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# Infestation rate of African giant snails (*Achatina fulica* and *Archachatina marginata*) by parasites during the rainy season in three localities of Cameroon

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**Abstract**

This study was designed during the rainy season in order to identify the parasites likely to infest edible snails. 360 *Achatina fulica* and *Archachatina marginata* was sampled in the Littoral, Center and West regions of Cameroon. After macroscopic observation of snails, the hepatopancreas, digestive tract, sex organs, slime and haemolymph were isolated. These samples were examined using the flotation techniques and direct rubbing. Of the 360 snails sampled, 213 (59.3%) were infested, that is 147 (82.1%) for *A. marginata* and 66 (36.7%) for A. fulica respectively. The highest infestation rate was recorded on protozoans (41.4%) followed by nematode (24.7%). The most represented parasites were *Trichodina achatinae* (23.9%) and *Strongyloides stercoralis* (16.1%); while the least represented were cyst of *Balantidium coli* (8.1%), *Enteromonas sp.* (8.1%), cyst of *Isospora sp.* (7.8%), larva of *Protostrongylus sp.* (7.5%), cyst of *Cryptosporidium sp.* (6.4%), mesocercariae of *Alaria sp.* (6.4%), larva of *Enterobius vermicularis* (4.2%), larva of *Angiostrongylus cantonensis* (2.5%), egg of *Hyostrongylus rubidus* (1.9%), egg of *Globocephallus urosubulatus* (1.4), non-identified mite (1.1%), egg of *Fasciola sp.* (0.3%), egg of *Oesophagostomum sp.* (0.3%) and egg of *Paragonimus westermani* (0.3%). Snails from Santchou were more infested (70.6%) followed by those from Wouri (58.3%) and then from Lekie (49.2%).

## INTRODUCTION

The issue of sustainable development and the high demand in animal protein has pushed the local community to develop and promote the non-conventional animal husbandry in Africa. Unconventional animal husbandry is the breeding of small wild vertebrates and invertebrates [1]. Various animal species such as snails are used in unconventional mini-farming. The consumption of snail meat increased exponentially over the years because of their high nutritive value. Around 1900 tons of these molluscs are sold in the Abidjan markets in Ivory Coast each year [2]. In Cameroon, statistics are scare, even though snails are found in almost all markets in the forest areas [3] and are highly consumed over time. However, the massive exploitation of snails and the expansion of cultivated land, the reduction of forest areas, the use of insecticides, bush fires and predators raises questions on the continued availability of snails, [4] hence an increasingly necessity towards their domestication.

Snails are highly appreciated for the flavor and meat quality that they provide [5]. Snail's meat can help to reduce protein deficiency and minerals deficiency in developing countries because of its high protein content which variable from 40% to 82.87% [6,7]; its proteins contained almost all the essential amino acids, energy [8,9] and minerals like Calcium, Zinc, Magnesium and Iron [10]. Their shell powder is used in animal feed such as broilers and layers, small livestock and cattle as a source of calcium [11]; it can also be used in crop production to reduce soil acidity [2]. The interest in snail meat consumption is currently very high because of the high demand in white meat for health reasons [12]. The largest quantities of snails consumed are fetched from the wild while only few are reared. The domestication of edible land snails is limited by a number of constraints including the lack of information related to their nutritional needs and health challenges [13]. In fact, snails are exposed to various types of pathogens like parasites, bacteria, fungi [13]. Parasites are among the main causes of health challenges in snails as previously reported [13]. But few data are available regarding edible snails, especially the giant African snails which are widely eaten all over Africa and beyond. In fact, the parasites reported to be present in African giant snails collected in Nigeria and Ivory Cost include *Dicrocoelium spp*, *Fasciola gigantica, Schistosoma mansoni, Strongyloides stercoralis, Protostrongylus sp., Balantidium sp., Trichomonas sp.* [14,15]. In addition, African giant snails have been reported to

be carrier of zoonotic parasites, like lungworm *Angiostrongylus cantonensis* [16] with the increasing risk of transmission to man and animals [17]. So, the establishment of a snail farm requires a prior control of parasites as well as the risks associated with snail consumption and its derivatives on public health. *Archachatina marginata* and *Achatina fulica* are much consumed in Cameroon; could these species be potential reservoirs of parasites? If yes, which type of parasites? What are the factors that can affect its infestations rate?

