



Physical characteristics and meat yield of snails sold in the dry season on Abobo (Abidjan, Côte D'ivoire) markets

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Abstract

In order to characterize the snails sold and consumed by the population of Abidjan during the long dry season, a study was carried out to evaluate the physical characteristics and the quantity of meat provided by the snails found for sale on the markets of Abobo during the said season. To do this, sites selling live snails were inventoried and visited once a month. At each visit, 10 snails of different categories (juveniles, sub-adults and adults) found on sale at the markets were purchased and transported to the laboratory. After fasting for three days, the animals were weighed and measured before being euthanised by scalding. Their various body parts were isolated and weighed in order to estimate the average quantities of fresh meat offered by each category of snail sold on the Abobo market. During the experiments, juveniles and sub-adults of the species *Achatina achatina* and *Archachatina ventricosa* were found for sale on the Abobo market. Juvenile and subadult *Achatina achatina* snails had respective mean live weights of 13.71 ± 2.96 g and 61.5 ± 10.40 g. Their average quantities of fresh meat were 13.71 ± 2.96 g and 22.5 ± 4.16 g respectively. *Archachatina ventricosa* juveniles had an average live weight of 38.8 ± 3.30 g and an average quantity of fresh meat of 14.456 ± 0.81 g. The subadults, on the other hand, had an average live weight of 56 ± 2.04 g, and an average weight of fresh meat of 19 ± 1.02 g.

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Introduction

The flesh of giant African snails is a real source of protein, containing all the amino acids needed by humans (Zongo *et al.*, 1990). This meat is highly prized by many West Africans for its flavour and quality (Otchoumou *et al.*, 2010). Snails consist of two essential parts: the shell and the soft tissue. The foot, the head, the mantle bead and the distal part of the genital tract, including the penile sleeve, are the soft tissue parts usually consumed by the Ivorian population (Aman, 2013). The snail shell, which consists almost entirely of calcium carbonate (Stievenart and Hardouin, 1990), is used in the manufacture of animal feed (Diomandé *et al.*, 2008). The viscera (the part not consumed) are used as a source of protein in animal feed (Otchoumou *et al.*, 2005).

The primary objective of wild snail collection and farming in Côte d'Ivoire is to provide edible meat to help meet the population's protein requirements. The majority of snails consumed and sold on the Ivorian market come from forest collection (Kouassi *et al.*, 2008). On the various markets in Abidjan, snails are very abundant in the rainy season and rare in the dry season (Memel *et al.*, 2009). During the dry season, the snails' activities diminish considerably, burying themselves in the soil or under dry leaves and withdrawing into their shells, which they seal with a self-produced calcareous material (Ategbo *et al.*, 1999). Large snails retreat to the forest or fallow land to encyst, so the snails you see on the market are generally small. These are snails that generally have not had time to lay their eggs in the wild before being caught.

The aim of this study is to estimate the physical characteristics and meat yield of the various snail species sold on the Abobo market during the long dry season.

Materials and methods

Animals

The study focused on snail species sold in the dry season on the markets of Abobo, a municipality of

approximately 1,340,083 inhabitants in the city of Abidjan. The species in question are *Achatina achatina* (Fig. 1) and *Achachatina ventricosa* (Fig. 2), which are the most popular with the Ivorian population. Most of these animals were collected in the forests of southern Côte d'Ivoire.



Fig. 1. Snail *Achatina achatina*



Fig. 2. Snail *Archachatina ventricosa*



Fig. 3. Electronic scale

Measuring equipment

A electronic scale balance (Fig. 3) with a sensitivity of 0.1 g was used to weigh individual snails in the live

state and to weigh the various body parts of these snails after shell removal. A mechanical vernier caliper with a precision of 1 mm (Fig. 4) was used to measure the shell length of these animals. A pair of scissors was used to separate the different parts of the snails' soft tissue.



Fig. 4. Werckmann electronic caliper

Collection of experimental snails

Samples of the different sizes of *Achatina achatina* and *Archachatina ventricosa* snails found on sale in the Abobo markets during the main dry season were purchased and transported to the laboratory. During the first 3 months of the long dry season (December, January and February), a sample of 10 snails of each category was purchased per month. The snails selected were those with shells that were not cracked.

Determining the physical characteristics of experimental snails

Once in the laboratory, the snails were marked with indelible ink before being weighed and measured individually. The longest shell length from the apex to the peristome was measured (Bouye *et al.*, 2017). The weighing and measurement data were used to calculate the average shell size and average live weight, respectively, of the different categories of snails collected.

