates were regularly cleaned of refusal food and animal feces. To assess the growth performance of snails, they were weighed every two weeks with a Sartorius balance which has 0.1 g accuracy. The shells length is measured using a caliper with 0.1 mm accuracy. Mortalities were recorded daily. The measurements of weight and lengths of shells were used to determine the mean of daily weight gain (g/d/snail) and mean daily shell growth (mm/d/snail).

**Table 1:** Composition and characteristics of concentrated diet

Composition of concentrate diet: raw material (g / 100g)									
Maze	Cottonseed meal	Soybean	Soft Wheat	phosphate bicalcique	Vitamin complex	Calcium carbonate	salt	Trace elements	Total
19.3	16	16	15	4	0.5	28.7	0.4	0.1	100

Caractéristiques de l'aliment concentré en % de matière sèche											
Dry matter	Mineral matter	Organic matter	Energy	calcium	Phosphorus	Potassium	Sodium	Cellulose	Crude protein	Sugar	Fat
81.07	33.43	47.64	2.79	12.02	1.2	1.02	0.37	4.76	17.48	3.1	4.71

### 2.4 Determination of Snails Meat Yield

After 80 weeks of rearing, thirty snails were taken randomly from each substrate to estimate the quantity of meat. After 24 hours of starvation, the selected snails were marked, measured and weighed before being euthanized by scalding (immersion in boiling water for 15 min). After cooling, the soft tissues were removed from the shells, and then placed on the mesh in order to be drained. The Empty shells were also drained and dried in open air for 30 minutes.

The foot was then separated from the visceral mass. For each snail, the weight of all flesh, the weight of the empty shell and that of the foot and visceral mass were determined. The proportions of different part of body produced on each type of substrate were calculated using the following formulas:

- % Empty shell =  $\frac{\text{weight of empty shell}}{\text{live weight of the snail}} \times 100$
- % visceral mass =  $\frac{\text{weight of visceral mass}}{\text{live weight of the snail}} \times 100$
- % soft tissue =  $\frac{\text{weight of soft tissue}}{\text{live weight of the snail}} \times 100$
- % foot =  $\frac{\text{weight of foot}}{\text{live weight of the snail}} \times 100$

### 2.5 Statistic Analysis

The homogeneity of the 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 treatments. LSD test was also applied to compare the means when no difference was detected by ANOVA.

Levene test was used to compare the mineral and organic composition of substrate. Correlation analysis was also conducted between snail parts proportions and the calcium contents of substrate.

## 3. Results

The rates of minerals other than calcium and organic matter show little variation from one substrate to another (Table 2). The calcium and organic matter in these substrates range respectively, from 0.17% (S<sub>0</sub>) to 22.03% (S<sub>Ca40</sub>) and from 61.01% (S<sub>Ca40</sub>) to 79.4% (S<sub>0</sub>). All substrates have their contents in organic matter higher than 50%. The content of this compound is similar between S<sub>0</sub> (79.4%) and S<sub>Ca5</sub> (78.8%) but statistically higher than those of the remaining substrates. Concerning calcium content, the substrates S<sub>0</sub> and S<sub>Ca5</sub> are statistically different from the others by their low levels of calcium (0.17% and 2.57% for S<sub>0</sub> to S<sub>Ca5</sub>).

The highest value is obtained on S<sub>Ca40</sub> (22.03%). Contents in calcium were not significantly different between S<sub>Ca20</sub> and S<sub>Ca30</sub>. After 80 weeks of breeding, snails live weights were between 214.g and 358 g with a daily weight growth ranging from 0.48 (S<sub>0</sub>) to 0.64 g/d/snail (S<sub>Ca30</sub>) (table 3). The average daily weight gain is lower on the soil S<sub>0</sub> than those on substrates amended with industrial calcium. The final mean lengths of snail shells vary between 112 mm (S<sub>0</sub>) and

