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RESEARCH ARTICLE

STRUCTURE AND DIVERSITY OF ZOOPLANKTON COMMUNITY IN TAABO RESERVOIR (CÔTE D'IVOIRE)

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Abstract

Zooplankton play a substantial role in the ecology of aquatic ecosystems and are usually used as bioindicators to assess their health. This study aims to assess the structure and diversity of Zooplankton community in Taabo reservoir. Zooplankton were sampled at five sites along a transect of seven kilometers every 45 days from November 2017 to October 2018 using a net of 20 µm mesh size. A total of 77 taxa belonging to four groups (59 rotifera, ten cladocera, five copepoda and three other zooplankton). High diversity of zooplankton (more than 87 %) was reported in the littoral areas (S1 and S5). The proportion of very frequent taxa are the most numerous at all the sampling sites, and Sorensen similarity indexes between these sites are higher than 80%. Zooplankton abundance was higher during the dry season at all sites. Zooplankton community of Taabo reservoir was qualitatively (76.6 % of the taxonomic richness) and quantitatively (more than 68.35 % of the relative abundance) dominated by rotifers group. Shannon-Weaver diversity and Pielou Evenness indices were lower in long rainy season than the other seasons. The RDA analysis shows that the abundances of zooplankton taxa such as *Mesocyclops* sp., *Thermocyclops* sp., *Ceriodaphnia cornulata* and *Diaphanosoma excisum* were positively affected by conductivity, water depth, pH, TP, and TN. However, water transparency and temperature had positively influenced the abundances of zooplankton taxa such as *Anuraeopsis fissa*, *Brachionus angularis*, *Brachionus caudatus*, *Brachionus falcatus*, *Keratella Lenzi*, *Keratella tropica*, *Hexathra intermediaire*, *Epiphanes macrourus*, *Filinia opoliensis*, *Lecane leontine*, and Nauplii. Zooplankton community was affected by anthropogenic disturbances.

Introduction:-

Reservoirs are aquatic ecosystems recognised for their social, economic and ecological importance (**Fan et al., 2019**). They are an essential source of water resources for the development of ecosystem services and biodiversity

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(**Cooke et al., 2016**). These reservoirs, beyond their socio-economic importance, shelter a great diversity of biological and aquatic organisms mainly represented by the ichthyofauna, macroinvertebrate and plankton (phytoplankton and zooplankton). Zooplankton communities occupy a crucial position in the food web of a lake and are sensitive to anthropogenic disturbances (**Jeppesenet al., 2011**). They are primary consumer in the aquatic ecosystems and feed on many types of phytoplankton, free-living algae, and on particulate organic substances (**Mwagona et al., 2018**). Zooplanktons are also sensitive to change in water quality and therefore are usually use as bioindicators to assess water quality (**Wang et al., 2020**). Their composition, distribution and structure are directly related to food availability and quantity, and water quality (**Ma et al., 2019**; **Makwinja et al., 2021**). However, reservoirs are under many pressures from various kinds of disturbances and both human land-use practices and natural disturbance (**Mwagona et al., 2018**).

Africa's freshwater systems are being degraded at an alarming rate despite their economic, social and ecological importance (**Hill et al., 2020**). In Côte d'Ivoire, Taabo reservoir has been created since 1979 on river Bandama for drinking water supply, irrigation for agriculture and hydroelectric power generation. Unfortunately, over the last decade, this reservoir is under increasing anthropogenic pressure mainly due to human activity, such as agricultural practices and pastoralism in its catchment area (**Groga et al., 2012**). This disturbance is characterized by the presence of aquatic macrophyte covering 26 % of the total reservoir area (**Vie, 2005**). These invasive macrophytes are located along the northern part of the reservoir, which receives more sediment and nutrients (**Anoh et al., 2012**).

In Côte d'Ivoire, the diversity and structure of zooplankton community in reservoirsare little known. The only studies were those of **Aka et al.** (**2000**) in 49 shallow tropical reservoirs in the North of Côte d'Ivoire, **Fofana et al.** (**2019**) in lake Kaby and **Ouattara et al.** (**2007**) in Bia and Agnebi rivers. Zooplankton community of Taabo reservoir is not known. To our knowledge, no study has deal with the diversity and ecological requirement of zooplankton in this reservoir.

The aims of this study were (i) to make the first inventory of zooplankton community in Taabo reservoir (ii) to assess the spatial and seasonal variability of this community in Taabo reservoir and (iii) to investigate the relationships between zooplankton densities and environmental variables in Taabo reservoir.

Material And Methods:-

Study area and sampling sites

Taabo reservoir (Fig 1) is located in the central part of Côte d'Ivoire (6°25'- 6°56' N, 5°07'-5°33' W). It covers an area of 69 km^2, with a mean depth of 16 m and a maximum depth of 30 m. Water residence time in the reservoiris approximately 49.2 days (**Kouassiet al., 2007**). The climate is characterized by four seasons (two rainy seasons and two dry seasons). The rainy seasons are represented by a long rainy season (LRS) from April to July and a short rainy season (SRS) from October to November. The two dry seasons are represented by a long dry season (LDS) from December to March and a short dry season (SDS) from August to September (**Kouassiet al., 2013**). The mean annual precipitation varies from 1100 to 1600 mm, and the mean annual air temperature ranges between 24.5 °C and 34 °C (**Aliko et al., 2010**).

Data were collected during the one-year survey from November 2017 to October 2018 at five sampling sites (S1 - S5) of the lake along a transect of seven kilometers in the open water area near the dam. Samples were collected every 45-days period. Sites S1 and S5 are located at nearshore area. Concerning sites S2 and S4, they are adjacent to the littoral zone. Site S3 is located in the deepest area of the lake. The sampling sites S1, S2 and S5 are more affected by anthropogenic activities (agriculture, domestic waste, fish farming, etc.) than the sites S3 and S4. The characteristics of the sampling sites are described in Tab 1.

Environmental variable

The environmental variables measured to assess water characteristics of Taabo reservoir were water temperature, conductivity, pH, dissolved oxygen, water depth, water transparency, and nutrient concentrations (Total nitrogen and Total phosphorus).