In order to answer these questions, the present study was designed to identify parasites in *Archachatina marginata* and *Achatina fulica* in the rainy season, which is the appropriate period to harvest snails in Cameroon.

## MATERIALS AND METHODS

### Study area and period

The study was carried out from March to November 2019 in three localities of the Littoral (Wouri), Center (Lekie) and West (Santchou) regions of Cameroon.

Littoral is a coastal city located in the humid dense forests zone of Cameroon with a monomodal rainfall. The town is located between latitude 2°6" - 6°12" North, and longitude 8°48" - 10°30" East. The climate is very humid and hot while the rains are abundant (mean rainfall 2,500 to 4,000 mm). The annual temperature varies between 22 and 29°C and the annual air humidity between 85 and 90% [18] Center is located in the wet forest zone with a bimodal rainfall, between latitude 2°6"- 4°54" North and longitude 10°30"- 16°12" East. The climate is warm and humid with an average temperature of 25°C and a rainfall of 1500-2000 mm per year [18]. The Western region is located between latitude 4 ° 54 " and 6 ° 36" North, and 9 ° 18 " and longitude 11 ° 24" East. The climate is marked by two seasons of unequal length: a dry season, going from mid-November to mid-March, and a rainy season which lasts from mid-March to mid-November. The mean temperature is low (19 ° C), and the rainfalls are heavy (1500-2000 mm) [18].

### Animal

A number of 360 snails belonging to two species, *Achatina fulica* (180) and *Archachatina marginata* (180) were collected for this study (that is 60 snails per species and per locality).

### Snail collection and identification

*A. fulica* and *A. marginata* (Figure 1) were collected in the forest by a local snail collector in each locality and stored in a ventilated container. The container was covered with a piece of mosquito net and transported to the laboratory. Snails were identified at the species level according to their shape, sizes, colors, the marks on the shells and the shape of apex of their shells [19].

### Procedure for parasite collection and identification

The snails were observed macroscopically using a stereomicroscope in order to detect any presence of ectoparasites. The observed parasites were removed from the snail using forceps and kept in a Petri dish until identification.

**Figure 1** Picture of *A. fulica* (left) and *A. marginata* (right).

After the macroscopic analysis of the outer part of the snails, the snails were washed with tap water and the slime was removed by scratching the foot and placing it on slide for examination. Then the apex of the snail shell was broken to extract the hemolymph. The apex was broken using a clean and sterile hammer. Following extraction, various organs (hepatopancreas, digestive tract and genital tract) were gently isolated into Petri dishes.

Smears of the slime and hemolymph were performed and examined (directly and after coloration with lugol staining techniques). A drop of the sample was placed on the slide and a drop of dye was added on it. Then, the mixture was homogenized before observation under the microscope.

The hepatopancreas, digestive tract and genital tract were carefully examined macroscopically for the presence of any parasite. Then, each organ was crushed into a mortar and subjected to the flotation analysis, using granulated sugar as flotation solution [20,21]. All these preparations were observed under the microscope at 10X magnifications.

The ectoparasites were identified based on their morphology, shape, size, shape of the head, shape of the legs, number of legs, structure and color as described by [22].

The larvae were identified based on the shape of the tail, the nature of the cell nuclei, the nature of the tail and the shape of the head as previously described [22]. The egg, oocyst and cyst were identified based on their morphology, size, structure, wall, shape and their color as described by Villeneuve and Damour [22] and Thienpont et al., [23].

### Statistical analysis

The analysis of the infestation rate of the different groups of parasites per host species, organs and sampling area was done using the Chi-square test with a significant level of 0.05. SPSS 20.0 and excel software was used.

## RESULTS AND DISCUSSION

### Results

**Parasite species identified:** A total of 16 parasites species (Figure 2) infested the African giant snails, with various infestation rates (Table 1). They were made up of five Protozoans, seven Nematodes, three Trematodes and one Mite.

