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Preliminary Data on the Taxonomic Composition and the Spatio-Seasonal Variation of the Zooplanktonic Population of Fish Ponds in Kisangani, DR Congo

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Abstract

The overall objective of this study was to determine the taxonomic composition and spatial seasonal variation of the zooplankton population in fish ponds in Kisangani, DR Congo. The collection of zooplankton in fishponds was carried out using plankton nets in the Artisanal and Plateau boyoma districts for four months, two months per season. At the end of this study, 3 sub-classes, 13 families and 22 species were listed. The subclass Monogononta (Rotifers) was the best represented with 7 families and 14 species identified. On the other hand, the family Brachionidae was the richest with 6 species. The high specific richness of zooplankton according to site and season was recorded in the Artisanal district with 19 species and in the rainy season with 22 species. Thus, it should be noted that the fish ponds of Kisangani have a high specific diversity of zooplankton that can vary according to the sites and seasons. Certain species such as *Tropocyclops prasinus prasinus*, *Moina macrocopa*, *Brachionus falcatus*, *Thermocyclops sp* and *Brachionus calyciflorus* are more abundant than others present. However, the list of species presented is not exhaustive given the sampling period, which was only 4 months, and the collection effort, which was only carried out at two sites.

Keywords: Zooplankton, species diversity, aquaculture, ponds, Kisangani.

1. INTRODUCTION

Zooplankton is a group of small organisms of animal origin generally living in open water and capable of active movement, but unable to oppose water currents [1]. It includes a wide variety of phyla of unicellular (Protozoa, Actinopoda, Retaria, Cercozoa and Ciliophora) and multicellular organisms (Cnidaria, Cteno- phora, Rotifera, Platyhelminthes, Nemertea, Annelida, Mollusca, Arthropoda, Chaetognatha and Chordata). There is also a great diversity of size and species occupancy in each phylum [2]. Given their great diversity and their role in transferring materials in aquatic environments, these organisms are essential in the organization of aquatic biocenosis. In freshwater, metazoan zooplankton consists mainly of rotifers, microcrustaceans, larvae of some insects, a freshwater jellyfish, larvae of mollusks [3].

In aquaculture, the key role played by zooplankton in the improvement of aquaculture production, especially in the low-intra one, is not to be demonstrated any more, especially in the feeding of aquaculture species, especially fish. Let us note that several authors mentioned the crucial role played by the zooplankton in the development of aquaculture sector while affirming that it constitutes a source of food most important for the fish larvae [4, 5, 6, 7, 8, 9] and improves yield [4, 6, 10]. For Amon et *al*., mastering the technique of zooplankton production in fish ponds would allow good management of the rearing, pre-growth and growout stages of cultured fish [10]. Let us specify that the average world consumption of fish is currently maintained around 20 kg/inhabitant/year and that well thanks to the spectacular development of fish farming in the world whose contribution now approaches that of the catches in the world [11].

The DR Congo located in the heart of Africa is renowned for its natural wealth. It is well known for its geological scandal and its mega biodiversity of flora and fauna both terrestrial and aquatic. In the field of hydrobiology, this country is endowed with a very dance network which makes it the second world power in hydric resource after Brazil and is thus considered the water tower of Africa. It is necessary to specify that up to now, the knowledge of its aquatic environments is still very fragmentary and limited.

Although the introduction of fish farming in DR Congo goes back to the 1960s, it has only developed spectacularly during these years with the breeding of some species of fish of the Tilapia group of the Cichlidae family, notably *Oreochromis niloticus* (Nile tilapia). Compared to other sub-Saharan countries such as Benin, Ghana, Nigeria and Uganda, Congolese fish farming has not managed to contribute significantly to the improvement of the socio-economic conditions of the population. Rather, there has been a sharp decline in fish farming activities over the past four decades. The number of production ponds has decreased significantly over time [12]. Note that several constraints are at the root of this decline among others the lack of quality feed for fish feeding, following the unavailability and cost of commercial feed [13]. For this author, aquaculture-agriculture integration (AAI) is one of the promising alternatives to manage this food crisis in a sustainable way in order to intensify fish production in DR Congo. This is in line with the assertions of some researchers who believe that the improvement of aquaculture production requires the fertilization of production environments [9, 14]. To achieve this ideal, it is now very essential to know the different planktonic groups that populate fish ponds and their dynamism in DR Congo.

