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Research Article

# FIRST DATA ON ZOOPLANKTON COMMUNITY STRUCTURE AND ABUNDANCE IN THE LAKE GUIDIMOUNI A RAMSAR SITE IN THE ZINDER REGION, NIGER

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## ABSTRACT

The objective of this study is to examine the structure, diversity, and abundance of the zooplankton community at the Guidimouni Ramsar site. To this end, a 50µm plankton net was used to collect samples (200 L of filtered water) over two seasons. The high-water period (December 17-19, 2025) and low-water period (May 4-7, 2026). A total of 42 taxa were identified, with rotifers dominating (67.46%), followed by copepods (21.89%) and cladoceran (10.65%) during the high-water period. In contrast, the low-water period was dominated by copepods (58.64%), followed by rotifers (32.80%) and cladoceran (8.56%). During this period, the Brachionidae family ($1.093 \times 10^3$ ind./L) and the Cyclopidae family ($2.830 \times 10^3$ ind./L) are the most diverse and abundant in Lake Guidimouni. A significant difference in diversity and abundance was observed, with higher numbers during low-water periods. Based on environmental variation data, Lake Guidimouni is an entirely alkaline body of water with a pH of ($9.17 \pm 1.06$) and a temperature of ($25.62 \pm 1.74$) during high-water periods, which influence zooplankton diversity. The Shannon diversity index ($2.9 \pm 0.19$) and the dominance of the Brachionidae family (8 taxa) indicate that Lake Guidimouni is a polluted environment and is threatened by severe eutrophication.

**Keywords:** Zooplankton diversity, Guidimouni Lake, Water quality, Spatial distribution.

## INTRODUCTION

Surface water covers most of the Earth's surface, with approximately 98% of this water being marine and the remaining 2% consisting of inland waters such as rivers, lakes, and ponds (Benfiala *et al*. 2013). In the context of Niger, wetlands are natural or artificial areas where water is stagnant or flowing, permanent or temporary: these include ponds, lakes, artificial reservoirs, watercourses, floodplains, and oasis systems (Awaïss, 1999). These wetlands provide ecosystem goods and services from which communities derive significant direct or indirect benefits (Boube I, 2018). They play several equally important economic and social roles for riparian populations and are therefore the subject of conservation efforts at the national level (Madougou & Oumani, 2025). These socio-economic activities, which cause pollution, are believed to disrupt the food chain of aquatic species by upsetting the nutrient balance in the water (Gueye *et al.,* 2023). Nevertheless, very little is known about the lakes in terms of both their fauna and flora (Tilman *et al.,* 2014). However, surface waters harbor a fairly diverse biodiversity that is significantly and continuously affected by human and climate-related activities that degrade the quality of the waters and habitats on which plankton depends (Sako *et al.,* 2019). Within this biodiversity, zooplankton is an ecologically important group of aquatic organisms (Berté *et al.,* 2019).

Zooplankton consists of living animal organisms that lack sufficient swimming ability to swim against currents and remain independent of water masses (Saint-Jean, 1985)

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and that exhibit horizontal movement (Das *et al.,* 2020). Zooplankton, or animal plankton, consists of all heterotrophic organisms that feed on other animals; since they cannot synthesize their own organic matter, they obtain it from the external environment by consuming living or non-living particles (detritivores). They are thus distinct from autotrophic phytoplankton (Souley, 2021). It serves as a vital intermediary between primary producers (phytoplankton) and higher trophic levels (fish); these organisms form highly diverse biological communities that are essential for developing models of how aquatic systems function, particularly for the management of fishery resources (Baaloudj, 2023). Zooplankton plays a central role in the aquatic food chain, as it acts as a consumer, predator, and prey; it thus represents an indispensable link in food webs and energy transfer within aquatic ecosystems (Fonty, 2021). Furthermore, ecologists have long emphasized the importance of biodiversity as an indicator of the health and proper functioning of ecosystems, of which zooplankton is a part (Van der Plas, 2019). Numerous studies have shown that zooplankton populations and communities have changed significantly over the past few decades due to environmental factors linked to human activities and climate change; this research highlights that zooplankton can be used as an indicator of the impact of these changes on a global scale (Zébazé Togouet 2000; Brassard, 2009; Fofana *et al.,* 2019). It also serves as a biological indicator of pollution and has a It has a very high turnover rate and is not commercially exploited; therefore, changes in abundance and community structure in response to environmental changes are quickly apparent (Monney *et al.,* 2016).

In West Africa, the main studies conducted on zooplankton (Arkhipov, 2015; Tiedemann and Brehmer, 2017; Badji, 2018) have primarily focused on the open ocean along the West African coast. In Niger, previous studies on zooplankton have been conducted only on a section of the Niger River (Souley, 2021), hence the relevance of conducting this study on Lake Guidimouni. Furthermore, the high level of ecological degradation in this aquatic environment and the lack of zooplankton studies in Niger justify the need for our study. The main objective of this study is to understand the structure and diversity of the zooplankton community in Lake Guidimouni in relation to natural and anthropogenic environmental parameters. Specifically, the study aims to: (1) analyze the physicochemical properties of the waters of Lake Guidimouni; (2) conduct a survey of zooplankton communities at different sampling sites and during different seasons in the lake; (3) assess the trophic status of the surface waters of Lake Guidimouni.

## MATERIALS AND METHODS

### Study Area

Lake Guidimouni is one of the major bodies of water in Niger, located in the municipality of Guidimouni in the Zinder region (13°41.577 N and 9°27'-9°30.74' E; Figure 1). The municipality of Guidimouni is located in the Damagaram Takaya department, bordered to the north by the municipalities of Damagarm Takaya and Mazamni, to the south by those of Bouné and Gouchi (Gouré and Magaria departments), to the east by the rural commune of Guidigur (Gouré), and to the west by the rural commune of Zermou (Issa, 2010). It has been listed as a Ramsar site in Niger since 2019, covering an area of 338.39 hectares (ha) (FDR, 2021). The area has a Sahelo-Saharan climate, characterized by two main seasons: a long dry season lasting eight (8) months (October through May) and a short rainy season lasting four months (June through September) (Karimou Barké *et al.,* 2026). Rainfall in this area is characterized by irregularity and poor distribution over time and space, with an annual average ranging from 300 to 600 mm in Guidimouni (Baboussouna & Andres, 2016).

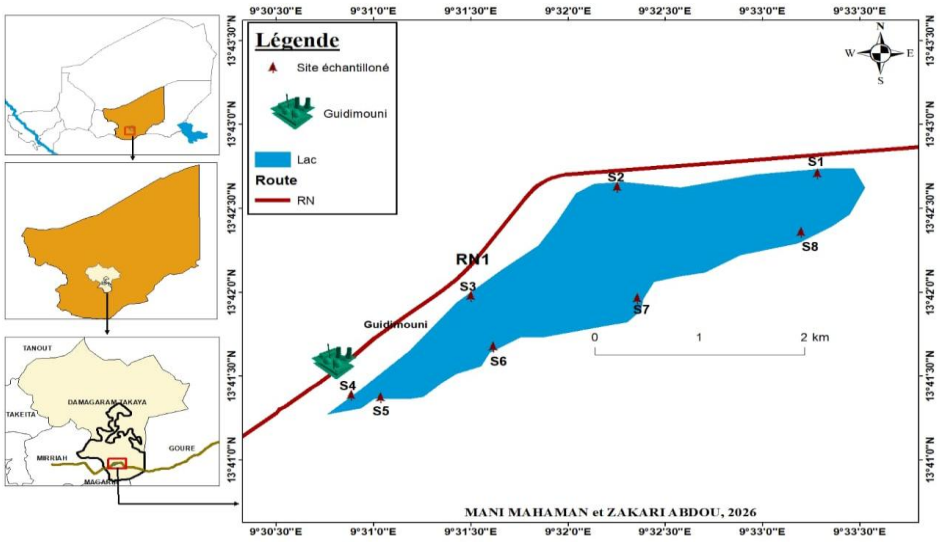



**Figure 1**. Map showing the location of the study site.

**Table 1**. Geographical location of the sampling stations.

| Stations | Latitude (N) | Longitude (E) |
|---|---|---|
| Station 1 | 13,710994 | 9,554684 |
| Station 2 | 13,709681 | 9,537453 |
| Station 3 | 13,698708 | 9,525012 |
| Station 4 | 13,688895 | 9,514735 |
| Station 5 | 13,688663 | 9,517208 |
| Station 6 | 13,693686 | 9,526867 |
| Station 7 | 13,698631 | 9,539230 |
| Station 8 | 13,705045 | 8,553370 |

