

RESEARCH ARTICLE

Effect of the Physical Form of Concentrate Feed on Reproduction, Embryonic Viability, Intake and Apparent Digestibility in Captive Giant African Land Snails (*Archachatina Marginata*)

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Abstract

This study evaluated the effect of three physical forms of the same concentrate feed - paste, meal and pellets - on reproduction, feed intake and apparent digestibility in captive giant African land snails (*Archachatina marginata*). Three hundred adult snails, approximately 8 months old, were assigned to a completely randomized design with three treatments and five replicates of 20 snails each. The diets had the same proximate composition and differed only in physical form. Feed intake was significantly higher with the paste ration (0.45 ± 0.28 g/day/snail) than with the pelleted (0.35 ± 0.40 g/day/snail) and meal (0.30 ± 0.00 g/day/snail) rations ($p < 0.05$). Dry matter excretion and apparent digestibility coefficients of nutrients were not significantly affected ($p > 0.05$). The paste ration improved reproductive performance, with the highest mean number of eggs (83.77 ± 6.98), fertilization rate ($96.09 \pm 0.49\%$), hatching rate of fertilized eggs ($96.58 \pm 0.97\%$), total egg hatching rate ($92.82 \pm 1.12\%$) and mean hatchling weight (1.04 ± 0.04 g). Snails fed the meal ration showed the lowest performance, whereas those fed pellets showed intermediate values. Total embryonic mortality was higher in eggs from snails fed the meal ration ($11.00 \pm 2.27\%$) than in those from snails fed the paste ration ($3.26 \pm 0.95\%$). Overall, feed intake and reproductive performance increased significantly when feed was offered as a paste, without significantly changing apparent nutrient digestibility.

Keywords: *Archachatina Marginata*, Feed Presentation, Apparent Digestibility, Reproduction; Hatchlings.

1. Introduction

In sub-Saharan Africa, the increase in demand for animal protein has promoted interest in unconventional species with high zootechnical potential. Among these, the giant African land snail (*Archachatina marginata*) holds an important place in the human diet because of its nutritional value, economic interest and relative ease of farming (Cobbinah et al., 2008; Aboua, 2010; Tchowan et al., 2022). Studies carried out in captivity in Cameroon on this species have also shown its zootechnical interest for growth and reproduction (Dafem et al., 2008; Kana et al., 2018a).

However, the development of *Archachatina* farming remains limited by feeding, which accounts for a large proportion of production costs and directly determines intake, digestive use of nutrients, growth and reproduction (Ademolu et al., 2015; Ebenso and Okon, 2020; Fagbuaro et al., 2021). Beyond the chemical composition of the ration, the physical form of the feed may modify palatability, prehension by the radula, voluntary consumption, passage rate, feed wastage and, consequently, animal biological responses (Abiona et al., 2013; Goodarzi Boroojeni et al., 2016; Jimoh and Akinola, 2020). In terrestrial snails, meal-type feeds can cause losses and selective

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feeding, whereas paste or pelleted forms may modify practical feed accessibility and improve zootechnical performance (Jimoh and Akinola, 2020; Zanou et al., 2020).

However, available data comparing ration presentation forms (meal, paste or pellets) in the giant African land snail (*Archachatina marginata*) remain limited, particularly when feed intake, apparent digestibility, laying performance, fertility, hatching rate, hatchling viability and embryonic mortality are assessed simultaneously. Therefore, this study was designed to evaluate the effect of three physical forms of the same concentrate feed on reproduction, embryonic viability, intake and apparent digestibility in captive giant African land snails (*Archachatina marginata*).

2. Materials and methods

2.1 Study Area

The study was conducted from 1 August to 17 November 2025 at the Application and Research Farm of the University of Dschang (FAR-UDS), located in the Menoua Division, West Region of Cameroon. The site lies between 5°38' and 5°40' N latitude and 9°47' and 10°06' E longitude.

