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REVIEW ARTICLE

COMPOSITION AND VARIATION IN ZOOPLANKTON DENSITY IN FISH AND RICE-FISH FARMING IN A LOWLAND AT BÉDIALA (CÔTE D'IVOIRE)

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ABSTRACT

Freshwater zooplankton are recognised as an important source of food for fish. The aim of this study was to compare the diversity of zooplankton populations in conventional and rice-fish culture ponds. Sampling campaigns will take place from June 2019 to May 2020 in a lowland in Bédiala. Zooplankton were sampled in the ponds by filtering 100 litres of water using a 64 µm mesh plankton net. Two ponds were used for fish farming and two others were used to simultaneously grow rice and fish. The results obtained show that the specific richness of the zooplankton population of all the ponds is 25 taxa. This population is divided between three permanent zooplankton groups. These are Rotifera (16 taxa), Copepoda (4 taxa) and Cladocera (3 taxa). Taxonomic richness and zooplankton density were significantly higher in rice-fish culture ponds than in fish culture ponds. These are more pronounced during the rainy season in rice-fish culture ponds. Rice-fish culture ponds are thus richer in food resources for fish than fish culture ponds.

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INTRODUCTION

In the aquatic environment, zooplankton play a central role in the trophic chain. They belong to the intermediate trophic level as the main consumers of phytoplankton. They are also a source of food for higher trophic level organisms such as fish. Over 60% of primary production in lakes is transferred by zooplankton to fish fry (Haberman, 1998; Brassard, 2009). As a result, fish reproductive success is not just dependent on the physical conditions of the environment, it is also dependent on biological factors. In addition, studies by Kamagaté *et al.* (2020) showed that the growth performance of *Oreochromis niloticus* and *Heterotis niloticus* is better in rice-fish culture ponds than in conventional fish culture ponds, even though the fish receive no external input. Fish performance is governed not only by their genetic potential but also by their immediate environmental conditions (Pickering, 1993). The differences observed between the gains in body mass of fish in fish farming and rice-fish farming environments are thought to be due to the richness of the 'rice-fish' ecosystem in zooplankton. The aim of this study was to verify this hypothesis. It aims to compare the composition and variation of the zooplankton population in ponds used for conventional fish farming with those used for rice-fish farming.

MATERIALS AND METHODS

Study area: The study was carried out in the Bédiala sub-prefecture in the upper Sassandra region. The ponds used to study the zooplankton population are located between latitude 7°07'-7°08' N and longitude 6°17'-6°18' W (Figure 1). Samples were taken from four dam ponds, each measuring 5 000 m^2, including two dam ponds for fish farming and two dam ponds for the simultaneous cultivation of rice and fish. The depth of the selected ponds varied from 20 cm at the water inlet to 125 cm at the water outlet. The ponds were fed by groundwater located upstream of the ponds.

Sampling of zooplankton: Plankton was collected using a 10-litre bucket and a plankton net with a mesh size of 64 µm. Zooplankton organisms were collected in the dry and rainy seasons by filtering 100 litres of water using a 64 µm mesh plankton net. Four samples were taken during each season. Samples were taken in the afternoon between 3pm and 4pm. The filtrate retained in the collector was collected in 30 cl pillboxes marked with the date, time of sampling and pond reference. In each sample, 2 mg of sucrose and 2 ml of liquid soap were added to limit deformation, splitting and suspension of the zooplankton organisms.

In addition, neutral red was added to the sample for zooplankton staining to facilitate observations with a binocular magnifying glass (Haney and Hall, 1973; Culver *et al*., 1985) and a light microscope. The samples were preserved with formaldehyde at a final concentration of 5%.

Sorting, identification and counting of zooplankton organisms: In the laboratory, the samples were reduced to a volume of 50 ml in a graduated cylinder. They were then homogenised by successive decanting into beakers. A 5 ml subsample was taken with a pipette. The entire sub-sample (5 ml) contained in the pipette was observed under a light microscope. The organisms observed were systematically identified using the keys of Dussart (1980), Rey et Saint Jean (1980), Pourriot (1980) and Amoros (1984) and then counted.

Study of the zooplankton population: Density was used to determine the composition and structure of the zooplankton population in the fish and rice ponds.