Decoquillage and determination of body proportions

Once the physical characteristics of the snails in the different batches had been recorded, they were

placed in a damp, shaded area so that they could be recovered in a dormant state. While asleep, the molluscs were immersed in a basin of boiling water for 10 minutes before being euthanised by scalding. After scalding, the soft tissues of each snail were removed from the shell. By hand, the viscera of each snail were separated from the consumed meat. The various body parts thus obtained (shell, viscera and consumed meat) were individually weighed.

Expression of results

The physical characteristics of the various categories of snails brought back from the markets were estimated from the average live weights and average shell lengths calculated according to the following formulae:

$$\text{Average live weight} = \frac{\sum \text{Live weight}}{\text{number of snails}}$$

$$\text{Average shell length} = \frac{\sum \text{Shell length}}{\text{number of snails}}$$

Based on the results of the weighing, the proportions of the various body parts of the snails were determined according to the following formulae:

$$P_{vis} = \frac{\sum Vw}{\sum Slw} \times 100$$

$$P_{sh} = \frac{\sum Sw}{\sum Slw} \times 100$$

$$P_{ef} = \frac{\sum Ffw}{\sum Slw} \times 100$$

With: P_{vis} = Proportion of viscera, Vw = Viscera weight, Slw = Snail live weight, Sw = Shell weight, P_{ef} = Proportion of edible fresh meat and Ffw = Weight of edible fresh meat.

Statistical analysis

STATISTICA version 7.1 software was used to carry out the various statistical treatments. The mean values of live weight, shell weight, soft tissue, edible meat and viscera of the different categories of snails brought back from the markets were compared by an analysis of variance (ANOVA) according to TURKEY'S HSD TEST at a confidence level of 5%. The body proportions of the different snail categories were also compared using the Scheffé Test at a confidence level of 5%.

Results

Physical characteristics and weights of different snails body parts

Juvenile snails

Table 1 shows the physical characteristics and weights of the various body parts of juvenile *Archachatina ventricosa* and *Achatina achatina* found for sale on the markets of Abobo from December 2003 to March 2024.

The smallest *Achatina achatina* snails found on the Abobo markets from December to March had an average shell length of 5.27 ± 2.02 cm shorter than

that of *Archachatina ventricosa* (5.94 ± 0.15 cm). Also, the average live weight of *A. achatina* (34.29 ± 6.18 g) is lower than that of *Archachatina ventricosa* (38.8 ± 3.30 g). The average quantities of viscera and soft tissues provided by *A. ventricosa* (23.26 ± 1.74 g for tissues and 8.57 ± 3.21 g for viscera) are significantly higher than those of *Achatina achatina* (20.51 ± 4.88 g for soft tissues and 7.14 ± 2.45 g for viscera). However, both species presented the same quantities of edible flesh (14.4 ± 0.81 g for *A. ventricosa* and 13.71 ± 2.96 g for *A. achatina*) and shell (10.86 ± 2.39 g for *A. achatina* and 10.8 ± 3.04 g for *Archachatina ventricosa*).

Table 1. Physical characteristics and weights of different body parts of juvenile snails sold in Abobo during the dry season

Species	Shell length	Weight live	Weight of fabrics	Weight of fresh edible flesh	Shell weight	Weight of viscera
<i>Achatina achatina</i>	5,27±2,02	34,29±6,18	20,51±4,88	13,71±2,96	10,86±2,39	7,14±2,45
<i>Archachatina ventricosa</i>	5,94±0,15	38,8±3,30	23,26±1,74	14,4±0,81	10,8±3,04	8,57±3,21
p-value	0,00*	0,00029*	0,011*	0,19*	0,93*	0,0063*

Table 2. Physical characteristics and weights of different body parts of sub-adult snails sold on the Abobo market during the dry season

Species	Shell length	Weight live	Weight of fabrics	Weight of fresh edible flesh	Shell weight	Weight of viscera
<i>Achatina achatina</i>	8,18±0,44	61,5±10,40	36,84±6,94	21,81±4,29	22,5±4,16	14,41±3,80
<i>Archachatina ventricosa</i>	6,8±0,1	56±2,04	32±2,04	14±2,04	19±1,02	13±1,02
p-values	0,00*	0,014*	0,0017*	0,00*	0,00018*	0,084*

Adult snails

Table 2 shows the physical characteristics and weights of the body parts of sub-adult snails found for sale on the markets of Abobo during the dry season. The sub-adult snails found on the Abobo market during this study had a higher mean live weight and mean shell length in *Achatina achatina* (61.5 ± 10.4 g and 8.18 ± 0.44 cm) than in *Archachatina ventricosa* (56 ± 2.04 g and 6.8 ± 0.1 cm). The quantities of soft tissue (36.84 ± 6.94 g), shell (21.81 ± 4.29 g) and edible flesh (19 ± 1.02 g) recorded in *Achatina achatina* were higher than those recorded in *Archachatina ventricosa* with values of 32 ± 2.04 g, 14 ± 2.04 g and 19 ± 1.02 g respectively. Both species presented the same quantities of viscera (14.41 ± 3.80 g for *A. achatina* and 13 ± 1.02 g for *A. ventricosa*).

