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Distribution strategy of *Nimbapanchax petersi* (Sauvage, 1882) and *Epiplatys chaperi sheljuzhkoi* (Poll, 1953) fish, in Banco National Park (Côte d'Ivoire, West Africa).

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ABSTRACT

Objective: This study highlights the distribution strategy of two fish species of *Nothobranchiidae* (*Nimbapanchax petersi* and *Epiplatys chaperi sheljuzhkoi*) according to environmental variables of Banco River in the National Park of Banco in order to characterize their preferential habitat.
Methodology and results: Sampling was conducted from December 2015 to January 2017 using dip nets. Four defined stations (B1 to B4) along the Banco River were visited. A total of 397 samples of *Nimbapanchax petersi* were collected. This species is more abundant upstream with 82.87% of the sampling. However, the 186 individuals of *Epiplatys chaperi sheljuzhkoi* captured were distributed homogeneously over the entire river along an upstream-downstream gradient. Canonical Correlation Analysis (CCA) has shown that the nature of the substrate (clay-mud mixture, rocks and deadwood-foliage mixture) and dissolved oxygen levels are critical factors in the distribution pattern of these species in the Banco River. *Epiplatys chaperi sheljuzhkoi* select habitats with mud, clay and deadwood-foliage mixture while *Nimbapanchax petersi* target rocky and more oxygenated environments.
Conclusion and application of results: These results, which are essential data on the ecology of aquatic species in the wild, could contribute to ensure better conservation of small freshwater fish. These baseline data for future studies will enable a sustainable stock conservation policy for these species to be put in place. In addition, faced with the anthropogenic pressures of the surrounding communities on this environment, park managers should pay more attention to the preservation of biodiversity in general and to the two species of Nothobranchiidae in particular.
Keywords : Distribution, Nothobranchiidae, aquarists, environmental factors, Banco River.

RÉSUMÉ

Objectif : Ce présent travail met en évidence la stratégie de distribution de deux espèces de Nothobranchiidae (*Nimbapanchax petersi et Epiplatys chaperi sheljuzhkoi*) en rapport avec les variables environnementales dans le Parc National de Banco en vue de caractériser leur habitat préférentiel.
Méthodologie et résultats : L'échantillonnage a été réalisé entre décembre 2015 et janvier 2017 à l'aide d'épuisette. Quatre stations (B1 à B4) définies ont été visitées le long de la rivière Banco lors des

différentes missions. Au total 397 individus de *Nimbapanchax petersi* ont été échantillonnés. Cette espèce est plus concentrée en amont avec 82.87 % de l'échantillonnage. Cependant les 186 individus d'*Epiplatys chaperi sheljuzhkoi* capturés se répartissent de façon homogène sur l'ensemble de la rivière suivant un gradient amont-aval. L'analyse canonique de correspondance (ACC) a montré que la nature du substrat (mélange argile-boue, bois mort, feuillage et rochers) et le taux d'oxygène dissous sont des facteurs déterminants de la stratégie de répartition de ces espèces dans la rivière Banco. *Epiplatys chaperi sheljuzhkoi* sélectionne les habitats à substrats boueux, argileux, couvert de feuillage et de bois morts tandis que *Nimbapanchax petersi* cible les milieux rocheux et plus oxygénés.
Conclusion et application des résultats : Ces résultats, qui constituent des données essentielles sur l'écologie des espèces aquariophiles en milieu naturel, pourrait contribuer à une meilleure conservation des petits poissons des eaux douces. Ces données de références pour les études futures permettront de mettre en place une politique de conservation durable du stock de ces espèces. Par ailleurs, face aux pressions anthropiques des communes environnantes sur ce milieu, les gestionnaires de ce parc devraient veiller davantage à la préservation de la biodiversité en général et des deux espèces de Nothobranchiidae en particulier.
Mots clés : Distribution, Nothobranchiidae, aquariophiles, facteurs environnementaux, rivière Banco.