**Physicochemical Parameters**

Environmental variables were measured at each station. For temperature, dissolved oxygen, pH, and conductivity, in situ measurements were taken using a multiparameter probe (HANNA 9829). For chemical parameters-namely nitrate, nitrite, and phosphate-250 mL of water was collected in polyethylene bottles at each station and stored in a cooler until they reached the laboratory. These parameters were analyzed in the laboratory using a spectrophotometer (Dionex high-performance HPIC [high-pressure ion chromatography] system).

**Zooplankton Sampling**

For zooplankton sampling, a plankton net with a diameter of 30 cm and a mesh size of 50 µm was used. Before each sampling, the net was thoroughly rinsed with water from the sampling site to remove any particles that might be present. A total of 200 L of water was filtered at each sampling station from the water's surface. A 15-liter bucket was used to collect lake water, which was then poured through a filter into a 125-liter container. The retained zooplankton was collected in polyethylene vials prior to analysis, identification, and counting of the species present. All samples were stored in a cooler until they reached the laboratory, where they were preserved long-term in a refrigerator at 4°C with the addition of a 4% formaldehyde solution. A total of 48 samples were collected during the two sampling periods: December (December 17-19, 2025), considered the high-water period, and May (May 4-7, 2026), considered the low-water period. These samples were collected at eight (8) stations set up horizontally across the lake against the current, with four (4) stations on each of the two shores (left and right). The stations were selected based on accessibility and the presence or absence of human activities.

**Identification and Counting of Zooplankton**

For each sample, 1 mL of thoroughly homogenized water was collected in two (2) or three (3) replicates to maximize the chance of comprehensively identifying the taxa present at the station, depending on the sample concentration. Identification was performed using a binocular magnifying glass (OLYMPUS SZX10, 40× and 90× magnifications). The minimum number of individuals counted ranged from 150 to 200 per sample. (The samples were placed on a petri dish divided into sections to facilitate counting, with a starting point marked.) Some identifications required analysis under a microscope (400× magnification) using a LEICA DM IRB or NIKON Optiphot 2. Copepods were dissected for identification. All organisms, with the exception of nauplii and copepodids, were identified at least to the genus level. Zooplanktonic organisms were identified to the genus and species levels using the keys by Dussart (1969; 1970), Koste (1978), Pontin (1978), Amoros (1984), Segers and Dumont (1995), Nogrady *et al.,* (1995), De Smet (1996), Alonso (1996), Nogrady and Segers (2002), and Fernando (2002).

**Statistical Analyses**

**Physicochemical Parameters of the Water**

The measured environmental variables are listed in Table 2.

**Biological Data**

The biological data obtained were used to determine taxonomic richness and various diversity indices that characterize the structure, composition, and spatiotemporal changes in zooplankton.

Zooplankton density (D) is the number of individuals per unit volume. It was calculated using the following formula:

$$\mathbf{D = (n/v1) \times (v2/v3)}$$

Where **n** = number of individuals counted, **v1** = volume of filtrate collected (150 mL), **v2** = volume of concentrated filtrate (1 mL with three replicates), **v3** = volume of filtered water (200 L).

The frequency of occurrence (F) of the species was also determined using the following equation:

$$\mathbf{F = (Si / St) \times 100}$$

Where **Si**= is the number of sites where taxon i was identified and St= is the total number of sampled sites. The Dajoz (2000) key was used to classify the species into the following categories: constant species (%Occ ≥ 50%), accessory species (25% < %Occ < 50%), and accidental species (%Occ ≤ 25%).

**Alpha Diversity Indices**

Alpha diversity indices were determined to understand the structure of the zooplankton community:

**Shannon-Wiener Index (H')**

The Shannon-Wiener diversity index is used to understand the taxonomic diversity of populations in the environment. It was calculated using the following formula:

$$H' = -\sum pi \times \log2(pi) \quad avec\ pi = ni/N$$

**H'** represents specific diversity in bits, ni the number of individuals of species i, **N** the total number of individuals considering all species and **log2** the logarithm in base 2.

**Piélou's equitability index (Eq)**

measures the equitability (or equipartition) of the species in the stand in relation to a theoretical equal distribution for all species. It is obtained by the formula:

$$E = H'/\log2S$$

Where H' is the Shannon-Wiener index, log2 is the logarithm to base2 and S is the number of species present.
The Student's t-test was conducted to assess the spatiotemporal variation in physicochemical parameters and zooplankton densities. It was performed using Minitab 18 software.

Multivariate analyses were conducted to analyses the relationship between the distribution of the zooplankton communities and environmental factors for each sampling campaign separately and for all data considered together. Abundances were transformed to log (x + 1) to obtain a normal distribution. A Detrended Correspondence Analysis (DCA) was first conducted on the zooplankton data using CANOCO software version 4.5 (Jongman *et al*., 1987; ter Braak, 1994) to determine the method of ordination to be used. Since the total inertia was less than 2.6, the species were considered to have a linear model and redundancy analyses (RDA) was performed. Abundance data of the identified taxa were centred and standardised. A Monte Carlo test (999 permutations) was applied to test statistical significance of the environmental variables in explaining the zooplankton distribution using a significance limit of $p < 0.05$.

## RESULTS AND DISCUSSION

The measured values of environmental variables during the two sampling seasons at all stations are summarized and presented in Table 1. Thus, the temperature of Lake Guidimouni is considerably higher at all stations during the warm season than during the cold season. In fact, the temperature measured during the warm season ranges from 30.09°C to 35.5°C, compared to 22°C to 28.9°C during the cold season. The minimum temperature of 22°C was measured at Station 8 during the cold season, and the maximum temperature of 35.5°C was recorded during the warm season at Station 2, with respective average values of 25.62 ± 1.74 and 33.26 ± 1.84. In comparison, there is a significant difference (0.001) in temperature between the two seasons. The conductivity of Lake Guidimouni was also higher during the warm season than during the cold season, ranging from 406 µs/cm to 790 µs/cm and from 652 µs/cm to 931 µs/cm, respectively. The minimum value (406 µs/cm) was recorded during the cold season at Station 3, and the maximum value (931 µs/cm) was measured at Station 7 during the warm season, with respective averages of 645.12 ± 111.84 and 791.75 ± 95.27. In contrast, the measured pH values at the Guidimouni Ramsar site are higher during the cold season than during the warm season. Thus, the sampled stations can be considered basic environments during the cold season, with the exception of Station 4, where the pH shows a slightly acidic variation. The pH value ranges from 6.88 to 11.17 during the cold season and from 7.02 to 7.89 during the warm season, with respective average values of 9.17 ± 1.06 and 7.44 ± 0.25. In summary, there is a significant difference (0.004) between the pH values during the sampling campaigns. The same observation applies to dissolved oxygen, where the concentration was higher at all stations during the cold season than during the warm season, with the exception of stations 7 and 8. The oxygen concentration ranges from 4.8 ml/L to 10.03 mg/L during the cold season and from 6.4 mg/L to 7.9 mg/L during low-water periods.

