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Supporting of biodiversity in Sahelian arid areas: Case of artificial lakes and macroinvertebrates

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Abstract

Protecting biodiversity is one of the challenges for achieving sustainable development. This protection requires a good knowledge of species richness and their habitats. It is why this study was conducted. It aimed to assess the diversity of macroinvertebrates in five artificial waterbodies, in order to determine their role in conserving biodiversity. To do so, macroinvertebrates were collected following multi-habitat sampling method using a standard AQEM/STAR net sampler, 25 cm × 25 cm, 500 µm mesh. The samples were fixed with alcohol (90%) and transported to the laboratory. Once in the laboratory, the organisms were carefully sorted and identified under a binocular microscope using an identification keys. The results showed that artificial ecosystems host a high diversity of macroinvertebrates. A total of 1633 macroinvertebrate specimens were collected, divided into 32 families, 9 orders, 5 classes and 3 phyla. Arthropods were the most abundant and diverse. The highest diversity (22 taxa) was reported in Talanga and Naguio reservoirs, followed by reservoirs of Ziga and Kozougou with 21 taxa, and Naguio had the lowest diversity (18 taxa). In these reservoirs, 72% of constant taxa and 28% of rare taxa were recorded. Artificials waterbodies are the main storage waters in Burkina Faso, and contribute significantly to the conservation of biodiversity, and supporting local population activities and development. Their suitable management is therefore essential for the preservation of rural socio-economic development and biodiversity conservation.

Keywords: Reservoir; Biodiversity; Hotspot; Macroinvertebrates; Sahelian area

1. Introduction

Freshwater, also called "blue gold", is an essential natural resource for all life, especially for aquatic organisms and human beings. However, surface waters are unevenly distributed, and its availability and accessibility are major challenges for populations living in Sahelian areas. In West Africa, landlocked countries, such as Burkina Faso located in the heart of West Africa has to face to chronic water shortage and drought. To do so, several reservoirs were built to meet urgent water demands. Therefore, these reservoirs constitute the main water storages, and are crucial for local populations activities development. They provide several services and goods to local populations, including water supply, fishing, agriculture, energy, recreation and education. These new artificial aquatic ecosystems constitute the refuges for many organisms including fauna and flora. Macroinvertebrates are composed of Arthropods, Annelids and Molluscs, are often amongst the first animals to colonize artificial lakes to reproduce. Many studies have shown that the majority of macroinvertebrates in natural aquatic ecosystems are one of the most diverse groups [1], [2], [3] and [4]. However, the studies on the benthic fauna in artificial lakes in Sahel region remains fragmentary, despite their important role in maintaining the balance of biota in aquatic ecosystems [5]. Indeed, macroinvertebrates constitute the base of food webs for the establishment of new organisms at higher trophic levels. Thus, these artificial waterbodies are also

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populated by several species of fish, amphibians and aquatic birds. Many studies have shown that aquatic biota, and particularly the macroinvertebrates are key animals in water because they are mostly influenced by several factors such as ecosystem types, waters variables and multiple anthropogenic pressures [4], [6], [7], [8], [9], [10] and [11]. These men-made lakes provide several advantages but they rarely documented. Therefore, promoting goods and services providing by these reservoirs, and leading the studies on wildlife communities living in these environments are crucial for suitable management of water, this is why we undertook this study with aimed to evaluate the biodiversity of artificial lakes in the areas arid Sahelian regions.

2. Material and methods

2.1. Study area

This study was undertaken in five artificial waterbodies (Figure 1). The Ziga reservoir, one of the important reservoirs of Burkina Faso, located northeast of the capital, Ouagadougou (0 °49'23,43'' W et 12°37'03, 22''). It provides mainly drinking water supply to the capital Ouagadougou and serves as fishing area and irrigated crops farming. The reservoirs of Naguio (11º07'39.1''N, 01º35'04'8''W), Talanga (11º08'23.0N, 01º30'22.5''W), Kozougou (11º09'29, 7'N', 01º31'46.3'W) and Bodjero (11º05'51.6''N, 001º30'28.9''W) are located in the Nazinga Game Ranch, a protected area, located in southern of Burkina Faso between latitudes (11º 03' 04''N, 11º 12' 47''N) and longitudes (01º 23' 25''W, 01º 43'00''W) bordering with neighbor country of Ghana. Fishing is the main anthropogenic activity practiced in these reservoirs. All these different waterbodies play a crucial role in biodiversity conservation.