INTRODUCTION

Forest ecosystems provide habitats for variety of wildlife ranging from terrestrial species to aquatic species and are one of the most complex ecosystems on earth (FAO, 1996). Similarly, aquatic ecosystems are complex environments with various physicochemical characteristics (Wetzel 2001, Kalff 2002). The combination forest-aquatic environment conserved away from human activities is undoubtedly a major asset for biodiversity (Tramers & Roger, 1973, Gammon *et al*., 1980) necessary for the survival of humanity. The accelerated development of human society is driving an increasing anthropic pressure on these environments. Human actions associated with climate change are real threats (Sala *et al.,* 2000). Yet, they have been largely neglected (Dynesius & Nilsson, 1994). In view of these threats and the importance of the conservation of biological diversity, Côte d'Ivoire has created 8 parks and 5 reserves well distributed according to the country's major ecosystems and covering more than 6% of the national territory (Lauginie, 2007). Among these parks is the National Park of Banco (NPB) which covers 3,474 hectares. This forest reserve is home to a river called Banco. Despite its location in this protected area, the Banco River is subjected to multiple human aggression due to sewage and surrounding communities drained into the NPB and runoff threatening the integrity and biodiversity of the river. The preservation of its biodiversity is therefore needed. Obviously, a lot of work has been done for both fauna and flora (Aké Assi *et al*., 1974, Béligné, 1994, Assemian *et al*., 2006, Kouamé *et al*., 2008, Tohé *et al.,* 2008, Yaokokoré -Beibro *et al*., 2014; Rodel *et al.,* 2009; Camara, 2013), but to date, few studies have focused on fish in the Banco National Park. Existing studies related to those of Daget & Iltis (1965), Paugy *et al.,* (2003b), which focused on the inventory and systematics of ichthyodiversity. According to these authors, 14 species composed of 14 genus and 11 families including that of *Nothobranchiidae* have been reported. Among the species reported in the Banco River are two small aquarium fish: *Nimbapanchax petersi* and *Epiplatys chaperi sheljuzkhoi*, which are popular with aquarists (Ewing & Evans, 1973, Down *et al.,* 1976). Despite the interest generated by these West African *Nothobranchiidae*, their ecologies are generally sketchy. As for aquarists, they naturally put their experience and their technical know-how into bear in breeding, without drawing scientific conclusions from their observations (Brosset, 1982). In any case, the taking of any measures as a result of the foregoing, requires a good knowledge of the species and the relationships that bind them to the environment. This study is on the distribution pattern of *Nimbapanchax petersi* and *Epiplatys* *chaperi sheljuzhkoi* in the Banco National Park in order to highlight the relationship between these fish species and environmental variables.

MATERIELS AND METHODS

Study area: The Banco National Park created in 1953 in the heart of Abidjan (Ivory Coast) has an area of 3474 hectares and is home to a river called Banco 9 km long. It lies between 5 ° 21 'and 5 ° 25' north latitude, 4 ° 01 'and 4 ° 05' west longitude with an altitude between 0 and 113 m (De Koning, 1983). Like the climate of southern Côte d'Ivoire, the Banco National Park has a humid tropical climate (Durand & Skubich, 1982) characterized by alternating dry seasons and rainy seasons. The Banco River is very shallow (0.01m to 1.2m) and rises near the northern edge of the Park at the foot of a steep hill and flows into the Ébrié lagoon to the south (Camara, 2013). The average air temperature of the NPB is 27 ° C, with an annual precipitation varying between 1600 and 2500 mm (Kouamé *et al*., 2008). There are two main types of soils in the Banco National Park: typical ferrallitic soils on clay sands and hydromorphic soils in temporary or permanent wetlands (Perraud, 1971). From upstream to downstream, four sampling stations B1, B2, B3 and B4 (figure 1) were selected. They are divided into the upper flow (B1 and B2), the middle flow (B3) and the lower flow (B4). The upstream stations (B1 and B2) have clear water with plant debris. These sites are lined with plants (*Turraenthus africanus, Petersianthus macrocarpus and Dacryodes klaineana*) and macrophyte flora (*Thaumatococcus daniellii*) with a sandy-loamy substrate (Camara, 2013). Station B1 a is a mainly rocky substrate. Station B2 is converted into a "natural pool" with the construction of a dam with an opening valve. Station B3 is covered with Indian bamboo (*Bambusa sp*) near a fish farm. Its substrate consists of clay and mud. Located at the entrance of the park and upstream in a place with a strong human washing activity, the B4 station has a clear water (clear) and lined with herbaceous or grassy vegetation. The substrate of this station composed mainly of sand.