It is in this perspective that the present study was carried out on the zooplanktonic population of the fish ponds of Kisangani in DR Congo in order to determine their taxonomic composition and their spatio-seasonal variation.

2. MATERIALS AND METHODS

2.1. Study environment

The present study was carried out in the city of Kisangani, the capital of the Tshopo Province. It is located in the eastern part of the central Congolese basin straddling the equator. Its geographical coordinates are 0°31'N, 25°11'E, the altitude is between 376 and 424 m. It occupies an area of 1910km² [15, 16]. Figure 1 locates and presents the city of Kisangani.

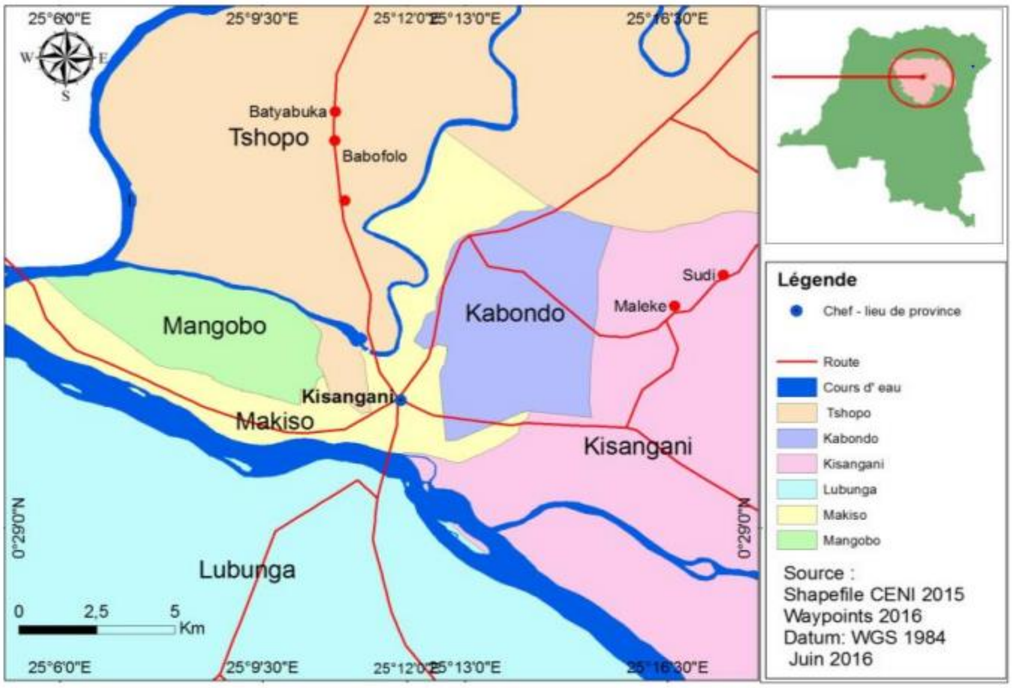

Figure 1: Location and administrative presentation of the city of Kisangani

The city of Kisangani according to the classification of Köppen, enjoys an equatorial, hot and humid climate of type Afi where "A" indicates the hot climate with the 12 monthly average higher than 18°C [17]. Rainfall is generally abundant, although there is a decrease from December to February and from June to August, with two short, relatively dry seasons [18]. Relative humidity and temperature remain high and vary little. The temperature varies from 23.6°C (August) to 25.7°C (March). The relative humidity oscillates between 79.5% (February) and 88.7% (November) [15]. In Kisangani four seasonal trends are recorded which correspond to the following periods: first dry season (December, January and February); first rainy season (March, April and May), second dry season (June, July and August) and second rainy season (September, October and November) [19]. The city of

Kisangani being fully included in a bioclimatic zone of dense equatorial evergreen rainforest [18].