Stocking density: The stocking density (D) is obtained by the following expression:

$$D\ (\mathrm{ind/L}) = \frac{\mathrm{n}}{\mathrm{V1}} \times \frac{V2}{V3}$$

n: being the number of individuals counted in the 5 ml sub-sample, V1: the volume of water in the sub-sample (5 ml), V2: the concentrated volume (50 ml) and V3: the volume of water filtered in the field (100 L)

Statistical analysis: The t-test was performed after transformation and verification of the normality of the data. It was used to compare the zooplankton abundance of fishponds and rice-fishponds. All these analyses were carried out using PAST 4.16 software. Differences are considered significant at *p-value*< 0.05.

RESULTS

Composition of the population: The composition of the zooplankton communities collected in fishponds and rice-fishponds is shown in Table 1. The population is composed of 25 zooplankton taxa, including 16 Rotifers (64% of the total population), 4 Copepods (16%) and 3 Cladocerans (12%). Other zooplanktonic organisms represented by Ostracods and Worms account for 8% of the population.Taxonomic diversity in rice-fish culture ponds (dry season = 19 and rainy season =18) was higher than in fish culture ponds (dry season = 13 and rainy season =15), both in the dry and rainy seasons (t-test, *p-value* < 0.05). It should be noted that we were unable to observe any cladocerans in the fish farm ponds. The 3 cladoceran taxa presented in Table 1 were all observed in rice-fish culture ponds**.**

Spatial and seasonal variations in density: Figure 2 shows that total zooplankton density is significantly greater in rice-fish culture ponds (233 ind/L) than in fish culture ponds (58 ind/L) (t-test, *p-value* < 0.05). The same result was observed for the major groups. Copepods and Rotifers had significantly higher densities in rice-fish culture ponds (Copepods=77 ind/L and Rotifers=132 ind/L) than in fish culture ponds (Copepods=21 ind/L and Rotifers=36 ind/L) (t-test, *p-value*< 0.05).

Table 1. Composition of the zooplankton population in fish and rice ponds at Bédiala (Côte d'Ivoire)

TAXA	FF-DS	FF-RS	RF-DS	RF-RS
COPEPODS				
Mesocyclops sp		+	+	+
Thermocyclops sp	+	+	+	+
copépodites	+	+	+	+
nauplii de copépodes	+	+	+	+
CLADOCERANS				
Diaphanosoma exisum			+	
Moina micrura			+	
Ceriodaphnia cornuta			+	+
ROTIFERS				
Ascomorpha sp				+
Keratella sp	+	+	+	
Keratella tropica	+		+	
Brachionus falcatus	+	+	+	+
Brachionus angularis	+	+	+	+
Brachionus quadridentatus	+	+	+	+
Brachionus calyciflorus	+			
Trichocerca similis	+	+	+	+
Trichocerca rousseleti	+	+	+	+
Hexarthras sp				+
Polyarthra sp	+	+	+	+
Filinia terminalis	+	+		+
Filinia opoliensis			+	+
Lecane ungulata		+		+
Lecane luna		+		+
Lecane bulla			+	
OTHERS				
Ostracods		+	+	+
Flatworms			+	
25	**13**	**15**	**19**	**18**

(+) : taxon present ; FF-DS : dry season fishpond;FF-RS : rainy season fishpond; RF-DS : dry season rice-fishpond ; RF-RS : rainy season rice-fishpond

In both types of pond, the density of Rotifers (rice-fish culture =132 ind/L and fish culture =36 ind/L) was higher than that of Copepods (rice-fish culture =77 ind/L and fish culture =21 ind/L). In the rice-fish ponds, Cladocerans are the least dense permanent zooplankton. No cladocerans were observed in the fish ponds. Seasonally, the maximum density (273 ind/L) was obtained in the rainy season, in the rice-fish culture ponds. The minimum density (51 ind/L) was recorded in the rainy season in fish farming ponds. In both dry and wet seasons, zooplankton density in rice-fish culture ponds was significantly higher than in fish culture ponds (t-test, *p-value*<0.05) (Figure 3).