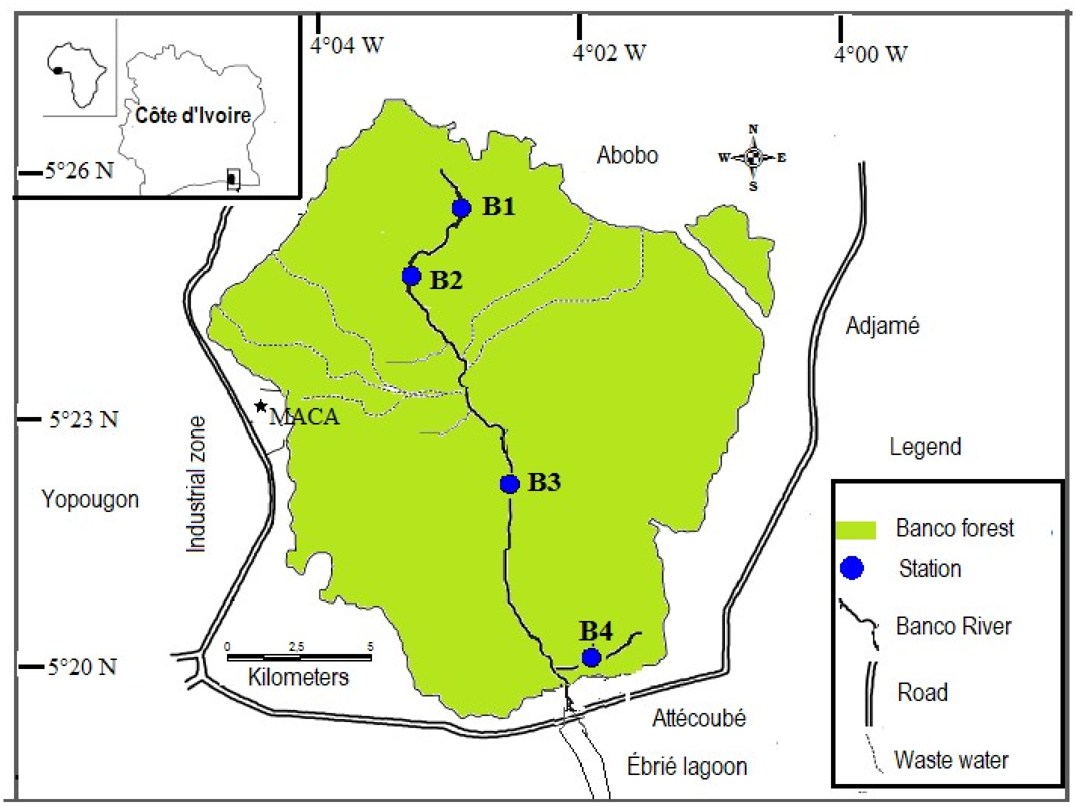


Figure 1: Location of the Banco River and Sampling Stations.

Data collection: Field data collection was conducted from December 2015 to January 2017 in four stations. Sampling of the fish was done in the water using a 1 mm in diameter. The captured fish were identified in the laboratory under a binocular microscope (SX25 vision) using the identification key of (Lévêque *et al.,* 1992, Paugy *et al.,* 2003b). These identifications were confirmed at the RMCA of Tervuren in Belgium by Jouke van der Zee & Rainer Sonnenberg on 9 May 2017. The fish were then measured and weighed (Sartorius TE 153S) to the nearest millimetre and gram respectively. The storage was in 10% formaldehyde.

