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Dynamics of Benthic Macroinvertebrates in Relation to Water Quality in Two Small Reservoirs in Burkina Faso, West Africa

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Abstract

In Burkina Faso, small reservoirs play a key ecological and socio-economic role for populations. Unfortunately, their biodiversity, ecological functioning, and response to diverse environmental changes remain less understood. This study aimed to determine the taxonomic composition and the temporal dynamics of macroinvertebrates and their environmental determinants in two small reservoirs in a semi-arid zone. Macroinvertebrates were collected from both sites monthly from May 2018 to March 2019, and physico-chemical parameters were monitored. The results revealed pronounced seasonal and spatial variability in water quality. In turn, this influenced macroinvertebrate diversity and assemblages. In total, 30 families of macroinvertebrates, composed of three phyla (Arthropoda, Mollusca, and Annelida) and five classes, were recorded. The diversity indices showed that species richness was high during the rainy or post-rainy seasons. This may reflect habitat complexity and resource availability. The lower values correspond to the dry season and are dominated by tolerant taxa. Notable community turnover occurred during periods of hydrological transition, where temporal beta diversity was high. The key environmental drivers structuring macroinvertebrate community composition were conductivity, TDS, water level, and pH. Sensitive taxa such as Baetidae, Caenidae, and Hydropsychidae appeared during stable, high water quality periods, while tolerant taxa such as Chironomidae and Oligochaetae dominated during stress periods. The more persistent presence of sensitive taxa in Ladwenda reservoir reveals better quality than in Bidiga. Findings of this study highlight narrow relationships between hydrology, water quality, and macroinvertebrate community structure. This information shows that protecting catchment integrity and adapting management to seasonal cycles are very important for conserving aquatic biodiversity and ecosystem services.

Keywords

Macroinvertebrate Diversity, Small Reservoirs, Seasonal Dynamics, Ecological Assessment, West Africa

1. Introduction

Burkina Faso is a landlocked country located in West Africa with a marked dry season and very variable rainfall [1]. The country's economy is mainly driven by agriculture, but unfortunately, crop production remains largely rainfed and limited to a growing season of 3 to 5 months from North to South. This reduced temporal window for agricultural activities, associated with population growth and the impacts of climate change, makes access to reliable water sources absolutely crucial for food security, rural livelihoods, and socio-economic development [2]. To face seasonal water deficits, many small reservoirs (over 970) have been constructed in Burkina Faso, with the majority built since the 1970s and serving for irrigation, livestock, fisheries, domestic needs, etc. [3]. These important ecosystems for local communities are becoming more vulnerable to challenges from growing agriculture, settlement, and changes in land use that come with them [4]. As a result, the hydrology changes, the habitat worsens, and the health of the overall ecosystem declines. Despite their significance, the ecological status and biodiversity of many small reservoirs in Burkina Faso remain poorly understood, particularly their benthic macroinvertebrate communities. These organisms are widely recognized as critical indicators of freshwater ecosystem integrity due to their ecological roles in nutrient cycling and organic matter breakdown, as well as their varied sensitivity to environmental stressors and anthropogenic disturbances [5]-[7]. Macroinvertebrate-based assessments offer significant advantages for water quality and ecosystem health monitoring because of their relative ubiquity, cost-effective sampling, and well-documented responses to pollution gradients, habitat alteration, and seasonal fluctuations [8].

Recent research efforts across Burkina Faso have documented a high richness of benthic macroinvertebrates in rivers and reservoirs, with communities composed predominantly of insects, molluscs, and annelids [5] [9].

They also demonstrated a strong relationship among environmental variables, seasonal hydrological cycles, land use types, and the composition and abundance of macroinvertebrate assemblages. Taxa known to be sensitive to pollution, such as Orders of Ephemeroptera, Plecoptera, and Trichoptera (EPT), are generally associated with clean and well-oxygenated waters. The tolerant taxa, like Chironomidae, Culicidae, and certain pulmonate snails, are more present in disturbed or eutrophic environments [10].

Comparable techniques based on macroinvertebrates have been used in other tropical and subtropical regions, demonstrating the global applicability of this method. This is the case of [11], who used macroinvertebrates to assess the ecological status of the Pinyinyi River in Tanzania during the dry and wet seasons. They showed that domestic water use, livestock grazing, and agricultural practices had a significant impact on macroinvertebrate assemblages and water chemistry. Furthermore, using a modified Biological Monitoring Working Party (BMWP) index, [12] also examined 36 watercourses in the Philippines to identify taxa that are sensitive and tolerant to important water quality variables such as faecal coliforms, BOD, and nitrates. Thus, the use of macroinvertebrates as bioindicators provides comparative frameworks for assessing ecosystem health and water quality in small freshwater systems, such as reservoirs in West Africa.

The reservoirs of Ladwenda and Bidiga, even modest in size, deliver essential ecosystem services including water provisioning, fisheries, and agricultural support for the local population around [2].

However, activities conducted in reservoir catchments, such as intensive farming, livestock grazing, etc., threaten local biodiversity and alter water quality, resulting in the loss of sensitive taxa [3]. The diversity, assemblage structure, and response of macroinvertebrates to environmental change are not yet well known in Bidiga and Ladwenda reservoirs. To address this gap, the present study evaluates the dynamics of benthic macroinvertebrates in Bidiga and Ladwenda reservoirs. Specifically, it aims to: 1) determine the taxonomic composition of macroinvertebrates in these reservoirs; 2) analyze their richness and abundance dynamics; and 3) determine the influence of key environmental variables on the distribution of macroinvertebrates. By addressing these objectives, this study aspires to provide insights to support improved biomonitoring and inform the sustainable management of Burkina Faso's increasingly vital small water bodies.

2. Methods

2.1. Study Area

The Bidiga and Lagwenda reservoirs are located in the Centre-East Region of Burkina Faso (**Figure 1**). The Bidiga reservoir, located at 11.788˚N and −0.043˚W, was built in 1959 for agricultural purposes and was last fixed up in 1991. With a capacity of 935,000 m^3 and covering an area of 20 ha, it provides water to people who live in the municipalities of Tenkodogo and Garango. The mean depth of the reservoir is around 3.125 m. The main activities done on its catchment are farming of maize, sorghum, rice, and vegetable growing. The use of fertilizers and chemical pesticides is also noted. Located on the east side of the Centre-East Region at 11.742˚N and −0.194˚W, the reservoir of Lagwenda can hold 63,000 m^3 of water with an area varying between 18 ha and 55 ha depending on the season [13]. The average depth of the reservoir is around 3.5 m. It was created in 2002 and is mostly used to water rice and vegetables. It is also used for cattle [13]. In this area, the weather is semi-arid with a wet season from mid-May to October and a dry season from October to mid-May. The average annual rainfall is between 800 and 900 mm, and the average temperature is 29˚C.