From the hydrographic point of view, etymologically Kisangani means island because this city is surrounded by rivers. It is located at the curve of the Congo River, at the end of its upper course and at the beginning of its middle course [20]. It should be noted that the Congo River flows completely through this town and has as its main tributaries the Monday and Tshopo Rivers, which in turn collect water from numerous streams and tributaries.

The zooplankton were collected in the nile tilapia ponds of two very distant sites without any hydrological communication. These sites are in the Artisanal and Plateau Boyoma neighborhoods.

2.2 Biological material

Zooplankton specimens collected from ponds formed the biological material for this study.

2.3 METHODS

2.3.1. Collection of zooplankton in ponds

Zooplankton were collected in breeding ponds in Artisanal and Plateau Boyoma districts in Kisangani during four months using the plankton net. Note that the four months of harvesting were selected as two months for the rainy season (i.e., November 2018 and May 2019) and two months for the dry season (i.e., December 2018 and January 2019). Thus, or each month of harvest, nine trips were made with three trips at the beginning of the month, three trips in the middle of the month and three trips at the end of the month. After harvesting, water samples containing zooplankton were placed in 5 ml vials labeled according to the site and date of collection and then fixed with 5% formalin.

2.3.2. Sampling of physico-chemical parametersof pond water

For each outlet, the different physico-chemical parameters of the water such as temperature (°C), dissolved oxygen (mg/l), conductivity (µS/cm) and turbidity (NTU) were measured in situ using a multimeter for the first four parameters and a HACH Turbidimeter for the last parameter.

2.3.3. Observation, identification and counting of zooplankton

After deforming the fixed water samples, the zooplankton were observed with an OLYMPUS electron microscope by placing 2 ml of water from each sample jar on a slide with an Eppendorf pipette (capacity: 1000 µl). The identification of the organisms was carried out, if possible, at the species level thanks to the different zooplankton determination keys of [8, 21-25].

2.3.4. Data analysis and statistical processing

The data of the present study were processed using the microsoft Excel 2010 program and PAST (PAlaeontological STatistics) software version 2.15. The following parameters: absolute abundance, relative abundance and different diversity indices were calculated as follows:

- Relative abundance of a species: Ab. Relative (%) = Number of individuals of a species x 100 / Total number of zooplankton
- Species richness: This refers to the total number of species that coexist in a given area.
- Shannon-Weaver index: The Shannon-Weaver diversity index is calculated using the following formula: H = $-\sum_{i=1}^{S} Pi \times log\ _2Pi$

Where Pi = ni/ N, the relative abundance of species i in sample S, ni = number of individuals of species i and N = number of individuals for all species; S = number of species in the community.

- Simpson's index (1-D): Simpson's index measures the probability that two randomly selected individuals belong to the same species [26]. It is expressed by the formula:

$$1 - D\ = 1 - \sum_{i=1}^{S} Pi\ \ ^2$$

- Piélou's equitability: This index measures the equitability in relation to a theoretical equal distribution for all species. It is calculated by the formula: E = E $= \frac{H}{\log S}$

3. RESULTS AND DISCUSSION

3.1 Evaluation of the physico-chemical parameters of the water during our study

During sampling, the physico-chemical parameters of the pond water fluctuated very little during the two seasons depending on the harvesting sites. The average water temperature at both sites was approximately 29°C. The average dissolved oxygen value at both sites was about 11 mg/l and the conductivity value ranged from 127.88 µS/cm at the Artisanal site to 137.61 µS/cm at the Plateau Boyoma site. The average turbidity and transparency were respectively about 150 NTU and 0.10 m in the two sites (Table 1).