Water samples for physical and chemical parameters analyses were collected at two depths (0.5 and 1 m) using a Van Dorn bottle at each sampling site. Water conductivity and temperature were measured using a conductivity meter (WTW COND 340-i model). A pHmeter (HANNA, Hi 991001 model) was used to measured water pH. Dissolved oxygen was measured with an oximeter HANNA (Hi 9146 model), water depth and transparency were

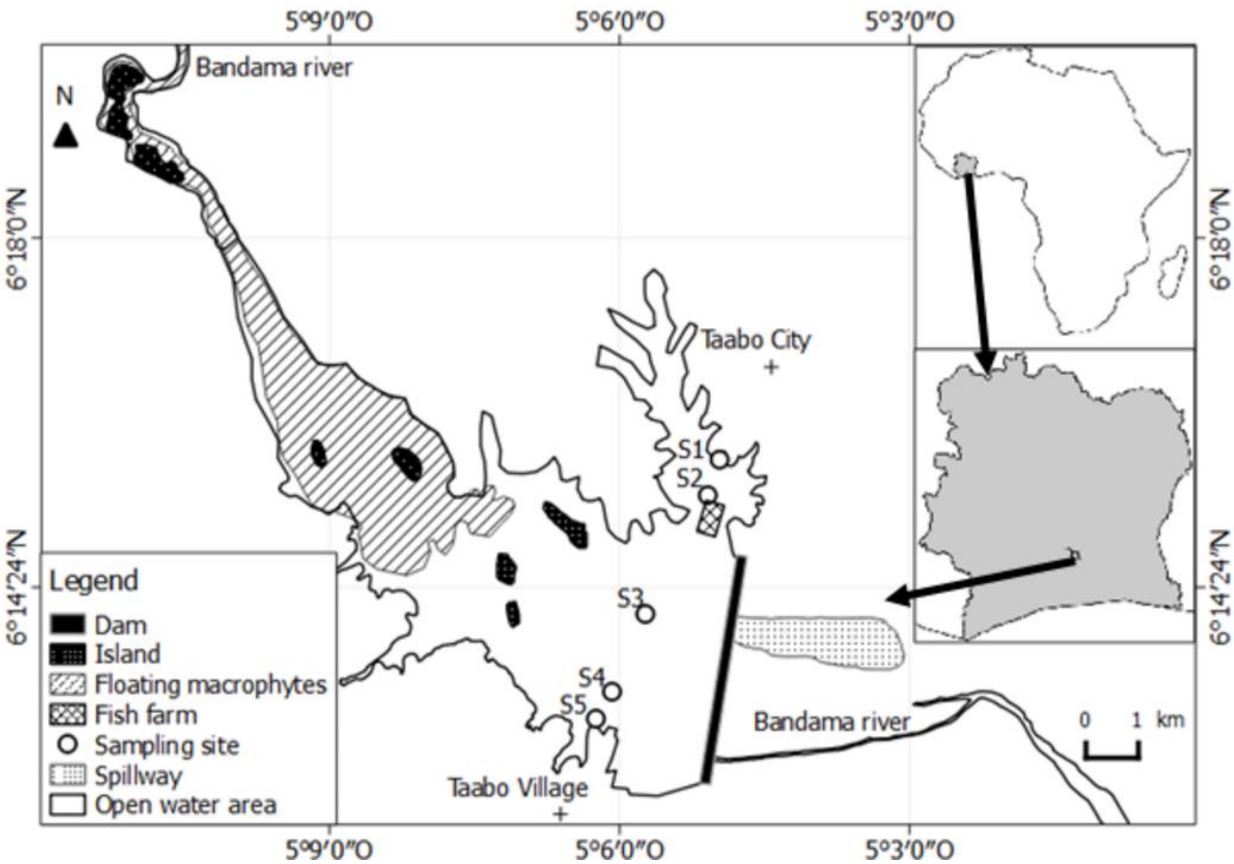

Fig 1:- Map showing the location of sampling sites in Taabo lake (Côte d'Ivoire): S1 - S5 = sampling sites.

Table 1:- Coordinates and characteristics of the sampling sites use for zooplankton sampling in Taabo reservoir (Côte d'Ivoire).

Sampling sites	Latitude (N)	Longitude (W)	Mean depth (m)	Characteristics of the sampling sites
S1	06°15'46.6"	05°04'57.4"	2.8	Urban area of the reservoir, cattle farming on the bank, agriculture, bathing and washing activities
S2	06°15'42.5"	05°04'59.3"	8	Fish farming operation into the reservoir
S3	06°15'06.3"	05°05'11.2"	19.7	Fishing area
S4	06°13'00.8"	05°06'13.7"	8.5	Fishing area
S5	06°12'59.2"	05°06'14.6"	3.2	Rural zone of the reservoir, fishing area, agriculture

measured respectively with a portable sounder ECHOTEST model, and a Secchi disk (20 cm diameter black and white). Spectrophotometer (HACH DR 2010 model) was used to measured nutrient concentrations in the water. Total nitrogen (TN) and Total phosphorus (TP) analysis were determined in the samples using standard method **NF EN ISO 10304-1** (**2009**).

Zooplankton sampling

Zooplankton samples were collected with one vertical hauls from 1 m of depth to the surface using the plankton net (34 cm in diameter, 108 cm in length, 20 µm mesh size) at each sampling site of Taabo reservoir. The net was towed at a speed of approximately 0.5 m.s^{-1}. All the samples were fixed with formaldehyde solution at 5 %. Estimation of species composition in zooplankton samples was carried out by examining several small fractions of each sample under microscope (Zeiss). Zooplankton taxa were identified to the lowest taxonomic level possible using the keys of **Pontin** (**1978**); **Pourriot** (**1980**); **Rey and Saint-Jean** (**1980**); **Idris** (**1983**) and **Shiel** (**1995**). For the abundance analysis, three counts of 1.5 ml subsamples were made on a Sedwick-Rafter having 100 ml (**Doulka and Kehayias, 2008**).

Data analysis

Zooplankton community structure was described through taxonomic richness, frequency of occurrence, Sorensen similarity index, Shannon-Weaver diversity index, and Pielou evenness index. The Sorensen similary index was used to assess zooplankton taxonomic similarity between sampling sites. The frequency of occurrence (FO) of each specie was calculated using the following formula: FO = (Ni/Nts) ×100; with Ni = number of samples containing a given specie i and Nts = total number of samples collected. The FO was used to classify taxa following **Dajoz** (**2000**): FO > 50 (common taxa); 25 < FO < 50 (occasional taxa); FO ≤ 25 (rare taxa).

Differences in zooplankton abundance, Shannon-Weaver diversity index, Pielou evenness index and environmental parameters between sampling sites and sampling months were evaluated using Kruskal-Wallis test, a non parametric analysis of variance, followed by Mann-Whitney test. Before performing comparison test, normality of data was checked by Shapiro test ($p > 0.05$ at all sampling sites). Analyses were conducted using Rstudio R 3.1.3 (**R Core Team, 2013**). Statistical analyses were performed at a level of significance of $p < 0.05$.

In order to assess relationships between zooplankton community and environmental variables, ReDundancy Analysis (RDA) was performed based on the data matrix of zooplankton densities.

Zooplankton densities and environmental variables were $\log_{10}$ (X+1) transformed prior to analysis. Monte Carlo permutation test (499 permutations) were done so as to identify a subset of measured environmental variables, which exerted significant and independent influences on zooplankton distribution at $p < 0.05$ (**Van Tongeren et al., 1992**). RDA was performed using CANOCO 4.5.