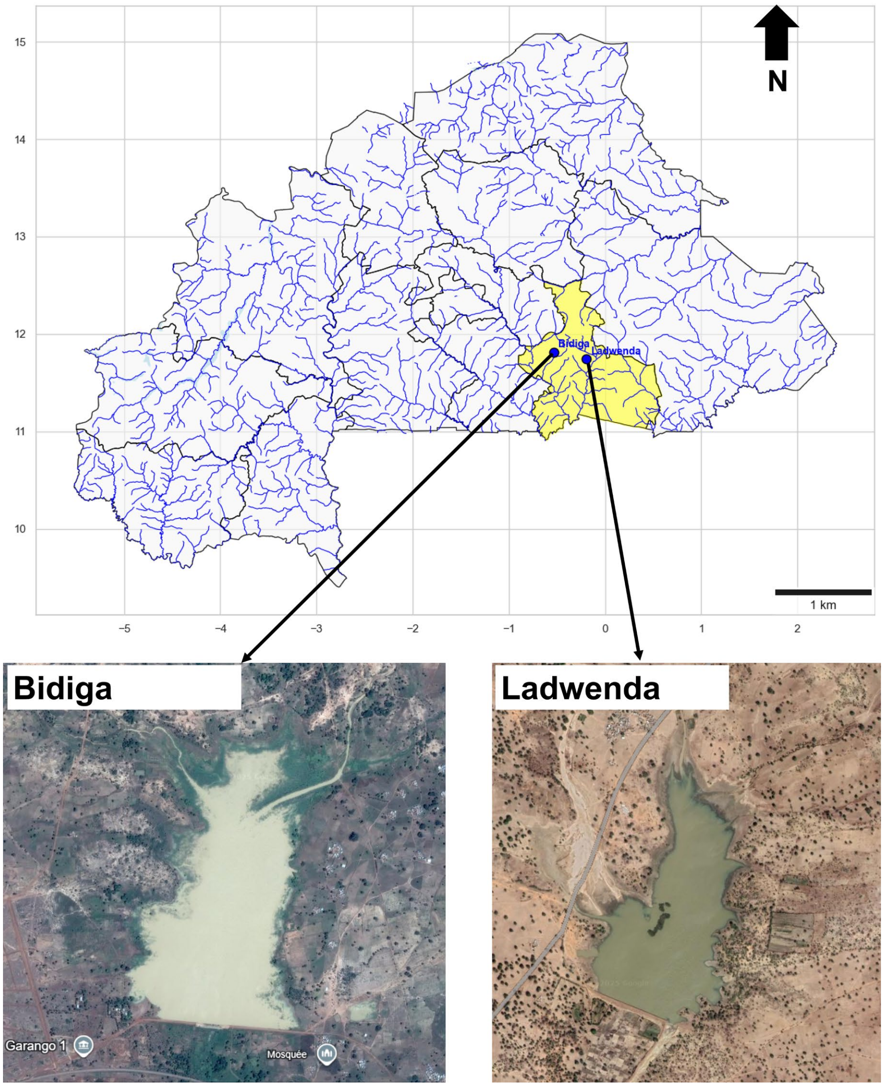

Figure 1. Maps showing the location of the sampled reservoirs.

2.2. Environmental Data Collection

Environmental data were collected monthly from May 2018 to March 2019. In each reservoir, the following key physicochemical variables, including temperature, pH, electrical conductivity, and Total Dissolved Solids (TDSs), were measured in situ between 9 and 11 am using a portable multi-parameter probe (HANNA Instrument). Transparency was measured using a secchi disk, and the water level was estimated by measuring the distance between the water's surface and the outer edge of the dam using a tape. This distance decreases as the water level rises.

2.3. Benthic Macroinvertebrates Sampling

The benthic macroinvertebrates were sampled monthly using the "multi-habitat sampling" methodology inspired by Babour *et al.* [14] and the "MHS-Sampling Manual" [15]. To do this, 20 subsamples were harvested per site and combined to form the sample. These 20 subsamples were distributed among the different microhabitat types available in proportion to their area. This included open water, mud, macrophytes, rocks, etc. A Surber net (type AQEM/STAR of 500 micrometer mesh size and 625-cm^2 surface, 25 × 25 cm) was used. For each habitat type, the samples were collected taking into account the recommendations and guidance of the MHS-Sampling Manual [15]. Immediately after field sampling, large flows (branches, leaves, stems and stones) were removed after rinsing with site water and inspected for organisms. These organisms were kept with 70% alcohol in a pillbox and labeled (date and sampling site). Each remaining sample was transferred to a large bottle (approximately 1 L), labeled, and stored with 70% alcohol. The samples were transported to the laboratory in a cooler.

In the laboratory, the samples were thoroughly rinsed with tap water under a series of sieves of different mesh sizes (mesh: 700 µm to 300 µm). The contents of each sieve were divided into fractions in a Petri dish and then carefully sorted with the naked eye and/or a stereomicroscope when necessary. The organisms obtained were preserved with 70% alcohol in pill containers and labeled for identification. After sorting, all organisms (field-sorted and laboratory-based) from each site were identified down to the family taxonomic level using the identification guides and keys: [16]-[19], and enumerated.

2.4. Data Analysis

Descriptive statistics were first calculated for all physicochemical parameters, including pH, temperature, conductivity, Total Dissolved Solids (TDSs), water transparency, and water level, to evaluate temporal variability across sampling dates. To characterize macroinvertebrate diversity, several community indices were computed. Taxonomic richness (S) was simply a count of families present in a site or the number of distinct taxa per sampling unit; the Shannon-Wiener index (H') (1) and Simpson's index (1-D) (2), combining richness and evenness, were used to describe community diversity; Pielou's Evenness (J) (3) indicated how evenly individuals were distributed among taxa.

$$H' = -\sum_{n=1}^{S} \left(P_i \ln \left(p_i \right) \right) \tag{1}$$

$$D = \sum_{i=1}^{S} P_i^2 \tag{2}$$

$$J = \frac{H'}{\ln S} \tag{3}$$

Beta diversity was calculated to evaluate species turnover between sampling dates using Sørensen and Bray-Curtis dissimilarities [20]. To visualize taxa occurrence, bubble plots were used. This showed the presence of taxa in the macroinvertebrate community structure. A stacked barplot was also used to show the relative abundance of families dominating in each month. After standardizing variables, a Principal Component Analysis (PCA) was used to identify the main gradient in environmental variation. Canonical Correspondence Analysis (CCA) was used to examine the relationship between macroinvertebrate assemblages and environmental variables. Taxa abundance data were Hellinger-transformed prior to analysis to reduce the influence of zeros and rare taxa. The significance of the environmental constraints was tested via Monte Carlo permutation (n = 999). All analyses were conducted using R software (version 4.2.1) and Python 3.13.1 with appropriate ecological and statistical packages.

Macroinvertebrates are generally classified into three groups according to their degree of sensitivity to pollution. There are so-called sensitive species, tolerant species, and moderately tolerant or sensitive species [5] [21]. These different groups were identified in both reservoirs.