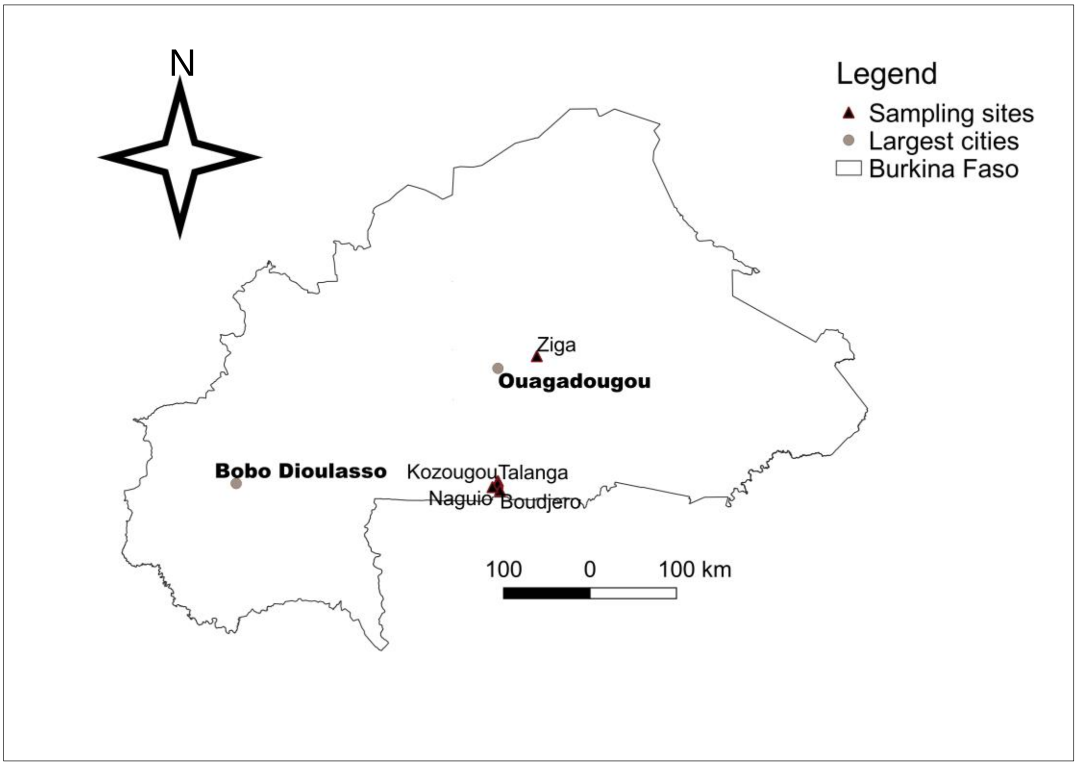

Figure 1 Map of Burkina Faso showing the study sites

2.2. Macroinvertebrates data collection

To determine the taxonomic composition and diversity in the study area, the macroinvertebrates were collected following the adapted multi-habitat sampling method [12], described in [4]. To do so, macroinvertebrates were sampled using a standard AQEM/STAR net sampler, 25 cm × 25 cm, 500 µm mesh. During this campaign, five reservoirs: Ziga, Talanga, Koudougou, Bodjero and Naguio were visited to sample macroinvertebrates. The habitats sampled include rocks, macrophytes and fine sediments. To have a quantitative and qualitative sample, a total of 20 sample units were taken in each site, corresponding to a total area of 1.25 m^2. The benthic macroinvertebrates were dislodged manually, and captured using the net. Macrophytes and all debris (roots, wood and dead leaves), as well as, fine sediments are shaken to search and capture all organisms. The surfaces of rocky habitats are brushed and stones are moved to capture any organisms hidden underneath. After sampling, the contents of the net are transferred to a bucket, then large debris such as coarse sediment and leaves are carefully inspected and then removed from the sample. Samples are fixed in alcohol (90%), and labeled (date and site name'), and then transported to the laboratory for detailed analyzes. Once in the laboratory, each sample was rinsed with tap water under sieves. The contents of the sieve are transferred in tray with a white background, and the organisms are sorted with the naked eye and under a binocular microscope. For each sample, once macroinvertebrates are sorted, they are preserved in ethanol (70%) for identification. The purpose of identification is to determine the taxonomic group of each specimen. Macroinvertebrates are identified at the family taxonomic level using manuals and taxonomic keys: [2], [13] for Arthropods and Annelids and [14] for Molluscs, and then counted.

2.3. Data Analyses