2.2 Animal Material

A total of 300 adult snails of the species *Archachatina*

marginata, approximately 8 months old, with an average weight of 85 ± 1 g, shell length of 87 ± 1 mm and shell width of 46 ± 1 mm, were used. The animals came from 48 clutches that hatched during the same week at FAR-UDS. They were selected on the basis of shell integrity, morphological homogeneity and absence of visible trauma.

2.3 Rearing Conditions and Substrate

The animals were first reared in 15 concrete-block pens measuring 50 x 50 x 25 cm, corresponding to a base area of 0.25 m² per pen, with 20 snails per pen. Each pen contained 15 cm of loose forest soil that had been sanitized by boiling and then cooled before use. A feeder, drinker and anti-escape device made of fine mesh were installed in each experimental unit. Substrate humidity was maintained above 85% through a standardized daily water supply.

At the end of the rearing phase, the snails were transferred to 15 wire-mesh digestibility cages measuring 50 x 50 cm, each equipped with a feeder, a drinker and a feces collection system placed beneath the floor. Pens and cages were cleaned before the start of the experiment.



Figure A. Concrete-block pen



Figure B. Digestibility cage

Figure 1. Experimental rearing environments.

2.4 Experimental Diets

The animals were fed three different forms of the same concentrate feed: meal (Rf), paste (Rp) and pellets (Rg) (Figure 2). The rations had the same composition and proximate values (Table 1). The paste ration was

prepared from the meal feed by adding 5% potable water, corresponding to approximately 50 ml per kilogram of feed. The pelleted ration was prepared by passing the meal feed through an electric pelletizer with a 6-mm die.

Table 1. Percentage composition and analyzed proximate values of the experimental feeds.

| Ingredients (kg) | Rations | | |
|-----------------------------------|----------|----------|----------|
| | Rp | Rf | Rg |
| Maize | 31 | 31 | 31 |
| Soybean meal (49% CP) | 36 | 36 | 36 |
| Fish meal (60% CP) | 10 | 10 | 10 |
| Shell meal | 19 | 19 | 19 |
| Oil | 2 | 2 | 2 |
| Premix 2% (kg) | 2 | 2 | 2 |
| Total (kg) | 100 | 100 | 100 |
| Analyzed proximate values | | | |
| Crude protein (%) | 20.0780 | 20.0823 | 20.0659 |
| Metabolizable energy (kcal/kg DM) | 3933.921 | 3933.899 | 3933.890 |
| Calcium (%) | 7.9851 | 7.9844 | 7.9851 |
| Phosphorus (%) | 0.553 | 0.556 | 0.557 |
| Crude fiber (%) | 1.855 | 1.860 | 1.850 |
| P/Ca ratio | 0.0692 | 0.0696 | 0.0697 |
| Lysine (%) | 1.8097 | 1.8090 | 1.8089 |
| Methionine (%) | 0.5385 | 0.5380 | 0.5387 |

Source: Rf = meal-form ration; Rp = paste-form ration; Rg = pelleted ration; CP = crude protein; DM = dry matter.



Figure A. Meal form



Figure B. Pelleted form



Figure C. Paste form

Figure 2. Presentation of the different forms of concentrate feed.

2.5 Experimental Design

Three hundred (300) snails were randomly allocated according to a completely randomized design to three treatments corresponding to the three feed

presentation forms: paste, meal and pellets (Figure 3). Each treatment had five replicates of 20 snails, i.e., 100 snails per treatment.

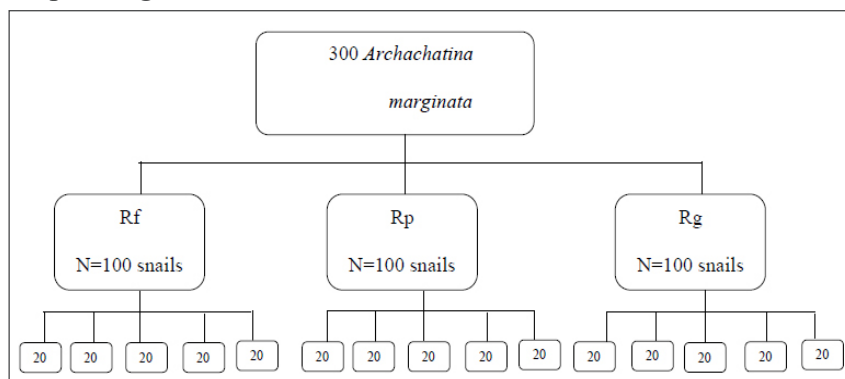


Figure 3. Experimental design diagram.