**Table 2:** Chemical composition of substrates

Substrates	Minerals (%)						Organic matter (%)
	Magnesium	Aluminium	Calcium	Iron	Potassium	Silicon	
S <sub>0</sub>	0.12 <sup>a</sup> ± 0.01	2.41 <sup>a</sup> ± 0.2	0.17 <sup>f</sup> ± 0.03	1.78 <sup>a</sup> ± 0.06	0.05 <sup>a</sup> ± 0.02	13.9 <sup>a</sup> ± 2.3	79.4 <sup>a</sup> ± 4.9
S <sub>Ca5</sub>	0.14 <sup>a</sup> ± 0.02	2.05 <sup>a</sup> ± 0.7	2.57 <sup>e</sup> ± 0.1	1.04 <sup>a</sup> ± 0.1	0.1 <sup>a</sup> ± 0.05	13.1 <sup>a</sup> ± 2.8	78.8 <sup>a</sup> ± 5.1
S <sub>Ca10</sub>	0.16 <sup>a</sup> ± 0.03	1.99 <sup>a</sup> ± 0.6	14.84 <sup>b</sup> ± 0.56	1.24 <sup>a</sup> ± 0.08	0.09 <sup>a</sup> ± 0.04	12.9 <sup>a</sup> ± 4.1	67.5 <sup>b</sup> ± 3.9
S <sub>Ca20</sub>	0.17 <sup>a</sup> ± 0.4	2.18 <sup>a</sup> ± 0.4	17.5 <sup>ba</sup> ± 2.7	1.15 <sup>a</sup> ± 0.2	0.07 <sup>a</sup> ± 0.06	12.3 <sup>a</sup> ± 3.3	65.2 <sup>b</sup> ± 4.4
S <sub>Ca30</sub>	0.18 <sup>a</sup> ± 0.02	2.08 <sup>a</sup> ± 0.2	20.5 <sup>ab</sup> ± 2.9	1.04 <sup>a</sup> ± 0.04	0.06 <sup>a</sup> ± 0.01	12.1 <sup>a</sup> ± 1.8	63.6 <sup>b</sup> ± 7.1
S <sub>Ca40</sub>	0.16 <sup>a</sup> ± 0.01	1.97 <sup>a</sup> ± 0.5	22.03 <sup>a</sup> ± 3.4	1.11 <sup>a</sup> ± 0.09	0.05 <sup>a</sup> ± 0.03	11.8 <sup>a</sup> ± 2.7	61.01 <sup>b</sup> ± 5.8

The average values for the same column indexed by the same letters are not statistically different at Levene test, P<0.05).

**Table 3:** Growth performance of *Archachatina marginata* depending on the amount of Mikhart

Variables	Substrates					
	S <sub>0</sub> (100% compost)	S <sub>Ca5</sub> (S <sub>0</sub> +5% Mikhart)	S <sub>Ca10</sub> (S <sub>0</sub> +10% Mikhart)	S <sub>Ca20</sub> (S <sub>0</sub> +20% Mikhart)	S <sub>Ca30</sub> (S <sub>0</sub> +30% Mikhart)	S <sub>Ca40</sub> (S <sub>0</sub> +40% Mikhart)
Initial live weight (g)	1.48 <sup>a</sup> ± 0.04	1.44 <sup>a</sup> ± 0.15	1.45 <sup>a</sup> ± 0.31	1.45 <sup>a</sup> ± 0.35	1.44 <sup>a</sup> ± 0.25	1.45 <sup>a</sup> ± 0.19
Final live weight (g)	214.1 <sup>f</sup> ± 22.3	267.9 <sup>e</sup> ± 26.2	304.4 <sup>e</sup> ± 21.4	332.9 <sup>b</sup> ± 19.8	358 <sup>a</sup> ± 16.9	285.2 <sup>d</sup> ± 31.9
Initial shell length (mm)	18.9 <sup>a</sup> ± 1.0	18.8 <sup>a</sup> ± 1.2	18.8 <sup>a</sup> ± 1.1	18.8 <sup>a</sup> ± 1.9	18.7 <sup>a</sup> ± 1.3	18.9 <sup>a</sup> ± 1.4
Final shell length (mm)	112 <sup>e</sup> ± 0.42	122.4 <sup>d</sup> ± 0.60	140.5 <sup>e</sup> ± 0.59	152 <sup>b</sup> ± 0.32	166 <sup>a</sup> ± 2.1	123.8 <sup>d</sup> ± 4.2
Survival rate (%)	86.08 <sup>d</sup> ± 4.67	94.97 <sup>b</sup> ± 1.22	96.49 <sup>ab</sup> ± 1.99	96.43 <sup>ab</sup> ± 1.99	96.84 <sup>ab</sup> ± 2.84	97.54 <sup>a</sup> ± 1.62

The average values of the same line indexed by the same signs are not statistically different at LSD Test, P <0.05.

