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ORIGINAL ARTICLE

Spatial Distribution pattern of Freshwater Mollusks in Mé, Agnéby and Banco basins (Ivory Coast; West Africa)

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ABSTRACT

An inventory and the spatial distribution of the mollusks in the Agnéby Mé and Banco basins was studied. This survey revealed low molluscan biodiversity in the three basins. Eleven species belonging to eight genera and six families were identified. Their spatial distribution showed an absence of mollusks from the Banco basin and Miadzin high school area. The most common species in the Agnéby and Mé basins were the ubiquitous species Melanoides tuberculata, Physa marmorata, Bulinus forskalii and Lymnaea natalensis. Conductivity, pH, redox potential and aquatic plants appeared to be the main factors responsible for the spatial distribution of the species in the studied localities. Three invasive species, Physa marmorata, Indoplanorbis exustus and Melanoides tuberculata were reported. Several surveyed species in our basins were important intermediary host of parasites, particularly Planorbidae who constituted potential risk to public health.

KEYWORDS: *mollusk, inventory, dynamic, Agnéby Mé Banco basins, Ivory Coast (West Africa)*

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INTRODUCTION

For several years, many water bodies have been built in Ivorian continental environment. Their initial role was the production of electricity, irrigation, drinking water production and livestock watering. They are also a huge hydro potential can support a large production in Côte d'Ivoire. Rational management of these waters would reduce the deficit in animal protein fish originally estimated at 73% and filled by a massive importation [1]. For better fisheries management and optimum utilization of this natural asset, it is necessary to understand the operation.

Indeed, the water very variable dimensions collections host many invertebrates including benthic fauna remains poorly known in Côte d'Ivoire. The benthic macrofauna is an essential part of food chains in freshwater ecosystems [2]. It is strongly affected by the construction of several hydroelectric dams on rivers in Côte d'Ivoire [3]. The effects of these profound changes result in significant changes in diversity and species composition of benthic communities [4].

The effect of human impact leads to the proliferation of the secondary fauna whose mollusks are the most important representatives of the biomass [5], and some species play an important role in the transmission of parasites of medical and veterinary interest. Côte d'Ivoire is ranked among the countries in the world have been reported for *Schistosoma mansoni* and *S. haematobium* [6]. Also, some mollusks are used in biological control against the vectors of these parasitic diseases. Their use can provide an interesting alternative to use of molluscocides, which are expensive and have an impact on local fauna [7]. mollusks are an important group in various ecological chain in number of species, their diversity and their numbers [8]. Reference [5] has been reported in Africa 341 species of freshwater mollusks, they are also involved in the determination of several indices of biotic integrity as the Global Standardized Biological Index (IBGN). Also, mollusks are being exploited economically, in food and also for aesthetics [9]. Finally, several species of African fish consume a greater or lesser mollusks [10].

In Côte d'Ivoire, the literature on mollusks is scarce in general and particularly in freshwater. The study of the ecology of aquatic mollusks is an essential foundation for a better understanding of these invertebrates in their environment and therefore their management (the exploitation of shellfish economic interest or control of those who have a medical or veterinary importance).
The objective of this study is to provide a better understanding of freshwater mollusks in coastal basins Mé, Agnéby and Banco. We conducted an inventory of the Malacological fauna of the three basins and we determined the distribution pattern of mollusks species encountered.

MATERIALS AND METHODS

Study area

The preliminary study permitted to choose six study areas located in three watersheds (Agnéby, Mé, and Banco) between latitudes 05 ° 21 '43'' North and 06 ° 06' 43'' North and longitudes 03 ° 51 '32'' West and 04 ° 05' 17'' West. In the watershed Agnéby we have Agboville (upstream) and Attinguié (downstream). In Mé basin, were retained Adzopé and Miadzin in the upstream and Azaguié in the middle course, and finally we have the Banco National Park which is located in Banco basin (Figure 1).