3. Results

3.1. Physico-Chemical Conditions of the Study Sites

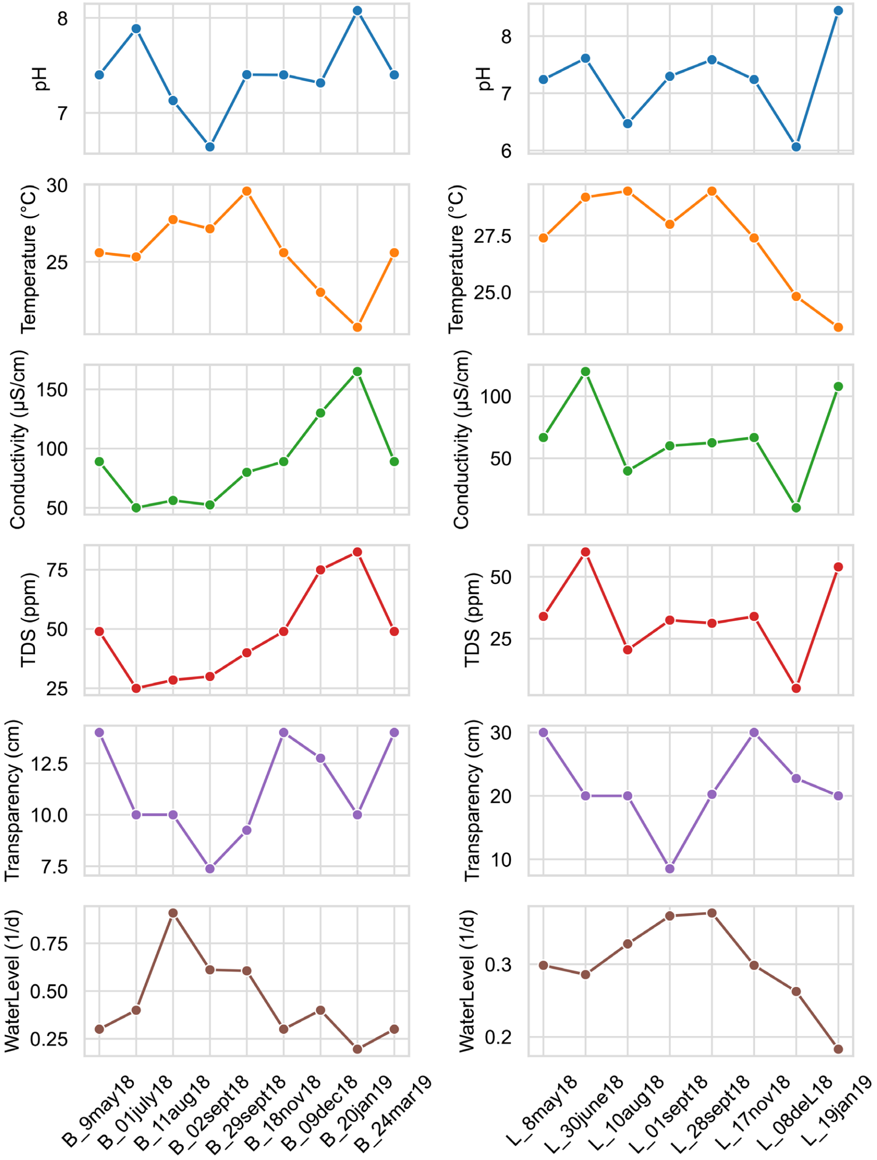

Figure 2. Evolution of environmental variables in Bidiga and Ladwenda reservoirs during the study period.

Figure 2 presents the variations of physico-chemical variables during the study period in both reservoirs. In Bidiga, pH values ranged from 6.6 to 8.1. Slight acidification was observed in September 2018. The lowest temperature value (20.8˚C) was observed in January 2019, and the highest value (29.6˚C) in late September 2018. Water conductivity and Total Dissolved Solids (TDSs) increased progressively from July 2018 to January 2019, reaching the highest values of 165 µS/cm and 82.5 ppm, respectively. Water transparency varied between 7.4 and 14 cm, and water level showed a global decline toward the dry season. Contrary to Bidiga, Ladwenda exhibited a wider pH range from 6.1 to 8.4 and generally higher transparency (8.5 to 30 cm). The temperature remained elevated throughout the study period (24.8˚C to 29.5˚C), while conductivity and TDS varied substantially, with a sharp decline to minimum values (10 µS/cm and 5 ppm) in December 2018. Water level followed a seasonal pattern, culminating during the rainy season and plummeting approaching the dry season.

3.2. Global Diversity and Taxonomic Composition

In total, 30 families of macroinvertebrates were encountered during this study. They are grouped into 5 classes (Insecta, Malacostraca, Clittelata, Gastropoda, and Bivalvia) and 3 phyla (Arthropoda, Annelida, and Mollusca). Among all families encountered, Oligochaetae were not found in Ladwenda reservoir, while the families Ecnomidae, Bivalvia, and Gastropoda were not encountered in Bidiga reservoir (**Table 1**).

Table 1. Macroinvertebrate composition in Bidiga and Ladwenda reservoirs.

Phylum	Class	Order	Family	Ladwenda	Bidiga
Arthropoda	Insecta	Coleoptera	Dytiscidae	X	X
			Hydrophilidae	X	X
		Diptera	Chironomidae	X	X
			Culicidae	X	X
			Ceratopogonidade	X	X
			Tabanidae	X	X
		Ephemeroptera	Baetidae	X	X
			Polymitarcyidae	X	X
			Ceanidae	X	X
		Hemiptera	Corixidae	X	X
			Veliidae	X	X

Continued

			Nepidae	X	X
			Ranatridae	X	X
			Belostomatidae	X	X
			Notonectidae	X	X
		Odonata	Gomphidae	X	X
			Libellulidae	X	X
			Coenagrionidae	X	X
		Trichoptera	Hydropschiscydae	X	X
			Ecnomidae	X	
	Malacostraca	Decapoda	Potamonautidae	X	X
Annelida	Clittelata	Arhynchobdellida	Hirudinae	X	X
		Haplotaxida	Oligochaetae		X
Mollusca	Gastropoda	Architaenioglossa	Ampularidae	X	X
			Viviparidae	X	X
		Basomatophora	Planorbidae	X	X
			Lymneidae	X	X
		Caenogastropoda incertae sedis	Thiaridae	X	X
	Bivalvia	Unionida	Unionidae	X	
			Iridinidae	X	

3.3. Diversity Indices' Evolution over Time

Figure 3 shows the evolution of the diversity indices during the study period. In the Bidiga reservoir, species richness varies from 5 in June to 20 in November. In the Ladwenda reservoir, it ranges from 7 in March to 25 in September. The Shannon-Wiener index shows a lower value of 0.91 in May and a higher value of 2.85 in September in the Ladwenda reservoir. In the Bidiga reservoir, it ranges from 0.95 in June to 2.41 in November.

The Equitability J ranges from 0.52 in March to 0.83 in September in the Bidiga reservoir, and from 0.37 in May to 0.88 in September in Ladwenda. The highest values of this index are observed during the rainy season in both reservoirs. In the Ladwenda reservoir, the Simpson index is low at 0.45 in May and high at 0.91 in September. In the Bidiga reservoir, this index fluctuates between 0.49 in June and 0.88 in November.