166 (S<sub>Ca30</sub>) mm with daily growth of 0.19 (S<sub>0</sub>) and 0.26 mm/d/snail (S<sub>Ca30</sub>). The highest weight (358 g) was recorded on the S<sub>Ca30</sub> against 285 g on the substrate S<sub>Ca40</sub>. The growth of snails thus decreased beyond 30% of Mikhart in the substrate. In this study, snails presented survival rates ranging between 86.08 and 97.54% (Table 3). The lowest survival rate was observed in the unamended soil (86.08%) and the highest one (97.54%) on the substrate containing 40% calcium source. Snails showed empty shell weight between 78.78 g (S<sub>0</sub>) and 172.01 g (S<sub>Ca30</sub>) and soft tissue weight between 115.5 g (S<sub>0</sub>) and 165.9 g (S<sub>Ca30</sub>). The average life weight ranged between 212.8g and 289.7 g (Table 4). Statistical analysis shows that the quantities of meat produced by the animal on the substrates S<sub>0</sub> (115.5 g), S<sub>Ca5</sub> (142.7 g), S<sub>Ca10</sub> (160.6 g) and S<sub>Ca20</sub> (159.7 g) are superior to those in shell (78.8 g, 101.7 g, 131.7g and 151.9 g), on S<sub>Ca30</sub> and S<sub>Ca40</sub>

substrates, snails produced more shells (172.01 and 149.9g) than soft tissue (165.9 and 120.8 g). The statistical test shows that the highest weight of snail shell is noted on the S<sub>Ca30</sub> substrate while the lowest is recorded on the unamended soil (S<sub>0</sub>) (Table 4). There is no significant difference between the amounts of soft tissue produced on substrates S<sub>Ca10</sub> (160.6 g), S<sub>Ca20</sub> (159.7 g) and S<sub>Ca30</sub> (165.9 g). However, they are arranged in the order, S<sub>Ca10</sub> < S<sub>Ca20</sub> < S<sub>Ca30</sub>. The weights of feet obtained on the substrates S<sub>0</sub> (61.3 g) and S<sub>Ca40</sub> (64.8 g) are statistically identical and less than that produced on the substrate S<sub>Ca5</sub> (74.9 g).

Snails have shell proportions that range between 37.1% (S<sub>0</sub>) and 51.8% (S<sub>Ca30</sub>). The proportion of soft tissue varies between 41.7% (S<sub>Ca40</sub>) and 54.2% (S<sub>0</sub>). Statistical analysis indicates that the animal bred on substrates containing less than 30% of industrial carbonate calcium have soft tissue levels significantly higher than those of their shells.