Rf: meal form ration; Rp: paste form ration; Rg: pelleted ration

2.6 Trial Management and Data Collection

2.6.1 Reproductive Parameters

The trial lasted 16 weeks. Reproductive performance was monitored from the seventh week of feeding.

Laying Parameters

Mean number of eggs. Each morning, the litter was gently disturbed to collect eggs. Mean number of eggs = total number of eggs laid / number of clutches.

Mean egg weight. Eggs were then weighed individually using an electronic precision scale, and mean egg weight was calculated. Mean egg weight (g/egg) = total egg weight per clutch / number of eggs laid.

Mean diameter and length. Egg diameter and length were measured using a caliper. Mean egg diameter and mean egg length were calculated as follows:

- Mean egg diameter (mm) = sum of measured diameters / number of eggs measured.
- Mean egg length (mm) = sum of measured lengths / number of eggs measured.

Fertility and Hatching Parameters

The eggs were incubated by clutch in plastic containers containing moistened loose soil. On day 35 of incubation, the containers were opened and examined to monitor hatching. The hatchlings obtained were weighed after hatching. The following fertility and hatching parameters were evaluated:

- Number of incubated eggs.
- Number of hatched eggs.
- Number of fertilized eggs.
- Number of fertile unhatched eggs.
- Fertilization rate (%) = number of fertilized eggs / total number of eggs laid x 100.
- Hatching rate of fertilized eggs (%) = number of hatched eggs / number of fertilized eggs x 100.
- Total egg hatching rate (%) = number of hatched eggs / number of incubated eggs x 100.
- Incubation duration (days) = hatching date - incubation date.
- Mean hatchling weight (g) = total hatchling weight / number of hatchlings weighed.
- Mean hatchling shell length (mm) = sum of shell lengths / number of hatchlings measured.
- Mean hatchling shell diameter (mm) = sum of shell diameters / number of hatchlings measured.
- Hatchlings per clutch (%) = number of hatchlings

obtained / total number of eggs laid x 100.

- Embryonic mortality rate (%) = [(eggs containing a dead embryo with shell + eggs containing a dead embryo without shell) / total number of eggs laid] x 100.
- Incubation failure rate (%) = [(eggs containing a dead embryo with shell + eggs containing a dead embryo without shell + eggs without embryo) / total number of eggs laid] x 100.

2.6.2 Digestibility Parameters

The digestibility trial was conducted at the end of the 14th week of rearing and lasted 15 days, consisting of 10 days of adaptation and 5 days of collection.

Dry refusal rate. Feed refusals were collected, dried and weighed daily to determine the dry refusal rate. Dry refusal rate (%) = quantity of dry refusals / quantity of feed offered x 100.

Feed intake. Every evening (17:00 h), the feed was weighed and offered, and refusals were collected. Feed intake was calculated as follows: feed intake (g/day/snail) = ration offered on day N - feed refusals measured on day N + 1.

Feces were collected every 24 h, weighed, dried at 60 °C for 48 h and stored for proximate analyses. Determinations included dry matter, ash, organic matter, crude protein and crude fiber according to AOAC (2005) methods.

- Quantity of dry matter excreted (g) = total mass of dry feces produced during the collection period.
- ADC of dry matter (DM, %) = [(DM ingested - fecal DM) / DM ingested] x 100.
- ADC of ash (%) = [(ash ingested - fecal ash) / ash ingested] x 100.
- ADC of crude protein (CP, %) = [(CP ingested - fecal CP) / CP ingested] x 100.
- ADC of organic matter (OM, %) = [(OM ingested - fecal OM) / OM ingested] x 100.
- ADC of crude fiber (CF, %) = [(CF ingested - fecal CF) / CF ingested] x 100.