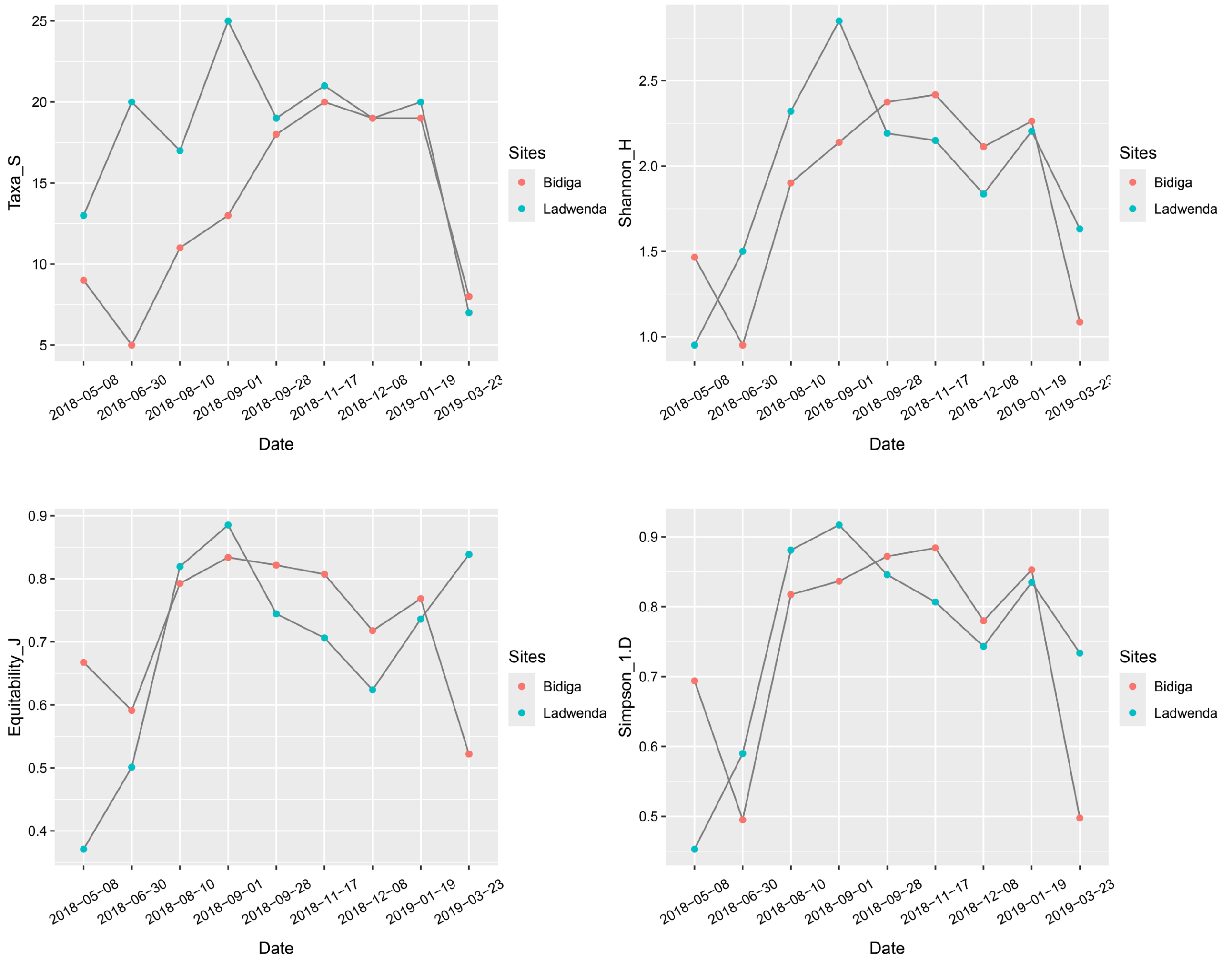

Figure 3. Evolution of diversity indices over time in Bidiga and Ladwenda reservoirs.

3.4. Abundance Evolution of Each Family over Time

In the reservoirs of Bidiga and Ladwenda, the macroinvertebrate abundance of different taxa showed temporal variation. In the Ladwenda reservoir, the most common taxa was the Corixidae family (**Figure 4**). It dominated in the early sampling periods in May and declined around August. At this time, the abundance of the Notonectidae family rose (June to September). The Chironomidae family showed high abundances throughout the study periods, and their lowest abundance coincided with a peak abundance of the Culicidae family. The Baetidae were very abundant in August and declined in November. Concerning the family Planorbidae, they proliferated between November and January. The community changed from low diversity dominated by Corixidae-Chironomidae in May-August to greater diversity in November-January. In the Bidiga reservoir, the Corixidae again showed high abundance in May and March (**Figure 5**). Its minimum abundance was found in September. The Chironomidae showed a seasonal decline from May to November and a partial recovery in January.