Results:-

Environmental variables

The spatial variations of the environmental parameters recorded in this study are shown in Fig 2. Temperature varied from 26.9 °C (S5) to 33.7 °C (S1). The lowest conductivity value (71.97 $\mu S.cm^{-1}$) was recorded at the littoral site S1, and its highest value (134.67 $\mu S.cm^{-1}$) was noted at the site S2 (sublittoral). The dissolved oxygen values in the study area varied from 3.7 $mg.L^{-1}$ (S1) to 7.1 $mg.L^{-1}$ (S3). Site S1 registered the highest value (9.8) of pH, and site S5 recorded the lowest value (6.5). Concerning water transparency, it was significantly higher (120 cm) at the deepest site S3 than the other sites (Mann-Whitney test; $p < 0.05$). Regarding the nutrient concentrations (TN; TP), their highest values were recorded at site S2 (TN = 2.9 $mg.L^{-1}$; TP = 0.71 $mg.L^{-1}$), while their lowest values were reported at site S1 (TN = 0.27 $mg.L^{-1}$; TP = 0.11 $mg.L^{-1}$). Except water transparency, the other physical and chemical parameters recorded in Taabo reservoir did not varied significantly between the sampling sites (Kruskal-Wallis test; $p > 0.05$).

Tab 2 shows the median, minimum and maximum values of the environmental variables recorded during the sampling seasons in Taabo reservoir. Maximum value (33.7 °C) of water temperature was registered in Long Dry Season (LDS) and the minimum value (26.9 °C) was observed in Short Rainy Season (SRS). Water temperature was significantly higher during the LDS than the other seasons (Mann-Whitney test; $p < 0.05$). The highest conductivity value (134.67 $\mu S.cm^{-1}$) was recorded in SRS and the lowest value (71.97 $\mu S.cm^{-1}$) was noted in LDS. Conductivity values registered in rainy seasons were significantly higher than those reported in dry seasons (Mann-Whitney test; $p < 0.05$). The lowest dissolved oxygen value (3.7 $mg.L^{-1}$) was registered in the Long Rainy Season (LRS) and the highest value (7.1 $mg.L^{-1}$) was recorded in Short Dry Season (SDS). Dissolved oxygen was significantly lower in SRS (Mann-Whitney test; $p < 0.05$). Taabo reservoir water was slightly basic with pH median values ranged between 7.06 (SRS) and 8.51 (SDS). pH did not varied significantly between seasons (Kruskal-Wallis test; $p > 0.05$). Concerning water transparency, it's significantly higher in LDS with a maximum value of 120 cm (Mann-Whitney test; $p < 0.05$). The high nutrient concentrations were recorded in SRS (TN = 2.9 $mg.L^{-1}$; TP = 0.8 $mg.L^{-1}$). However, the lowest values were registered in LDS (TN = 0.28 $mg.L^{-1}$; TP = 0.05 $mg.L^{-1}$). Nutrient concentrations were significantly higher in rainy seasons than dry seasons (Mann-Whitney test; $p < 0.05$).

Zooplankton composition, distribution, frequency of occurrence, and taxonomic similarity

Zooplankton community recorded in Taabo reservoir revealed 77 taxa belonging to four groups (rotifera, cladocera, copepoda and others zooplankton). Rotifera with 59 taxa were the most diversity group. This group was followed by cladocera with ten taxa, copepod with five taxa and the other zooplankton with three taxa (Tab 3). Littoral zones of the reservoir (S1 and S5), with more than 87 % of the taxa richness were the most richness areas.

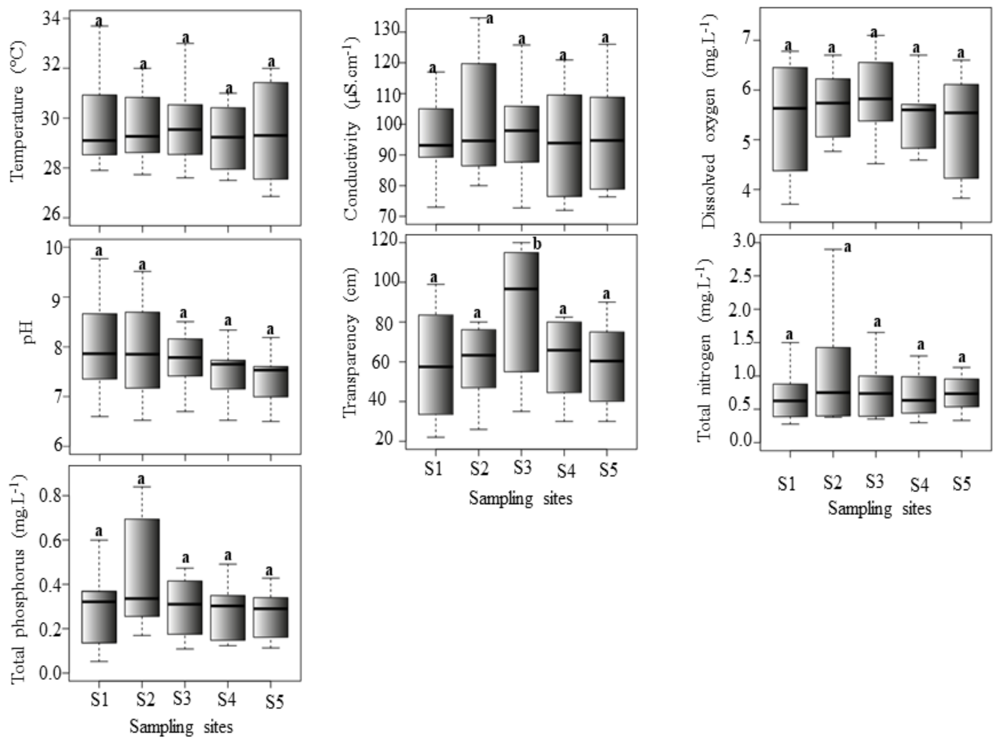

Fig 2:- Boxplots showing the spatial variations of the environmental variables recorded in Taabo reservoir sampling sites (Côte d'Ivoire): different letters denote significant differences between sampling sites ($p < 0.05$; Kruskall-Wallis test).

Table 2:- Minimum, maximum and median values of the environmental variables measured at five sampling sites in Taabo reservoir (Côte d'Ivoire): Min = minimum; Max = maximum; Med = median; median values with a letter (a and b) in common do not differ significantly (Kruskal-Wallis test; $p > 0.05$).