Data analysis: This study focuses on spatial data analysis, exploring variations between different stations. The comparison of temporal variations in the different stations during the rainy and dry seasons will be examined in another publication. A descriptive analysis based on the mean and the standard deviation was applied to the physico-chemical variables data in order to highlight the spatial variation of these parameters. A Kruskall-Wallis H test was performed at the 5% threshold to assess the level of significance of this variation. Biological data were expressed from an abundance analysis at the spatial scale. The Kruskall-Wallis H test was performed at the 5% threshold to assess the spatial variation of *Nothobranchiidae* populations in the Banco River. This inferential analysis was preceded by a Shapiro-Wilk normality test at the significance level of 5% and was performed using the XLSTAT software. All these data have been the subject of a canonical correspondence analysis (CCA) through the CANOCO 4.5 software to highlight the main environmental variables that influence the distribution of *Nothobanchiidae* in the Banco River.

RESULTS

Physico-chemical environment: The spatial variations of the physicochemical parameters measured in the Banco River are shown in Table I. These results showed that the water temperature varies from 25.3 ± 0.64 ° C at B1 to 26.12 ± 0, 22 ° C at B4. The oxygen level varies from upstream to downstream. In fact, it is 6.37 ± 1.28 mg / l at station B1 and 4.79 ± 2.33 at station B3. The water of the Banco River is acidic. Its pH ranges from 5.51 ± 0.33 at B4 to 6.05 ± 0.3 at B3. The electrical conductivity ranges from 26.47 ± 3.68 µs / cm at B2 to 50.92 ± 1.34 µs / cm at B4. TDS (Dissolved Solids) ranged from 16.25 ± 0.23 mg / l at station B2 to 32.76 ± 1.36 mg / l at B4. The Kruskall-Wallis H test indicated a significant variation ($p < 0.05$) of conductivity and TDS at stations B2 and B4. On the other hand, the variation in pH, dissolved oxygen, and water temperature is not significant along the river (Kruskall-Wallis test, $p < 0.05$).

Table 1: Physico-chemical parameters (minimum, maximum, mean and standard deviation) of the stations studied in the Banco River from December 2015 to January 2017.

Parameters		STATIONS			
		B1 (a)	B2 (b)	B3 (c)	B4 (d)
water temperature	Min	24.7	25.5	25.1	25.9
	Max	26.2	26.9	27.2	26.4
	Mean	25.3 ± 0.64	26.02 ± 0.6	26.05 ± 0.94	26.12 ± 0.22
DO	Min	5	4,1	2.1	5.2
	Max	7.9	6,3	6.99	6.7
	Mean	6.37 ± 1,28	5.25 ± 1.02	4.79 ± 2.33	5.75 ± 0,68
pH	Min	5.23	5.15	5.61	5.12
	Max	6.73	6.35	6.3	5.89
	Mean	5.99 ± 0.82	5.84 ± 0.57	6.05 ± 0.3	5.51 ± 0.33
CND	Min	32.5	23.3	33.9	49.1
	Max	49.7	31.7	53.5	52.3
	Mean	38.65 ± 7.57	26.47 ± 3.67 (d)	45,5 ± 8.26	50.92 ± 1.34 (b)
TDS	Min	21.1	16	31	31,2
	Max	24.1	16.5	31.9	34,4
	Mean	22.6 ± 1.31	16,25 ± 0.23 (d)	31,35 ± 0.38	32,76 ± 1.36 (b)

Species distribution: A total of 583 individuals of *Nothobranchiidae* were captured from all the stations visited. This population composed of 397 *Nimbapanchax petersi* and 186 *Epiplatys chaperi sheljuzhkoi*. The spatial variation in abundance of *Nimbapanchax petersi* is shown in figure 2. This result indicates a significant spatial variation (Kruskall-Wallis, $p < 0.05$) with a high concentration of *Nimbapanchax petersi* (82.87%) upstream (B1) of the Banco River. The spatial variation of the numerical abundance of *Epiplatys chaperi sheljuzhkoi* is shown in figure 3. This result shows a homogeneous distribution (Kruskall-Wallis test, $p > 0.05$) of *Epiplatys chaperi sheljuzhkoi* throughout the river Banco.

