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Oscar Wembo Ndeo
(A) Department of Hydrobiology and Aquaculture, University of Kisangani, B.P 2012, Kisangani, D. R. Congo
(B) Department of Biology, Faculty of Science, Mbarara University of Science and Technology, P. O. Box 1410, Mbarara, Uganda
(C) Department of Aquatic Biology, Faculty of Sciences, Ruwenzori State University, Butembo, B.P 560 Butembo, D. R. Congo

Victor Kangela
Departement d'Eaux et Forêts, Institut Supérieur d'Etudes Agronomiques de Bengamisa, B. P 202, Kisangani, R. D. Congo

Floribert Mathe Saliki
Department of Aquatic Biology, Faculty of Sciences, Ruwenzori State University, Butembo, B.P 560 Butembo, D. R. Congo

Raphael Yende Grevisse
Department of Environmental management, Nile Basin High School, B.P 100, Beni, D. R. Congo

Alidor Kankonda
Department of Hydrobiology and Aquaculture, University of Kisangani, B.P 2012, Kisangani, D. R. Congo

Correspondence
Oscar Wembo Ndeo
(A) Department of Hydrobiology and Aquaculture, University of Kisangani, B.P 2012, Kisangani, D. R. Congo
(B) Department of Biology, Faculty of Science, Mbarara University of Science and Technology, P. O. Box 1410, Mbarara, Uganda
(C) Department of Aquatic Biology, Faculty of Sciences, Ruwenzori State University, Butembo, B.P 560 Butembo, D. R. Congo

Endemic gastropods of the Central Congo River: A conservation assessment

Oscar Wembo Ndeo, Victor Kangela, Floribert Mathe Saliki, Raphael Yende Grevisse and Alidor Kankonda

Abstract
The recognition of the Congo River as hotspot of biodiversity is mostly based on fish biodiversity and endemism, not for invertebrates in general. Considering both the role of molluscs as aquatic resource for riparian people and the expected threats by various factors, the knowledge of actual populations, their conservation status and their distribution in this region becomes an urgent necessity. We collected 1,425 specimens, belonging to 4 species of the genus *Potadoma* in remote areas of the Congo basin, partly in regions that have not been visited for 100 years for any mollusc sampling. Our survey showed the scarcity of molluscs in the river Aruwimi, the alarming outcomes of the IUCN assessment for *Potadoma* species and the consumption and business made with *Potadoma* species. A permanent monitoring system could allow better assessments of the impacts of temporal fluctuations and the conservations status of endemic gastropods of the Central Congo River.

Keywords: Central Congo River, endemic gastropods, conservation assessment

1. Introduction
Although the Congo River is known to be a global hotspot of freshwater biodiversity, this recognition is mostly based on fish biodiversity and endemism. Less attention has been paid to invertebrates; this is also true for molluscs [1]. The few existing old data refer to original taxonomic descriptions or dealt with the Congo Basin molluscs in general [2]. The recent publication of Graf *et al.* (2011) [3] on the freshwater molluscs of Central Africa showed that in the region, the historical data exist in relatively small number of specimens, and there are no new data collections in the way to confirm the existence of that biodiversity. However, it is clear that present-day diversity and distribution are extremely different from that based on these previous records due to a number of reasons, (1) only a very restricted regions were explored, (2) the threats to freshwater mollusc and their ecosystems (habitat loss, fragmentation and modification, associated with growing human populations, industrialisation and changes in land use, as well as expanding ranges of non-native invasive species), (3) the extreme morphological variability of freshwater mollusc. Considering both the role as aquatic resource for riparian people and the expected threats by various factors, the knowledge of actual populations and their distribution in this region becomes an urgent necessity.
About 20 *Potadoma* species are recognised in modern taxonomy and the genus has an enigmatic, disjunct distribution over the African continent [4, 5]. In Kisangani, Three localities are currently known from historical records, stretches of the Congo River, the Tshopo River (below dam), Lindi River, Aruwimi River and parts of the Lualaba River. The range core seems to be towards Ubundu, 60 km south of Kisangani. The habitat of the lower part of the genus' range is degrading due to urbanization, with pollution and sedimentation being the main drivers. Until now, there is no information available regarding population sizes, no conservation measures in place specific for this species, and zero data about population trends. Moreover, the species of the target genus are currently known to be consumed in large quantities by riparian people. No assessment of this unknown threat exists. This study aims to collect baseline data that will facilitate the development of future conservation efforts of the freshwater mollusc (*Potadoma*) of the Central Congo River. The main objectives of this study are (a) To assess the mollusc biodiversity of the genus *Potadoma* in the central Congo River and its tributaries around the town Kisangani, with particular focus on the type locality and