Parameters	**Values**	**LDS**	**LRS**	**SDS**	**SRS**
	Min	31	27.7	29.2	26.85
Temperature (°C)	Max	33.7	29.8	30.85	29.55
	Med	32 **a**	28.8 **b**	30.1 **ab**	28.54 **a**
	Min	71.9	84.7	76.1	99.35
Conductivity (µS.cm^{-1})	Max	90	130.3	94.7	134.67
	Med	77.7 **a**	106.6 **b**	88.2 **a**	110.7 **b**
	Min	5.72	3.7	5.12	4
Dissolved oxygen (mg.L^{-1})	Max	6.78	6.5	7.1	5.97
	Med	6.55 **a**	5.4 **ab**	5.71 **ab**	4.74 **b**
	Min	7	7.20	8.85	6.5
pH	Max	8.02	8.6	9.77	8.89
	Med	7.5 **a**	7.7 **a**	8.51 **a**	7.06 **a**
	Min	80	38	40	22
Transparency (cm)	Max	120	95	110	98.3
	Med	90 **a**	60 **ab**	60.3 **ab**	32.5 **b**
	Min	0.28	0.59	0.39	0.53
Total nitrogen (mg.L^{-1})	Max	0.47	1.05	1.01	2.9
	Med	0.36 **a**	0.72 **b**	0.42 **a**	1.13 **b**
	Min	0.11	0.24	0.05	0.2
Total phosphorus (mg.L^{-1})	Max	0.72	0.67	0.23	0.84
	Med	0.13 **a**	0.33 **b**	0.17 **a**	0.39 **b**

Table 3:- Taxonomic composition and the frequency of occurrence (FO) of zooplankton recorded in Taabo reservoir (Côte d'Ivoire): * = rare taxa; ** = occasional taxa ; *** = common taxa.

Zooplankton taxa	Acronyms	Sampling sites				
		S1	S2	S3	S4	S5
COPEPODA						
Cyclopidae						
Copepodites	Cope	***	***	***	***	***
Mesocyclops sp.	Mesp	***	***	***	***	***
Thermocyclops sp.	Thsp	***	***	***	***	***
Harpactidae						
Harpacticoida undetermined	Harp	*				*
undetermined						
Nauplii	Naup	***	***	***	***	***
CLADOCERA						
Bosminidae						
Bosmina longirostris Müller	Bolp	**	**	***	***	***
Bosminopsis dietersi Dodson & Frey	Bodi	*	*	**	**	**
Chydoridae						
Alona sp.	Alsp	*		*	**	**
Alona affinis Leyd	Alaf	*				
Pleuroxus striatus Schoedler	Plst	*			*	***
Daphnidae						
Ceriodaphnia cornulata Sars	Ceco	***	***	***	***	***
Scapholebris sp.	Scsp		**	*	**	*
Simocephalus sp.	Sisp	*	***	***	***	**
Moinidae						
Moina micrura Kurz	Momi	***	***	***	***	***
Sididae						
Diaphanosoma excisum Sars	Diex	***	***	***	***	***
ROTIFERA						
Asplanchnidae						
Asplanchna sp. 1	Asp1	**	***	***	***	***
Asplanchna sp. 2	Asp2	**	***	***	***	***
Brachionidae						
Anuraeopsis coelata De Beauchamp	Anco		*			
Anuraeopsis fissa Gosse	Anfi	***	***	***	***	***
Anuraeopsis navicular Rousselete	Anna	***	***	***	***	***
Brachionus angularis Gosse	Bran	***	***	***	***	***
Brachionus calyciflorus Pallas	Brca	**	**	***	*	**
Brachionus caudatus Barrois & Daday	Baca	***	***	***	***	***
Brachionus falcatus Zacharias	Brfa	***	***	***	***	***
Brachionus patulus Müller	Brpa	***	*	***	***	**
Keratella cochlearis Gosse	Keco	***	***	***	***	***
Keratella Lenzi Hauer	Kele	***	***	***	***	***
Keratella tropica Berzins	Ketr	***	***	***	***	***
Notholca sp.	Nosp	***	**	***	**	**
Platyias quadricornis Ehrenberg	Plqu	**				
Colurellidae						
Colurella sp.	Cosp	*		*		*
Lepadella ovalis Müller	Leov	**				*
Collothecidae						
Collotheca sp.	Clsp					*

Table 3:- Continued.

Zooplankton taxa	Acronyms	Sampling sites				
		S1	S2	S3	S4	S5
Hexarthridae						
Hexathra intermediaire Wiszniews	Hein	***	***	***	***	***
Epiphanidae						
Epiphanes clavulata Ehrenberg	Epcl	***	***	***	***	**
Epiphanes macrourus Barrois & Daday	Epma	***	***	***	***	***
Euchlanidae						
Euchlanis dilatata Ehrenberg	Eudi					*
Filinidae						
Filinia longiseta Ehrenberg	Filo	***	***	**	**	**
Filinia opoliensis Zacharias	Fiop	***	***	***	***	***
Filinia pejleri Hutchinson	Fipe	***	***	***	**	***
Filinia terminalis Plate	Fite	***	***	***	**	***
Gastropodidae						
Ascomorpha sp.	Assp	***	***	*	*	***
Gastropus sp.	Gasp	**	*	***	***	**
Lecanidae						
Lecane bulla Gosse	Lebu	***	***	***	***	**
Lecane closterocerca Schmarda	Lecl			*		
Lecane flexilis Gosse	Lefl	**	**	**	**	**
Lecane leontine Turner	Lele	***	***	***	***	***
Lecane luna Müller	Lelu	***	***	**	*	**
Lecane papuana Murray	Lepa	*			*	**
Lecane sp.	Lesp	*			*	
Notommatidae						
Cephalodella sp.	Cesp			*		
Monommata maculata Harring & Meryers	Moma	**	*	**	**	*
Notommata sp.	Ntsp	*				*
Scaridium sp.	Sasp	*		*	*	
Proalidae						
Proalides sp.	Prsp	**		*	*	
Synchaetidae						
Pleosoma sp.	Plsp	*		**		*
Polyarthra vulgaris Carlin	Povu	***	*	***	***	***
Polyarthra sp. 1	Psp1	***	*	***	***	***
Polyarthra sp. 2	Psp2	***	*	***	***	***
Synchaeta sp.	Sysp	*		*		
Testudinellidae						
Pomphulyx sp.	Posp				*	
Trichocercidae						
Trichocerca chattoni De Beauchamp	Trch	***	**	***	***	***
Trichocerca cylindrique Imhof	Trcy	***	***	***	***	***
Trichocerca mus Hauer	Trmu	*		**		**
Trichocerca pusilla Lauterborn	Trpu	***	**	**	***	*
Trichocerca rousseleti Voigt	Trro	**	*	***	*	*
Trichocerca similis Wierzezski	Trsi	***	***	***	***	***
Trichocerca weberi Jennings	Trwe	**	**	***	**	**
Trichocerca sp. 1	Tsp1	***	***	***	***	***
Trichocerca sp. 2	Tsp2	*	*	*	*	*
Trichocerca sp. 3	Tsp3	*	*	*	*	*

Table 3:- end.