Table 1: Physico-chemical parameters of sampled ponds

Parameters	Sites		
	Plateau Boyoma	**Artisanal**	**Mean±Sd**
Temperature (Mean±Sd °C)	29,11±1,70	29,49±1,87	29,30±1,78
Oxygen (Mean±Sd mg/l)	11,97±7,87	11,58±7,61	11,78±7,77
Conductivity (Mean± Sd µS/cm)	137,61±15,63	127,88±19,16	133,25±17,40
Turbidity (Mean±Sd NTU)	149,59±90,36	150,49±76,55	150,04±83,46
Transparency (Mean±Sd m)	0,10±0,16	0,10±1,59	0,10±0,86

Legends: Sd: Standard deviation; °C: degree celcius mg/l: milligram per liter; µS/cm: microsiemens per centimeter NTU: Nephelometric Turbidity Unit; m: meter

The results obtained on the physico-chemical parameters showed a low variation of these parameters according to the harvesting sites and the seasonal periods. The values obtained for dissolved oxygen, conductivity, turbidity and transparency could be explained by the fact that the harvesting ponds were fertilized by organic matter thus leading to the improvement of the physico-chemical quality of the water and then the proliferation of phytoplankton. Akodogbo *et al*., report that the use of fertilizers and especially organic fertilizers significantly improves the physico-chemical properties of the water as well as the densities of phytoplankton and zooplankton organisms [9].

3.2 Taxonomic composition of the zooplankton population

The identification of the specimens informed the presence of 3 subclasses, 13 families and 22 species of zooplankton in ponds of Kisangani. Among these subclasses, the subclass of Monogonontes (Rotifers) is the best represented with 7 families and 14 species compared to those of Branchiopoda (Cladocera) with 3 families and 3 species and copepods with 2 families and 5 species. On the other hand, the family Brachionidae of the subclass Monogononta is the richest with 6 species, followed by those of Pseudodiaptomidae of the subclass Copepoda and Trichocercidae of the subclass Monogononta represented with 3 species each, while the other remaining families were each represented with less than 3 species (Table 2).

Table 2: Taxonomic inventory of zooplankton identified in Kisangani fish ponds

Subclass	Family	Species
Copepoda	Cyclopidae	*Thermocyclops sp*
		Tropocyclops prasinus prasinus
	Pseudodiaptomidae	*Pseudodiaptomus annandelei*
		Pseudodiaptomus incisus
		Pseudodiaptomus trihamatus
Monogononta	Asplanchnidae	*Asplanchna sieboldi*
	Brachionidae	*Brachionus angularis angularis*
		Brachionus calyciflorus
		Brachionus caudatus
		Brachionus falcatus
		Brachionus forficula
		Brachionus plicatilis
	Conochilidae	*Conochilus hippocrepis*
	Lecanidae	*Lecane lunaris*
	Synchaetidae	*Polyarthra vulgaris*
	Testudinellidae	*Testudinella patina patina*
	Trichocercidae	*Trichocerca capucina*
		Trichocerca longiseta
		Trichocerca pusilla
Branchiopoda	Bosminidae	*Bosminopsis deitersi*
	Daphniidae	*Moina macrocopa*
	Sididae	*Diaphanosoma sarsi*

It should be noted that the number of taxa obtained is not exhaustive. The results obtained on the different diversity indices clearly show that the selected fish ponds of Kisangani are diversified in zooplankton. Zébazé-Togouet *et al.*, obtained 37 and 41 species of zooplankton respectively in Ossa and Mwembe lakes in Cameroon [27]. Abandedjan *et al.*, inventoried 3 subclasses (Cladocera, Copepods, and Rotifers) divided into 31 species among which Rotifers were represented with 24 species grouped into 12 families in Lake

Nokoué in South Benin. The high number of species obtained by these authors could be explained by the nature of the ecosystem and the harvesting effort. It should be noted that these authors worked in one lake while harvesting in several stations [28]. In addition, Amon et *al*. recorded 4subclasses (Cladocerans, Copepods, Rotifers and Insect larvae), 14 families and 36 species among which Rotifers were represented with 22 species grouped in 8 families in *Chrysichthys nigrodigitatus* pre-growth ponds fertilized with three organic feeds composed of agricultural by-products harvested in Côte d'Ivoire [10].