remaining populations of the target genus. (b) To estimate the habitat status and its pollution and human pressure trends. (c) To assess the conservation status and develop a conservation plan for the target species.

2. Methodology

The study was based on extensive field work in remote areas of the Congo basin, partly in regions that have not been visited for 100 years or mostly have never been targeted for any mollusc sampling (see Fig.1). We collected in River Congo (below Boyoma Falls) 14 stations, River Lualaba 20 stations and in 3 tributaries of Congo rivers 30 stations (Tshopo, Aruwimi and Lindi). This totals of 66 stations allowed us to have a representative sampling.

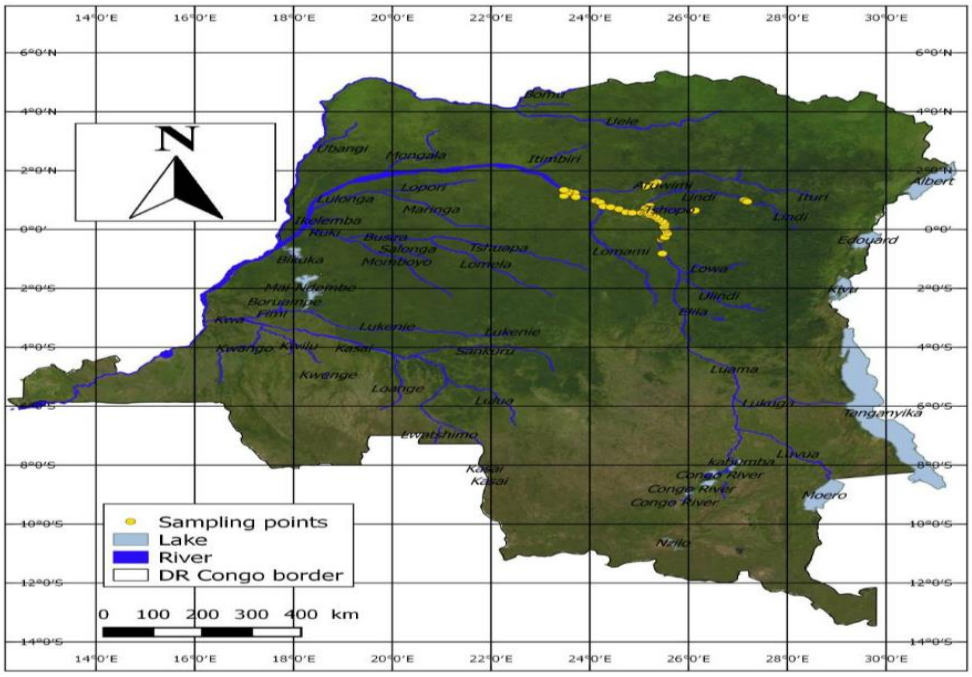

Fig 1: Map of the study area showing the 64 sampling points in DRC, in areas of the Central Congo River and tributaries.

2.1 Mollusc collection

The species of the target genus lives in special habitats, e.g. zones with rocky substrate, rapids, and falls, sampling was executed by hand picking in most of the case. Moreover, we used also a scoop net with a diameter of 20 cm and mesh size of 1 mm and dredge for to collect in area with soft substrates and in deeper water. The collected molluscs were transferred into 80% ethanol and stored in the Hydrobiological and Aquaculture Laboratory of the University of Kisangani.