Zooplankton taxa	Acronyms	Sampling sites				
		S1	**S2**	**S3**	**S4**	**S5**
Trichocerca sp. 4	Tsp4	*	*	*	*	*
Trichocerca sp. 5	Tsp5	*	*	*	*	*
Trichocerca sp. 6	Tsp6	*	*		*	*
OTHER ZOOPLANKTON						
Chaoboridae						
Larves de Chaoborus	Lach	**				*
undetermined						
Hydracarina sp.	Hydr				*	*
Protozoaire	Proto	*	*		*	*
Total	77	69	55	61	62	67

The proportion of common taxa (FO > 50 %) are the most numerous at all the sites with percentages ranging between 49.3 % (S5) and 65.6 % (S4) (Tab 4). For the occasional taxa (25 < FO < 50 %), the highest proportion (22.4 %) was observed at site S5, whereas the lowest proportion (13.1 %) was noted at site S3. Regarding the rare taxa (FO ≤ 25 %), the highest proportion was noted at site S1 (28.98 %), and the lowest proportion was observed at site S3 (21.3 %). Taxa such as Copepodites, *Mesocyclops* sp., *Thermocyclops* sp., Nauplii, *Ceriodaphnia cornulata*, *Diaphanosoma excisum*, *Moina micrura*, *Anuraeopsis fissa*, *Anuraeopsis navicular*, *Brachionus angularis*, *Brachionus caudatus*, *Brachionus falcatus*, *Keratella cochlearis*, *Keratella Lenzi*, *Keratella tropica*, *Hexathra intermediaire*, *Epiphanes macrourus*, *Filinia opoliensis*, *Lecane leontine*, *Trichocerca cylindrique*, and *Trichocerca similis* had high occurrence (FO > 50 %) in all the sampling sites. Forty one taxa were common to the five sampling sites.

The highest values (more than 80 %) of Sorensen similarity index between all the sampled sites highlight the great homogeneity in zooplankton community among the sites (Tab 5).

Tableau 4:- Proportions of common (***), occasional (**) and rare (*) taxa of zooplankton at the five sampling sites (S1 - S5) in the Taabo reservoir (Côte d'Ivoire).

Sites	Common taxa (%)	Occasional taxa (%)	Rare taxa (%)
S1	52.18	18.84	28.98
S2	58.18	14.54	27.28
S3	65.6	13.1	21.3
S4	56.45	16.14	27.41
S5	49.3	22.4	28.3

Tableau 5:- Proportions of the Sorensen similarity index between the five sampling sites (S1 - S5) of zooplankton in Taabo reservoir (Côte d'Ivoire).

	S1	S2	S3	S4
S2	85 %			
S3	89 %	90 %		
S4	90 %	92 %	90 %	
S5	93 %	88 %	87 %	89 %

Densities and relative abundances of zooplankton

The high value (1788.77 Ind.L^{-1}) of zooplankton total abundance was registered at site S4, and the low value (166.91 Ind.L^{-1}) was recorded at site S1 (Fig 3a). Zooplankton total abundance was significantly higher at site S4 than the others sites (Mann-Whitney test; $p < 0.05$). Concerning the relative abundance of the zooplankton groups identifies in Taabo reservoir, rotifer were the most dominant group at all the sampling sites with more than 68.35 % of the relative abundance. This group was followed by the copepoda and cladocera at all the sites (Fig 3b).

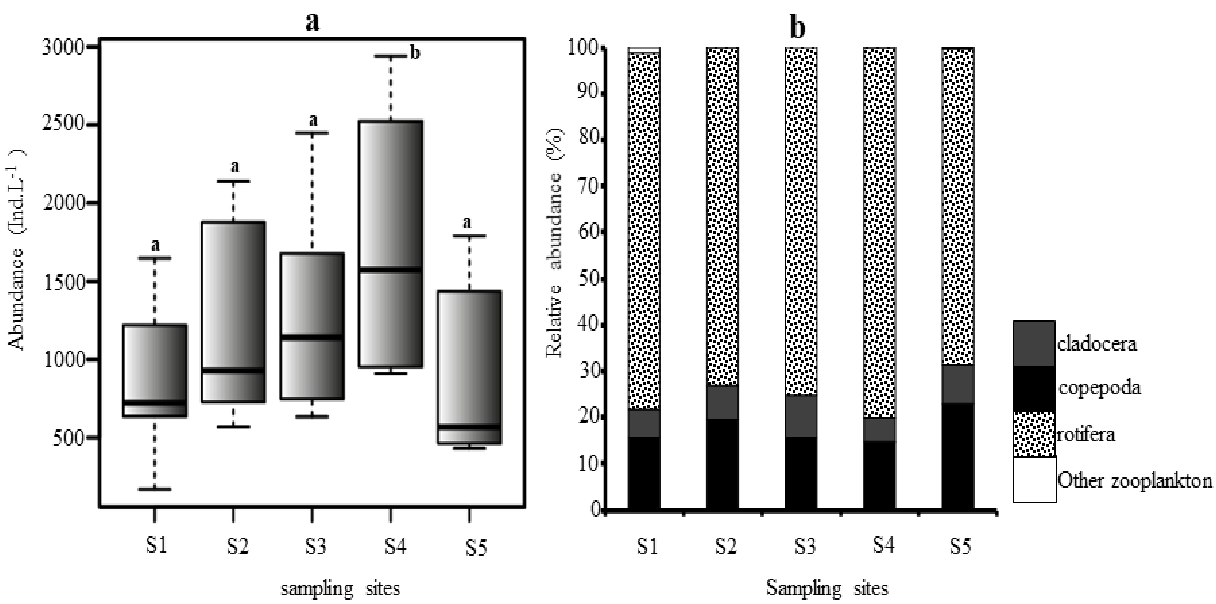

Fig 3:- Spatial variations of the total zooplankton abundance (A) and the relative abundance of zooplankton groups (B) in Taabo reservoir (Côte d'Ivoire).