The oxygen concentration ranges from 4.8 ml/L to 10.03 mg/L during the cold season and from 6.4 mg/L to 7.9 mg/L during low-water periods. The minimum value (4.8 mg/L) was observed at Station 8 and the maximum value at Station 3 during high water, with the average ranging from 7.1 ± 0.53 during the warm season to 8.28 ± 1.39 during the cold season. As for depth, it ranged from 0.3 m to 0.67 m during the two sampling campaigns. In general, there was a highly significant difference (0.001) among the sampled stations between the two seasons. It is important to note that water sampling depends on water level and the accessibility of the site. Finally, the salinity of Lake Guidimouni ranged from 200 ppm to 457 ppm during the two seasons. The maximum value was recorded during high water at Station 2, and the maximum value during the dry season was recorded at Station 7, with respective average values. There is no significant difference (0.031) in salinity between the high-water and low-water periods.

**Table 2**. average and extreme values of environmental parameters for Guidimouni Lake (high and low water), **Min**: minimum; **Max**: maximum et **Moy**: average.

| Environmental Parameters | High water | | | Low water | | |
|---|---|---|---|---|---|---|
| | Min | Max | Moy | Min | Max | Moy |
| **Temp (°C)** | 22 | 28,9 | 25,62±1,74 | 30,09 | 35,5 | 33,26±1,84 |
| **Cond (µs/cm)** | 406 | 790 | 645,12±111,84 | 652 | 931 | 791,75±95,27 |
| **P$^{H}$** | 6,88 | 11,17 | 9,17±1,06 | 7,02 | 7,89 | 7,44±0,25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **OD (mg/L)** | 4,8 | 10,03 | 8,28±1,39 | 6,4 | 7,9 | 7,1±0,53 |
| **Prof (m)** | 0,38 | 0,66 | 0,51±0,07 | 0,3 | 0,67 | 0,38±0,13 |
| **Salinité (PPM)** | 200 | 386 | 293,125±45,062 | 280 | 457 | 372,375±56,625 |

A total of three zooplankton groups were identified during this study period, comprising 20 families, 32 genera, and 48 taxa. Thus, rotifers are the most diverse group with 23 taxa, or 47.91%, followed by copepods with 15 taxa, or 31.25% of the total identified taxa (Table 2). Cladocera constitute the least diverse group with 10 taxa recorded, representing 20.83%. The Brachionidae family (8 species and 3 genera) and the Cyclopoidae family (8 species and 4 genera) are the most diverse families, followed by Philodinidae (4 species and 2 genera), Canthocamptidae (4 species and 3 genera), Bosminidae (3 species and 2 genera), Diatomidae (3 species and 3 genera), Chydoridae (3 species and 1 genus), Moinidae (2 species and 2 genera), Asplanchnidae (2 species and 2 genera), and the other 11 families are monospecific. Among the identified taxa, only *Asplanchna girodi* (100%), *Brachionus angularis* ( 87,5%), *Brachionus dimidiatus* ( 100%), *Brachionus falcatus* (75%), *Brachionus plicatilis* (93,75%), *Keratella cochlearis* (87,5%), *Keratella lenzi* (62,%,), *Rotaria citrina* (75%), *Lecane leontina* (56,2%), *Trichocerca chattoni* (68,75%), *Canthocamps staphylinus* (56,25%), *Eucyclops serralatus* (68,75%), *Thermocyclops dicipiens* (56,25%), *Tropodiaptomus processifer* (62,50%), *Alona monacantha* (50%), *Daphnia similis* (93,75%) are constant, and the others are all either incidental or accidental.

**Table 3.** Qualitative analysis of the zooplankton community, F %: species frequency; numbers 1 through 8: stations 1 through 8.

| | | **High water** | | | | | | | | **Low water** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Groups** | **Species** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **F%** |
| *Rotifera* | *Asplanchna girodi* Guerne, 1888 | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | 100 |
| | *Asplanchna priodonta* Gosse, 1850 | | | + | | + | | | | | | | | | | | | 12.5 |
| | *Brachionus angularis* Gosse, 1851 | + | + | + | | + | + | + | + | + | + | + | + | | + | + | + | 87.5 |
| | *Brachionus bidentatus* Kertesz, 1894 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | 100 |
| | *Brachionus falcatus* Zacharias, 1898 | | + | + | + | | | + | + | + | | + | + | + | + | + | | 75 |
| | *Brachionus plicatilis* O.F Müller, 1786 | + | + | + | + | + | + | + | + | + | + | + | + | | + | + | + | 93.7 |
| | *Platyias patulus* O.F. Müller, 1776 | | | | | | | | | + | + | | + | | | | | 18.7 |
| | *Keratella chochlearis* (Gosse, 1851) | + | + | + | + | + | + | + | + | + | + | + | | + | + | | + | 87.5 |
| | *Keratella lenzi* Hauer, 1953 | | + | + | | + | | + | + | + | + | + | | | | | + | 62.5 |
| | *Keratella quadrata* (O.F. Müller, 1786) | + | | | | | + | + | | + | | | + | + | | | | 37.5 |
| | *Philodina citrina* Ehrenberg, 1830 | | | + | | + | + | + | + | | + | | | | | + | | 43.7 |
| | *Pilodina rugosa* Bryce, 1903 | | | | | | | | | + | | | | | | | + | 12.5 |
| | *Ratoria haptica* (Gosse 1886) | + | | + | + | | | | | | | | | | | | | 18.7 |
| | *Rotaria citrina* (Ehrenberg, 1838) | + | + | + | + | + | + | + | + | + | + | + | | + | | | | 75 |
| | *Lecane leontina* (Turner, 1892) | + | | | | + | | | | + | + | | + | + | + | + | + | 56.2 |
| | *Pholyarthra vulgarus* Carlin, 1943 | | | | | | | | | + | + | | + | | | | + | 25 |
| | *Lepadella patella* (Müller, 1773) | + | | | | | | | + | | | | | | | | | 12.5 |
| | *Lindia torulosa* Dajurdin, 1841 | + | + | + | | + | + | + | | | | | | | | | | 37.5 |
| | *Proales dicipiens* (Gosse 1886) | | | + | | | + | | | | | | | | | | + | 18.7 |
| | *Cephalodella gibba* (Ehrenberg, 1830) | | | | | | | | | + | + | | | | | | | 12.5 |
| | *Euchlanis triquetra* (Ehrenberg, 1838) | | | | | | | | | | | + | | | | | | 6.25 |
| | *Tertudinella patina* (Hermann, 1783) | | | | | | | | | + | + | + | | | | | | 18.7 |
| | *Trichocerca chattoni* (de Beauchamp, 1907) | + | + | | + | + | + | + | + | + | + | | | + | | | + | 68,7 |
| *Copepoda* | *Bryocamptus minutus* (Claus, 1863) | + | | | | + | + | + | | + | + | | + | | | | | 43,7 |
| | *Canthocamptus hirsutus* (Chappuis, 1951) | | + | | | | | | | | | | | + | + | | | 18,7 |
| | *Canthocamptus staphylinus* (Jurine, 1820) | + | | | | + | + | + | | + | + | + | + | | + | | | 56,2 |
| | *Elaphoidella bidens* (Schmeil, 1893) | | | + | | | | | | + | | | | | | | | 12,5 |
| | *Eucyclops agilis* (Koch, 1838) | | | | | | | | | + | + | | + | + | + | + | + | 43.7 |
| | *Eucyclops serralatus* (Fischer, 1851) | + | + | | + | + | + | + | | + | + | + | + | + | | | | 68.7 |
| | *Eucyclops spatharum* Harding, 1942 | + | + | | | | | | + | | + | + | | | | | | 31.2 |
| | *Trophocyclops confenis* (Kiefer, 1930) | + | | | | + | | + | | + | + | | | + | + | | + | 43.7 |
| | *Tropocyclops tenellus* (Sars G.O., 1909) | | | | | | | | | | + | + | + | | + | + | | 31,2 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Tropocyclops varicans* (Sars G.O., 1863) | | | | | | | | | + | | | | | + | | | 12.5 |
| | *Microcyclops varicans* (Sars G.O., 1863) | | | | | | | | + | | | | | | | | | 6.25 |
| | *Thermocyclops Decipiens* (Kiefer, 1929) | + | + | | | | | + | | + | + | + | + | | + | + | | 56.2 |
| | *Thermodiatomus Yabensis* (Wright S. & Tressler, 1928) | | | | | | | | | | + | + | + | | + | | | 25 |
| | *Metadiaptomus Chevreuxi* (Guerne & Richard, 1894) | | | | | | | | | + | + | + | | + | | | | 25 |
| | *Tropodioaptomus Processifer* (Kiefer, 1926) | + | + | + | | | | | + | + | + | + | + | | + | + | | 62.5 |
| *Cladocera* | *Alona affinis* (Leydig, 1860) | | | | | | | | | | | + | | + | | | | 12.5 |
| | *Alona monacantha* Sars, 1901 | + | | + | | + | + | | + | + | | | | | + | + | | 50 |
| | *Alona quadrangularis* O.F. Müller, 1776 | | | | | | | | | | | | + | | | | | 6.25 |
| | *Basminopsis deitersi* Richard, 1895 | | | | | | | | | | + | | + | | | | | 12.5 |
| | *Bosmina coregoni* Baird, 1857 | | | | | | | | | | | + | | | | | | 6.25 |
| | *Bosmina longirostris* (O.F. Müller, 1785) | | | | | | | | + | + | + | | | | | | | 18.7 |
| | *Daphnia similis* | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | 93.7 |
| | *Moina brachiata* (Jurine, 1820) | | | + | | | | | | | + | + | + | | + | + | + | 43.7 |
| | *Moinadaphnia macleayi* (de Goulden, 1968) | + | | | | | | | | | | | | | | | | 6.25 |
| | *Sida crystallina* O.F. Müller, 1776 | | | | | | | | | + | | | | | + | + | | 18.7 |