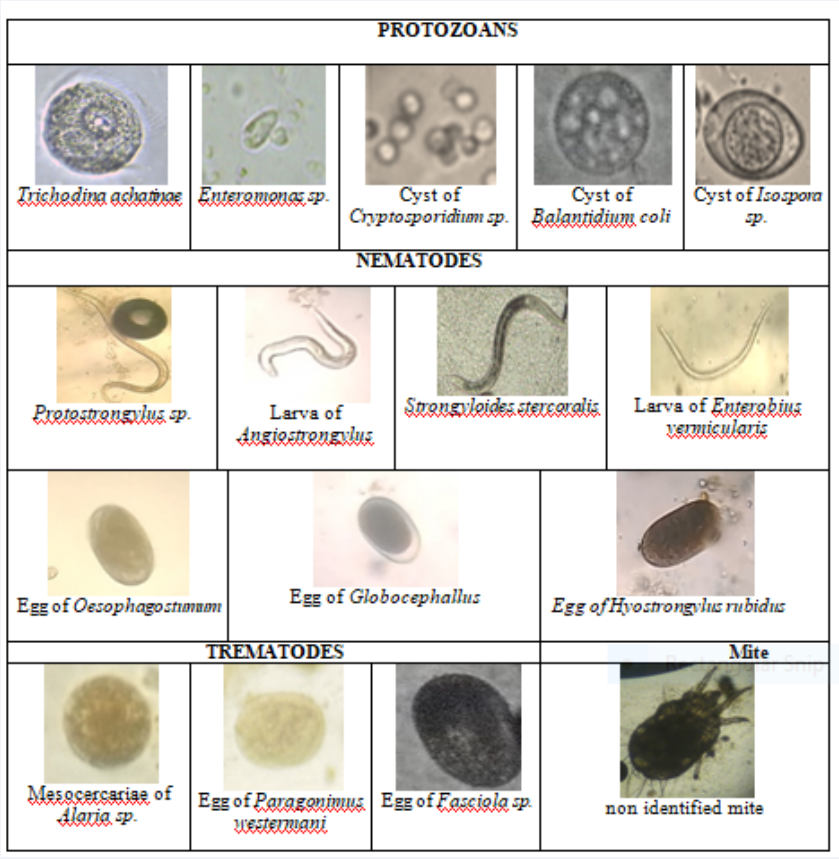


**Figure 2** Gallery of the parasite stages found in African giant snail in Cameroon.

**Table 1:** Parasites species of edible African giant snails (*A. fulica* and *A. marginata*) in the rainy season in Cameroon.

| Parasites | Sampling area | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Wouri (N=120) | | Menoua (N=120) | | Lekie (N=120) | | Total (N=360) | | |
| | (n) | (%) | (n) | (%) | (n) | (%) | (n) | (%) | *P-value* |
| *Isospora sp.* | 14 | 11.7 [a] | 2 | 1.7 [c] | 12 | 10.0 [b] | 28 | 7.8 | 0.008 [×] |
| *Balantidium coli* | 5 | 4.2 [a] | 13 | 10.8 [a] | 11 | 9.2 [a] | 29 | 8.1 | 0.142 |
| *Trichodina achatinae* | 18 | 15.0 [b] | 58 | 48.3 [a] | 10 | 8.3 [c] | 86 | 23.9 | 0.000 [×] |
| *Enteromonas sp.* | 11 | 9.2 [b] | 15 | 12.5 [a] | 3 | 2.5 [c] | 29 | 8.1 | 0.015 |
| *Cryptosporidium sp.* | 3 | 2.5 [a] | 9 | 7.5 [a] | 11 | 9.2 [a] | 23 | 6.4 | 0.089 |
| **Protozoans** | **39** | **32.5** | **78** | **65.0** | **32** | **26.7** | **149** | **41.4** | **0.000** |
| *Angiostrongylus cantonensis* | 9 | 7.5 [a] | 0 | 0.0 [b] | 0 | 0.0 [b] | 9 | 2.5 | 0.000 [×] |
| *Protostrongylus sp.* | 22 | 18.3 [a] | 2 | 1.7 [c] | 3 | 2.5 [b] | 27 | 7.5 | 0.000 |
| *Strongyloides stercoralis* | 26 | 21.7 [a] | 6 | 5.0 [b] | 26 | 21.7 [a] | 58 | 16.1 | 0.000 [×] |
| *Hyostrongylus sp.* | 1 | 0.8 [a] | 1 | 0.8 [a] | 5 | 4.2 [a] | 7 | 1.9 | 0.097 |
| *Enterobius vermicularis* | 9 | 7.5 [a] | 2 | 1.7 [a] | 4 | 3.3 [a] | 15 | 4.2 | 0.066 [×] |
| *Globocephallus urosubulatus* | 0 | 0.0 [a] | 1 | 0.8 [a] | 4 | 3.3 [a] | 5 | 1.4 | 0.072 |
| *Oesophagostomum sp.* | 0 | 0.0 [a] | 0 | 0.0 [a] | 1 | 0.8 [a] | 1 | 0.8 [a] | 0.367 |
| **Nematodes** | **44** | **28.3** | **11** | **9.2** | **34** | **36.7** | **89** | **24.7** | **0.000** [×] |
| *Fasciola sp.* | 0 | 0.0 [a] | 0 | 0.0 [a] | 1 | 0.8 [a] | 1 | 0.8 | 1.000 |
| *Alaria sp.* | 12 | 10.0 [a] | 2 | 1.7 [c] | 9 | 7.5 [b] | 23 | 6.4 | 0.025 [×] |
| *Paragonimus westermani* | 1 | 0.8 [a] | 0 | 0.0 [a] | 0 | 0.0 [a] | 1 | 0.3 | 0.367 |
| **Trematodes** | 12 | 8.3 | 2 | 1.7 | 10 | 10.0 | 24 | 6.7 | 0.024 [×] |
| non identified mite | 2 | 1.7 [a] | 1 | 0.8 [a] | 1 | 0.8 [a] | 4 | 1.1 | 1.000 |
| **Mite** | 2 | 1.7 | 1 | 0.8 | 1 | 0.8 | 4 | 1.1 | 1.000 |