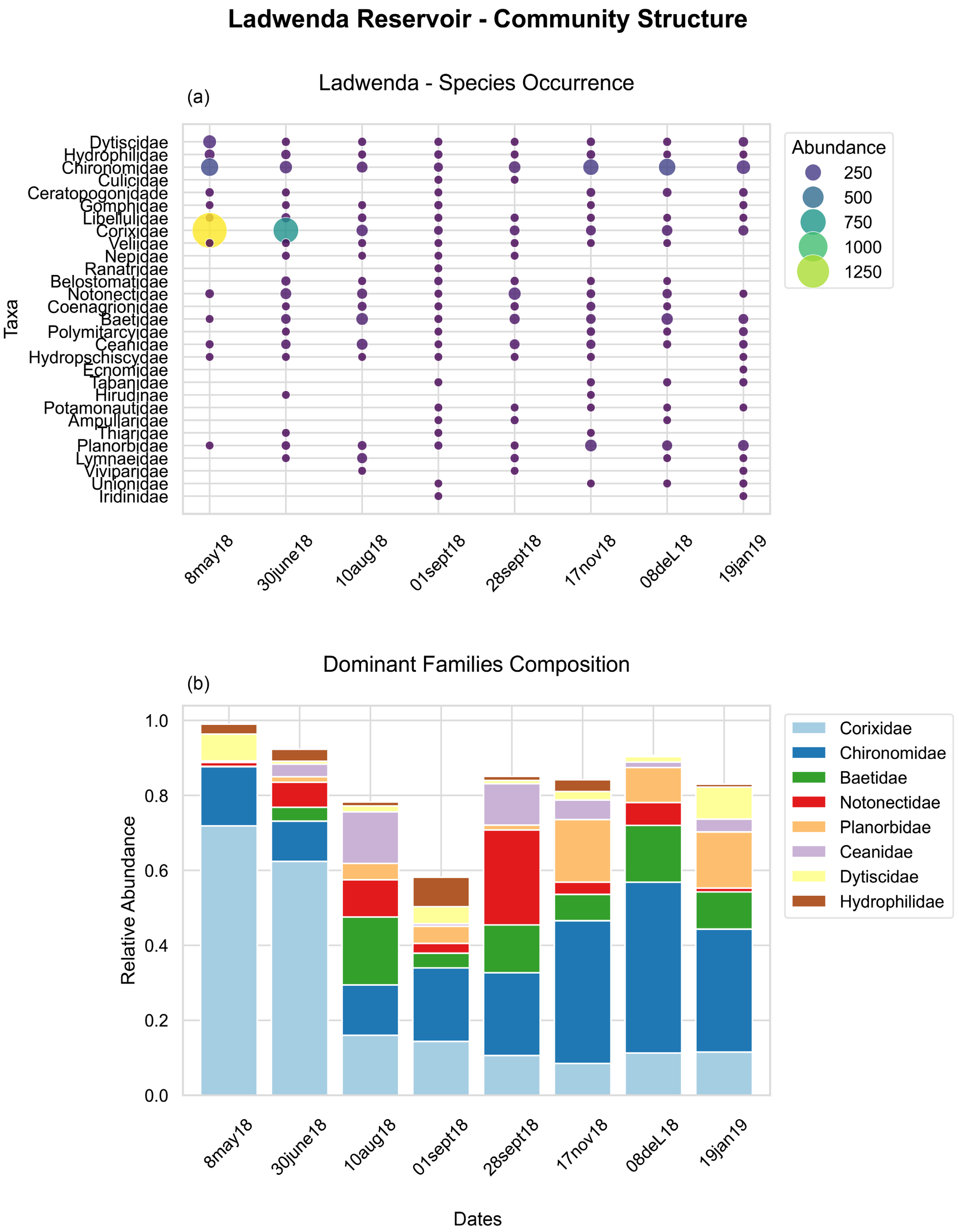

Figure 4. Ladwenda occurrence and composition: (a) Bubble plot showing presence/absence and abundance magnitude; (b) Relative abundance of dominant taxa. Bubble sizes in (a) are scaled to √ (abundance).

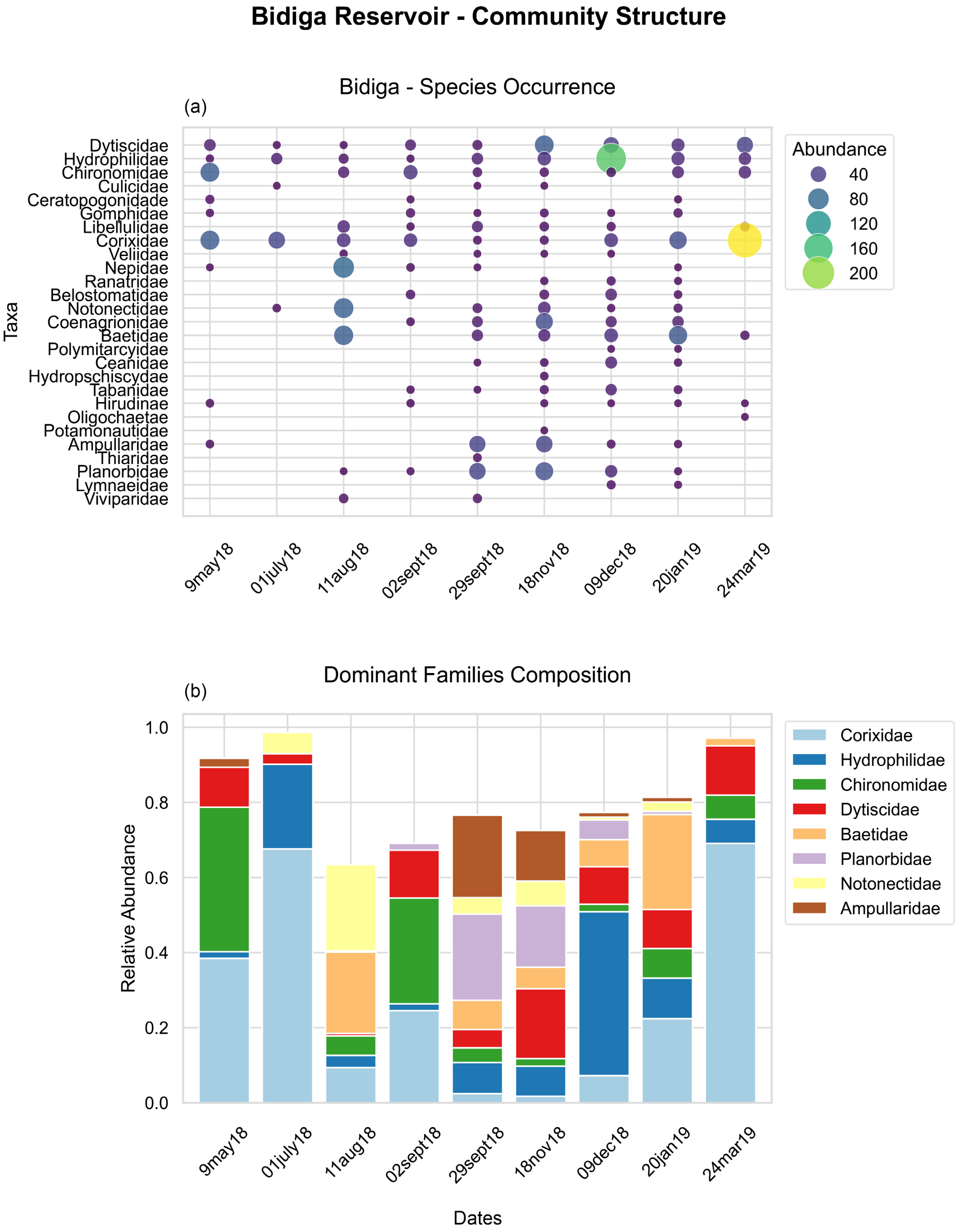

Figure 5. Bidiga occurrence and composition: (a) Bubble plot showing presence/absence and abundance magnitude; (b) Relative abundance of dominant taxa. Bubble sizes in (a) are scaled to √ (abundance).

3.5. Temporal Beta Diversity Index (TBI)

The Temporal Beta Index (TBI) showed significant variations in the benthic macroinvertebrate community composition in both reservoirs (**Figure 6**). In the Ladwenda reservoir, the TBI values varied from 0.23 (November-December) to 0.71 (June-September). In the Bidiga reservoir, TBI was high in July and late September (0.77) and low in the period September-November (0.34).