The highest values of zooplankton abundances were recorded in dry seasons, and the lowest abundances were noted in rainy seasons at all the sampling sites (Fig 4). These high values were observed in January at all the sites: S1 (1645.87 Ind.L-1) ; S2 (2138.20 Ind.L^{-1}) ; S3 (2448.51 Ind.L^{-1}) ; S4 (2940.8 Ind.L^{-1}) and S5 (1788.77 Ind.L^{-1}). In contrast, the lowest values of abundance were recorded in November at sites S1 (166.91 Ind.L^{-1}) ; S2 (569.32 Ind.L^{-1}) ; S3 (632.08 Ind.L^{-1}) ; S5 (429.87 Ind.L^{-1}) and in June at site S4 (910.43 Ind.L^{-1}). The seasonal variability of zooplankton density shows that zooplankton densities were significantly higher (Mann-Whitney test; $p < 0.05$) in dry seasons than rainy seasons (Tab 6).
Rotifera group represents the most dominant group in zooplankton community of Taabo reservoir at all the sampling sites and months (Fig 5). Rotifera abundance varied from 124.34 Ind.L^{-1} in November (SRS) to 2256.47 Ind.L^{-1} in September (SDS). Rotifera were followed by copepods at all the sampling sites and months. Copepods abundances varied from 27.87 Ind.L^{-1} in November (SRS) to 1142.2 Ind.L^{-1} in January (LDS). After rotifera and copepoda, cladocera, was the most dominant group at all the sampling sites and months. Cladocera abundances varied from 4.26 Ind.L^{-1} (September) to 286.26 Ind.L^{-1} in February (LDS). The abundance of the others zooplankton remains low than those of the major zooplankton groups at all the sampling sites and months. Their highest abundance (28.77 Ind.L^{-1}) was observed at site S1 in October (SRS). At the other sites, their abundances remains below 5.11 Ind.L^{-1}at all the sampling months.

Diversity indices
The lowest value of Shannon-Weaver diversity (2.2 bits.$cell^{-1}$) and Pielou Evenness (0.65) were registered at site S1 (Fig 6) ; while, the highest values (Shannon-weaver diversity index: 3.37 bits.$cell^{-1}$ and Piélou Evenness index: 0.96) were recorded at site S4. However, Shannon index and Pielou Evenness index were not significantly different between sampling sites in Taabo reservoir (Kruskall-Wallis test; p> 0.05). Temporal variation of Shannon diversity index indicates that the lowest value was recorded in July (2.22 bits.$cell^{-1}$) at LRS and the highest value was recorded in February (3.37 bits.$cell^{-1}$) at LDS. The highest value of Pielou Evenness index was observed in February (0.96) during the LDS and the lowest value was noted in April (0.65) during LRS. Shannon's diversity and Evenness indices were significantly lower in LRS than the other seasons (Mann-Whitney test; $p < 0.05$).

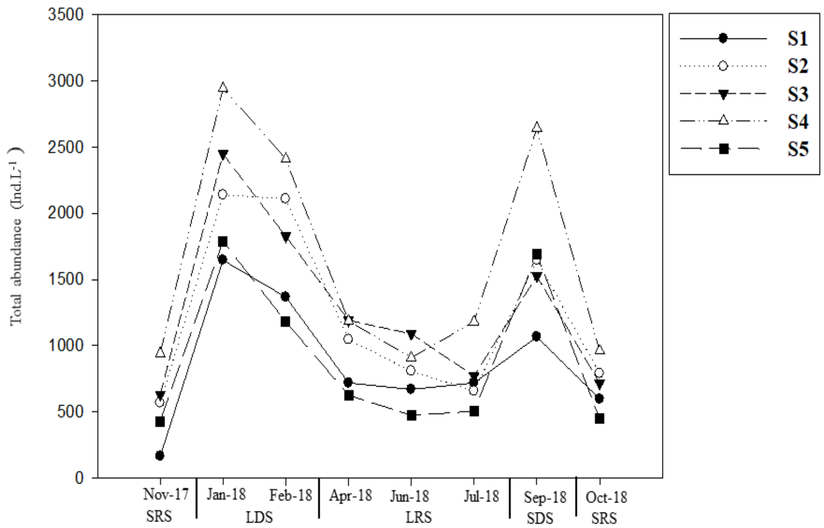

Fig 4:- Temporal variations of the total zooplankton abundance in Taabo reservoir (Côte d'Ivoire): S1- S5 = sampling sites ; Jan = January ; Feb = February ; Apr = April ; Jun = June ; Sept = September ; Oct = October; Nov = November; LRS = long rainy season, SDS = short dry season, SRS = short rainy season ; LDS = long dry season.

Table 6:- Results of the seasonal variability analysis of total zooplankton densities collected in Taabo reservoir 2018 (Côte d'Ivoire): values with a letter (a and b) in common do not differ significantly (Kruskal-Wallis test; $p > 0.05$).

Abundance ($Ind.L^{-1}$)	**Long dry season (LDS)**	**Long rainy season (LRS)**	**Short dry season (SDS)**	**Short rainy season (SRS)**
Maximum	2940.8	2108.20	2640.8	961.62
Minimum	1181.93	474.29	1045.25	166.91
Médian	1807.75 **a**	771.77 **b**	1526.72 **a**	615.31 **b**

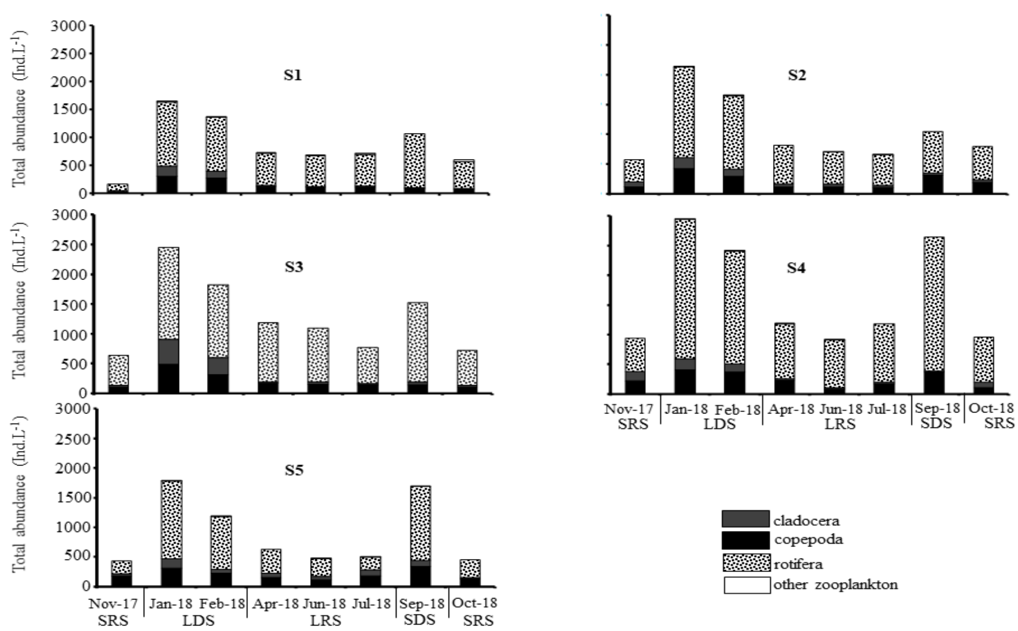

Fig 5:- Temporal variations of the abundance of zooplankton groups in Taabo reservoir (Côte d'Ivoire): S1 - S5 = sampling sites ; Jan = January ; Feb = February ; Apr = April ; Jun = June ; Sept = September ; Oct = October; Nov = November; LRS = long rainy season, SDS = short dry season, SRS = short rainy season ; LDS = long dry season.