2.2 Water parameters

Water temperature (°C), pH and conductivity were measured using a combined Multi- parameters tool HACH LANGE HQ40d, depth was measured by a depthmeter.

2.3 Habitats status and pollution

These were estimated directly at each sampling site using a standardized protocol with measured and categorical variables to be estimated (e.g. width, substrate type, land use impact, waste water discharge etc.) and geographic coordinates were recorded and pictures were made by using a camera with GPS Ricoh VG-4. We interviewed also local people to estimate the extent to which the exploit the *Potadoma* species as food resource.

2.4 Laboratory work

Mollusks were determined up to species level using the nomenclature of Pilsbry and Bequaert (1927) [2], Mandahl-Barth (1988) [5], Brown (1994) [4], and Daget (1998) [6]. The number of individuals of each taxon and the number of species at each sampling site were counted.

2.5 Statistical analyses

Statistical analyses were achieved utilizing the software Excel and R. We used the Function Envfit in the Vegan package for the statistical software R 3.3.2 (R Core Team, 2016) [7] for to know which environmental variable correlated with macrobenthos composition. The CCA to establish the relation between *Potadoma* species and their habitats, and indices of diversity, similarity were calculated using the software PAST3.

2.6 Conservation assessments

Redlisting assessments followed categories and criteria of Red List of the IUCN [8].

3. Results and discussions

Sampling of molluscs at the 64 stations resulted in a total of 1,425 specimens, belonging to 4 species of the genus *Potadoma* (see table 1). To the 12 forms listed for the neighborhood of Kisangani by Pilsbry and Bequaert (1927) [2], summarized to six forms by Brown (1994) [4], we collected four species. However, it is noteworthy that some of the endemic elements of the genus *Potadoma* explicitly mentioned by the latter authors were present also in our study, namely *Potadoma ponthiervillensis, P. alutacea, P. ignobilis, and P. liricincta*. Nevertheless, we also missed some of species at some places that they were mentioned by the latter authors, for example *P. ignobilis* (Congo River, Aruwimi), *P. liricincta* (Aruwimi rivers).The growth of the town of Kisangani and some of the small town around Kisangani has ever increased and the environmental impact by human activities is high [3, 9], which might have led to changes in the overall faunal composition of the area [10].

Table 1: Collection sites with their respective sampled species, systematic position of collected species and the IUCN Red List Status. RLi: river Lindi, RT: river Tshopo, RA: river Aruwimi, RL: River Lualaba, RC: Congo River; VU: Vulnerable, EN: Endangered, CR: Critique, LC: Least Concern and DD: Data Deficient

Family	Species	IUCN-CS	RLi	RT	RA	RL	CR
Pachychilidae	*Potadoma alutacea*	VU	+	+	-	+	+
	P.ponthirvillensis	EN	+	+	-	+	+
	P.ignobilis	LC	-	+	-	+	-
	P.liricincta	NT	+	-	-	+	+

Schultheiss *et al.* (2011) [11] showed that the conservation status of many freshwater molluscs from the Central Africa cannot be assessed adequately due to insufficient data. Of the sampled species, one is assessed as Least Concern, one as Vulnerable, one as Endangered and one as NT in the IUCN Red List of endangered species (table 1). It is clear that the outcomes of the IUCN assessment (Table 1) are alarming for two *Potadoma* species and reiterate the call for urgent conservation activities. Whereas, changes are recognizable in their habitat, for example, the introduction of the species *Melanoides* cf. *tuberculata* in the Kisangani area has been recently shown (Van Bocxlaer *et al.*, 2015) [12] and the results of Thieme *et al.* (2005) [13] that confirmed that the freshwater fauna of large parts of Central Africa has experienced considerable anthropogenic pressure due to deforestation, mining and untreated waste waters that are playing a considerable role nowadays in the faunal composition of the Central Africa rivers.