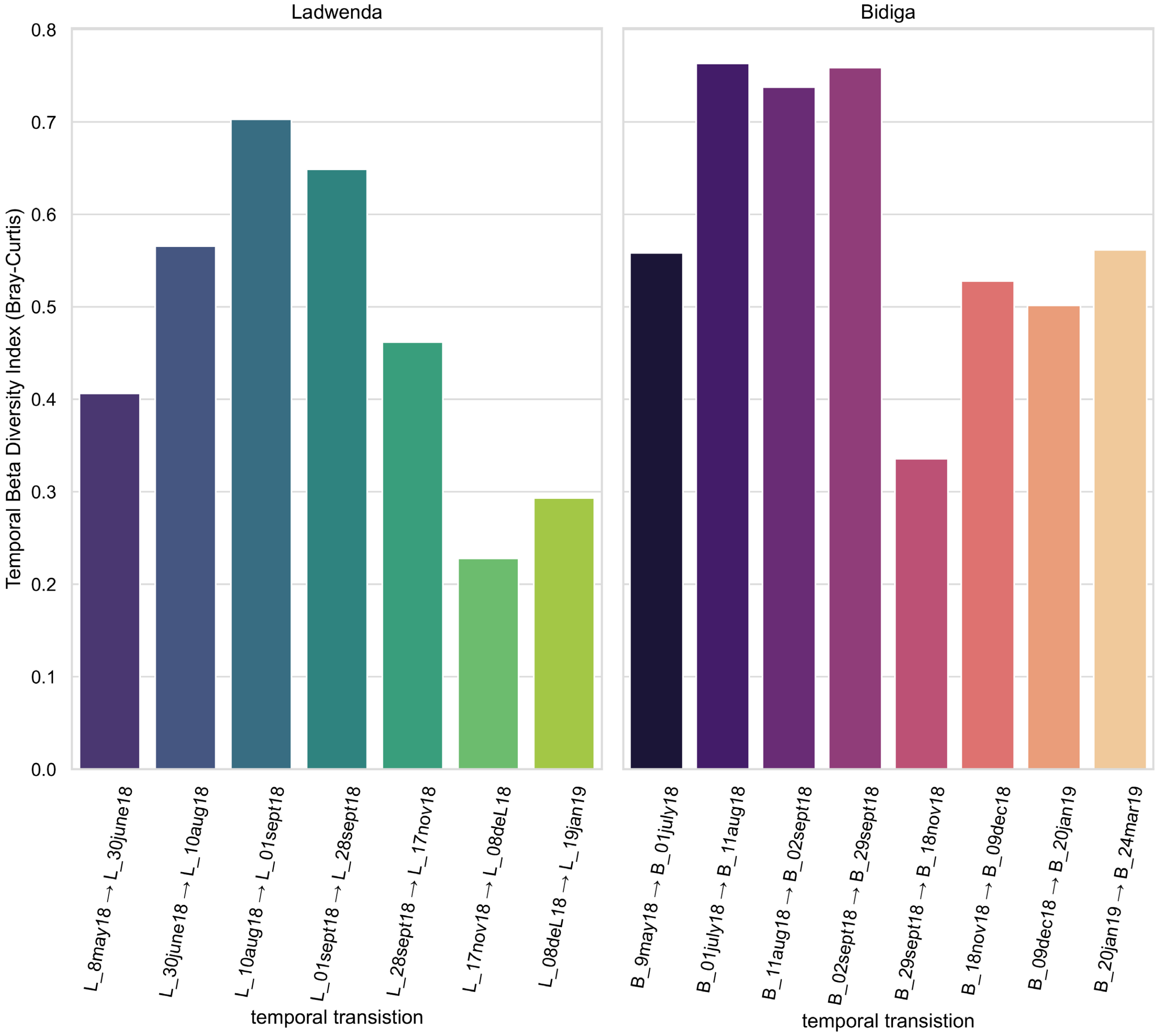

Figure 6. Temporal Beta Index (TBI) variations in benthic macroinvertebrate community composition in both reservoirs.

3.6. Influence of Environmental Conditions on Taxa Distribution

The Principal Component Analysis (PCA) showed two major environmental gradients, which explain 76.7% of the total variance (**Figure 7**). The first axis, explaining 52.2%, was strongly associated with water chemistry. It showed positive correlations with conductivity (r = 0.95, contribution = 28.7%) and TDS (r = 0.94, contribution = 28.2%), and a negative correlation with temperature (r = −0.70, contribution = 15.8%). The second axis, which explained 24.5% of the total variance, was mainly represented by habitat characteristics. It presented positive loading for water level (r = 0.80, contribution = 43.7%) and negative for transparency (r = −0.89, contribution = 54.2%). The pH was moderately aligned with PC1 (r = 0.78) but had minimal contribution to PC2 ($\cos^2 = 0.003$), indicating independent variation from the physical habitat gradient.

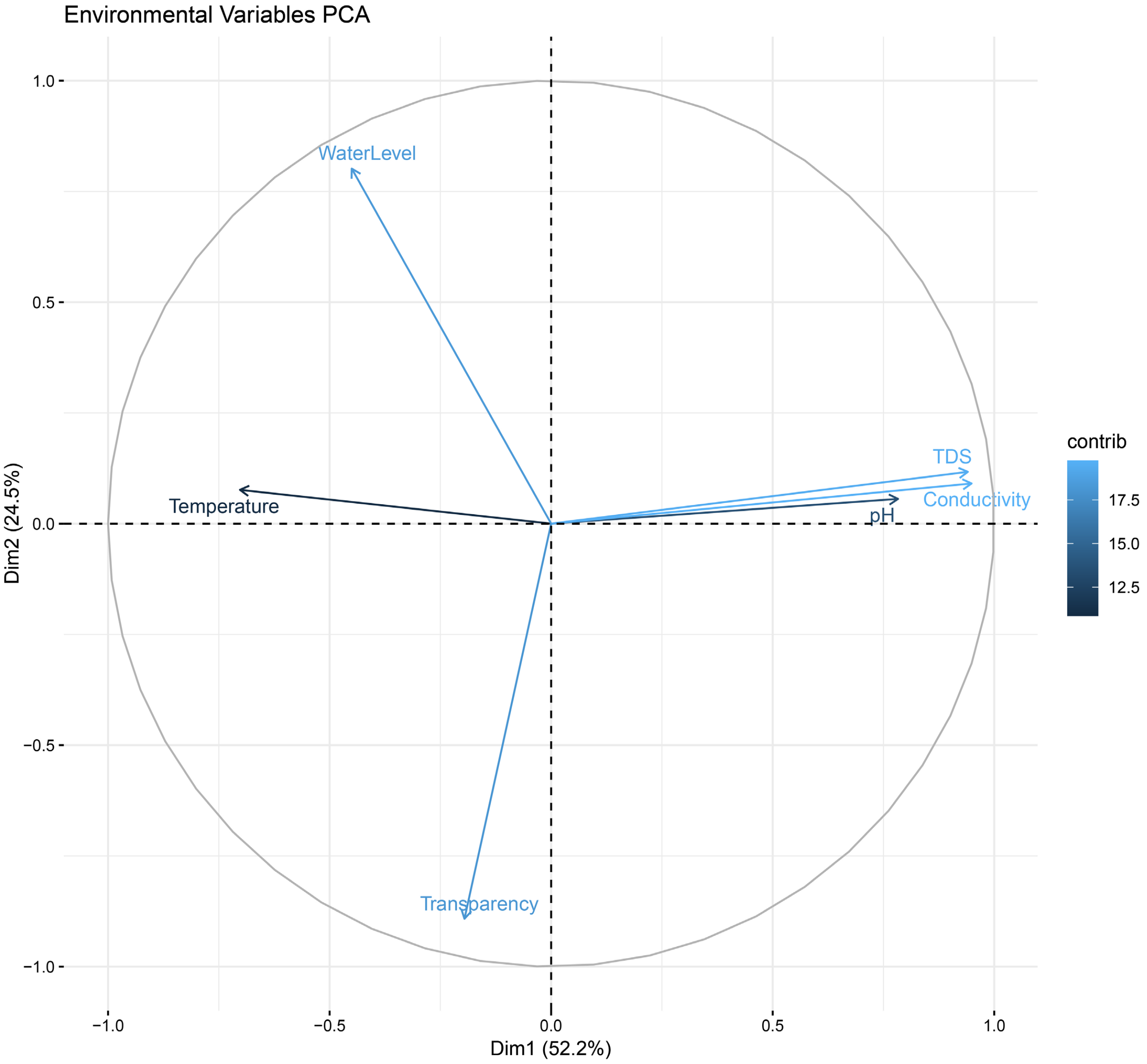

Figure 7. PCA biplot showing environmental vectors and sample scores.