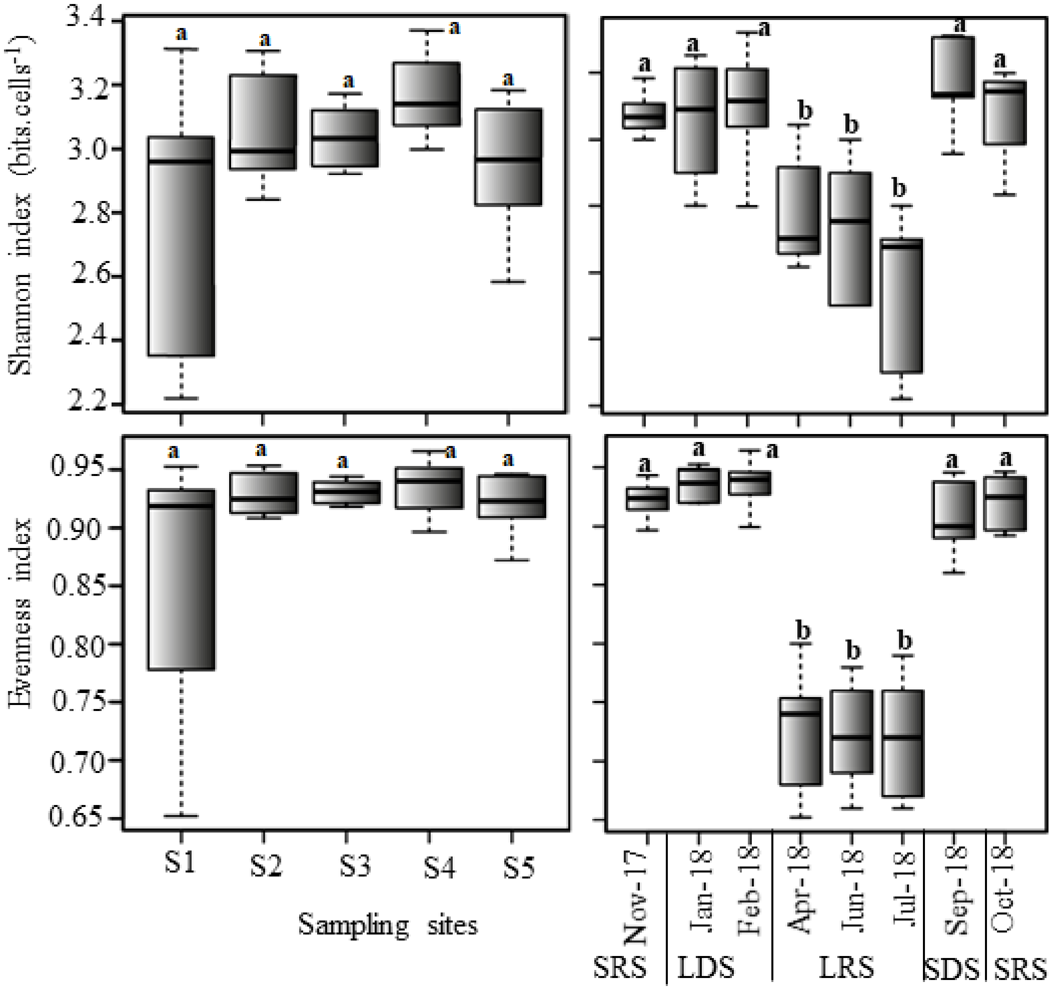

Fig 6:- Boxplots showing spatial and temporal variations of Shannon index and Pielou's Evenness index of Taabo reservoir (Côte d'Ivoire): Nov = November, Jan = January, Feb = February, Apr = April, Jun = June, Jul = July, Sep = September, Oct = October, LRS = long rainy season, SDS = short dry season, SRS = short rainy season, LDS = long dry season, different letters denote significant differences between sampling sites ($p < 0.05$; Kruskal-Wallis test).

Taxa relationships with environmental variables

The relationships between the environmental variables and the abundance of the mains zooplankton taxa were assessed using the redundancy analysis (RDA). Only the twenty-one (21) zooplankton taxa conforming more than 10 % of total zooplankton abundance were considered for this analysis. The result of RDA explained 68 % of the data variability in the first two ordination axes (Fig 7).

The first axis (56.98 %) shows a seasonal gradient clustering in his positive coordinates, the samples from rainy seasons and in his negative coordinates, the samples from dry seasons. Environmental variables such as conductivity, water depth, pH, TP, and TN were strongly and positively correlated with the first axis. The abundances of zooplankton taxa such as *Mesocyclops* sp., *Thermocyclops* sp., *Ceriodaphnia cornulata* and *Diaphanosoma excisum* were positively affected by these variables. However, water transparency and temperature were strongly and negatively correlated with axis 1. These environmental variables positively influence the abundance of zooplankton taxa, such as *Anuraeopsis fissa*, *Brachionus angularis*, *Brachionus caudatus*, *Brachionus falcatus*, *Keratella Lenzi*, *Keratella tropica*, *Hexathra intermediaire*, *Epiphanes macrourus*, *Filinia opoliensis*, *Lecane leontine*, and Nauplii. Dissolved oxygen was negatively correlated with the second axis (axis 2).