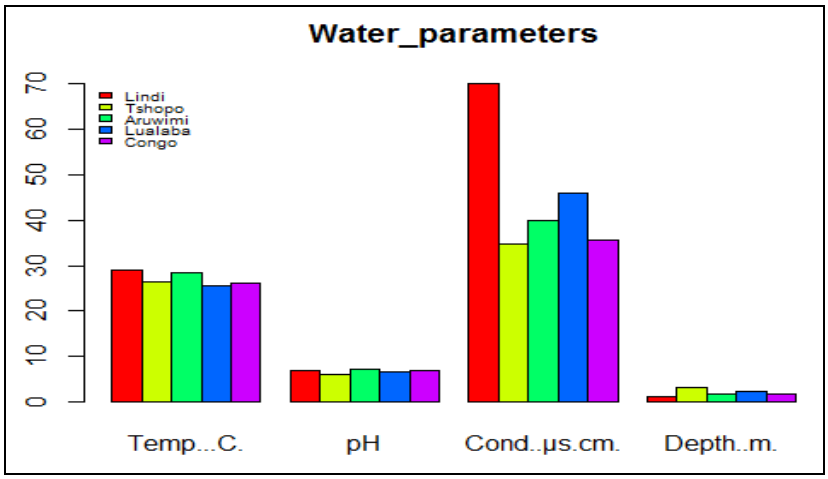

Fig 2: Environmental variables measured in each sampling point.

Our results showed that, following the evaluation of the water parameters (Temperature, pH and Conductivity) at the sampling sites, there were not marked differences between the sites, except the conductivity at Lindi river that was higher than at the others site (see Fig. 2). Testing the result, the NMDS showed that local environmental factors, especially those related to substrate characteristics such as rocks, were significantly correlated with mollusc community composition, but the explained variation was low (Tab. 2).

Table 2: Results of Non-metric multidimensional scaling testing if environmental variables affected mollusc community composition

	NMDS1	NMDS2	r2	Pr(>r)
Temp(°C)	0.26337	0.9647	0.5388	0.41
pH	0.23502	0.97199	0.5958	0.41
Cond(µs/cm)	-0.05988	0.99821	0.6984	0.3
Depth(m)	-0.05966	-0.99822	0.7096	0.32
Rocks	-0.5924	-0.80564	0.976	0.05*
Stones	-0.33406	0.94255	0.8916	0.08
Sand	0.95	0.31225	0.9887	0.2
Mud	-0.75287	0.65817	0.2448	0.8
Detritus	-0.75287	0.65817	0.2448	0.8

r2 gives the squared correlation coefficient, the significances (Pr>r), or P-values are based on random permutations of the data. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Potadoma species were collected in four rivers, in the stations dominated by the rocks and stones substratum. The river Aruwimi was an exception, where all the stations were dominated by a bank of sand. This scarcity of molluscs in the Aruwimi River has not been mentioned by researchers. Our sampling efforts were severely hampered by this bank of sand, which allowed only limited exploration of the river.

The relation between *Potadoma* species and their habitats was influenced by the presence of the rocks substratum (Fig. 3). None *Potadoma* species was found in Aruwimi River that was dominated by the sand substrate, for example. However, our study confirms expectations, as the substrate is known to influence the benthic assemblages found in fluviatile environments [14, 15]. Abundance and species richness have been demonstrated to correlate with size and heterogeneity of the substrates [16]. Living in the flowing rivers, requires some degree of adaptation towards rheophilous life-styles. Hard bedrock (*i.e.*, substrate rocks) develops pools and boulder, which represent microhabitats for certain gastropod species [4]. These types of substrate structure were also assumed to account for relatively high local biodiversity of mollusks at Wagenia Cataracts [2], reconfirmed by our study.