a, b, c: averages bearing the same letters on the same line are not significantly($P$>0.05) different; N: Total number of samples; n: number of positive samples; (%) infestation rate in percentage; [×]: significant *p-value.*

13 parasites species were identified in snails collected in Wouri against 12 in Santchou and 14 in the Lekie (Table 1). There was a significant ($p < 0.05$) difference in the infestation rate for *Isospora sp., Trichodina acahtinae, Enteromonas sp., A. cantonensis, Prostrongylus sp.* and *Alaria sp.* between the study locations. The infestation rate of most parasites was significantly ($p<0.05$) higher in Santchou for protozoa and in the Wouri for nematodes than other localities. However, the parasite mostly present in Santchou was *Trichodina achatinae* whereas in the Wouri was Strongyloides stercoralis.

**Distribution of parasites according to organs:** The majority of the parasites identified were observed in slime and digestive tract. Indeed, genital tract was the least parasitized organ with a single parasite followed by the hemolymph with three parasites (Table 2). *Balantidium coli* were found in all organs examined as well as *Isospora sp.* which was also found in all organs except in the genital tract.

**Infestation rate of different groups of parasites by location, weight and species:** The highest infestation rate was recorded in protozoans and in nematodes. The infestation rates of these classes of parasites were significantly ($p<0.05$) higher in *A. marginata*, Santchou locality and in snails with weights between 50 and 100g (Table 3).

**Infestation rate of parasites by location, weight and species:** Of the 360 snails sampled, 213 (59.3%) were infested, that is 147 (82.1%) for *A. marginata* and 66 (36.7%) for A. fulica respectively. The weight has a significant ($p<0.05$) influence on the infestation rate of parasite; snails with weights between 50 and 100 g recorded the highest infestation rate (73.9%) followed by those with weights of more than 100 g (55.8%). There was a significant ($p<0.05$) difference in the infestation rate of parasites by location. Indeed, snails collected in Santchou had the highest infestation rate (70.6%) followed by snails collected in the Wouri (58.3%) and then those from Lekie (49.2%) (Table 4).

**Infestation rate of detected parasites by host species:** A total of 11 parasite species were identified in *A. fulica* and 16 in *A. marginata* (Table 5). The infestation rate between *A. fulica* and *A. marginata* was significantly ($p<0.05$) different for *Trichodina achatinae, Cryptosporidium sp., A. cantonenesis, Protostrongylus sp*, *Strongyloides stercoralis* and egg of *Hyostrongylus rubidus*. The highest infestation rate was recorded with *Trichodina achatinae* (23.9%) followed by *Strongyloides stercoralis* (16.1%).