Taxonomic richness, relative abundance, Shannon-Wiener diversity index (H') and Equitability index were estimated to assess invertebrate communities structure in each site. Relative abundance is the percentage of a particular taxon in the total number of all taxa. The Shannon-Wiener diversity index (H') [15] and Equitability [16] are commonly used because they provide information on the composition and regularity of the community. They were calculated using formulas (1) and (2), respectively.

$$H' = -\Sigma\,((\mathrm{Ni}\,/\,\mathrm{N})\ \mathrm{x}\ \ln\left(\frac{\mathrm{Ni}}{\mathrm{N}}\right)\ (1)$$

Where Ni: number of individuals of a given taxon and N: total number of individuals.

$$E = \mathrm{H}'/\,\mathrm{H\,max} = \mathrm{H}'\,/\,\mathrm{Log2\ S}\ (2)$$

Where S: number of species observed.

The occurrence determine the habitat preference by an organism. The frequency of occurrence (FO) is the quotient of the number of samples in which an organism i was found by the total number of samples [17]. It is calculated according to formula (3) where Pi is the number of samples containing family I and Pt is the total number of samples collected. Three groups can be distinguished based on the occurrence value: constant taxa (FO ≥ 50%); incidental taxa (25% ≤ FO < 50%) and rare taxa (FO < 25%).

$$\mathbf{FO} = (\mathbf{Pi}\ *\ \mathbf{100})/\mathbf{Pt}\ \textit{(3)}$$

Finally, the Venn diagram was used to assess the similarity of macroinvertebrates community' in the sites.

3. Results

3.1. Global composition of macroinvertebrates

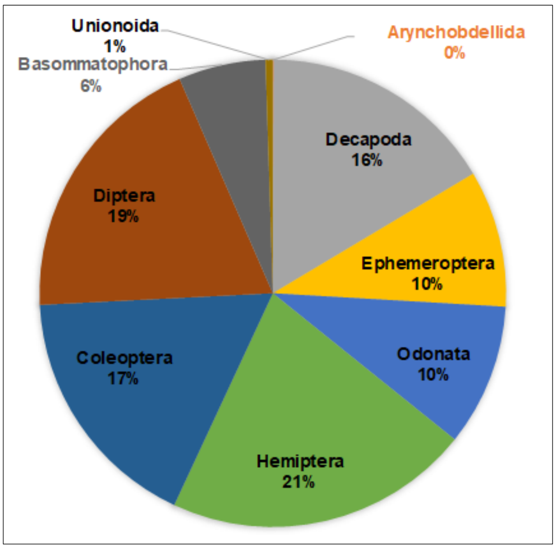

Figure 2 Relative abundance of macroinvertebrate reported in this study

A total of 1633 specimens were collected in the five artificial sampled sites. All these individuals belong to 32 families, 9 orders, 5 classes and 3 phyla. The results showed that macroinvertebrates community' is dominated by Insects (>70% of the total abundance), followed by Crustaceans (16%), Molluscs (8%) and Clitellates (less than 0.06%). Insects are well diversified (5 orders), dominated by Hemiptera, (27.5%), followed by Diptera (25%), Coleoptera (22.4%), Odonata (12.78%) and Ephemeroptera (12.29%). Crustaceans are represented by one order of Decapoda. Among Molluscs, Gastropods are represented by two orders, dominated by Basommatophora (73%), Architaenioglossa (21%), and one Order 'Unionoida' (6%) of Bivalvia is reported.