2.7 Statistical Analysis

Data were subjected to one-way analysis of variance (ANOVA) according to a completely randomized design. When the treatment effect was significant, means were separated using Duncan's test at the 5% level and were expressed as mean ± standard deviation. Analyses were performed using SPSS (Statistical Package for the Social Sciences), version 26.0.

3. Results

3.1 Effect of Feed Presentation Form on Intake and Apparent Nutrient Digestibility

The physical form of the feed significantly influenced feed intake ($p < 0.05$). Snails fed the paste ration had

the highest feed intake, followed by snails receiving pellets, whereas the meal ration induced the lowest intake. In contrast, dry matter excretion and the apparent digestibility coefficients of dry matter, ash, crude protein, organic matter and crude fiber were not significantly affected by treatment ($p > 0.05$).

Table 2. Effect of feed presentation form on feed intake, dry matter excretion and apparent nutrient digestibility.

| Digestibility parameters | Rations | | | SE | p |
|-------------------------------|---------------|---------------|---------------|------|------|
| | Rp | Rf | Rg | | |
| Feed intake (g/day/snail) | 0.45 ± 0.28a | 0.30 ± 0.00c | 0.35 ± 0.40b | 0.01 | 0.00 |
| Dry matter excreted (g/snail) | 0.05 ± 0.00a | 0.04 ± 0.00a | 0.04 ± 0.01a | 0.00 | 0.23 |
| ADC dry matter (%) | 76.04 ± 2.43a | 74.34 ± 6.75a | 80.51 ± 6.41a | 1.50 | 0.23 |
| ADC ash (%) | 85.50 ± 2.83a | 81.75 ± 8.85a | 83.40 ± 8.58a | 1.79 | 0.72 |
| ADC crude protein (%) | 86.57 ± 2.16a | 85.69 ± 4.40a | 89.93 ± 3.28a | 0.94 | 0.15 |
| ADC organic matter (%) | 88.57 ± 1.32a | 88.11 ± 3.07a | 90.80 ± 3.28a | 0.71 | 0.28 |
| ADC crude fiber (%) | 85.35 ± 2.31a | 82.92 ± 6.47a | 88.50 ± 6.65a | 1.45 | 0.31 |

Source: a, b, c: within the same row, values bearing the same letter are not significantly different ($p > 0.05$); ADC = apparent digestibility coefficient; SE = standard error.

3.2 Effect of Feed Presentation Form on Laying Characteristics

The mean number of eggs laid was significantly influenced ($p < 0.05$) by feed form, with the highest

value observed for the paste ration (Table 3). In contrast, mean egg weight and egg dimensions did not differ significantly among treatments ($p > 0.05$).

Table 3. Effect of feed presentation form on laying characteristics in *Archachatina marginata*.

| Laying characteristics | Rations | | | SE | p |
|------------------------|----------------|----------------|---------------|------|-------|
| | Rp | Rf | Rg | | |
| MNE | 83.77 ± 6.98a | 58.22 ± 8.054c | 69.07 ± 8.37b | 3.36 | 0.001 |
| MEW (g) | 1.24 ± 0.10a | 1.05 ± 0.19a | 1.22 ± 0.21a | 0.04 | 0.22 |
| MED (mm) | 11.98 ± 0.350a | 11.56 ± 0.29a | 11.50 ± 0.80a | 0.13 | 0.32 |
| MEL (mm) | 15.04 ± 0.90a | 14.23 ± 0.93a | 14.60 ± 1.39a | 0.27 | 0.52 |

Source: a, b, c: within the same row, values bearing the same letter are not significantly different ($p > 0.05$); MNE = mean number of eggs; MEW = mean egg weight; MED = mean egg diameter; MEL = mean egg length; SE = standard error.