## Discussion

*Archachatina marginata* and *Achatina fulica* were colonized by different groups of parasites, including nematodes (24.7%), trematodes (6.7%), protozoans (41.4%) and mite (1.1%). These results corroborate the findings of [15] in which protozoa were also highly present (97.7%) followed by nematodes (95.8%) and

**Table 2:** Distribution of parasites in snail organs.

| | Hepatopancreas (N= 360) | | Digestive tract (N= 360) | | Genital tract (N= 360) | | Hemolymph (N= 360) | | Slime (N= 360) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parasites** | **N** | **%** | **n** | **%** | **N** | **%** | **n** | **%** | **n** | **%** |
| **Protozoans** | | | | | | | | | | |
| *Isospora sp* | 6 | 1.67 | 9 | 2.50 | 0 | 0.00 | 2 | 0.56 | 14 | 3.89 |
| *Enteromonas sp.* | 0 | 0.00 | 26 | 7.22 | 0 | 0.00 | 3 | 0.83 | 15 | 4.17 |
| *Trichodinae achatinae* | 0 | 0.00 | 4 | 1.11 | 0 | 0.00 | 0 | 0.00 | 84 | 23.33 |
| *Cryptosporidium sp.* | 0 | 0.00 | 15 | 4.17 | 0 | 0.00 | 0 | 0.00 | 9 | 2.50 |
| *Balantidium coli* | 3 | 0.83 | 16 | 4.44 | 4 | 1.11 | 5 | 1.39 | 5 | 1.39 |
| **Nematodes** | | | | | | | | | | |
| *Angiostrongylus sp.* | 1 | 0.28 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 9 | 2.50 |
| *Strongyloides stercoralis* | 1 | 0.28 | 5 | 1.39 | 0 | 0.00 | 0 | 0.00 | 52 | 14.44 |
| *Protostrongylus sp.* | 0 | 0.00 | 3 | 0.83 | 0 | 0.00 | 0 | 0.00 | 25 | 6.94 |
| *Enterobius vermicularis* | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| *Hyostrongylus sp.* | 1 | 0.28 | 4 | 1.11 | 0 | 0.00 | 0 | 0.00 | 2 | 0.56 |
| *Oesophagostomum sp.* | 1 | 0.28 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| *Globocephallus sp.* | 0 | 0.00 | 3 | 0.83 | 0 | 0.00 | 0 | 0.00 | 2 | 0.56 |
| **Trematodes** | | | | | | | | | | |
| *Fasciola sp.* | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 1 | 0.28 |
| *Dicrocoelium dendriticum* | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| *Shistosoma mansoni* | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| *Alaria sp.* | 6 | 0.00 | 7 | 0.00 | 0 | 0.00 | 0 | 0.00 | 10 | 2.77 |
| *Paragonimus sp.* | 0 | 0.00 | 1 | 0.28 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| **Mite** | | | | | | | | | | |
| Non identified mite | 3 | 0.83 | 1 | 0.28 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |

N: number of examined organs; n: number of infested organs; %: infestation rate in percentages.

**Table 3:** Infestation rate of different groups of parasites as affected by location, weight and species of snail.

| Parameters | | PROTOZOANS | | NEMATODES | | TREMATODES | | Mite | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | % | N | % | n | % | n | % |
| Species | *A. fulica* (N= 180) | 42 | 23.3[b] | 13 | 7.2[b] | 13 | 7.2[a] | 2 | 1.1[a] |
| | *A. marginata* (N= 180) | 107 | 59.4[a] | 76 | 42.2[a] | 11 | 6.1[a] | 2 | 1.1[a] |
| | Total (N= 360) | 149 | 41.4 | 89 | 24.7 | 24 | 6.7 | 4 | 1.1 |
| | *P-value* | 0.000* | | 0.000* | | 0.417 | | 0.689 | |
| Locality | Lekie (N=120) | 32 | 26.7[c] | 34 | 36.7[a] | 10 | 10.0[a] | 1 | 0.8[a] |
| | Santchou (N=120) | 78 | 65.0[a] | 11 | 9.2[c] | 2 | 1.7[c] | 1 | 0.8[a] |
| | Wouri (N=120) | 39 | 32.5[b] | 44 | 28.3[b] | 12 | 8.3[b] | 2 | 1.7[a] |
| | Total (N= 360) | 149 | 41.4 | 89 | 24.7 | 24 | 6.7 | 4 | 1.1 |
| | *P-value* | 0.000* | | 0.000* | | 0.024* | | 1.000 | |
| Weight | <20 (N=19) | 2 | 10.5[d] | 0 | 0.0[c] | 2 | 10.5[a] | 0 | 0.0[a] |
| | 20-50 (N=150) | 51 | 34.6[c] | 30 | 20.0[b] | 8 | 5.3[a] | 3 | 2.0[a] |
| | 50-100 (N=138) | 74 | 53.6[a] | 49 | 35.5[a] | 10 | 7.2[a] | 1 | 0.7[a] |
| | >100 (N =53) | 22 | 41.5[b] | 10 | 18.9[b] | 4 | 7.5[a] | 0 | 0.0[a] |
| | Total | 149 | 41.4 | 89 | 24.7 | 24 | 6.7 | 4 | 1.1 |
| | *P-value* | 0.000* | | 0.001* | | 0.795 | | 0.557 | |

a, b, c, d: averages bearing the same letter on the same line are not significantly different ($P>0.05$);N: Total number of samples; n: number of positive samples; (%) infestation rate in percentage;*: significant *p-value.*