3.2. Taxa' composition

Figure 3 shows that the majority of taxa (50%) have a relative abundance less than 1%, and 32% of taxa have a relative abundance between 1 and 5%. Three taxa of (Dytiscidae, Paleamonidae and Chironomidae) with a relative abundance greater than 10% were recorded.

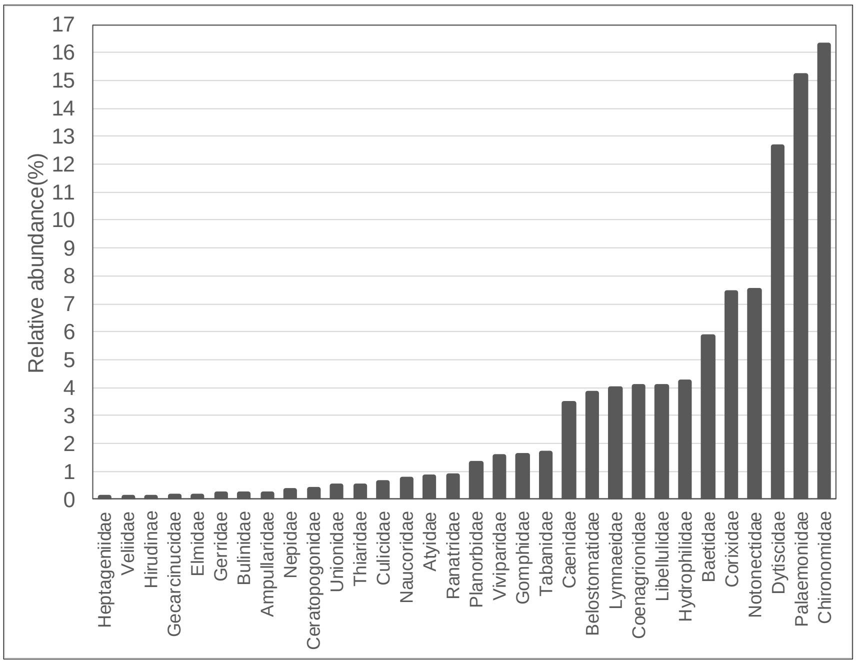

Figure 3 Relative abundance of taxa encountered during this study

3.3. Taxa occurrence

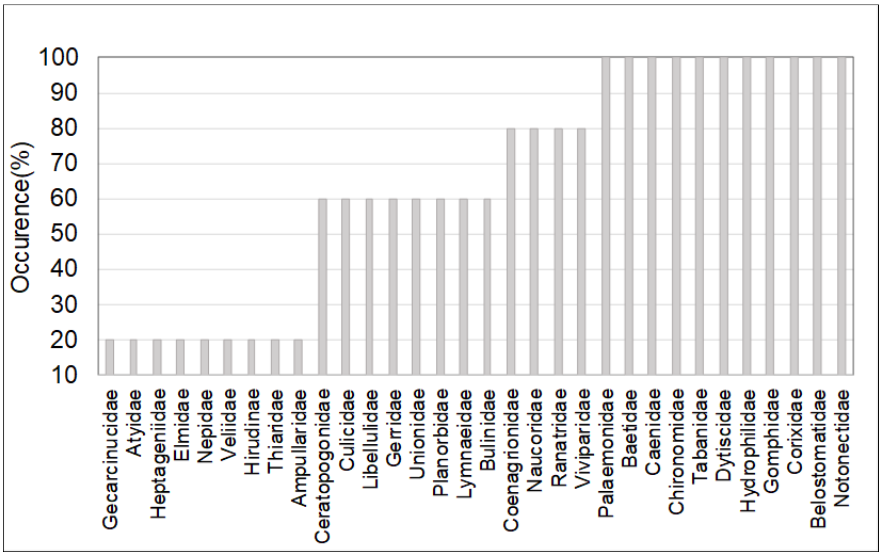

Figure 4 Occurrence of macroinvertebrates taxa recorded

In terms of occurrence, 4 groups can be distinguished (Figure 4). The first group made up of 9 taxa with an occurrence of 20%, the second made up of 8 taxa with an occurrence of 60%, the third group made up of 4 taxa with an occurrence of 80%, and the fourth group includes more than 13 taxa with an occurrence of 100%. In overall, 28% of taxa encountered are rare.

3.4. Diversity of macroinvertebrates in the study sites

Table 1 shows the taxonomic diversity in the sites. The highest diversity (22 taxa) was recorded in Talanga and Naguio, followed by Ziga and Kozougou with 21 taxa, and the lowest diversity was observed in Naguio (18 taxa). In all sites, the Shannon diversity and Piélou equitability indices are greater than 2 and 0.7, respectively, revealing that the macroinvertebrates community are diverse and stable in all sites.

Table 1 Site biodiversity recorded during this study

	Ziga	Talanga	Kozougou	Bodjero	Naguio
Taxonomic richness	21	22	21	18	22
Shannon-Wiener index	2.25	2.61	2.63	2.53	2.36
Equitability index	0.74	0.84	0.86	0.87	0.76

3.5. Similarity of benthic fauna in sampling sites

Figure 5 shows that only 11 taxa (34%) occur in all sites, reflecting the particularity of each artificial waterbody in term of habitat type and fauna. The Ziga reservoir harbors more specific taxa (06) including Gecarcinucidae, Atyidae, Elmidae, Nepidae, Hirudinae and Ampullaridae, followed by Talanga with 2 specific taxa (Veliidae and Thiaridae) and Bodjero with 1 specific taxon (Heptageniidae).