Sampling procedure

The survey was conducted monthly for nine months. All types of environment (ponds, lakes, canals and rivers) were visited in each station for at least 3 hours. Mollusks were sampled using long-handled scoop for a variable period of time depending on density, but always by the same collector. Mollusks have been identified subsequently with literature [11], [12], [13], [14], [15], [5], [16], grouped by species and counted.
Sample sites were characterized by measuring several environmental variables using a multiparameter apparatus *WTW* 840i: pH, conductivity (µS/cm), dissolved oxygen (mg/l), temperature (°C) and redox potential (mV). In addition, rainfall (mm) was measured by the meteorological Research Station at Adiopodoumé. The percentage of aquatic vegetation cover was also estimated for each plant species.

Statistical analysis

Variance analyzes performed using *SPSS* 10.0 software at 5% were used to compare the means of physico-chemical parameters measured, and test the significance of differences. The Kolmogorov-Smirnov one sample was performed to check the normality of the data and the Kruskal Wallis test was used to compare variables. A Factorial Correspondence Analysis (FCA) has brought together the study sites, species of mollusks and relate them, and Canonical Analysis (RDA) was performed with the *CANOCO* 4.5 software to highlight settings medium that influence the distribution of species.

RESULTS

In this study, a total of 11 species belonging to 8 genera and 6 families were reported in Agnéby and Mé basins. families Bithyniidae, Thiaridae, Lymnaeidae and Physidae are represented by a single instance, the Ampullariidae two species and Planorbidae five species. A Factorial Correspondence Analysis (FCA) using the matrix (16 factors and 11 species) highlighted five groups (Figure 2). the lake at Adzopé is characterized by the association of *Bulinus truncatus* and *Lanistes varicus*. Agnéby river is associated to *Indoplanorbis exustus* and *Bulinus forskallii* and ponds and channels at miadzin to *Bulinus globosus*. *Physa marmorata* characterized Attinguié pool, Adzopé and Agboville rivers. The other environments are associated with any particular specie and you will usually found *Melanoides tuberculata*.
The Analysis of the malacological spatial distribution indicates that no mollusk was collected in the Banco basin, lake and ponds in agricultural college Miadzin and the pond at Azaguié. In the Agnéby basin, we have reported 10 species at Agboville and 6 at Attinguié. While on Mé we note 7 species at Adzopé and Azaguié and 5 at Miadzin. Species with specific locations are: *Gabbiella africana* only present in Agnéby river at Agboville and Attinguié, *Pila africana* occured in canals and the river at Agboville and *B. globosus* was only collected in the fish farm village at Miadzin. *Melanoides tuberculata*, *Lymnaea natalensis*, *Bulinus forskalii* and *Physa marmorata* are common species to all areas of the Agnéby and Mé basins. *Biomphalaria pfeifferi* and *B. truncatus* are present at Agboville Adzopé and Azaguié. *Indoplanorbis exustus* was related to Agboville and Azaguié, and *Lanistes varicus* to Adzopé and Attinguié.
Redundancy analysis (RDA) of physical and biotic parameters that influence the spatial distribution of species in our study areas was performed (Figure 3). The percentage of variances of the first two axis is highly significant (Axis I 46% and axis II 27%). Conductivity, redox potential and plant most influenced the presence of mollusks in the localities. On the axis I Pulmonates *Physa marmorata*, *Bulinus forskalii*, *Lymnaea natalensis* are positively and significantly associated with vegetation cover and conductivity and negatively to redox potential. The presence of other species (*B. globosus*, *B. truncatus*, *Biomphalaria pfeifferi*, *Pila Africana, Lanistes varicus* and *Indoplanorbis* exustus) is less influenced by these two parameters. On Axis II, we note that *Gabbiella africana* is strongly associated with the conductivity and

less to pH, while the presence of the ubiquitous species *Melanoides tuberculata* appears to be less influenced by high values of conductivity and pH.

DISCUSSION

The main characteristic of molluscan communities in the basins studied is their low species richness. Indeed, the faunal inventory presents 11 species belonging to 6 families with different characteristics. This is consistent with the general observation of malacological fauna in tropical freshwaters. It is relatively low in comparison to the marine or land [17]. This is due to the low diversity of freshwater habitats and the various existing interspecific competition.