Proportions of snail body parts

Juveniles snails

The body proportions of juvenile snails sold on the Abobo market in the dry season are summarised in Table 3.

In juveniles, the average percentages of meat consumed ($39.92 \pm 3.91\%$) and shell ($32.01 \pm 5.9\%$) in relation to live weight determined for *A. achatina* were greater than those determined for *Archachatina ventricosa* ($37.39 \pm 3.89\%$ for meat consumed and $27.68 \pm 6.36\%$ for shell). However, the same percentages of viscera were noted in both species. *A. achatina* had a percentage of viscera in relation to its live weight of $20.46 \pm 8.15\%$, whereas the percentage determined for *A. ventricosa* was $22.85 \pm 0.8\%$.

Table 3. Body proportions of juvenile snails

Species	Juveniles		
	% fresh edible flesh	% Shell	% viscera
<i>Achatina achatina</i>	39,92± 3,91	32,01±5,9	20,46±8,15
<i>Archachatina ventricosa</i>	37,39±3,89	27,68±6,36	22,85±0,8
p-value	0,0077*	0,0039*	0,14*

Table 4. Body proportions of subadult snails

Species	% fresh edible flesh	% Shell	% viscera
<i>Achatina achatina</i>	36,80a±5,57	35,65a±5,24	23,12±2,84
<i>Archachatina ventricosa</i>	34,04b±3,06	24,9b±2,74	23,31±2,67
P-value	0,033*	0,00*	0,81*

Subadults snails

Table 4 summarises the percentages of live weight of sub-adult *Achatina achatina* and *Archachatina ventricosa* snails sold on the Abobo markets.

In subadults, the shell proportions of the two species are statistically different. The proportion of *Achatina achatina* shells (35.65 ± 5.24%) is higher according to the 5% Schellé test than that of *Archachatina ventricosa* (24.9 ± 2.74%). Also, the percentage of edible fresh flesh in *A. ventricosa* (36.80 ± 5.57%) is lower than that of *A. achatina* (34.04 ± 3.06). However, the proportions of viscera in the two species are statically identical (23.12 ± 2.84% for *Achatina achatina* and 23.31 ± 2.67% for *Archachatina ventricosa*).

Variation in the body proportions of snails according to their stage of development

Achatina achatina

In *Achatina achatina*, the percentage of edible fresh meat in relation to the live weight of juveniles was higher than that of subadults (Table 5). However, according to the results of the statistical test, the proportion of shells in subadults (35.65 ± 5.24%) is greater than in juveniles (32.01 ± 5.9%). Also, the percentage of viscera in subadults is higher than in juveniles. In this species of snail, the average proportions (36.80 ± 5.57%) of shell and fresh edible meat (35.65 ± 5.24%) are statistically identical. As for the average proportion of viscera (23.12 ± 2.84%), it remains statistically lower than those of shell and edible fresh meat.

Table 5. Variation in body proportion of *Achatina achatina* according to development stage

Species	Body proportion		
	% fresh edible flesh	% Shell	% viscera
<i>Achatina achatina</i> juvenile	39,92± 3,91	32,01 ^b ± 5,9	20,46± 8,15
<i>Achatina achatina</i> subadults	36,80±5,57	35,65 ^a ±5,24	23,12±2,84
p-value	0,0097*	0,0098*	0,0098*
Average	36,80 ^a	35,65 ^a	23,13 ^b

The values of the last line indexed by the same letters are not statistically different in the Scheffé test at 5%

Table 6. Variation in the body proportion of *Archachatina ventricosa* according to development stage

Species	% fresh edible flesh	% Shell	% viscera
<i>Achatina achatina</i> juvenile	37,39±3,89	27,68±6,36	22,85±0,8
<i>Achatina achatina</i> subadults	34,04±3,06	24,9±2,74	23,31±2,67
p-value	0,00083*	0,049*	0,69*
Average	36,03 ^a ±3,89	26,55 ^b ±5,34	23,04 ^b ±4,24

Archachatina ventricosa

Table 6 shows the variation in the proportions of body parts of *Archachatina ventricosa* according to development stage.