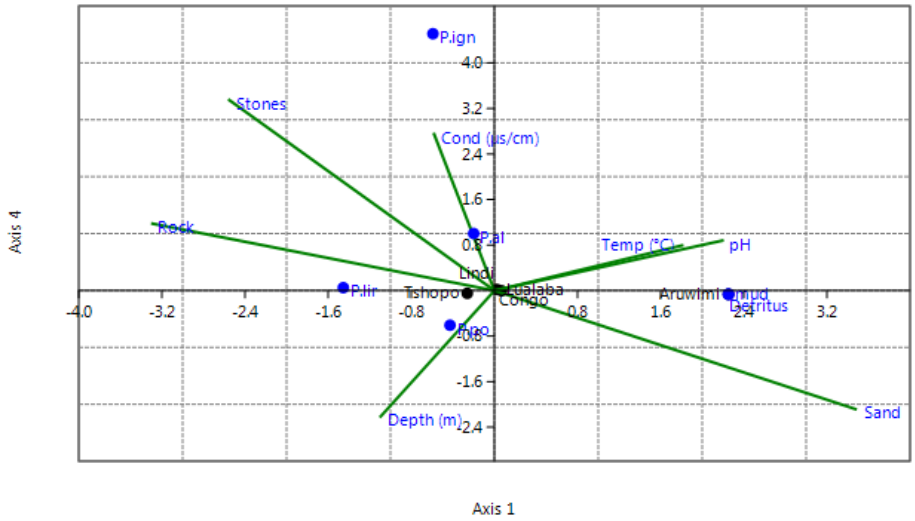

Fig 3: Canonical Correspondence Analysis for four species of *Potadoma* (presence/ absence data) with respect to seven water quality parameters at 64 sites in Congo River and tributaries. Environmental triplots amplified for better visualization.

Congo River and Tshopo are similar of 80 %. However these two rivers indicate more affinity with Lualaba River than Aruwimi River. This low degree of similarity with Aruwimi River could be explained by this scarcity of molluscs in the river Aruwimi (fig. 4).

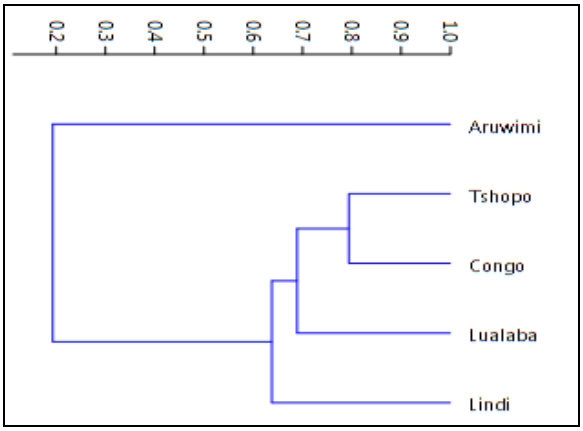

Fig 4: Jaccard similarity dendrogram based on the environmental factors measured and on species found in sampling sites. Indicates the information on the degree of similarity of species caught between rivers.

A total of 100 persons were interviewed so far, more than 92% of interviewed people reported that the species of the genus *Potadoma* are consumed by riparian people and 68 % of them recognized that *Potadoma* species are very tasteful food. It is important to mention that, when we were collected molluscs, we discovered that *Potadoma* species were sold in local markets by riparian people and 69 % of sellers confirmed that this activity is rentable versus 24 % that unconfirmed.

Despite the danger on their habitats [13] and by the fact that this unique molluscan diversity of the region is fully appreciated by neither the relevant governments nor indigenous communities [3] that we reconfirm here, the present work show the consumption and business made on the *Potadoma* species, an important reason that can allow a good discussion with local authorities and conservation NGOs for a concrete species management (see table 3) plan under the umbrella of a specific strategy for the protection of endangered freshwater mollusc diversity, especially the *Potadoma* species.