**Table 4:** Effect of Mikhart content of the culture substrate on the weight of different parts of *A. marginata* body

Variables (g)	Substrates					
	S <sub>0</sub> (100% compost)	S <sub>Ca5</sub> (S <sub>0</sub> +5% Mikhart)	S <sub>Ca10</sub> (S <sub>0</sub> +10% Mikhart)	S <sub>Ca20</sub> (S <sub>0</sub> +20% Mikhart)	S <sub>Ca30</sub> (S <sub>0</sub> +30% Mikhart)	S <sub>Ca40</sub> (S <sub>0</sub> +40% Mikhart)
Total average live weight	212.8 <sup>^</sup> ± 23	264.3 <sup>#</sup> ± 27	310.3 <sup>*</sup> ± 19	330.9 <sup>+</sup> ± 19.0	357.2 <sup>S</sup> ± 18.9	289.7 <sup>&amp;</sup> ± 31.9
Shell weight	78.78 <sup>b^</sup> ± 8.01	101.69 <sup>b#</sup> ± 16.4	131.7 <sup>b*</sup> ± 11.8	151.9 <sup>b+</sup> ± 11.2	172.01 <sup>a&amp;</sup> ± 10.01	149.9 <sup>a+</sup> ± 18.8
Soft tissues weight	115.5 <sup>a*</sup> ± 14.5	142.7 <sup>a&amp;</sup> ± 15.09	160.6 <sup>a+</sup> ± 15.2	159.7 <sup>a+</sup> ± 12.4	165.9 <sup>b+</sup> ± 13.2	120.8 <sup>b*</sup> ± 17.1
Loss of weight due to preparation	18.5 <sup>e*</sup> ± 4.4	19.9 <sup>e*</sup> ± 5.4	17.9 <sup>e*</sup> ± 11.4	19.2 <sup>e*</sup> ± 3.03	19.3 <sup>e*</sup> ± 7.5	18.9 <sup>e*</sup> ± 4.9
Weight of consumable fabrics	61.3 <sup>c&amp;</sup> ± 8.9	74.9 <sup>c*</sup> ± 9.2	83.9 <sup>c+</sup> ± 12.8	83.9 <sup>c+</sup> ± 7.8	88.2 <sup>c+</sup> ± 9.8	64.8 <sup>c&amp;</sup> ± 9.9
Weight of viscera not consumed	54.6 <sup>d^</sup> ± 9.5	67.8 <sup>d*</sup> ± 8.8	76.8 <sup>d+</sup> ± 15.0	75.8 <sup>d+</sup> ± 7.1	77.7 <sup>d+</sup> ± 5.7	56.1 <sup>d*</sup> ± 13.0

The average values for the same column indexed by the same letters are not statistically different at LSD test,  $P < 0.05$ . The average values of the same line indexed by the same signs are not statistically different at LSD Test,  $P < 0.05$ .

In contrast, on the  $S_{Ca30}$  and  $S_{Ca40}$  substrates, shells proportions are greater than those of soft tissue. Statistical

comparison of these proportions (Table 5) shows that shell production increases with the increasing of the levels of calcium in the substrate. Contrary, the flesh decreases gradually as the calcium level of the substrate increases.

**Table 5:** Proportions of different parts of snails body depending on the content of the substrates in Mikhart

Variables (%)	Substrates					
	$S_0$ (100% compost)	$S_{Ca5}$ (5% Mikhart)	$S_{Ca10}$ (10% Mikhart)	$S_{Ca20}$ (20% Mikhart)	$S_{Ca30}$ (30% Mikhart)	$S_{Ca40}$ (40% Mikhart)
Empty shell	37.1 <sup>b</sup> ± 1.6	38.47 <sup>b</sup> ± 4.6	42.4 <sup>b</sup> ± 2.5	45.9 <sup>b</sup> ± 2.6	48.2 <sup>a*</sup> ± 2.6	51.8 <sup>a*</sup> ± 3.6
Soft tissues	54.2 <sup>a</sup> ± 2.2	54.03 <sup>a+</sup> ± 3.1	51.7 <sup>a*</sup> ± 2.8	48.3 <sup>a&amp;</sup> ± 2.4	46.4 <sup>b*</sup> ± 2.2	41.7 <sup>b*</sup> ± 3.7
Loss due to preparation	8.66 <sup>c</sup> ± 1.6	7.56 <sup>e+</sup> ± 1.9	5.84 <sup>e*</sup> ± 3.9	5.79 <sup>e*</sup> ± 0.75	5.4 <sup>e*</sup> ± 2.01	6.5 <sup>e*</sup> ± 1.3
Consumable fabrics (foot)	28.8 <sup>c</sup> ± 2.7	28.4 <sup>c+</sup> ± 2.7	27.0 <sup>c+</sup> ± 3.8	25.4 <sup>c*</sup> ± 1.9	24.7 <sup>c*</sup> ± 2	22.3 <sup>c*</sup> ± 1.9
Viscera not consumed	25.6 <sup>d</sup> ± 3.1	25.6 <sup>d</sup> ± 2.2	24.7 <sup>d</sup> ± 4.4	22.8 <sup>d*</sup> ± 1.6	21.8 <sup>d*</sup> ± 1.2	19.4 <sup>dx</sup> ± 4.3