The presence of several invasive species in our sampling stations were indeed affect local molluscan fauna. This is the case of *Melanoides tuberculata* who is a very effective competitor some medical interest planorbids. He is responsible for the scarcity and even the disappearance of these mollusks in certain habitats [18]. The reproductive strategy is an advantage for this species in the invasion process. We collected this ubiquitous specie in all our sites in Agnéby and Mé basins.

Physa marmorata is also a native of the Lesser Antilles on the island of Saint Vincent invasive species. The introduction of this species in Africa predates the late nineteenth century and it is reported in West Africa, Ghana, Togo, Benin, Nigeria [5] and recently in Côte d'Ivoire [16]. Some authors suggest placing it in the genera Aplexa [19], [5], [20] because of the absence of preputial gland while [21] keeps it in *Physa*. No parasite can infect *Physa marmorata* is known.

The third invasive species is the Planorbid *Indoplanorbis exustus*, the type locality is in the Malabar coast of south-west India. This is a species that is now distributed in South and Southeast Asia, Saudi Arabia and has recently been reported in Nigeria [22], Cote d'Ivoire [23] and Bénin [24]. It is found in lentic environments often rich in vegetation. It is known as the intermediate host of *Schistosoma indicum*, *S. nasal, S. spindale* and Schistosomes of Arctiodactyles in Asia.

Ampullariidae family is represented by two species. *Pila Africana*, from Ghana and Accra Abetifi. It was harvested in ponds, canals thoroughly ground and in the Agnéby river at Agboville. *Lanistes varicus*, for its part, has to mean *L. guinaica*. The type locality is not known and its range extends from Ghana, Gambia, Senegal, Mali and Niger. This species is present in the leaves of *Nymphaea lotus* and rocks submerged in the lake Adzopé in ponds and canals land to Attinguié.

The Bithyniidae are generally common to many freshwater, but only one, *Gabbiella africana* also known under the name of *G. tournieri* is present in our samples. The type locality is in Côte d'Ivoire in Davo river near Gagnoa (Central West).

The Lymnaeidae family has a universal distribution in freshwater. *Lymnaea natalensis* is the only known species in West Africa. Its type locality is located in Natal, South Africa. This species has several synonyms due to the high variability of the shape of the shell. *Lymnaea natalensis* is common in perennial streams in small dams unpolluted, in impoundments shallow but rarely in temporary pools. It plays the role of intermediate host of *Fasciola hepatica* and *F. gigantica* in Africa.

Family Planorbidae is best represented in our stations with five species. Several species of this family are important intermediate hosts of parasites and therefore pose a potential risk to public health. It consists of two sub-families: Planorbinae with shells generally discoid (flat or lenticular) and Bulininae with turreted shell.

We have *Biomphalaria pfeifferi* whose type locality is in the Umgeni Valley in Natal in South Africa. This species is common throughout Africa. It is found in a variety of habitats such as streams, irrigation canals, ponds, lakes, dams, temporary water points. In tropical Africa, *B. pfeifferi* is the most important intermediate host of *Schistosoma mansoni*. The type locality of *B. globosus* is in the Dande River in Angola. Its range extends throughout Africa south of the Sahara. It is the intermediate host for many parasites such as *Schistosoma haematobium*, *S. bovis*, *S. curassoni*, *S. intercalatum*, *S. leileri* and *S. mattheii*.

B. truncatus has its type locality in Egypt. In Africa, it is found in several countries. The distribution of this species in West Africa was reviewed by [25]. It is the main intermediate host of *Schistosoma haematobium* in Africa and can accommodate *S. Bovis*, *S. margrebowiei*, *Calicophoron microbithrium* and *Echinostoma sp.*

Bulinus forskalii is widespread in Africa south of the Sahara and West Africa where it is a common species. *Bulinus forskalii* is the intermediate host of *Schistosoma intercalatum* in Gabon and Cameroon.

Freshwater mollusks are absent from the Banco River as noted in reference [26]. This is due to the fact that the National Park is a remnant of dense rainforest. Its conservation status is exceptional despite threats from various types of attacks [27]. Wildlife in general is quite poor [28] and the health state of the environment is not conducive to the development of mollusks in the Banco River. In addition, much of the flow of the river comes from the Banco resurgence of water tertiary continental sands. It runs entirely in the woods and acidic waters are unfavorable to the development of molluscs. The process of

photosynthesis is limited and periphyton production which feed on mollusks is very low, which does not encourage their development in this environment.