Compared to the results obtained on the high richness of Monogononta, our results agree with those obtained by Zébazé-Togouet *et al*., Onana *et al*., Abandedjan *et al*., and Amon *et al*., [10, 27, 28, 29] For Togouet et *al*., the high representativeness of Rotifers in an environment biologically indicates the high trophic level of that environment [30]. The values obtained from different specific diversity indices really testify the specific diversity in zooplankton in fish ponds of Kisangani. According to Frontier, the Shannon index varies both according to the number of species present and according to the relative proportion of the cover of the different species; it can vary between 0 and 4.5. This index is therefore minimal (H'=0) when all the individuals in the stand belong to the same species. It is also minimal if, in a stand, each species is represented by a single individual, except for one species which accounts for all the other individuals in the stand. Conversely, the index is maximum when all the individuals are equally distributed among all the species present [31]. For Simpson, the index that bears his name has a zero value to indicate the minimum diversity (i.e. when the probability is low that two individuals drawn at random belong to the same species) and a value of 1 to indicate the maximum diversity (i.e. when the probability is high that all individuals belong to two different species). It is also important to note that this index gives more weight to abundant species than to rare species [26]. Equitability is deduced from the Shannon-Weaver diversity index, it measures the equitability with respect to a theoretical equal distribution for all species. This index varies from 0 to 1 according to the level of equitability of the species. When it is equal to 1, it corresponds to a perfectly equitable community, i.e. where all species have the same number of individuals, but the value 0 means that a single species dominates [32].

3.3. Spatial variation of the zooplanktonic population in fish ponds in Kisangani

According to the harvesting sites, the high specific richness of zooplankton was recorded in the Artisanal area with 19 species and the low value was observed in the Plateau Boyoma area with 15 species. It was also observed that zooplankton abundance was relatively high at the Artisanal site (56.58% of overall abundance) compared to the Plateau boyoma site (43.42% of overall abundance) (Figure 1). Note that the t-Student test had shown that there was no significant difference between the two sites in terms of abundance (t=0.45; p-value =0.65>0.05).

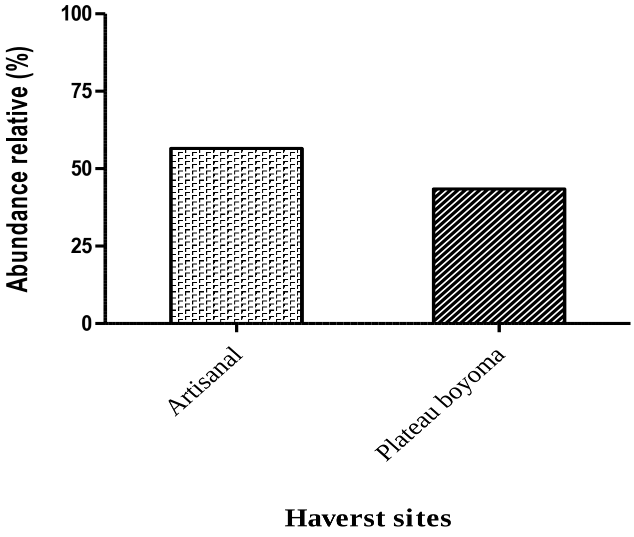

Figure 1: Relative abundance of all species in relation to harvest sites

For both harvest sites, the species *Tropocyclops prasinus prasinus*, *Moina macrocopa*, *Brachionus falcatus*, *Thermocyclops sp* and *Brachionus calyciflorus* accounted for over 80% of the overall abundance at each site (Table 3).