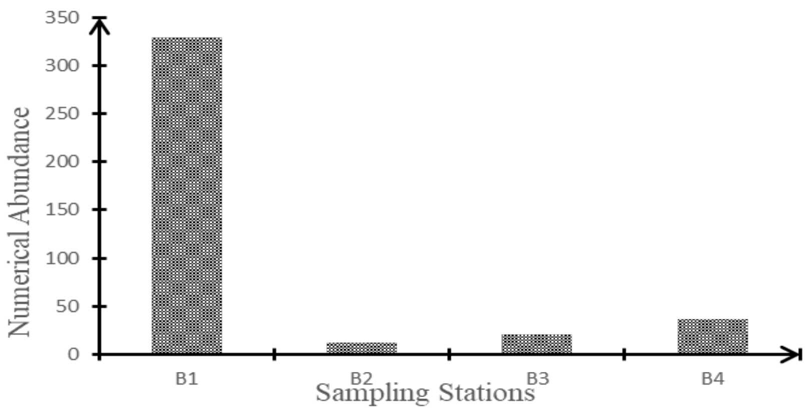


Figure 2: Spatial Variations of the Numerical Abundance of *Nimbapanchax petersi* in the Banco River.

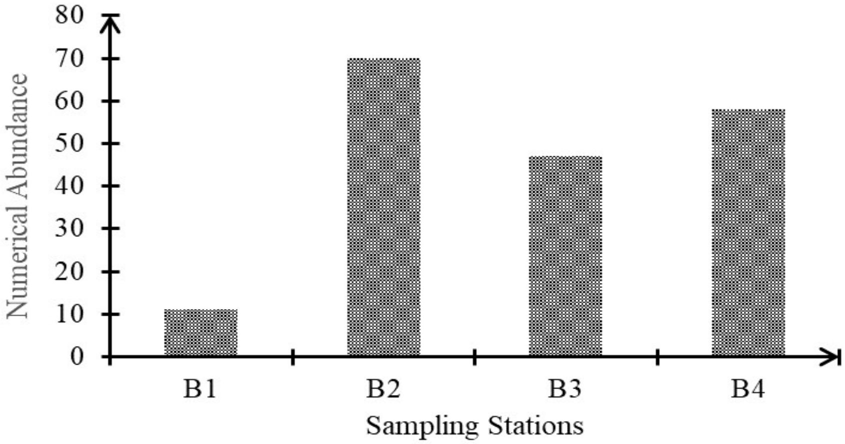
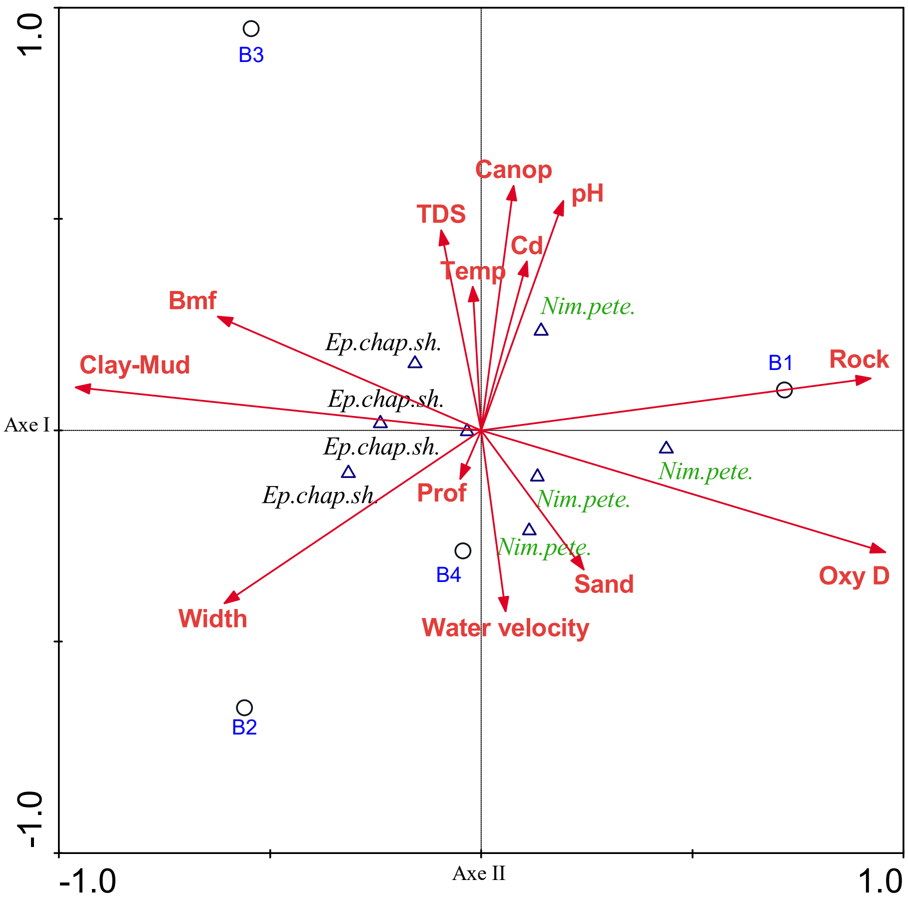