**Table 4:** Over all infection rates (%) of parasites by location, weight and species.

| Variation factors | | n | % | p |
|---|---|---|---|---|
| Snail species | *A. fulica* (N= 180) | 66 | 36.7[b] | 0.000* |
| | *A. marginata* (N= 180) | 147 | 82.1[a] | |
| | **Total (N=360)** | **213** | **59.3** | |
| Locality | Lekie (N=120) | 59 | 49.2[c] | 0.003* |
| | Santchou (N=120) | 84 | 70.6[a] | |
| | Wouri (N=120) | 70 | 58.3[b] | |
| | **Total (N=360)** | **213** | **59.3** | |
| weight | <20 (N=19) | 4 | 21.1[d] | 0.000* |
| | 20-50 (N=150) | 78 | 52.0[c] | |
| | 50-100 (N=138) | 102 | 73.9[a] | |
| | >100 (N =53) | 29 | 55.8[b] | |
| | **Total (N=360)** | **213** | **59.3** | |

a, b, c: averages bearing the same letter on the same column are not significantly ($p<0.05$) different; N: Total number of samples; n: number of positive samples; (%) infestation rate in percentage;*: significant *p value.*

**Table 5:** Infestation rate of detected parasites by host species.

| Parasites | Species | | | | | | |
|---|---|---|---|---|---|---|---|
| | *A. fulica* (N=180) | | *A. marginata* (N=180) | | Total (N=360) | | |
| | (n) | (%) | (n) | (%) | (n) | (%) | *P-value* |
| *Isospora sp.* | 11 | 6.1[a] | 17 | 9.4[a] | 28 | 7.8 | 0.238 |
| *Balantidium coli* | 13 | 7.2[a] | 16 | 8.9[a] | 29 | 8.1 | 0.561 |
| *Trichodina achatinae* | 1 | 0.6[b] | 85 | 47.2[a] | 86 | 23.9 | 0.000* |
| *Enteromonas sp.* | 14 | 7.8[a] | 15 | 8.3[a] | 29 | 8.1 | 0.846 |
| *Cryptosporidium sp.* | 18 | 10.0[b] | 5 | 2.8[a] | 23 | 6.4 | 0.005* |
| **Protozoans** | **42** | **23.3** | **107** | **59.4** | **149** | **41.4** | **0.000** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Angiostrongylus Cantonensis* | 0 | 0.0 [b] | 9 | 5.0 [a] | 9 | 2.5 | 0.002[x] |
| *Protostrongylus sp.* | 1 | 0.6 [b] | 26 | 14.4 [a] | 27 | 7.5 | 0.000[x] |
| *Strongyloides stercoralis* | 5 | 2.8 [b] | 53 | 29.4 [a] | 58 | 16.1 | 0.000[x] |
| *Egg of Hyostrongylus* | 0 | 0.0 [b] | 7 | 3.9 [a] | 7 | 1.9 | 0.008[x] |
| *Enterobius vermicularis* | 6 | 3.3 [a] | 9 | 5.0 [a] | 15 | 4.2 | 0.429 |
| *Globocephallus urosubulatus* | 1 | 0.6 [a] | 4 | 2.2 [a] | 5 | 1.4 | 0.177 |
| *Oesophagostomum sp.* | 0 | 0.0 [a] | 1 | 0.6[a] | 1 | 0.3 | 0.317 |
| **Nematodes** | **13** | **7.2** | **76** | **42.2** | **89** | **24.7** | **0.000** |
| *Fasciola sp.* | 0 | 0.0 [a] | 1 | 0.6[a] | 1 | 0.3 | 0.317 |
| *Alaria sp.* | 13 | 7.2 [a] | 10 | 5.6 [a] | 23 | 6.4 | 0.518 |
| *Paragonimus westermani* | 0 | 0.0 [a] | 1 | 0.6 [a] | 1 | 0.3 | 0.317 |
| **Trematodes** | **13** | **7.2** | **11** | **6.1** | **24** | **6.7** | **0.417** |
| Non identified mite | 2 | 1.1 [a] | 2 | 1.1 [a] | 4 | 1.1 | 0.689 |
| **Mite** | 2 | 1.1 | 2 | 1.1 | 4 | 1.1 | 0.689 |