The zooplankton community of Lake Guidimouni is characterized by a dominance of rotifers (67.46%), followed by copepods (21.89%), while Cladocera's constitute the least abundant group, accounting for 10.65% during the cold season (Figure 2a). Among the rotifer families, Brachionidae is the most abundant, accounting for 49%, followed by Philodinidae (19%), Asplanchnidae (11%), and Trichocercidae (10%); the other families are the least abundant. Rotifers (17 taxa) are dominated by *Brachionus angularis* (12%) and *Rotaria citrina* (12%) (Figure 2b). As for copepods, they are dominated by the Cyclopoidae (57%), within which *Eucyclops serralatus* (27%) is the most abundant species, followed by the Canthocamptidae (32%), dominated by *Canthocamps staphylinus* (16%); the Diaptomidae is the least abundant family, accounting for 11% (Figure 2c). Finally, the cladoceran phylum is overwhelmingly dominated by *Daphnia similis* (50%), followed by *Alona monacantha* (33%), while *Moinaphnia macleayi*, *Bosmina longirostris*, and *Moina brachiata* account for 5%, 6%, and 6%, respectively (Figure 2d).

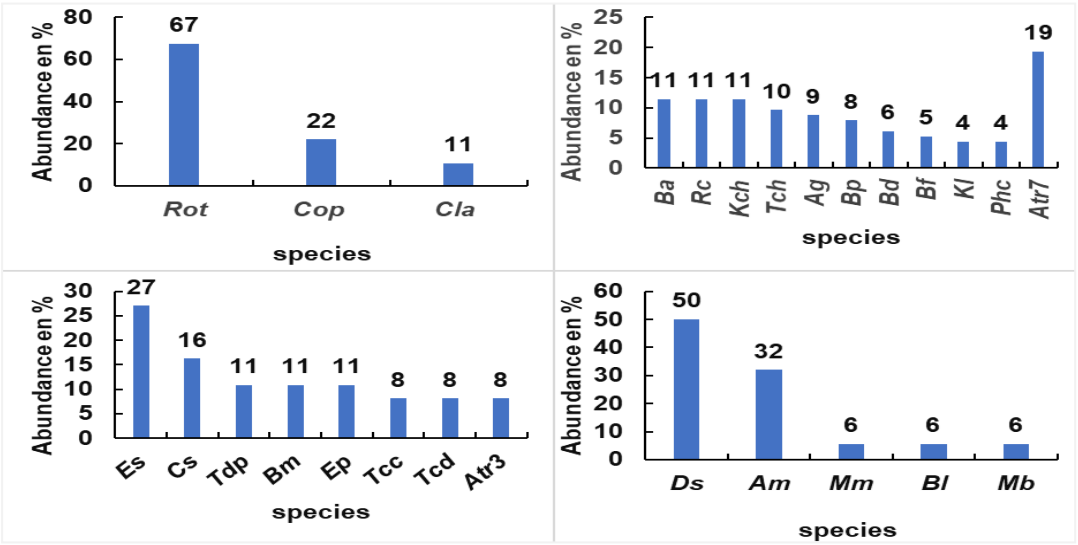



**Figure 2.** Percentage distribution of species. a) total species, b) rotifera, c) copepoda, d) Cladocera, *Rotifère(rot);copépodes (cop); cladocères(cla); Brachionus angularis (Ba) ; Rotaria citrina(Rc) ;Keratella cholerais(Kch) ;Asplanchna girodi(Ag ;Brachionus dimidiatus (Bd); Keratella lenzi(Kl) ;Eucyclops*

*serralatus(Es);Canthocamps staphylinus; Tropodioptomus processifer(Tdp) ; Bryocamptus minutus (Bm) ; Eucyclops. Spatharum(Esp); Trophocyclops confenis(Tcc) Thermocyclops dicipiens(Tcd) ;Daphnia similis(Ds) ;Alona monacantha(Am) ; Moinaphnia macleayi(Mm); Bosmina longirostris (Bl); Moina brachiata(Mb);Autres avec le nombre(Atr).*

Unlike during the cold season, zooplankton communities are characterized by the dominance of copepods (58.64%), followed by rotifers (32.80%), while cladocerans remain the least abundant group (8.56%) (Figure 3a). Thus, the abundance of rotifers is characterized by the dominance of Brachionidae (62%), followed by Asplanchnidae (13%) and Philodinidae (7%), while the other families are characterized by low abundance, each representing a proportion of 5% or less. The rotifer population is still dominated by *Brachionus angularis* (20%), followed by *Brachionus plicatilis* (14%), *Asplanchna girodi* (13%), *Brachionus dimidiatus* (9%), *Brachionus falcatus* (8%), while the remaining 13 taxa account for 5% or less (Figure 3b). The copepod phylum is also characterized by a dominance of Cyclopoidae (73%), followed by Diaptomidae (19%) and Canthocamptidae (8%). However, during the warm season, *Thermocyclops dicipiens* is the most abundant species at 15%, followed by *Trophocyclops processifer* (14%), *Eucyclops agilis* (13%), *Trophocyclops confenis* and *Eucyclops serralatus* (11%), and *Trophocyclops tenellus* (10%). The remaining 8 taxa each account for 6% or less (Figure 3c).