Figure 3: Spatial variations of the numerical abundance of *Epiplatys chaperi sheljuzhkoi* in the Banco River.

Patterns of species composition in relation to environmental variables: The influence of environmental variables on the distribution of *Nimbapanchax petersi* and *Epiplatys chaperi sheljuzhkoi* in the Banco River has been highlighted by the Canonical Correspondence Analysis (CCA) figure 4. The I ($\lambda1 = 0.188$) and II ($\lambda1 = 0.069$) axes express 92.9% of the cumulative variance values for the species data. These two axes were considered for the explanation of the results. The species *Epiplatys chaperi sheljuzhkoi* negatively correlated to axis I is associated with stations B2, B3, B4. These stations are characterized by the presence of dead-foliage and clay-mud. The species *Nimbapanchax petersi* positively correlated to axis I is associated with station B1. This station is characterized respectively by a bedrock with a high rate of dissolved oxygen.



Bmf =Dead Wood Foliage, TDS = total Dissolved Solids, Temp = Temperature, Canop = Canopy, Cd = conductivity, pH = Hydrogen potential, Oxy D = Dissolved Oxygen, *Ep.chap.sh.* = *Epiplatys chaperi sheljuzhkoi, Nim. Pete* = *Nimbapanchax petersi.* B1, B2, B4, B4 = the stations.

Figure 4: Canonic Correspondence Analysis (CCA) applied to environmental variables, sampling stations and species (*Nimbapanchax petersi* and *Epiplatys chaperi sheljuzhkoi*) captured using dip nets in the Banco River.