The lake and ponds of agricultural school at Miadzin also lack mollusks. Just as Banco, these environments are characterized by a very low conductivity and a high redox potential. Indeed, the conductivity measurement used to assess the amount of dissolved solids in the water that is in the form of electrically charged ions [29]. It increases with the secondary production environment and the mobility of ions. The redox potential is an important measure in water loaded with organic material parameter. It reflects the intensity of chemical, biochemical activities, and many vital processes such as breathing. Low values reflect a reduction or anthropic environment, often resulting in anaerobic conditions. The extreme values of these parameters have a negative impact on the colonization of these areas by mollusks. The vegetation is also a factor influencing the distribution of mollusks. It is for these nesting sites, shelter against predators, food sources or food stands.

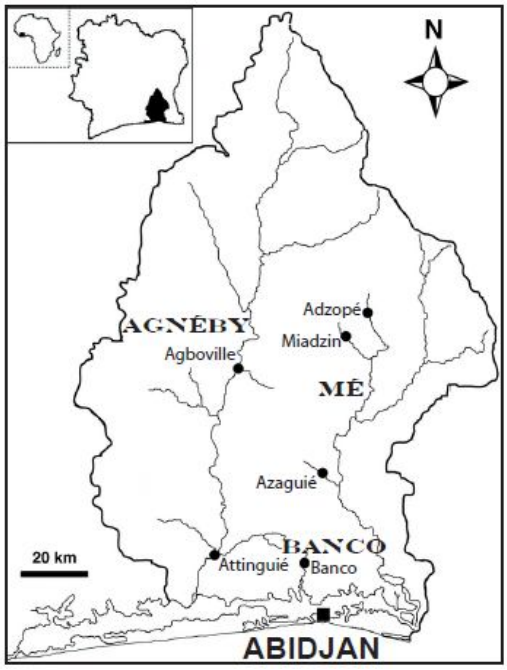

Figure 1 : Location of Agnéby, Mé and Banco basins and sampling stations.

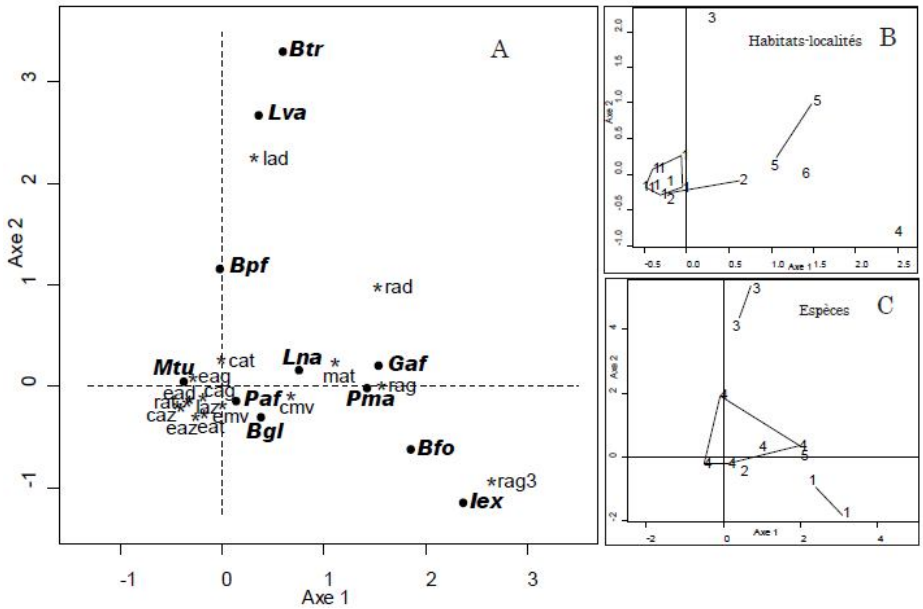

Figure 2 : Factorial Plan (1.2) resulting from the factorial correspondence analysis showing the spatial distribution of mollusks and sampling station (A), with the class representation of habitats (B) and species (C) obtained in the hierarchical cluster. *Bfo = Bulinus fiorskalii; Bgl = B. globosus, B.*

truncatus Btr =; Bpf = Biomphalaria pfeifferi; Gaf = Gabbiella africana Iex = Indoplanorbis exustus; Lna = Lymnaea natalensis; Lva = Lanistes varicus; Mtu = Melanoides tuberculata; Paf = Pila africana; pma = Physa marmorata, ad = Adzopé, ag = Agboville, at = Attinguié; Azaguié az = c = channel e = pond, pond m = r = river mv = Miadzin village.