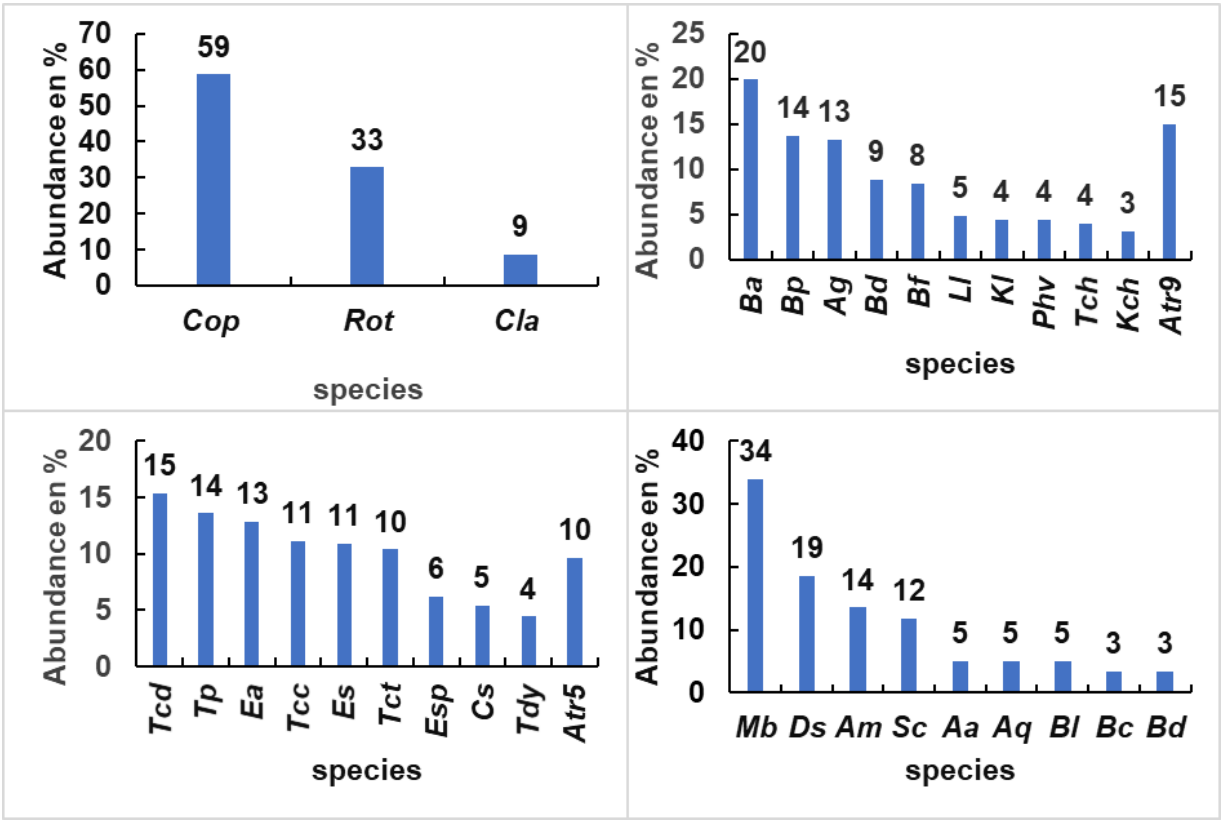



**Figure 3.** Percentage Distribution of Species. a) total species, b) rotifera, c) copepoda, d) Cladocera, *Rotifère(Rot) ;copépodes (Cop) ;cladocères(Cla) ;Brachionus angularis(Ba);Brachionus falcatus(Bf);Keratella cholerais(Kch) ;Asplanchna girodi(Ag) ;Brachionus dimidiatus(Bd) ;Brachionus plicatilis(Bp) ;Pholyarthra vulgarus(Phv) ;Keratella lenzi(Kl) ;Lecane leontina(Ll) ;Trichocerca chattoni(Tch) ;Eucyclops serralatus(Es);Canthocamps staphylinus ; Tropodioptomus processifer(Tdp) ; Eucyclops agilis(Ea) ; Thermodiaptomus yabensis(Tdy) ;Bryocamptus minutus(Bm) ; Eucyclops Spatharum(Esp) ; Tropodiaptomus processifer(Tp) ;Trophocyclops confenis(Tcc) Thermocyclops dicipiens(Tcd) ; Alona affinis(Aa);Daphnia similis(Ds) ;Alona monacantha(Am); Bosmina longirostris(Bl) ; Moina brachiata(Mb) ; Sida crystallina(Sc) ; Alona quadrangularis(Aq) ;Bosmina coregoni(Bc) ; Basminopsis deitersi(Bd) et Autres et nombre d'espèces(Atr).*

Figure 4 shows the spatial and temporal variation in zooplankton abundance over the two sampling seasons. Thus, the phylum Rotifera is the most abundant group, with an average of $15.10^3$ ind/L, followed by copepods at $5.10^3$ ind/L, while cladocerans account for $3.10^3$ ind/L of the total abundance during the cold season. In contrast, during the warm season, copepods ranked first by far with $51.10^3$ ind/L, followed by rotifers in second place with $29.10^3$

ind/L, while the cladoceran group remained in last place with $8.10^3$ ind/L. In summary, the total abundance of the zooplankton community is significantly higher during the warm season than during the cold season, particularly in S1 ($161.10^3$ ind/L), S2 ($113.10^3$ ind/L), S3 ($116.10^3$ ind/L), and S7 ($108.10^3$ ind/L).

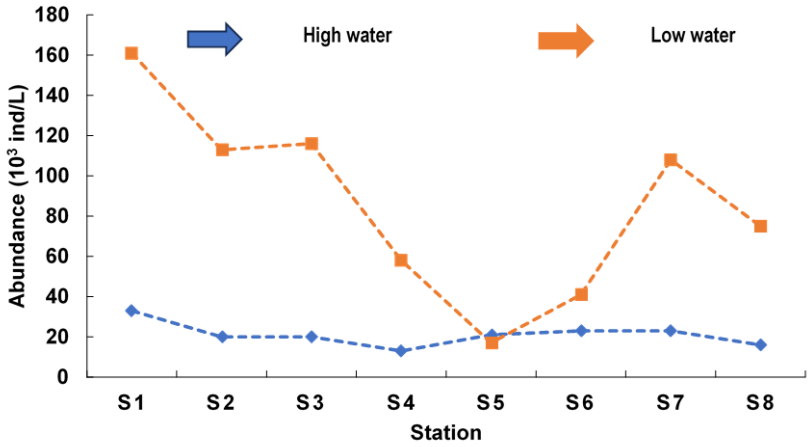



**Figure 4**. Zooplankton Structure and Total Abundance.

The rotifer group is more abundant at all stations during the warm season, with the exception of Station 5, where this group is most abundant during the cold season (Figure 5). In both the warm and cold seasons, Station 1with $58.10^3$ ind/L and $19.10^3$ ind/L, respectively, had the highest abundance compared to all sampling stations, while the lowest abundance was observed at Station 5 ($10.10^3$ ind/L) during the warm season and at Station 8 ($10.10^3$ ind/L) during the cold season. A gradual decrease in rotifer density is observed from Station 1 to Station 5, followed by a steady increase up to the last station during the warm season. However, rotifer abundance followed a sinusoidal pattern during the cold season.