In rice-fish culture ponds, zooplankton density was significantly higher in the wet season (273 ind/L) than in the dry season (191 ind/L) (t-test, *p-value*< 0.05). Copepod density was significantly higher in the dry season (104 ind/L) than in the wet season (50 ind/L) (t-test, *p-value* < 0.05). For rotifers, the density was significantly greater in the rainy season (207 ind/L) than in the dry season (56 ind/L) (t-test, *p-value*< 0.05). For cladocerans, the density in the dry season (21 ind/L) is greater than that in the rainy season (11 ind/L). In fish farm ponds, zooplankton density was higher in the dry season (64 ind/L) than in the rainy season (51 ind/L), although the difference between the two densities was not significant (t-test, *p-value*> 0.05). While copepod density was higher in the wet season (25 ind/L) than in the dry season (17 ind/L), rotifer density was higher in the dry season (47 ind/L) than in the wet season (25 ind/L). The difference in densities between the two seasons was significant for rotifers (t-test, *p-value*< 0.05), but not for copepods (t-test, *p-value*> 0.05).

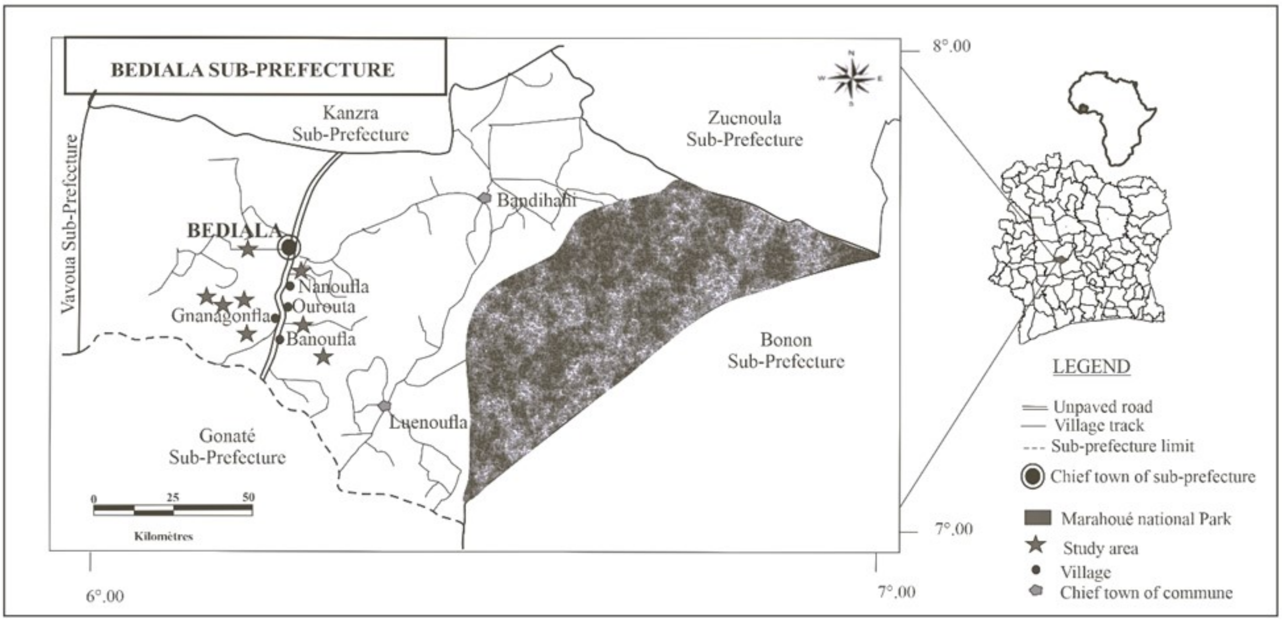


Figure 1. Presentation of the study area (Source: NCRSGI2016)