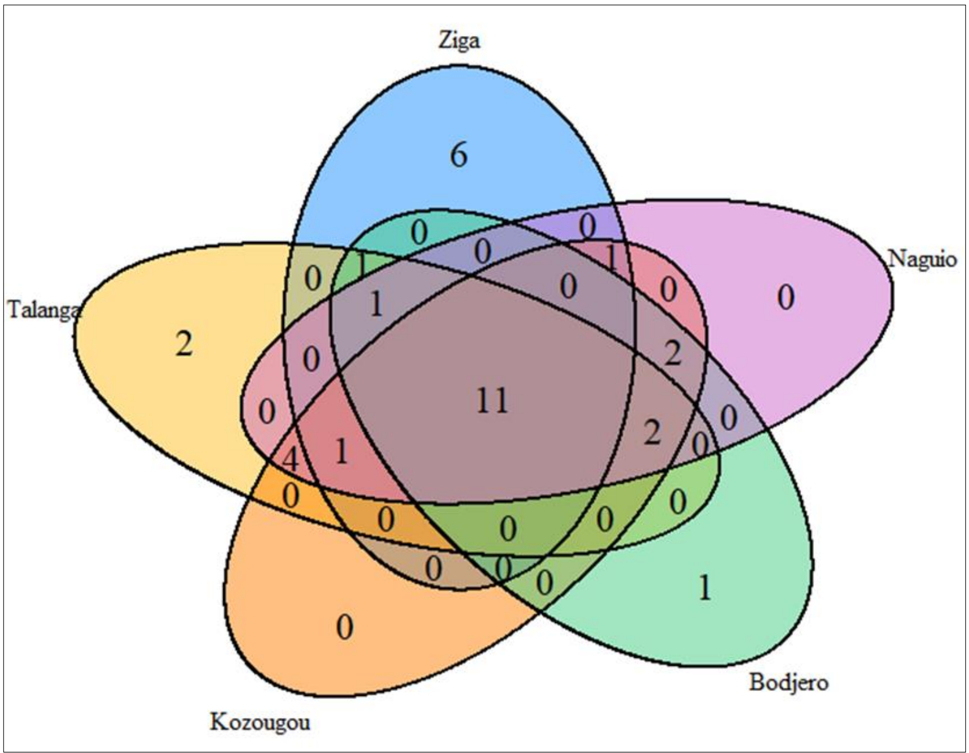

Figure 1 Similarity of macroinvertebrates taxa in the sites

4. Discussion

The results showed that the reservoirs sampled during this study host a high diversity of macroinvertebrates, reflecting their importance in preserving aquatic organisms. The macroinvertebrates encountered in the present study are composed of insects, crustaceans, molluscs and annelids. The taxonomic composition in these artificial ecosystems is similar to those of the natural ecosystems in Sahelian tropical zones [2], [4] and [18]. This shows that artificial aquatic ecosystems can be suitable for wildlife because they provide habitats and foods for these organisms [19]. Insects constitute the most abundant and divers groups in all sites. These results lie in the same line to those of [4], [6], [7], [8], [9], [10], [18] and [20] who have demonstrated that insects are the most abundant and diverse group in tropical aquatic ecosystems. This can be explained by the fact that insects are resistant groups, and can adapt to different habitat conditions, even those of man-made, as demonstrated by authors [4]. The high occurrence of taxa obtained in this study confirms the high capacity of macroinvertebrates to survive in Sahelian dryland areas such as Burkina Faso. According to [9], these ecosystems provide habitats for most constant taxa, such as Ephemeroptera (Baetidae, Caenidae), Diptera (Chironomidae), Odonata (Coenagrionidae, Gomphidae), Hemiptera (Corixidae, Notonectidae, Belostomatidae), Coleoptera (Dytiscidae, Naucoridae). A high proposition (28%) of rare taxa found here reveal that macroinvertebrates are perfectly adapted to these artificial aquatic ecosystems. Due to the fact that most natural waters dry out during the dry season, the new waterbodies are colonized by several faunistic organisms including macroinvertebrates, which find shelters to reproduce, and that may increase the biomass of these new ecosystems.