a, b: averages bearing the same letter on the same line are not significantly ($p$<0.05) different; N: Total number of samples; n: number of positive samples; (%) infestation rate in percentage;[x]: significant *p value.*

finally trematodes (0.4%) in two snail species (*Achatina achatina* and *Archachatina ventricosa*) in southeastern Ivory Coast. The presence of non identified mite is a new result.

The 16 parasite identified in this study were *Trichodina achatinae* (23.9%), *Strongyloides stercoralis* (16.1%), cyst of *Balantidium coli* (8.1%), *Enteromonas sp.* (8.1%), cyst of *Isospora sp.* (7.8%), larva of *Protostrongylus sp.* (7.5%), cyst of *Cryptosporidium sp.* (6.4%), mesocercariae of *Alaria sp.* (6.4%), larva of *Enterobius vermicularis* (4.2%), larva of *Angiostrongylus cantonensis* (2.5%), egg of *Hyostrongylus rubidus* (1.9%), egg of *Globocephallus urosubulatus* (1.4), Non identified mite (1.1%), egg of *Fasciola sp.* (0.3%), egg of *Oesophagostomum sp.* (0.3%) and egg of *Paragonimus westermani* (0.3%). The presence of these parasites is in accordance with the work of Igbinosa et al., [14]. Who isolated *S. ransoni, Alaria sp., D. dendriticum, A. cantonensis* and *S. mansoni* in terrestrial snails (*Achatina achatina, Achatina fulica, Acharchatina marginata, Limicolaria aurora, L. flammea and Limicolariopsis sp*.) in Benin? This result is also similar to that of Karamoko et al. [14] who found B. coli, *Protostrongylus sp.* and *D. dendriticum* in two snail species (*Achatina achatina* and *Archachatina ventricosa*) in southeastern Ivory Coast. These correlations could be justified by the fact that these two localities roughly share the same geo-climatic characteristics with the surveyed regions of Cameroon.

The parasite highly present in this study was *Trichodina achatinae* (23.9%). Its presence is similar to the findings of Zongo (1996) [24] who identified this parasite in A. zebra. In fact, during their infectious stage, this parasite is found especially in the external area, in water, vegetation and soil in particular where they can stay for much time. These characteristics can explain the abundance of this parasite in this study due to the ecological behavior of snails which like to feed on soil, vegetation and wet environment to ensure their activities.

*Strongyloides stercoralis* (16.1%) was the second parasite highly present. These results corroborate those of Igbinosa et al., [14] in which this parasite was the most prevalent (54.04%) in terrestrial snails (*A. fulica*) in a study conducted in Nigeria in both dry and wet seasons. This could be explained by the fact that this study was carried out during the rainy season, and, this parasite is known to thrive in wetlands of the tropical and subtropical regions, and also in regions with a temperate climate [25]. The presence of this parasite could also be attributed to its abundance in the soil coupled with its ability to easily locate snail host because of its secretions (slime) [26].

*Balantidium coli* were identified in this study with an infestation rate of 8.1%. These results are similar to those obtained by Karamoko et al., [14]. Who found *B. coli* in the two snail species *Achatina achatina* and *Archachatina ventricosa*, with an infestation rate of 8%. This result is also similar to the findings of Igbinosa et al., [13]. who isolated this parasite in the mantle, and genital apparatus and with those of Manaphraim [ 27] who isolated these parasites in the hemolymph, slime and hepatopancreas of *Achatina achatina* and *Achatina fulica* with high infestation rate. The presence of this parasite raises many questions because of its monoxenic life cycle. As its evolution proceeds on the same host or partially in the external environment [28], African giant snail can be considered as a definitive host for this parasite.