3.3 Effect of Feed Presentation Form on Fertility and Hatching

Snails fed the paste feed showed the best fertility and hatching performance (Table 4). They had the highest number of incubated eggs, the highest number of hatched eggs, the best fertilization rate, the highest

total hatching rate and the heaviest hatchlings. The meal ration produced the lowest values, while the pelleted ration showed intermediate results. The hatching rate of fertilized eggs was also higher with the paste ration.

Table 4. Effect of feed presentation form on fertility and hatching characteristics.

| Parameters | Rations | | | SE | p |
|------------|---------------|----------------|---------------|------|------|
| | Rp | Rf | Rg | | |
| NIE | 83.77 ± 6.98a | 58.22 ± 8.054c | 69.07 ± 8.37b | 3.36 | 0.00 |
| NHE | 78.05 ± 7.18a | 42.60 ± 8.18c | 56.30 ± 7.80b | 4.31 | 0.00 |
| NFE | 80.57 ± 7.09a | 49.35 ± 8.87c | 61.65 ± 8.41b | 3.94 | 0.00 |
| NFU | 2.53 ± 0.47a | 6.75 ± 1.57b | 5.35 ± 0.91b | 0.53 | 0.00 |
| FR (%) | 96.09 ± 0.49a | 83.47 ± 3.28c | 88.30 ± 1.58b | 1.47 | 0.00 |
| HRFE (%) | 96.58 ± 0.97a | 86.88 ± 2.86c | 90.61 ± 1.16b | 1.15 | 0.01 |
| THE (%) | 92.82 ± 1.12a | 72.46 ± 4.12c | 80.04 ± 2.03b | 2.33 | 0.00 |
| MHW (g) | 1.04 ± 0.04a | 0.91 ± 0.03b | 0.91 ± 0.03b | 0.01 | 0.00 |

| | | | | | |
|----------|---------------|---------------|---------------|------|------|
| HSD (mm) | 11.14 ± 0.48a | 10.87 ± 1.20a | 11.01 ± 0.81a | 0.21 | 0.88 |
| HSL (mm) | 14.63 ± 0.92a | 13.96 ± 0.89a | 14.26 ± 0.80a | 0.22 | 0.50 |

Source: a, b, c: within the same row, values bearing the same letter are not significantly different ($p > 0.05$); NIE = number of incubated eggs; NHE = number of hatched eggs; NFE = number of fertilized eggs; NFU = number of fertile unhatched eggs; FR = fertilization rate; HRFE = hatching rate of fertilized eggs; THE = total hatching rate of eggs; MHW = mean hatchling weight; HSD = hatchling shell diameter; HSL = hatchling shell length; SE = standard error.

3.4 Effect of Feed Presentation Form on Embryonic Mortality

The number of eggs containing a dead embryo without a shell, the early embryonic mortality rate, total embryonic mortality rate of eggs and mean incubation failure rate were significantly ($p < 0.05$) influenced by feed presentation form (Table 5). In contrast, no significant difference was observed in

the number of eggs with dead embryos with shells or in late embryonic mortality rate, regardless of feed form. The paste form resulted in the lowest number of eggs containing dead embryos without shells, the lowest early embryonic mortality and the lowest mean incubation failure rate, whereas the meal ration showed the highest values.

Table 5. Effect of feed presentation form on embryonic mortality.

| Parameters | Rations | | | SE | p |
|------------|--------------|---------------|--------------|------|------|
| | Rp | Rf | Rg | | |
| NEDWS | 0.65 ± 0.24a | 4.52 ± 1.08c | 3.22 ± 0.54b | 0.46 | 0.00 |
| NEDSS | 1.81 ± 0.23a | 2.22 ± 0.51a | 2.12 ± 0.61a | 0.12 | 0.39 |
| EEMR (%) | 0.82 ± 0.33a | 7.50 ± 1.64c | 5.15 ± 0.95b | 0.78 | 0.00 |
| LEMR (%) | 2.44 ± 0.69a | 3.50 ± 0.64a | 3.10 ± 0.83a | 0.20 | 0.10 |
| TEMR (%) | 3.26 ± 0.95a | 11.00 ± 2.27c | 8.26 ± 1.00b | 0.93 | 0.00 |
| MIFR | 0.65 ± 0.24 | 4.52 ± 1.08 | 3.22 ± 0.54 | 2.33 | 0.00 |