The CCA analysis explained 22.3% of the total variance (constrained inertia = 0.190). The first three CCA axes captured 11.1%, 5.5%, and 2.4% of species variance, respectively. The most influential parameter was conductivity (F = 3.2, p =

0.002). It is followed by water level (F = 2.1, p = 0.028) and pH (F = 1.8, p = 0.048). The CCA triplot in Figure 8 presents a conductivity-driven distribution with Dytiscidae (r = 0.62) and Hydrophilidae (r = 0.58) showing positive associations with high conductivity/TDS conditions. The water level specialists, such as Nepidae and Belostomatidae, clustered at the opposite ends of the water level gradient (r = ±0.51); and pH-sensitive taxa, Corixidae (r = −0.49) and Chironomidae (r = 0.42), showed divergent responses to pH variation. The species-environment correlations were 0.89, 0.82, and 0.75 for CCA1-3, respectively, indicating strong multivariate relationships. Monte Carlo permutation tests confirmed a significant overall model fit (p = 0.001).

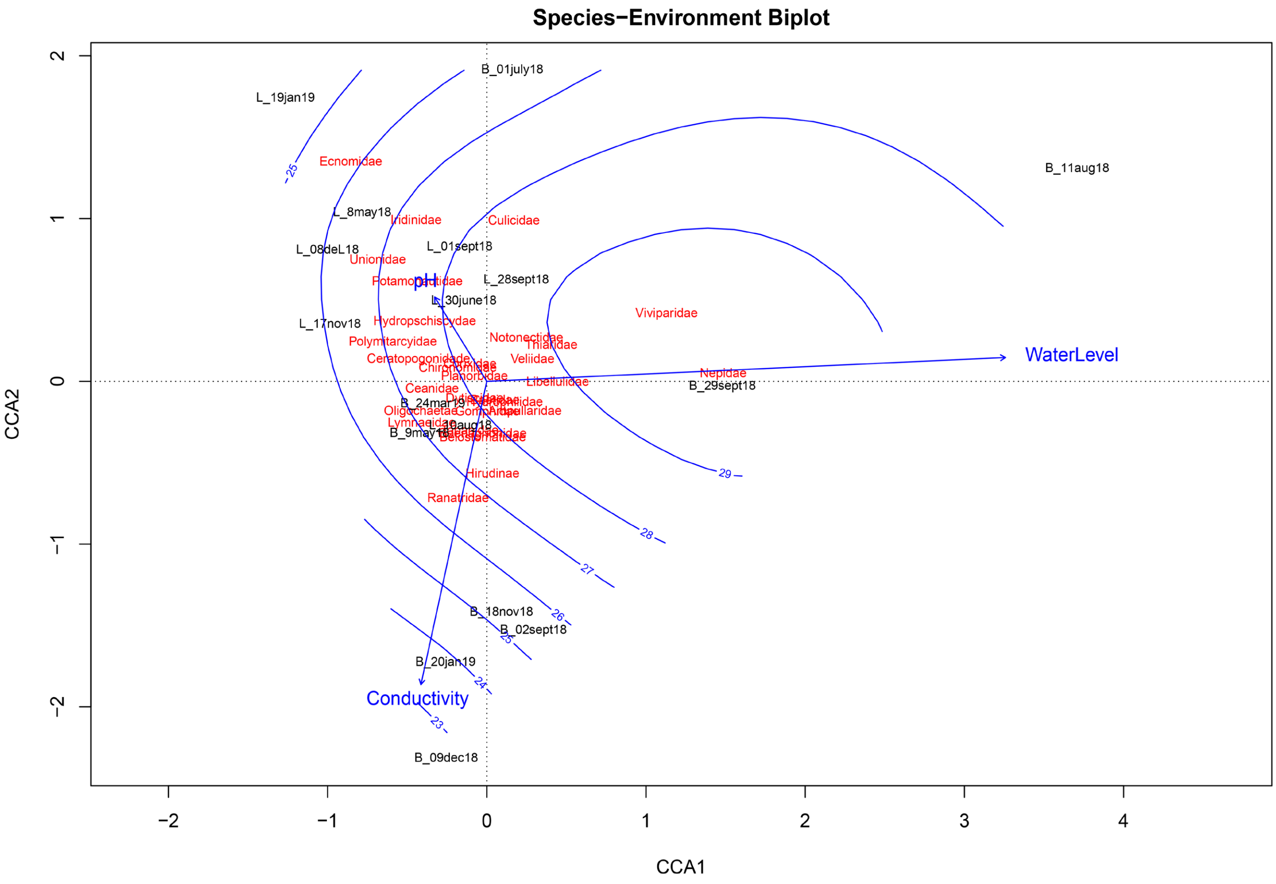

Figure 8. CCA triplot with species, sample periods, and environmental variables.

3.7. Dynamics of Sensitive Taxa

Sensitive taxa encountered at Bidida reservoirs are: Polymitarcydae, Hydropsychydae, Caenidae, and Baetidae. Their presence is noted from the month of October, when the rainfall quantity is decreasing and the aquatic environment is stabilizing. However, tolerant species such as Hirudinae and Chironomidae are more abundant in the month of May, coinciding with the end of the dry season and the beginning of the rainy season. In Ladwenda also, species sensitive to water quality were encountered. In addition to those encountered in Bidiga, we noted the presence of the Ecnomidae family. Unlike Bidiga, some of these sensitive taxa were encountered in all samples and well before the onset of the rainy season.

4. Discussion

The physico-chemical conditions of the study sites and their variability are similar to those reported for small reservoirs across Burkina Faso and West Africa [3] [4] [22] [23]. The 30 taxa of macroinvertebrate families recorded and distributed across three phyla—Arthropoda, Annelida, and Mollusca—and five classes (Insecta, Malacostraca, Clitellata, Gastropoda, and Bivalvia) are indicative of a relatively diverse benthic community in the studied reservoirs. This significant richness is consistent with reports in other reservoirs in Burkina Faso. For example, in newly impounded and older small reservoirs, 25 to 34 macroinvertebrate taxa are observed, dominated by insects and molluscs [5] [6].

The predominance of Insecta is characteristic of West African reservoirs and rivers, and this aligns with findings elsewhere in the region [5] [24]. This group generally dominates macroinvertebrate assemblages in tropical standing waters because of their adaptive traits, life cycle strategies, and broad tolerance spectrum [5] [6]. Other key contributors to West African macroinvertebrate diversity are molluscs and annelids. The overall abundance and diversity of these organisms reflect the diverse microhabitats and productivity often observed in tropical ecosystems [4] [6].

Oligochaetae were found only in Bidiga. They are known for their tolerance to organic enrichment and fine, soft sediments [5] [6]. Their absence in Ladwenda may indicate lower sediment organic matter, different substrate composition, or better oxygenation compared to Bidiga. The absence of Ecnomidae (Trichoptera), Gastropoda, and Bivalvia in Bidiga suggests that environmental conditions are not suitable for these groups. Gastropods and bivalves, for instance, require suitable substrates, stable water levels, and moderate levels of productivity [4]. Their absence might reflect lower calcium concentrations, more variable water levels, or greater disturbance—patterns echoed in studies across West African small water bodies, where mollusc abundance is closely tied to both water chemistry and habitat stability [4] [6].