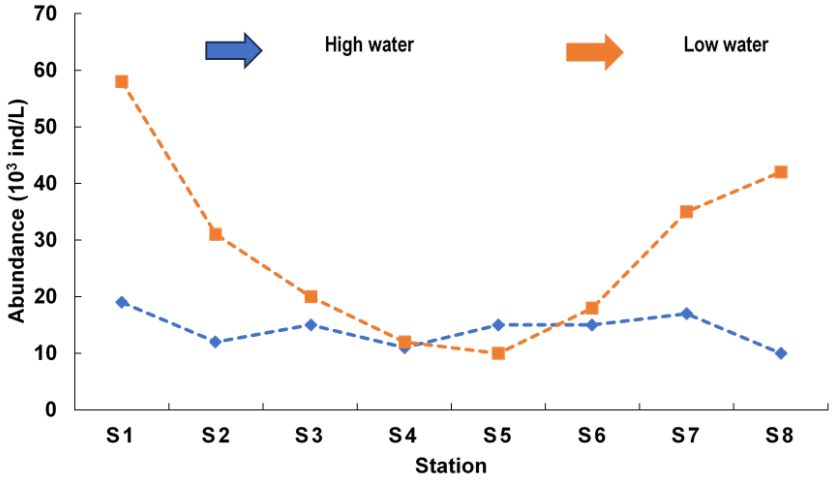



**Figure 5**. Structure and Abundance of Rotifer Groups.

Figure 6 summarizes the total copepod abundance, which ranged from $95.10^3$ to $10^3$ ind/L during the two sampling campaigns. The copepod phylum showed high abundance at Station S1 ($95.10^3$ ind/L) and low density at Station S5 ($5.10^3$ ind/L) during the warm season. Furthermore, Station 1 ($9.10^3$ ind/L) had the highest copepod abundance during the cold season, while the lowest abundance was recorded at Station 4 ($10^3$ ind/L). Low abundance was observed at all stations located near the villages of Guidimouni and Kilaloum; however, although Station 2 is far from the village, it showed higher abundance compared to Station 3, which is more exposed to human activity. This group of copepods is generally characterized by significantly higher abundance during the warm season than during the cold season at all sampling stations.

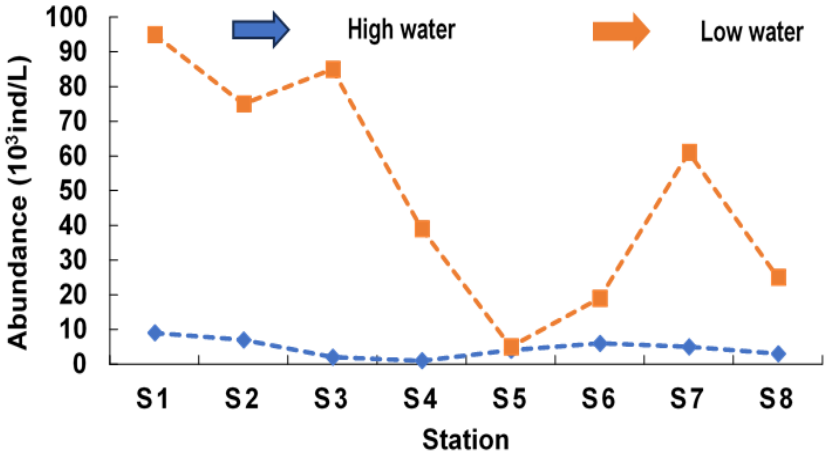



**Figure 6.** Structure and Abundance of Copepod Groups.

The total abundance of the cladoceran group is shown in Figure 7. Thus, the zooplankton community of the phylum Cladocera also exhibits higher abundance in low water than in high water (Figure 7). The highest abundance of the Cladocera phylum in low-water conditions was observed at Station 7 ($12.10^3$ ind/L), while Station 5 ($2.10^3$ ind/L) had the lowest. In contrast, during high water, Station 7 (103 ind/L) was among the stations with the lowest abundance, while Station 1 ($5.10^3$ ind/L) was characterized by the highest abundance.

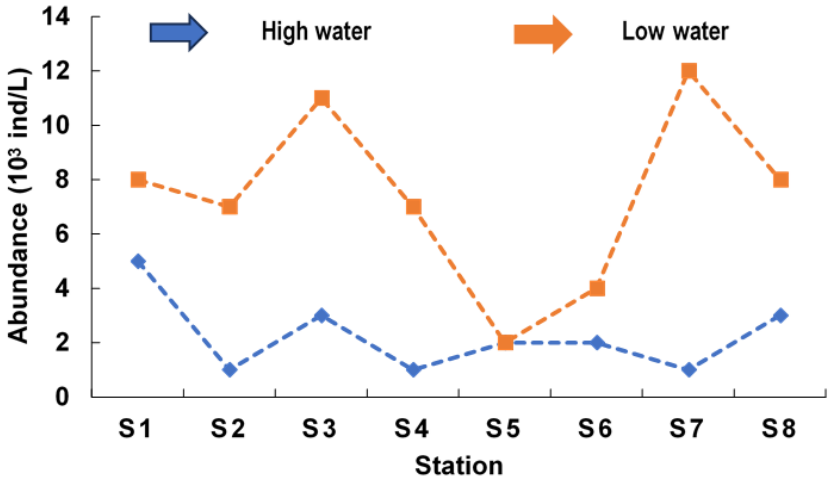



**Figure 7.** Cladoceran Group Composition and Abundance.

Table 4 shows the spatio-temporal variation in biodiversity indices for the two sampling seasons, broken down by station. During high water, the Shannon diversity index ranges from 2.53 bits/ind to 0.97 bits/ind, and from 3.62 bits/ind to 4.39 bits/ind during low water. Station 1 is the most diverse station during both high-water and low-water periods, with values of 2.53 bits/ind and 2.86 bits/ind, respectively, while Stations 4 and 5 have the lowest biological diversity, with values of 0.97 bits/ind and 1.28 bits/ind, respectively. In general, the Shannon diversity index values for the different stations show that the zooplankton community exhibits a taxonomic richness that is significantly different ($p = 0.001$) between low and high-water levels. Indeed, 32 taxa were identified during high water levels compared to 42 taxa during low water levels, of which 6 and 17 taxa, respectively, are specific to those conditions. As for the evenness indices, they range from 0.32 to 0.99 in high water and from 0.86 to 0.98 in low water. Thus, stations S3, S5, and S8, with a value of 0.99, are the stations where the abundance of taxa is nearly evenly distributed; however, the taxa identified at station 4 (0.32) showed a dominance of certain taxa during in high water. During low water levels (S1 through S8), the equitability index values do not indicate a dominance of any of the observed taxa. In summary, zooplankton abundance is characterized by the dominance of certain taxa during high water levels and by an almost even taxonomic distribution during low water levels.

**Table 4.** Biological Diversity Index **(H'**: Shannon index; **Eq**: equitability index; **S**: station)

| | High water | | Low water | | P-value |
|---|---|---|---|---|---|
| **Station** | **H'** | **Eq** | **H'** | **Eq** | |
| S1 | 2,53 | 0,95 | 4,39 | 0,89 | |
| S2 | 1,83 | 0,65 | 4,20 | 0,86 | |
| S3 | 2,08 | 0,99 | 3,77 | 0,85 | |
| S4 | 0,97 | 0,32 | 3,78 | 0,86 | 0,001 |
| S5 | 2,17 | 0,99 | 3,73 | 0,98 | |
| S6 | 1,91 | 0,96 | 3,62 | 0,91 | |
| S7 | 1,95 | 0,65 | 3,59 | 0,88 | |
| S8 | 2,10 | 0,99 | 3,78 | 0,94 | |
| **Taxonomic diversity** | **32** | | **42** | | |
| **Specific taxa** | **6** | | **17** | | |

**Influence of environmental parameters on the zooplankton community**

Redundancy analyses were performed exclusively on the constant taxa observed at the Guidimouni Ramsar site during both seasons.

- ✓ During high water

The results of the redundancy analyses conducted among species, stations, and environmental parameters during the cold season are shown in Figure x. Thus, 69% of the total variance is explained by the first two axes: 42% by axis 1 and 27% by axis 2 (Figure 8). Three groups of species were formed based on environmental variables, namely:

**Group 1**. *Brachionus angularis, Alona monacantha, Philodina citrina, Keratella lenzi, Asplanchna girodi, Tropodiaptomus processifer, Brachionus plicatilis et Brachionus falcatus* are correlated with pH ;

**Group 2**. *Daphnia similis, Eucyclops serralatus, Brachionus dimidiatus et Rotaria citrina* are correlated with dissolved oxygen, depth, and temperature;

**Group 3**. *Canthocamps staphylinus, Bryocamptus minutus, Keratella cochlearis et Trichocerca chattoni* are correlated with salinity and conductivity.