DISCUSSION

The analysis of the physical-chemical parameters of the Banco River did not indicate any significant spatial variation in temperature, pH, and dissolved oxygen levels in the water. In agreement with Camara, 2012, this invariability of temperature is due to the fact that the river is entirely located in the forest of the National Park of Banco. The treetops thus constitute a shade that reduces the impact of sun rays on the spatial variation of temperature. Rosseti *et al.* (2015) has demonstrated the existence of an interaction between water temperature and other physicochemical parameters such as water pH and dissolved oxygen level. This interaction of these physicochemical parameters would be responsible for the spatial invariability of the water pH and the level of the dissolved oxygen. On the other hand, a significant variation was observed in the electrical conductivity of the water and the level of dissolved solids, particularly at the B2 and B4 stations. This variation could be explained by the position of the stations in relation to the forest of the Banco National Park. Indeed, the station B2 is located upstream in the park while the station B4 is downstream near the peripheral area. This area is close to human activities and could receive runoff from human activities carried out on this watershed. The analysis of the abundance of the two species of *Nothobranchiidae* studied showed a predominance of *Nimbapanchax petersi* compared to *Epiplatys chaperi sheljuzhkoi* which represents half of the abundance of *N. petersi*. In addition, analysis of the distribution of the two species of *Nothobranchiidae* indicated a significant spatial variation. *Nimbapanchax petersi* is more abundant upstream of the river (82.87%) than *Epiplatys chaperi sheljuzhkoi,* its distribution is almost homogeneous in all stations. The results of the canonical correspondence analysis make it possible to deduce that *Nimbapanchax petersi* prefer the rocky or sandy environments which characterized the upstream of the river. These zones intensify the mixing of the water, which allows a good oxygenation of the environment. Generally shallow, these rocky and sandy areas upstream of the streams offer a very unfavourable environmental condition, favourable to the predators of these small fish adapted to the water current. In addition, the sandy substrate plays a major role in the fish reproduction. It contributes to clogging of the spawning grounds. It is likely that rocky or gravelly substrates would be used in spawning as indicated (Lévêque & Paugy, 2006) for some species. According to Morin, 2003 sandy substrates are suitable environments for the development of insect larvae and other small organisms that are important food sources for fish. The species *Epiplatys chaperi sheljuzhkoi* (*Nothobranchiidae*) adopted the muddy, muddy environments sheltering dead woods and foliage due to an important cover of the canopy. Similar studies indicated that *Nothobranchius* (Nothobranchiidae) also adopted partially overgrown muddy substrates (Reichard *et al.* 2009). This could be explained by the fact that clay and mud maintain the dead woods and foliage that are found in the bed of the stream under the effect of the wind. The terrestrial insects that live there would be a source of food to these *Epiplatys chaperi sheljuzhkoi*. Studies have shown that terrestrial insects have sometimes been found in the intestines of *Nothobranchius (N. furzeri, N. orthonotus and N. rachovii*) belonging to the family *Nothobranchiidae* (Reichard *et al.,* 2009)

CONCLUSION

Analysis of the physico-chemical parameters of the Banco River indicated the absence of significant spatial variation in temperature, pH and dissolved oxygen. This situation is related to the fact that this river is entirely located in the forest of the park. However, the proximity of anthropogenic activities downstream of the river could explain the significant variation observed in the conductivity and TDS of water. *Nimbapanchax petersi* has a high abundance upstream of the river while *Epiplatys chaperi sheljuzhkoi* is homogeneously distributed over the entire stream. Environmental factors such as clay-mud mix, the presence of dead wood and foliage influence the distribution of *Epiplatys chaperi sheljuzhkoi* while dissolved oxygen and the nature of the bedrock explain the distribution of *Nimbapanchax petersi* in Banco River.

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REFERENCES

Aké Assi L, Adjanohoun E, Camefortal H, 1974. Les milieux naturels en Afrique intertropicaux et à Madagascar. Tome IV: Écologie des forêts denses humides. La forêt du Banco. Projet pilote pour l'enseignement de la biologie en Afrique et à Madagascar, 63p.

Assemian NE, Kouamé NG, Tohe B, Gourène G, Rödel MO, 2006. The anurans of the Banco National Park, Côte d'Ivoire, a treatened West African rainforest. Salamandra, 42: 41-51.

Béligné V, 1994. Étude de l'état du milieu naturel du Parc National de Banco. Rapport WWF pour MINAGRA-DGEF-DPN. Recommandation pour sa sauvegarde et son aménagement, Côte d'Ivoire (1), 48 p.

Brosset A, 1982. Le peuplement de Cyprinodontes du bassin de l'Ivindo, Gabon. Revue d'Écologie Terre et Vie, 36: 233-295.

Camara A, 2013. Composition, structure et déterminisme des macro invertébrés de la rivière Banco (Parc National du Banco; Côte d'Ivoire). Thèse de Doctorat de l'Université Nangui Abrogoua, Abidjan, Côte d'Ivoire, 139 p.

Daget J, Iltis A, 1965. Poisson de Côte d'Ivoire. Eaux douces et saumâtres. IFAN, DAKAR, 74: 324-366.

De Koning J, 1983. La forêt du Banco; tome I: La forêt; tome II: La flore. Veenman, H. & Zonen, B. V., Université de Wageningen, 156p.

Down M, Ewing AW, Sutherland I, 1976. Studies in the behaviour of Cyprinodont fishes. III. The temporal patterning of aggression in Aphyosemion striatum (Boulenger). Behaviour, 3: 252-268.