Table 4: Relative abundance of identified species by site

Subclass	Familly	Species	Site	
			Artisanal	**Plateau boyoma**
			Ab. Rel (%)	**Ab. Rel (%)**
Copepoda	Cyclopidae	*Tropocyclops prasinus prasinus*	31,70	31,17
Branchiopoda	Daphniidae	*Moina macrocopa*	25,70	16,25
Monogononta	Brachionidae	*Brachionus falcatus*	18,50	13,58
Copepoda	Cyclopidae	*Thermocyclops sp*	10,10	11,66
Monogononta	Brachionidae	*Brachionus calyciflorus*	7,10	12,43
Sum of these 5 espèces			93,10	85,09
Other species			6,90	14,91
Total			**100**	**100**

The Artisanal site is the richest in species compared to the Plateau Boyoma site. However, the latter presented slightly high values of Simpson's, Shannon's and equitability indices (0.82; 2.01 and 0.73 respectively) compared to the Artisanal site (0.79; 1.83 and 0.62 respectively) (Table 4).

Table 4: Species richness and diversity indices according to harvest sites

Indexes	Sites		Total
	Artisanal	**Plateau boyoma**	
Specific richness	19	15	22
Simpson's Index	0,79	0,82	0,8
Shannon Index	1,83	2,01	1,94
Equitability	0,62	0,73	0,61

According to Onyema and Ojo, the spatial distribution of zooplanktonic organisms depends on a variety of ecological factors including water temperature, light penetration, water chemistry (particularly pH, dissolved oxygen, salinity, toxic contaminants), phytoplankton availability and predation by fish and invertebrates [33].

3.4. Seasonal variation in zooplankton populations in fish ponds

In the Kisangani fish ponds, the richness and species diversity of zooplankton fluctuated with the seasons. It was also found that zooplankton were more abundant in the wet season (70.69%) than in the dry season (29.31%) (Figure 2). The non-parametric Mann-Whitney test affirmed that there is significant difference between the two seasons in terms of abundance (U=146, p-value =0.02<0.05).

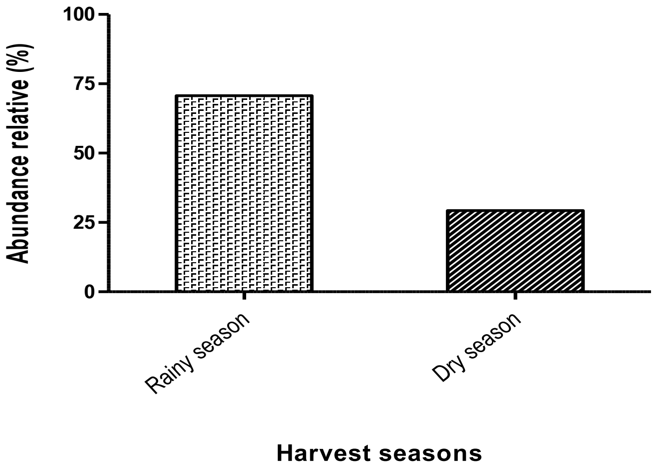

Figure 2: Relative abundance of all species by season

For the seasons observed in Kisangani, the species *Tropocyclops prasinus prasinus*, *Moina macrocopa*, Brachionus falcatus, *Thermocyclops sp* and *Brachionus calyciflorus* remained the most abundant during both seasons, with a relative abundance of up to about 90 % (Table 5).

Table 5: Absolute and relative abundance of zooplankton species by seasonal period

Subclass	Familly	Species	Season	
			Rainy	Dry
			Ab. Rel (%)	Ab. Rel (%)
Copepoda	Cyclopidae	*Tropocyclops prasinus prasinus*	32,33	30,43
Branchiopoda	Daphniidae	*Moina macrocopa*	20,91	23,77
Monogononta	Brachionidae	*Brachionus falcatus*	16,95	15,36
Copepoda	Cyclopidae	*Thermocyclops sp*	10,58	11,59
Monogononta	Brachionidae	*Brachionus calyciflorus*	10,10	8,12
Sum of these 5 espèces			90,87	89,27
Other species			9,13	10,73
Total			**100**	**100**

The rainy season was the richest season with 22 species and presented slightly high values of the calculated Simpson's and Shannon's indices (0.8 and 1.9 respectively) compared to the dry season which was represented with half of species (11 species) and presented the slightly higher value of equitability i.e. 0.72 (Table 6).