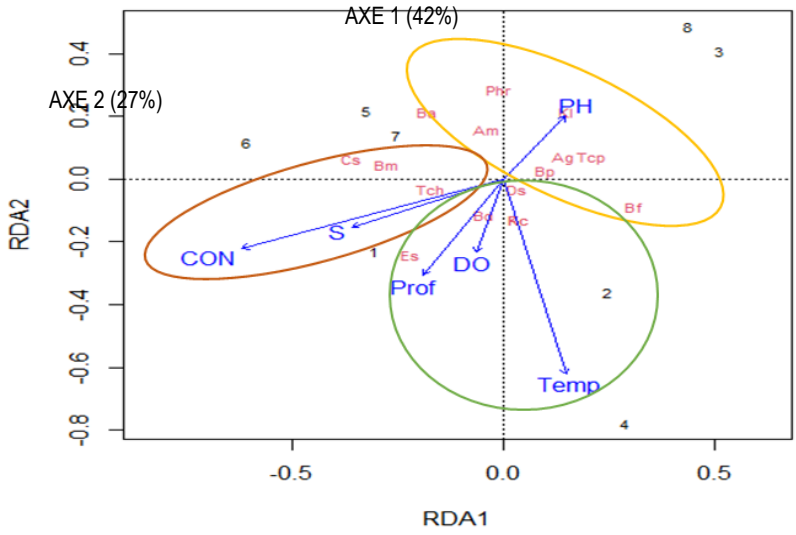



**Figure 8.** Distribution of species based on environmental parameters during high water.

*Brachionus angularis (Ba); Philodina citrina(Phr) ;Rotaria citrina(Rc) ; Brachionus falcatus(Bf); Asplanchna girodi(Ag) ;Brachionus dimidiatus(Bd) ;Brachionus plicatilis(Bp) ; Keratella lenzi(Kl) ; Trichocerca chattoni(Tch) ;Eucyclops serralatus(Es);Canthocamps staphylinus ; Tropodioptomus processifer(Tcp) ; Daphnia similis(Ds) ;Alona monacantha(Am); Moina brachiata(Mb).*

✓ During low water

Figure 9 shows the results of redundancy analyses relating environmental variables, species, and stations during the warm season. These RDA results indicate that 58% of the total variance is explained, with axis 1 accounting for 34% and the remaining 24% attributed to axis 2. Three groups can generally be identified, with groups 1 and 2 showing a negative correlation with axis 1. These are:

**Group 1**. *Trophocyclops tenellus, Brachionus angularis, Brachionus plicatilis, Keratella lenzi, Pholyarthra vulgaris, Canthocamps staphylinus, Moina brachiata, Trophocyclops processifer et Thermocyclops dicipiens* are correlated with pH

**Group 2**. *Trophocyclops confenis, Daphnia similis, Lecane leontina, Brachionus dimidiatus et Eucyclops serralatus*, these species are correlated with temperature, depth, and dissolved oxygen. **Group 3**. *Asplanchna girodi, Brachionus falcatus et Eucyclops agilis* are influenced by conductivity and salinity.

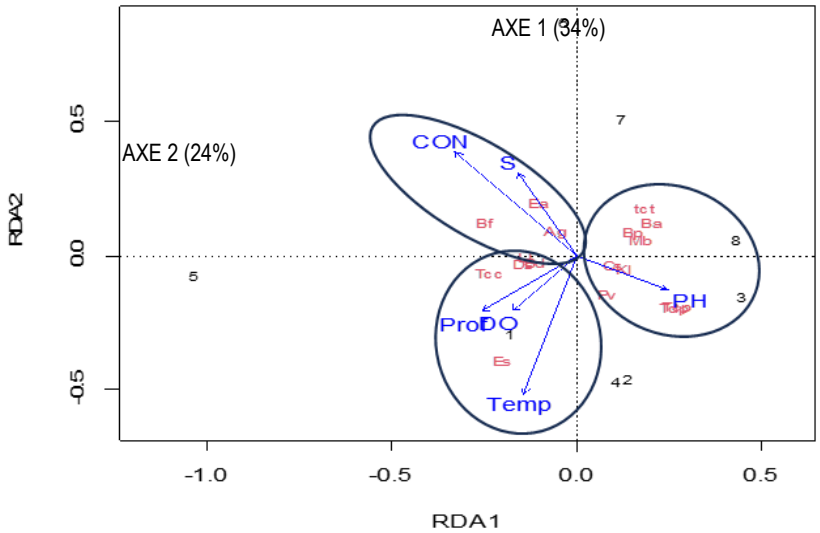



**Figure 9.** Distribution of species based on environmental parameters during low-water conditions. *Trophocyclops tenellus (Tct); Brachionus angularis (Ba); Brachionus plicatilis(Bp), Keratella lenzi(Ll); Pholyarthra vulgaris (Phv); Canthocamps staphylinus(Cs); Moina brachiata(Mb); Trophocyclops processifer(Tcp) et Thermocyclops dicipiens(Thcp); Trophocyclops confenis(Tcc); Daphnia similis(Ds); Lecane leontina(Ll), Brachionus dimidiatus (Bd); Eucyclops serralatus(Es); Asplanchna girodi(Ag), Brachionus falcatus(Bf) et Eucyclops agilis (Ea).*

Environmental variables indicating water quality in a lentic ecosystem can provide information on the level of pollution in that biotope. Thus, temperature showed a significant difference (0.001) between the cold and low water, with average values of 25.62±1.74 and 33.26±1.84, respectively. These results are largely consistent with those found (30.66°C) in April by Sako *et al.,* (2019) along the Niger River in Mali. This rise in temperature in the Sahel regions could be explained by the absence of cloud cover, leading to intense sunlight during low water. The recorded pH values showed a significant difference (0.001) between the two sampling seasons, with Lake Guidimouni being entirely alkaline during high water (9.17 ± 1.06). This finding is consistent with that reported by Youchaou *et al.,* (2025) for Lake Guidimouni during the high-water, where the pH ranged from 7.8 to 10.2, with an average of 9.3. During the high water, the increase in pH may be linked to the increased dissolution of alkaline minerals due to lower temperatures, which reduce dissolved $CO_2$ (Romero-Mujalli *et al.,* 2019). The depth of sampling stations shows a significant difference (0.001) between the high and low water periods, with average values of 0.51 ± 0.07 and 0.38 ± 0.13, respectively. These results are consistent with those reported by Hamadou Yacouba *et al.,* (2025), who recorded values of 1.4 ± 0.16 in December and 0.36 ± 0.8 in May in Lake Madarounfa in Niger. Indeed, water shrinkage and a decrease in depth during low water are among the general characteristics of lakes in Niger.