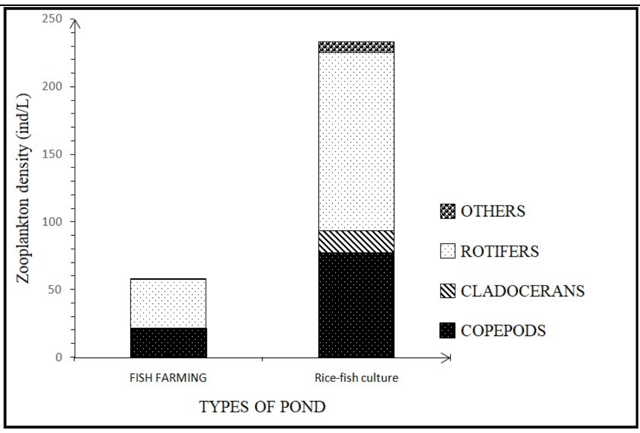
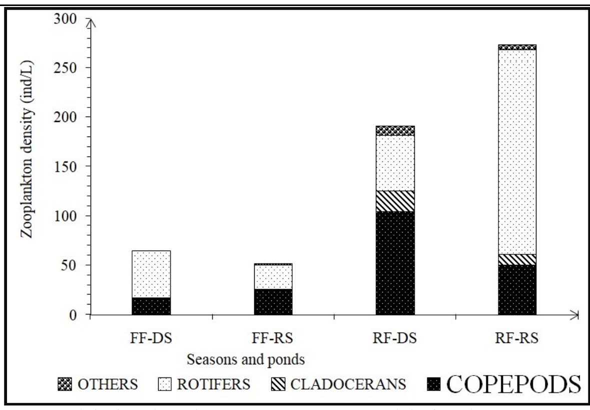


Figure 2. Variation in zooplankton density in fishponds and lowland rice-fishponds between June 2019 and May 2020 (Bédiala, Côte d'Ivoire)



FF-DS : Fish farming dry season; FF- RS : Fish farming run season; RF-DS : Rice farming culture dry season ; RF-RS Rice farming culture run season

Figure 3. Seasonal variations in zooplankton density in fishponds and lowland rice-fishponds between June 2019 and May 2020 (Bédiala, Côte d'Ivoire)

DISCUSSION

The number of taxa (25) identified during this study is relatively lower than those recorded in lowland waters in Gagnoa (Côte d'Ivoire) (31 taxa) by Yté *et al*. (2009) and in Benin in traditional aquaculture ponds in the Delta River (30 taxa) by Elegbe *et al*. (2016). This variation in taxonomic richness could be explained by the lack of exogenous input to the ponds. According to Gneba (2021), ponds that received an exogenous feed (by-products, maize bran, rice bran) recorded the highest numbers of taxa compared with ponds with no external feed. In addition, more than 80% of the total taxa identified were collected in rice-fish ponds. This diversity could be linked to the presence of rice plants, which favours an increase in primary production. Primary production is a source of food for zooplankton. Consequently, the accumulation of nutrients would lead to a proliferation of zooplanktonic organisms (Onana *et al*., 2014). In the same vein, De Azevedo and Bonecker (2003) assert that a large diet stimulated by high primary production increases the fertility and recruitment rate of zooplankton.

Analysis of the different densities showed that in fish farming, this parameter is higher in the dry season than in the rainy season. Conversely, in rice-fish culture, zooplankton density is higher in the rainy season than in the dry season. The high density in the dry season could be explained by the low turbulence of the fishponds due to the low inflow of run-off water (Dufour *et al*.,1994). According to Amblard and Pinel-Alloul (1995), the increase in zooplankton density during the dry and warm seasons could be justified by the fact that temperature conditions the metabolism, feeding activity and development and reproduction cycle of zooplankton. Furthermore, Rosa and Bonecker (2003) showed that the dilution effect is a factor responsible for the low density of zooplankton (Rotifers in particular) in the rainy season. The opposite phenomenon observed in rice-fish ponds is thought to be due to the presence of rice and the supply of water and nutrients during the rainy season (Soro *et al*.,2019). Since zooplankton are organisms that cannot swim, they will be held back by the rice plants in these ponds. In addition to spatial density, the taxonomic composition of zooplankton is dominated by Rotifers (64%).

The high diversity of this group could be linked to turbulence, nutrient inputs (Soro *et al*. 2019) and the nature of the hydrosystem. In tropical regions, lake ecosystems display a high diversity of Rotifers. These same observations have been made by several authors (Kâ *et al*., 2006 ; Ouéda *et al*., 2007 ; Aka *et al*., 2011). In addition, Mwebaza-Ndawula *et al*. (2005) point out that the qualitative dominance of Rotifera is characteristic of tropical environments.

CONCLUSION

This study has enabled us to show that rice-fish culture ponds are systems that enhance the nutritional quality and quantity of food naturally available to fish. Zooplankton density is higher in rice-fish culture than in fish farming. Rice-fish culture environments are therefore richer in food resources than fish culture environments. With a view to contributing to food security by improving the incomes of farmers in rural and peri-urban areas, rice-fish farming should be recommended as it is a low-cost fish production system, with no major dependence on inputs.

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