In studies of other Burkina Faso reservoirs, differences in macroinvertebrate community composition between sites have been attributed to spatial variability in habitat complexity, water quality (e.g., conductivity, pH, transparency), local catchment land use, and seasonal hydrology [4]-[6]. For example, [5] observed that certain mollusks and annelids were present in some semi-aquatic habitats but absent from others, correlating these patterns with resource availability, predation pressure, and disturbance gradients.

Reservoirs with higher macroinvertebrate family richness and a balance of sensitive and tolerant groups tend to support healthier ecosystems and greater water purification potential [5] [24]. The presence or absence of certain indicator families (e.g., Oligochaetae as pollution-tolerant, some caddisflies as sensitive) can be a useful tool for rapid ecological assessment and may reflect recent environmental changes or anthropogenic pressures [6] [24]. At the regional scale, such findings reinforce the importance of catchment management and the regular monitoring of physical habitats and water quality in sustaining reservoir biodiversity in the face of increasing human and climatic pressures across West Africa [3] [4].

Seasonal and regional fluctuations in macroinvertebrate diversity are characteristic of small reservoirs and semi-arid water bodies in West Africa and around the world [4]-[6] [23]. In the Bidiga and Ladwenda reservoirs, species richness and the Shannon-Wiener index showed distinct seasonal maxima that coincided with or followed the rainy season. This is consistent with the traditional view that high water levels and post-rainfall intervals induce habitat heterogeneity, pollutant dilution, and an influx of organic matter—elements that facilitate the colonization, reproduction, and dispersal of more diverse macroinvertebrate assemblages [4] [5] [23] [25]. The J-equity index and Simpson's diversity index showed similar seasonality, with both indices reaching maximum values during the rainy season. High values for the equity and Simpson indices indicate that the community is richer and more balanced, rather than being dominated by a few stress-tolerant species [6] [24]. Low values at the beginning of the dry season or at the onset of rains correspond to periods of 'bottlenecks' characterized by reduced water volume, increased disturbance, and the dominance of a few very robust species [4] [5].

Macroinvertebrate abundance and composition in both reservoirs were highly dynamic. The dominance of Corixidae, followed by Notonectidae, Chironomidae, Baetidae, and Planorbidae, is indicative of sequential resource use and niche replacement, which are classic features of aquatic invertebrate succession in seasonally variable tropical waters [4] [23] [26]. The early and high Corixidae numbers likely reflect their opportunistic colonization in newly flooded, nutrient-enriched post-dry season waters—a pattern also seen in other West African and global reservoirs [5] [23]. The subsequent rise of predators such as Notonectidae and the later establishment of Planorbidae and further diversification as the season progressed align with successional models, where environmental stabilization (increasing water levels, declining disturbance) permits the establishment of less-tolerant taxa [4] [6] [23]. The persistent abundance of Chironomidae in both reservoirs—and especially during stress periods—confirms the genus's reputation as a resilient, generalist group able to withstand wide changes in oxygen, temperature, and organic content [27]. Baetidae surges followed by abrupt declines hint at windows of optimal water quality or flow, paralleled in other global studies where mayflies are sensitive to even brief lapses in water quality [24] [23]. Bidiga's bimodal Corixidae pattern, low Chironomidae, and the staggered resurgence of abundance toward the end of the season further demonstrate the interplay between hydrology, water quality, and biological adaptation [5] [25].

Analysis of temporal beta diversity (Bray-Curtis dissimilarity) quantifies the magnitude of community composition changes over time, revealing periods of disturbance and stabilization. The higher TBI values observed in the Ladwenda and Bidiga reservoirs during the rainy season transitions reflect substantial community turnover driven by new taxa entering as habitat diversity peaks and water quality improves [4] [6] [23]. These findings are mirrored in regional and international studies, which report that rainy season flooding in semi-arid zones causes sharp dissimilarity as new species colonize, migrants arrive, and habitat shifts disrupt resident assemblages [5] [6] [26]. Periods of low beta diversity (post-rainy season and lower dissimilarity in November-December) indicate community stabilization, mirroring the broader "flood pulse" ecological theory [4] [28].

The clear relationships between environmental gradients and taxonomic composition are strongly supported by the regional and global literature. Multivariate analyses (PCA, CCA) in this study showed conductivity, TDS, and water level as primary structuring forces, with further influences from pH and transparency—a conclusion repeatedly confirmed for tropical and subtropical lentic systems. For instance, in Burkina Faso, [4] and [5] found that ionic load (conductivity/TDS) and water level predict not only the presence of particular families but also their abundance dynamics. Dytiscidae and Hydrophilidae preference for high-conductivity conditions is well documented [4] [29], while Nepidae and Belostomatidae are known to partition sites along depth and water level axes, reflecting their different respiratory and microhabitat requirements [23] [30].

The role of pH in segregating Corixidae and Chironomidae echoes the findings of [24] and Odume *et al.* [27], who show that certain Hemiptera and Diptera have divergent tolerances to acidification and nutrient pulses. Strong species-environment correlations and permutation-test significance confirm that environmental heterogeneity is the main driver of temporal and spatial community structure in these reservoirs [4] [6] [23].

The appearance and disappearance of sensitive (EPT) and tolerant (Oligochaetes, Chironomidae) groups at different times underline the power of functional group analysis in biomonitoring. Sensitive mayflies (Baetidae, Caenidae), caddisflies (Hydropsychidae, Ecnomidae), and burrowing mayflies (Polymitarcyidae) are internationally accepted as indicators of high-quality, stable aquatic habitats [23] [24] [31]. Their absence during the dry season or early rains, and increased appearance post-flood when physical and chemical stability improve, echoes studies from Burkina Faso, Ghana, Zimbabwe, and elsewhere [5] [6] [23].

More consistent detection of sensitive taxa in Ladwenda, including Ecnomidae, suggests sustained or less disturbed ecological quality year-round compared to Bidiga—a pattern often attributed to smaller, less disturbed catchments, reduced pollutant input, or managed water abstraction [4] [6]. High abundances of tolerant groups coinciding with stressful, low-water, or early flood periods are a global feature of lentic macroinvertebrate succession in systems affected by hydrological variation and anthropogenic impacts [4] [27].

This study was limited to two reservoirs and covered a single annual cycle. The interannual variability in the hydrology, water chemistry, and biological dynamics could not be well assessed. While these constraints reduce the extent to which the findings can be generalised, the results nonetheless provide valuable baseline information on the diversity and dynamics of macroinvertebrate communities in West African small reservoirs. They also highlight the importance of continued multi-year and multi-site monitoring to strengthen ecological assessments in the region.

5. Conclusion

This study shows that the diversity and dynamics of benthic macroinvertebrate assemblages in studied reservoirs are closely governed by seasonal environmental variation—especially hydrological regime, water chemistry, and physical habitat structure. High diversity, evenness, and the occurrence of sensitive taxa are linked to the rainy season and post-flood stabilization. Dry seasons and transitional periods favor more homogeneous and tolerant communities. Rapid ecological renewal, following environmental disturbances and recovery, is highlighted by substantial temporal beta diversity. Environmental gradients, particularly conductivity, TDS, water level, and pH, significantly shape community composition, as validated by robust multivariate analyses. The appearance and persistence of sensitive taxa can serve as effective indicators of ecosystem health and water quality.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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