This study identified 48 zooplankton taxa divided into three groups (rotifers, copepods, and cladocerans). These taxa consist exclusively of cosmopolitan species found in the surface waters of West Africa, documented by, Houssou *et al*. in 2017 in Benin; Soro *et al.,* (2019), in Côte d'Ivoire; Anyanwu *et al.,* (2021), in Nigeria; and Souley *et al.,* (2021), in Niger. Our results exceed those found (31 taxa) by Fofana *et al.,* (2019) in Lake Kaby but are significantly lower than those found (127 taxa) by Traoré *et al.,* (2025) at Banoufla in Côte d'Ivoire. This significant difference could be explained by the nature of the environment and the sampling method. Indeed, Lake Kaby is located near a densely populated area of the city of Bongouanou, which has a direct impact on water quality as well as on aquatic organisms (Fofana *et al.,* 2019). Furthermore, the net used by Fofana had a mesh size of 60

µm, compared to 50 µm in the present study and 20 µm in Traoré *et al.,* (2025). During the study period, the zooplankton community of Lake Guidimouni was dominated by the phylum Rotifera (67.46%), followed by copepods (21.89%) during the high water. In contrast, the zooplankton community is largely characterized by the dominance of copepods (58.64%), followed by rotifers (32.80%) during the warm season. Thus, the zooplankton structure observed during the cold season has become common in freshwater ecosystems in Africa (Aka *et al.,* 2025; Baitiche *et al.,* 2025; Were *et al.,* 2026; Appaiah *et al.,* 2026). Among all the studies reviewed, only the work by Amani (2025) naturally reported the dominance of copepods in Lake Hassi Ben Abdallah (Ouargla, southeastern Algeria), and Anougbo *et al.,* (2020) in certain ponds in Côte d'Ivoire, where they enriched the ponds by adding organic fertilizers composed of agricultural byproducts. This dominance of copepods at Station 1 (95,000 ind/L) during low-water periods could be explained by the low fish diversity in Lake Guidimouni; the warm season is a period of intense fishing pressure, which reduces predation pressure on fry, allowing them to complete their life cycles. Although *Eucyclops serralatus* (10.89%) dominates the copepod community during high-water periods, the species *Thermocyclops dicipiens* (15.34%) emerges as the dominant species overall due to the high numbers recorded during low-water periods. This situation is similar to that observed by Fofana *et al.,* (2020), in reservoirs in Côte d'Ivoire. The dominance of *Thermocyclops dicipiens* may be due to the high temperatures during low-water periods, which are favorable for its development. Despite the dominance of copepods during the study period, rotifers were the most diverse phylum across all sampling sites and seasons. Indeed, the high diversity of rotifers is due to their very short development time and their parthenogenetic reproduction, which they undertake under favorable conditions (Shah *et al.,* 2015).

Rotifers were characterized by the dominance of certain families, such as the Brachionidae (*Brachionus*, *Keratella*, and *Platyias*), Asplanchnidae (*Asplanchna*), and Philodinidae (Philodina and Rotaria), which consist almost entirely of species that are consistently present in Lake Guidimouni. Among these families, the Brachionidae (55.5%) is the most diverse, with 8 species and 3 genera. Thus, the dominance of the Brachionidae family within the rotifer community has become a general principle in freshwater ecosystems in tropical regions (Adandejan *et al.,* 2017; Souley *et al.,* 2024). Furthermore, Brachionidae have a thick chitinous shell that protects them from predation by invertebrates (Pourriot and Francez, 1986) and are generally represented by the largest number of species (Ayougui *et al.,* 2004). The dominance of rotifers during the cold season confirms the poor water quality causing pollution at the Guidimouni Ramsar site. High temperatures and/or declining water quality can affect abundance and taxonomic richness, though to a lesser extent for rotifers, which are more tolerant of variations in environmental conditions and are also found in habitats very rich in organic matter (Onana *et al.,* 2014).

During the period covered by this study, cladoceran communities dominated by Daphnia similis (34.5%) represented the least diverse group at all sampling sites. These results contradict those found by Biki-Akli *et al.,* (2022) at the Zéralda Game Reserve dam in Algeria, where they reported a dominance of cladoceran species. This low diversity and abundance of the cladoceran phylum could be explained by anthropogenic disturbance in Lake Guidimouni. Indeed, cladoceran abundance is lower and they are found in the calmer areas of a body of water (Cherrahi and Ben Mahmoud, 2020). In summary, the zooplankton community of Lake Guidimouni was characterized by high abundance and diversity during the sampling period, with a clear dominance during low-water periods. These results are significantly higher than those recorded by Souley *et al.,* (2023) in the Niger River. The high abundance and significant diversity recorded during these studies could be explained by the limnological nature of this ecosystem. Indeed, the Guidimouni Ramsar site is a lentic aquatic environment where the water is stagnant, so the zooplankton population would have ample time to complete its entire life cycle. However, low abundance was observed in all seasons at stations near Guidimouni and Kilaloum specifically stations 4 and 5. This finding was previously reported by Monney *et al.,* (2016), who demonstrated that zooplankton abundance increases as one moves farther away from the discharge points of the coastal rivers in southeastern Côte d'Ivoire.

Despite the high oxygen concentration-which is highly conducive to zooplankton growth-in deep water, high biological diversity (H': 4.39) was recorded in shallow water. Our results contradict those obtained by Badji *et al*. in 2023 in Senegal, where they recorded high diversity during the cold season. This difference could be explained in particular by the high temperature (33.26 ± 1.84) and the moderately near-neutral pH (7.4 ± 0.25) in shallow waters, which are very favorable for the growth of certain identified species. Indeed, a pH greater than 9, as recorded during the cold season (9.17 ± 1.06), is adverse for most aquatic species, affecting both vertebrates and invertebrates, and increases the toxicity of ammonia (Dimon *et al*., 2014). Redundancy analyses identified three groups of species that correlate with environmental parameters across the seasons. The distribution and abundance of species in Group 1, whether during high or low water levels, are influenced by pH. The observed response of these species largely contradicts that observed by Fofana *et al.,* (2019) in Lake Kaby, where only the species *Pholyarthra vulgaris* showed a correlation with pH. This difference in correlation could be due to the numerous environmental parameters measured in these two studies. In fact, Fofana and his colleagues measured up to ten environmental variables, compared to the five measured in this study; this suggests that species may be more selective about the variables with which they correlate. However, the correlation between *Pholyarthra vulgaris* and pH confirms its absence in high-water conditions (basic environment) and its presence or abundance during the warm season (neutral environment), making it one of the taxa specific to

the warm season according to this study. The second group identified by the RDA is strongly influenced by depth, dissolved oxygen, and temperature in both seasons. These findings regarding the species in the second group are inconsistent with those observed by Traoré *et al.,* (2025), particularly with regard to temperature, which is not an environmental variable that strongly influences zooplankton abundance. The strong influence of dissolved oxygen and depth (*Rotaria citrina, Brachionus dimidiatus Eucyclops serralatus et Daphnia similis*) and temperature *(Eucyclops serralatus*) could be explained by a large and unevenly distributed number of these variables, recorded during high and low water levels, respectively. Finally, conductivity and salinity are the variables that strongly influence *Canthocamps staphylinus, Bryocamptus minutus et Trichocerca chattoni* at high water et *Brachionus falcatus, Asplanchna girodi et Eucyclops agilis* at low water. This strong influence, characterized by conductivity and salinity, is similar to that observed by Adandejan *et al.,* (2017) at the Ket1 and Cen1 stations in Lake Nakoué in Côte d'Ivoire. In general, the environmental parameters measured during the study period play an important role in the structure, composition, and abundance of the zooplankton community at the Guidimouni Ramsar site.

## CONCLUSION

The environmental parameters measured during the study period indicate that Lake Guidimouni is a shallow, alkaline environment with a lower temperature and is strongly influenced by the vegetable farming activities carried out by the local population during periods of high water. In contrast, these variables indicate that this water body is moderately neutral, shallower, and has a higher temperature during low-water periods. Analysis of the zooplankton samples identified 48 taxa, including 19 rotifers, 15 copepods, and 10 Cladocera's, with higher abundances observed during low-water periods compared to high-water periods. Thus, copepods are by far the most abundant during high-water periods, while rotifers exhibit greater diversity during both sampling seasons. These six measured variables (DO, Cond, Prof, Temp, Salinity, pH) in explaining the distribution of the different taxa: 17 rotifer taxa, 10 copepod taxa, 5 Cladocera taxa during high water levels, and 19 rotifer taxa, 14 copepod taxa, and 9 Cladocera taxa during low water levels. A more robust dataset would therefore be necessary to understand the physicochemical characteristics as well as the distribution of taxa in the lake.

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## CONFLICT OF INTERESTS

The authors declare no conflict of interest

## ETHICS APPROVAL

Not applicable

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## AI TOOL DECLARATION

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

## DATA AVAILABILITY

Data will be available on request

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