Table 6: Seasonal richness and diversity of zooplankton

Indexes	Season		Total
	Rainy	Dry	
Specific richness	22	11	22
Simpson's Index	0,8	0,77	0,8
Shannon Index	1,9	1,73	1,94
Equitability	0,61	0,72	0,61

The richness and species diversity obtained fluctuated according to the seasons recorded in the city of Kisangani. The rainy season showed a high diversity compared to the dry season. These results are consistent with those obtained by Masundireh and Okogvu and Ugwumba who recorded more species during the rainy season [34, 35]. These results are discordant with those obtained by Zébazé-Togouet *et al*., who recorded more species during the dry season [27]. According to the literature, the rainy season brings new nutrients and mixes the indigenous nutrients present in the ponds thus contributing positively to the growth of zooplankton populations. On the other hand, there is an increase in species richness due to interspecific competition during the dry season. For Abandedjan *et al*., the spatio-temporal distribution of zooplankton depends mainly on the physico -chemical parameters of the water including salinity, pH, temperature, nitrite content and ammonium content [28].

4. CONCLUSION

In order to solve the problem of lack of quality food for farmed fish in DR Congo in a sustainable way, it is imperative to promote the integration of aquaculture and agriculture in order to intensify aquaculture production. Indeed, this promotion will only be achieved through the knowledge of zooplankton that populates ponds as it constitutes a food source very rich in proteins and preferential for farmed fish. The overall objective was to determine the taxonomic composition and the spatio-seasonal variation of the zooplankton population in ponds of Kisangani in DR Congo.

The biological material consisted of zooplankton collected from the fish ponds of two sites Artisanal and Plateau boyoma. The physico-chemical parameters of the water were measured in situ using a multimeter and a Turbidimeter of the HACH brand. After harvesting zooplankton with the plankton net, the water samples containing zooplankton were placed in a 5 ml jar and fixed with 5% formalin. Note that the zooplankton collection lasted four months, with two months per season, i.e. November 2018 and May 2019 for the rainy season and December 2018 and January 2019 for the dry season. The observations for the identification and enumeration of zooplankton were carried out using the OLYMPUS microscope at the Laboratory of Hydrobiology and Aquaculture of the University of Kisangani.

At the end of this study, it was observed that the physico-chemical parameters of the water measured varied less according to the sites and the seasons during the investigation. A total of 3 sub-classes, 13 families and 22 species were listed. It should be noted that this list is not exhaustive given the period and the effort of collection made. The subclass Monogonontes (Rotifers) was the best represented with 7 families and 14 species identified. In addition, the family Brachionidae of the subclass Monogonontes was the richest with 6 species, followed by the families Pseudodiaptomidae of the subclass Copepoda and Trichocercidae of the subclass Monogonontes, each represented with 3 species, the other families identified were each represented with less than 3 species. The species *Tropocyclops prasinus prasinus*, *Moina macrocopa*, *Brachionus falcatus*, *Thermocyclops sp* and *Brachionus calyciflorus* accounted for more than 80 % of the overall abundance in relation to the harvest sites and seasons observed.

The high species richness of zooplankton was recorded at the Artisanal site with 19 species compared to the Plateau boyoma site with 15 species. High species diversity was also observed at both harvesting sites. No significant difference was found in terms of abundance between the two sampling sites. Moreover, the rainy season was the richest season with the totality of species identified (22 species), compared to the dry season which recorded only half of the species (11 species). It was found that the specific diversity of zooplankton was high during both seasons and there was a significant difference in zooplankton abundance between the two seasons.

The results obtained would allow the continuation of studies on the composition of zooplankton in fish ponds in DR Congo and to initiate research on the feeding and reproduction biology of the most abundant species with a view to their mass production in well-controlled environments, particularly ponds.

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