The average values of same line indexed by the same signs are not statistically different at LSD test,  $P < 0.05$

#### 4. Discussion

The results show that increasing the calcium content of the culture substrate of *A. marginata* causes an increase in growth rate and shell gain. Indeed, the snail extracted some minerals through the soil using his foot [5]. Among these minerals, calcium is very important for the physiological development of the animal. He uses it to develop its shell [9], [10]. Results are consistent with those of Codjia [11], Otchoumou [3] and Kouassi and al. [4] which showed that a concentrated diet, rich in calcium induces a better snail growth. Indeed, depletion of body reserves in mineral compromises the general metabolic activity of the animal; which results in slower growth rate [12]. However, the substrate amendment with Mikhart as calcium source is optimal at an incorporation rate of Mikhart at 30% beyond which the growth performance decreases.

The growth performance drop recorded beyond the 30% threshold could be due to the texture of the substrate. Indeed, at this rate of amendment the Mikhart renders the substrate very compact and becomes very pasty and sticky under the effect of daily watering. This type of substrate breaks the fragile borders of snail's shell, which try to bury itself during the hottest hours of the day, delaying their growth. Also, this aspect of the substrate does not facilitate the movement of animals for their nutrition. These results agree with those of Cobbinah and al. [13] who reported that snail farming is not well with the use of a clay substrate with too much water. Moreover, an excess of calcium intake leads an early tightening of borders of snail shell [3] consequence of a slower growth rate.

Despite the richness in nutrients of the snails food (calcium rate of 12.02%), the breeding substrate has presented a strong influence on their growth performance. This shows that soil minerals are of great importance for these animals. It is therefore right that Jess [5] believes that the snails derive nearly 40% of their nutrients in the soil through using their foot sole.

The increase rate of the calcium source in the substrate resulted in a reduction of animal mortality. This result is in agreement with Otchoumou [3] which states that the higher the rate of calcium available is important, over the shell of the snail is heavy and durable. This limits the mortalities due to the broken rice commonly observed on soilless farming shells.

Mortality rates recorded on the amended substrates (2.46 to 5.03%) with Mikhart remain well below that presented by Kouassi et al. [14], which reported 10.67%.

Increasing Mikhart rate (from 5% to 30%) in the substrate resulted in the increase in the amount of snail meat produced by individual. Thus, there has been improvement in the amount of meat due to Mikhart even if this source of calcium has also caused an increase of shell. However, beyond 30%, the average amount of meat induced per snail, decreases with the addition of Mikhart. This is due to an excessive production of the shell in spite of flesh. This production of shell could be justified by a bioavailability of calcium. This result seems to agree with that of Otchoumou [3] who finds that calcium is an essential element in the manufacture of the snails shell.

The total quantity of meat produced on the substrate containing 40% Mikhart, is comparable to that produced on the control substrate ( $S_0$ ). This suggests that 30% is the optimum rate of this calcium source necessary in the substrate to produce snails with an important meat and shell.

On all substrates, the amount of meat produced remained higher than that of the visceral mass. This indicates that most of the flesh of the snail is consumed by humans. In this study, the proportion of foot sole of *Archachatina marginata* varies between 22.3 to 28.8%. This proportion is around 33% obtained by Otchoumou and al. [7] with the species *A. achatina*, *A. fulica* and *A. venticosa* but remain below 38% obtained by Ayayi and al. [2] with the same species. This observed difference is mainly due to the fact that these authors did not scald (immersion in hot water) snails before cutting different parts. Indeed, the boiling resulted in the loss

of weight from 17.9 g to 19.9 g of either percentages of the total live weight of the animals to 5.4 8.6%.

## 5. Conclusion

The calcium content of the culturing substrate has some effect not only on growth but also on snails' body proportions. These snails growth performance improves with increasing the content of breeding substrate with 30% of Mikhart as threshold. Beyond this threshold there is slower growth rate. Also, an increased calcium level in the substrate induces a decrease in the proportion of flesh for the proportion of shell. However, the addition of industrial calcium in the substrate produces a large amount of meat. Thus the substrate amended with a Mikhart at a rate of 20-30% with an industrial diet rich in calcium (12%) are necessary to produce snails of high quality in a relatively short time.

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