Table 3: Conservation plan showing activities that should be implemented at *Potadoma* habitats

	Danger	Concrete action	Actors
1	Habitat	- Stop (fight) deforestation and mining activities - Control the using of agriculture fertilizer - Control untreated wastewaters - Control the growth of the town and industries	Scientists, local authorities, riparian population and Conservation NGOs
2	Missing awareness	- Conference, debates, seminars - Environmental education on the role and importance of freshwater molluscs	Scientists, local authorities, conservation NGOs and riparian population
3	Consumption	- Creation of aquatic reserves - Control and management of the consumption	Scientists, government, NGOs and Local population

4. Conclusion

The interesting results of our study are the scarcity of molluscs in the river Aruwimi, the alarming outcomes of the IUCN assessment for *Potadoma* species and the consumption and business made with *Potadoma* species. We are aware, however, that our survey is rather limited, permanent monitoring system could allow better assessments of the impacts of temporal fluctuations and the conservations status of endemic gastropods of the Central Congo River. Future studies should focus on the execution of the conservation plan and the permanent monitoring.

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6. References

1. Albrecht C, Kankonda AB, Von Rintelen T, Bocxlaert BV. From a neglected fauna to major insights into African freshwater biogeography: A research agenda for biodiversity research on molluscs and decapods of the Congo Basin. Abstracts of the 1st International Conference on Biodiversity in the Congo Basin, 6-10 June 2014, Kisangani, Democratic Republic of the Congo, 2014, 151.
2. Pilsbry, Bequaert. The aquatic mollusks of the Belgian Congo. With a geographical and ecological accountof Congo malacology. Bull. Am. Mus. Nat. Hist. 1927; 53:70-658.
3. Graf DL, Jørgensen A, Van Damme D, Kristensen TK. The status and distribution offreshwater molluscs (Mollusca). In: Brooks, E.G.E., Allen, D.J. &Darwall, W.R.T., eds, The Status and Distribution of Freshwater Biodiversity in Central Africa. Cambridge, UK and Gland, Switzerland: IUCN, 2011, 48-61.
4. Brown. Freshwater snails of Africa and their medical importance. Taylor & Francis, London 1994, 687.
5. Mandahl-Barth. Studies on African, freshwater bivalves. Danish Bilharziasis Laboratory, Charlottenlund, Denmark, 1988, 161.
6. Daget. [Catalogue raisonné des mollusques bivalvesd'eau douce africains].[Book in French]. IRD Editions, Leiden/Paris 1998, 340.
7. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria, 2016.
8. IUCN. IUCN Red List Categories and Criteria: Version3.1. IUCN Species Survival Commission, Gland, Switzerland, Cambridge, 2011.
9. Verhaert V, Covaci A, Bouillon S, Abrantes K, Musibono D, Bervoets L *et al*. Baseline levels andtrophic transfer of persistent organic pollutants in sediments and biota from the Congo River Basin (DR Congo). Environ. Int. 2013; 59:290-302.
10. Wembo NO, Hauffe T, Delicado D, Kankonda BA, Albtrecht C. Mollusk communities of the central Congo River shaped by combined effectsof barriers, environmental gradients, and species dispersal. J Limnol. 2017; 76(3):491-501
11. Schultheiß R, Ndeo OW, Malikwisha M, Marek C, Bößneck U, Albrecht C. Freshwater molluscs of the Eastern Congo: notes on taxonomy, biogeography and conservation.Afr. Invertebr. 2011; 52:265-284.
12. Van Bocxlaer B, Clewing C, Etimosundja J-PM, Kankonda A, Ndeo OW, Albrecht C. Recurrent camouflaged invasions and dispersal of an Asian freshwater gastropod in tropical Africa. BMC Evol. Biol. 2015; 15:1-18.
13. Thieme ML, Abell R, Stiassny MLJ, Skelton P, Lehner B, Teugels GG *et al*. Freshwater ecoregions of Africa and Madagascar: aconservation assessment. Washington: Island Press, 2005.
14. Allan and Castillo.Stream ecology: structure and function of running waters. Springer, Dordrecht, The Netherlands, 2007, 444.
15. Wronski T, Dusabe MC, Apio A, Hausdorf B, Albrecht C. Biological assessment of water quality and biodiversity in Rwandan rivers draining into Lake Kivu. Aquat. Ecol. 2015; 49:309-320.
16. Mackay. Colonization by lotic macroinvertebrates: areview of processes and patterns. Can. J Fish. Aquat. Sci 1992; 49:617-628.