The nematode *Protostrongylus sp.* was also isolated in this study with low infestation rate (7.5%). The presence of this parasite is in accordance with the results of Patrelle et al., [29] who identified this parasite with an infestation rate of 0.54% on 3622 snails in France. However, The infestation rate obtained in this study was very little, which contradicts those of Karamoko et al., [14] who recorded an infestation rate of 24% and 48% respectively in *Archachatina ventricosa* and *Achatina achatina*. The presence of this parasite can be explained by the fact that, snails live mainly on litter of humid and hot forest environments of tropical Africa, but this litter is rich in microorganisms like Protostrongylus. The relatively low infestation rate of this parasite in this study could be explained by the fact that, snails are vegetarian. Indeed, among the plants prized by snails, there are some which have antiparasitic properties, which could explain this relatively low infestation rate; since this study was

carried out in the rainy season, a season where a dense flora is made available.

Another parasite identified was *E. vermicularis* with an infestation rate of 4.2%. This parasite is a cosmopolitan parasite, frequent in developing countries, Russia, Europe and North America [30]. In this study, the larvae stage of this parasite was found in the snail body. African giant snail can be considered as an intermediate host for this parasite.

*A. cantonensis* has also been isolated from these snails with an infestation rate of 2.5%. Its presence here corroborates the work of Igbinosa et al [13]. Who isolated this nematode in the African giant snail (*A. fulica*) in Nigeria. *A. fulica* has been incriminated as the intermediate host of *A. cantonensis* [31]. Thus, its presence in edible snails in Cameroon is a cause for concern because human is at risk infection with *A. cantonensis* if infective larvae are ingested [32,33].

Several factors influenced the infestation rate of the observed parasites including snail species and sampling area. The average infestation rate was 59.3% (82.1% in *A. marginata* and 36.7% in *A. fulica*). These results contradict those of Cardoso et al., [34] who revealed that, *Achatina fulica* is the most parasitized of all the other snail species with metabolic activity and the largest microbial community. However, the infestation rate recorded in this study is very close to the results of Karamoko et al., who had an infestation rate of 52% in *A. achatina* and 74% in *Archachatina ventricosa*. This could be explained by the fact that Littoral, Center and West regions of Cameroon have approximately the same geo-climatic characteristics as the locality of Azaguié investigated by Karamoko et al., [15] in Ivory Coast. At the same time, there was a significant ($p<0.05$) difference in the infestation rate of parasites by location. Indeed, Snails collected in Santchou were more infested (70.6%) followed by snail from Wouri (58.3%) and then those from Lekie (49.2%). The higher infestation rate observed in Santchou can be explained by the facts that, the temperature is very low in this locality in the rainy season. These low temperatures made the snails vulnerable to many parasites. The higher infestation rate observed in Wouri can be explained by the higher level of insalubrity in this locality. In fact, the locality of Wouri is characterized by water stagnating, high density of population and the affluence of rain.

Results related to organ distribution of parasites showed that *Protostrongylus sp.* was restricted to the slime and digestive tract. These results contradict those of Karamoko et al., [14] who isolated this parasite on snail foot, mantle, intestine and even the stomach and this with very high prevalence of 48% in *A. achatina* and 24% in A. ventricosa against a total infestation rate of 2.5% recorded in this study. On the other hand, the presence of this parasite in these snails corroborates the results of Dreyfuss and Rondelaud [35] who reported that terrestrial molluscs constitute intermediate hosts for the majority of nematode and trematode species. Similarly, the preferential localization of this parasite in the flesh and between the flesh and the mantle could be explained by the fact that this parasite infests the mollusc in its larval form (L1) by transcutaneous penetration [35]. *S. stercoralis* was identified in the hepatopancres, digestive tract and even slime. This may be explained by the fact that the morphological characteristics of this parasite facilitate its penetration through the foot of the snail or through other exposed regions, which justifies its presence in the mantle [36], On the other hand, the majority of the parasites identified were observed in the slime and digestive tract. Indeed, the genital tract was the least parasitized organ with a single parasite followed by the hemolymph with three parasites. In fact, snails use different innate mechanisms involving mediating cells and humoral reactions such as soluble hemolymph factors that suppress invading pathogens. This mechanism can explain the low infestation rate observed in the hemolymph in this study [37].

## CONCLUSION

At the end of this study, we concluded that *Archachatina marginata* and *Achatina fulica* were colonized by different groups of parasites, including nematodes, trematodes, protozoans and mite. *A. marginata* were more infested than *A. fulica* and snails collected in Santchou were more infested followed by snails from Wouri and finally snails from Lekie. The highest infestation rate was recorded with *Trichodina achatinae* followed by *Strongyloides stercoralis*. Amongst the identified parasites, some are own to snails, others used snails as intermediate host and others as paratenic host.

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