Source: a, b, c: within the same row, values bearing the same letter are not significantly different ($p > 0.05$); NEDWS = number of eggs with dead embryo without shell; NEDSS = number of eggs with dead embryo with shell; EEMR = early embryonic mortality rate; LEMR = late embryonic mortality rate; TEMR = total embryonic mortality rate; MIFR = mean incubation failure rate; SE = standard error.

4. Discussion

Feed presentation form significantly modified feed intake in *Archachatina marginata*. The highest feed intake observed with the paste ration could be explained by better feed accessibility and probably greater palatability. These observations agree with those of Akinwale et al. (2019), who reported that feed form modifies intake and digestive use in gastropods, and with those of Odaibo et al. (2017), who showed that ration presentation influences the biological response of snails.

The absence of significant differences in apparent digestibility coefficients indicates that the differences observed among treatments did not result from a marked change in nutrient digestibility, but rather from variation in effective intake. In other words, the paste form appears to have allowed snails to consume more of a ration with unchanged composition, which subsequently benefited reproductive functions. This observation corroborates those of Ademolu et al. (2015) and Obakanurhe et al. (2024), who stated that

biological utilization of rations in snails depends not only on composition but also on how the animal uses the feed.

The superiority of the paste ration in terms of mean number of eggs, fertilization rate, total hatching rate and hatchling weight shows that improved intake translated into better reproductive performance. These results are consistent with the work of Ejidike (2004) and Ademolu et al. (2019), who showed that nutrition quality and actual nutrient availability condition reproduction in *Archachatina marginata*.

The fact that mean egg weight and egg dimensions did not differ significantly among treatments suggests that feed form did not alter individual egg morphology. Since the rations were iso-protein and iso-energetic, the observed differences were probably linked to physical accessibility of the feed rather than to analytical composition. This interpretation is consistent with Oliveira et al. (2019), who showed that feed processing can influence practical nutrient availability without substantially modifying chemical composition.

The superiority of the paste ration was also confirmed by hatchling quality. Young snails from this treatment were heavier and had larger shell dimensions than those from the other treatments. These results may reflect better allocation of nutrient reserves to the egg and better embryonic mineralization. Daouda (1995) highlighted the importance of calcium in snail diets, while Kana et al. (2018b) and Tchoumboué et al. (2020) showed that improving ration quality has positive repercussions for growth, survival and overall performance of farmed snails.

The lowest embryonic mortality observed with the paste ration may be related to the low numbers of eggs with dead embryos with shells and eggs with dead embryos without shells, suggesting that this feed form improved overall reproductive viability. This situation may be linked to better fertilization, better formation of egg reserves and reduced feed wastage, which is generally more marked with meal feeds. This result agrees with Zanou et al. (2020), who showed that feed losses vary with ration form, and with Jimoh and Akinola (2020), Oyeagu et al. (2018) and Sika et al. (2023), who reported that better-utilized diets improve fertility, hatchability and some growth traits in snails.

5. Conclusion

This study on the effect of concentrate feed presentation form on feed intake, reproduction, hatchling viability and apparent nutrient digestibility in the giant African land snail (*Archachatina marginata*) showed that:

- The paste form resulted in better feed intake than the pelleted or meal forms.
- With paste feed, the mean number of eggs laid was higher than with the other ration forms.
- Fertility and hatching characteristics were better in animals fed the paste form than in those fed the other rations.
- The paste feed resulted in a lower embryonic mortality rate than the meal or pelleted rations.

These results indicate that the physical presentation of feed should be considered a major zootechnical factor in *Archachatina marginata* farming systems.

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