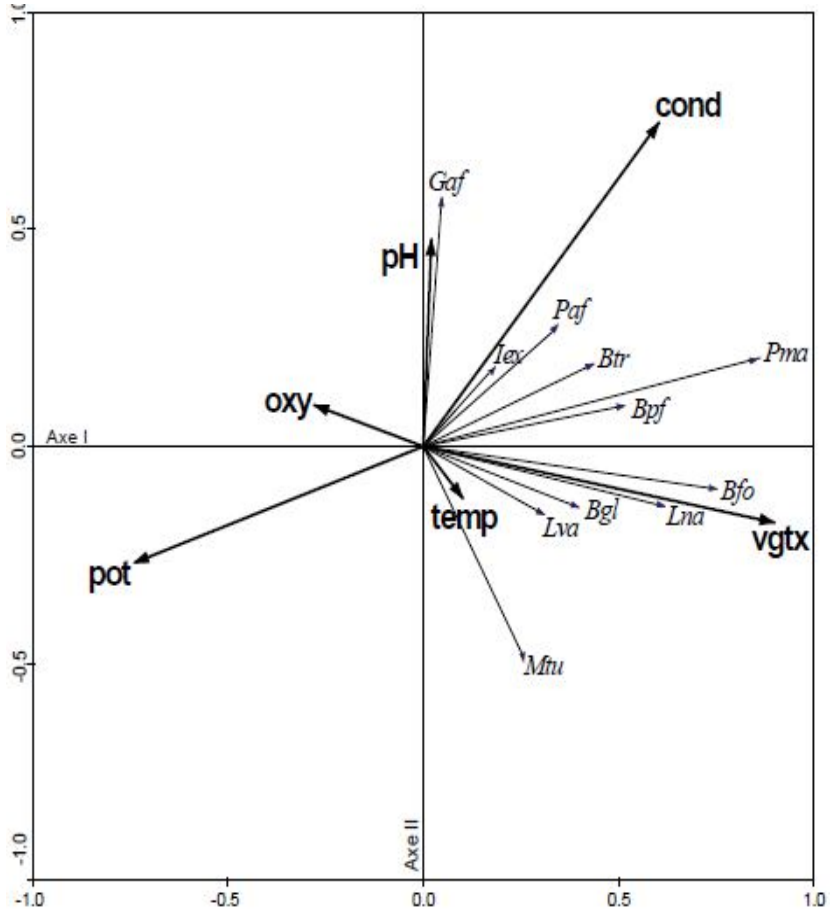

Figure 3 : Redundancy analysis (RDA) of the spatial distribution of the main species of molluscs and medium physical and biotic parameters. *Paf = Pila africana Lva = Lanistes varicus, Gaf = Gabbiella africana, Mtu = Melanoides tuberculata, Lna = Lymnaea natalensis Bpf = Biomphalaria pfeifferi, lex = Indoplanorbis exustus, Bgl = B. globosus, Btr = B. truncatus, Bulinus Bfo = forskalii, pma = Physa marmorata, cond = conductivity, dissolved oxygen = oxy, pot = ORP, temp = temperature of water = vgtx cover.*

CONCLUSION

The diversity of all three basins is low. Banco basin does not host any aquatic mollusk. Several species harvested in our watersheds are important intermediate hosts of parasites, especially Planorbidae which represent a potential risk to public health. Conductivity, redox potential and plant mainly influence the spatial distribution of mollusks. The presence of main species is positively correlated with conductivity and vegetation cover. However, this association is negative with redox potential. *Melanoides tuberculata* is an ubiquitous species whose spatial distribution is weakly influenced by conductivity and pH.

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