Durand JR, Skubich M, 1982. Les lagunes ivoiriennes. Aquaculture, 27: 211-250.

Dynesius M, Nilsson C, 1994. Fragmentation and flow regulation of river systems in the northern third of the world. Science 266: 753-762.

Ewing AW, Evans V, 1973. The agonistic and sexual behaviour of Aphyosemion bivittatum. Behaviour, 46: 264-278.

FAO, 1996. Code modèle des pratiques d'exploitation forestière. Rome. En ligne: www.fao.org/docrep/ V6530E/V6530E00.HTM

Gammon JR, 1980. The use of the community parameters derived from electrifishing catches of river fish as indicators of environmental quality. Seminar on water quality trades-offs, EPA-905/9-80-009, U.S environmental protection agengy, Washington, D.C 335-363.

Kalff J, 2002. Limnology: inland water ecosystems. New Jersey: Printice Hall. 592 p.

Kouamé NG, Tohe B, Assemian NE, Gourène G, Rödel MO, 2008. Prey composition of two syntopic Phrynobatrachus species in the swamp forest of Banco National Park, Ivory Coast. Salamandra, 44: 177-186.

Lauginie F, 2007. Conservation de la nature et aires protégées en Côte d'Ivoire. CEDA/NEI et Afrique Nature (Eds), Côte d'Ivoire, 668 p.

Lévêque C, Paugy D, Teugels GG, 1992. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Tome 2. MRAC, Tervuren; ORSTOM, Paris. Collection Faune Tropicale 28, pp. 385-902.

Lévêque C, Paugy D, 2006. Impacts des activités humaines. In: Les Poissons des Eaux Continentales Africaines: Diversité, Écologie, Utilisation par l'Homme, Lévêque C, Paugy D (eds). IRD: Paris; 395-413.

Morin EBS, 2003. Restauration des berges et sensibilisation de la population à de bonnes pratiques en milieu riverain. Document de synthèse, 51 p.

Paugy D, Lévêque C, Teugels GG, 2003 b. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest, Tome II. Éditions IRD (Paris), MNHN (Paris), MRAC (Tervuren), 356-386 p.

Perraud A, Avenard JM, Eldin M, Girard G, Sircoulon J, Touche beuf P, Guillaumet JL, Adjanohoun E, 1971. Les sols. In: Le milieu naturel de la Côte d'Ivoire. Mémoire ORSTOM, Paris, 50, 391 p.

Reichard M, Polacik M, Sedlácek O, 2009. Distribution, colour polymorphism and habitat use of the African killifish Nothobranchius furzeri, the vertebrate with the shortest life span. Journal of Fish Biology 74, 198 - 212.

Rödel MO, Kosuch J, Grafe UT, Boistel R, Assemian EN, Kouamé GN, Tohé B, Gourène G, Perret JL, Henle K, Tafforeau P, Pollet N, Veith M, 2009. A new tree-frog genus and species from Ivory Coast, West Africa (Amphibia: Anura: Hyperoliidae). Zootaxa, 2044: 23-45.

Sala OE, Chapin FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, 2000. Global biodiversity scénarios for the year 2100. Science, 287: 1770-1774.

Tohé B, Assemian NE, Kouamé NG, Gourène G, Rödel MO, 2008. Déterminisme des Coassements des Anoures de la ferme piscicole du Parc National du Banco (Côte d'Ivoire). Sciences & Nature, 5 (1): 71-79.

Tramers EJ, Roger PM, 1973. Diversité and longitudinal zonation fish population of two streams enteringa metropolitan area mild. Nat. 90: 366-374.

Yaokokoré BK, Kouadio KP, Assa ES, Konan EM, Odoukpe K, 2014. Diversité des oiseaux du sous-bois du parc national du banco, Abidjan (Côte d'Ivoire) Rev. Ivoir. Sci. Technol, 24: 196 -212.

Wetzel RG, 2001. Limnology: Lake and river ecosystems. San Diego: Academic Press, 998 p.