The high diversity of macroinvertebrates found here, reflect the good ecological status and the capacity of these ecosystems to maintain biodiversity. Indeed, macroinvertebrates are an important link in the trophic chain, and contribute to the supporting other aquatic faunistic groups such as fish, birds and amphibians which feed on them. Most of Burkina Faso's reservoirs are the main water storages, and some never dry out over the year. They are essential for human activities and biodiversity conservation, but, the construction of these reservoirs does not promote the continuity of watercourses for aquatic organisms' migration, particularly fish. Indeed, the absence of "fish passes" and high dikes buildings constitute a big obstacle for fish reproduction, and can decrease fish biomass in these artificial water bodies. Indeed, during fish reproduction period, they migrate in the upstream to seek a suitable spawning ground, but the lack of fish passes may prevent their migration, and can limit their reproduction. Therefore, for good sustainability of artificial waterbodies services and goods in dryland areas, it is essential to promote suitable fish passes construction, and this may increase fish diversity and the establishment of useful fauna for the happiness of local populations.

5. Conclusion

The reservoirs host a high diversity of macroinvertebrates composed mainly of Arthropods, followed by molluscs and Annelids. These ecosystems, although artificial, offer habitats and food for macroinvertebrates and others fauna. As a result, they contribute to the preservation of aquatic fauna. it is essential to protect these artificial ecosystems, which support anthropogenic activities and biodiversity. But, building new ecosystem waterbody must integrated fish passes for long term sustainability of fisheries and local economy development. Thus, a good cooperation between all stakeholders including hydrologist, hydrobiologists, politicians and any experts has to be explored before and after reservoirs construction.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declared no conflict of interest.

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