In *Archachatina ventricosa*, the proportions of shell (27.68 ± 6.36%) and edible fresh meat (37.39 ± 3.89%) determined in juveniles are statistically higher than those determined in subadults (34.04 ± 3.06%

for fresh meat and $24.9 \pm 2.74\%$ for shell). On the other hand, the percentage of viscera ($23.31 \pm 2.67\%$) obtained in adults and that determined in juveniles (22.85 ± 0.8) were statically identical. Generally speaking, the average percentage of edible fresh meat ($34.04 \pm 3.06\%$) determined in *Archachatina ventricosa* is higher than the percentage of shell ($26.55 \pm 5.34\%$) and that of viscera. On the other hand, the percentages of viscera and shell are equal in this species.

Discussion

During the dry season, two species of snails are sold on the Abobo market: *Achatina achatina* and *Archachatina ventricosa*.

In fact, these are the two species most appreciated by the Ivorian population (Kouassi *et al.*, 2008). They are also the first species to be farmed (Otchoumou *et al.*, 2004). The absence of the *Achatina fulica* species on the snail market may be due to the fact that these snails are not sold by retail traders live, but the meat is sold by them in the form of skewers or in dried or fried form (Kouassi *et al.*, 2008). As this species is eaten less by the population, it is not profitable enough for traders when it is sold live. In order to sell it better, traders prefer to present it with its shell removed in order to fool consumers.

The *Achatina achatina* and *Archachatina marginata* snails found on the market are juvenile and subadult snails. This could be explained by the fact that during the season of abundance, snail collectors in the wild gather the largest snails and leave the smaller ones behind. On the other hand, during the dry season, when large snails become scarce not only because of the pressure exerted on them during the rainy season but also because of unfavourable environmental conditions, the population throws its lot in with the small snails left in the wild during periods of abundance.

The absence of large snails on the market could also be explained by the fact that those that have not been seen and collected by poachers during the

rainy season hide in the forest during the dry season, out of the poachers' reach. Small snails, on the other hand, have little experience of camouflage and remain within the poachers' reach for the most part.

The snails found for sale during the dry season on the Abobo market showed a higher proportion of edible fresh meat in juveniles than in sub-adults. On the other hand, the proportion of shells in subadults was greater than in juveniles.

This suggests that as snail's age, they produce much more shell than meat (Nyglé *et al.*, 2014). In fact, snails consume more calcium as adults to solidify their shells and to make their egg shells (Aman *et al.*, 2019 and 2023).

Analysis of the results showed that the juveniles of *A. achatina* sold on the abobo market during the dry season were smaller in size and live weight than the *Archachatina ventricosa* snails found on sale during this period. This would mean that during the season of shortage, the markets are supplied by a large number of immature snails collected from the wild and from farms. And yet this has enormous consequences for the natural snail stock because these immature snails do not have time to lay eggs and leave offspring in the wild before being collected for consumption. *Archachatina ventricosa*, on the other hand, would be accepted by consumers at a relatively higher weight and length. Whatever the physiological stage, *A. achatina* snails showed a higher proportion of shell and fresh meat than *Archachatina ventricosa* snails. This could be explained by the fact that *Archachatina ventricosa* in the live state would contain more haemolymph, slime and water than *Achatina achatina*.

This study showed that in *Achatina achatina*, the proportion of edible flesh is equal to the proportion of empty shell, whereas in *Archachatina ventricosa* the proportions of edible flesh and shell are identical. *A. ventricosa* is an arboreal species, whereas *A. achatina* remains permanently on the ground, where it draws

minerals, particularly calcium. This leads to high shell production in this species.

Conclusion

During the dry season, two species of snails are sold on the Abobo market. These are the species *Achatina Achatina* and *Archachatina ventricosa*. The snails sold are exclusively juveniles and subadults, weighing on average between 34.29 ± 6.18 and 61.5 ± 10.40 g with a yield of edible fresh meat of between 13.71 ± 2.96 and 22.5 ± 4.16 g. Dry-season markets offer *Archachatina ventricosa* snails with an average live weight ranging from 38.8 ± 3.30 to 56.04 g and an average quantity of edible fresh meat varying from 14.4 ± 0.81 to 19 ± 1.02 g. So, during the dry season, the majority of snails sold for consumption are immature snails. This poses a real danger to Ivorian malacofauna, as most of these snails have not been able to produce offspring in the wild before being collected. To avoid seasonal shortages and the consumption of immature snails of the wild, it is essential to promote the breeding of these molluscs.

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