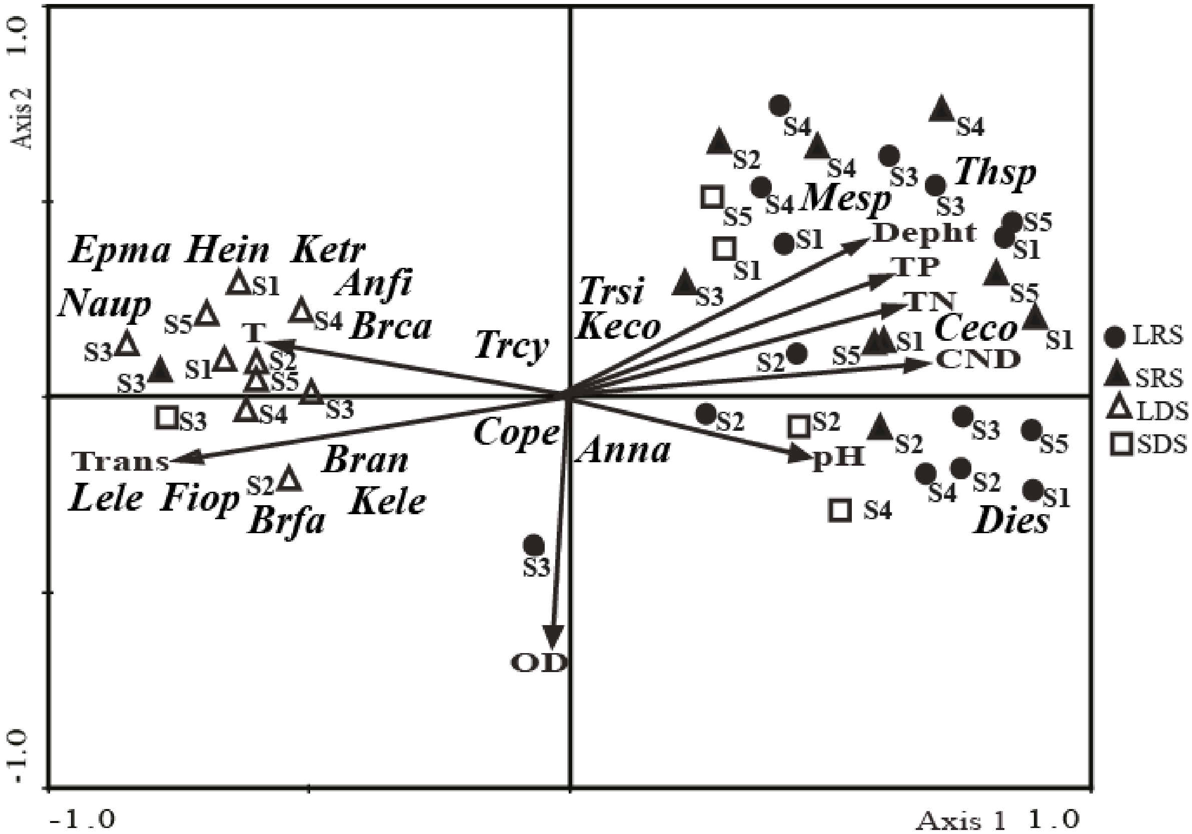

Fig 7:- ReDundancy Analysis triplot showing zooplankton species and sampling sites, and seasons in relation to environmental variables in Taabo reservoir (Côte d'Ivoire): T = temperature; CND = conductivity; DO = dissolved oxygen ; TRANS = Transparency; sampling sites = S1 - S5 ; Cope =Copépodites ; Mesp = *Mesocyclops* sp. ; Thsp = *Thermocyclops* sp. ; Naup = Nauplii ; Ceco = *Ceriodaphnia cornulata* ; Dies = *Diaphanosoma excisum* ; Momi = *Moina micrura* ; Anfi = *Anuraeopsis fissa* ; Anna = *Anuraeopsis navicular* ; Bran = *Brachionus angularis* ; Brca = *Brachionus caudatus* ; Brfa = *Brachionus falcatus* ; Keco = *Keratella cochlearis* ; Kele = *Keratella Lenzi* ; Ketr = *Keratella tropica* ; Hein = *Hexathra intermediaire* ; Epma = *Epiphanes macrourus* ; Fiop = *Filinia opoliensis* ; Lele = *Lecane leontine* ; Trcy = *Trichocerca cylindrique* ;Trsi = *Trichocerca similis*; LRS = long rainy season ; SDS = short dry season ; SRS = short rainy season ; LDS = long dry season.

Discussion:-

The analysis of environmental variables in Taabo reservoir has shown that the seasonal variation was more significant than the spatial variations. This spatial invariability of environmental variables could be explained by the location of all the sampling sites on the same radial near the dam. It could also be linked to the slow renewed of the reservoir's waters. The spatial invariability of environmental variables in Ivorian's reservoirs has been shown by authors such as **Adon et al.** (**2012**) in Adzope reservoir and **Aka et al.** (**2020**) in Fae reservoir. Temperatures recorded in Taabo reservoir remain within the range of temperatures measured on lakes in Côte d'Ivoire (**Aka et al**., **2020**; **Dotchemin et al., 2021**) and West Africa (**Mama et al., 2011**; **Zébazé Togouet et al., 2011**). Moreover, high transparency values observed during this season reflect a great penetration of light rays into the water column, which is essential for the photosynthetic activity that generates dissolved oxygen (**Odjohou et al., 2020**; **Tahir et al., 2020**). Rainy seasons registered the highest values of conductivity and nutrient concentrations in Taabo reservoir. These high values in rainy seasons could be explained by the input of running waters rich in nutrients and mineral elements coming from the catchment area. The high concentrations of nitrate and phosphate during rainy seasons were also reported by **Patil et al.** (**2011**) in Lotus reservoir (India) ; **Okoro et al.** (**2017**) in Opi lake (Nigeria) and **Adhikari et al.** (**2017**) in Kulekhani reservoir (Nepal).

The study of zooplankton community in Taabo reservoir revealed 77 taxa belonging to four groups (rotifers, cladocerans, copepods and others organism). This high diversity of zooplankton is close to that reported by **Ouattara et al.** (**2007**) in Ayamé reservoir (56 taxa) in Côte d'Ivoire. Zooplankton richness of Taabo reservoir is higher than those reported in small reservoirs. Indeed, 30 taxa were recorded by **Aka et al.** (**2000**) in small lakes in North Côte d'Ivoire. **Fofana et al.** (**2019**) in Kaby Lake (South Côte d'Ivoire) and **Adandedjan et al.** (**2017**) in Nokoué Lake (Benin) had identified 31 taxa each other. Difference in taxonomic richness between these studies could be explained on the one hand by the size of these reservoirs and, on the other hand by the difference in the mesh size of the nets used. On Taabo and Ayamé reservoir, which are greatest than lakes Kaby and Nokoué, a net of 20 µm mesh size was used for zooplankton sampling. While **Aka et al.** (**2000**) ; **Adandejan et al.** (**2017**) and **Fofana et al.** (**2019**) whom worked in small reservoirs had used a net of 60 µm mesh size.

High diversity of zooplankton (more than 87 %) was reported in the littoral areas (S1 and S5). higher richness at the littoral areas is hypothesized to greater habitat diversity of the former region. **Sharma and Sharma** (**2020**) found high zooplankton richness in littoral areas of Meghalaya reservoir in Northeast India.

Zooplankton community of Taabo reservoir was qualitatively (76.6 % of the taxonomic richness) and quantitatively (more than 68.35 % of the relative abundance) dominated by rotifers group. This high diversity and abundance of rotifers in zooplankton community were reported in many studies (**Vincent et al., 2012**; **Dembowska et al., 2015**; **Kuczyńska-Kippen and Joniak, 2016**). Moreover, the high diversity of rotifers can be explained by the fact that this group contains several polluo-resistant species that proliferate in nutrient-rich environments (**Ismail and Adnan, 2016**). Dominance of rotifer group indicates organic pollution due to direct entry of untreated sewage from the catchment area (**Okogwu, 2010**). Taabo reservoir is under increasing anthropogenic pressure mainly due to human activity, such as agricultural practices and pastoralism in its catchment area (**Groga et al., 2012**). According to their feeding strategy, rotifers were known to be opportunistic consumers. This characteristic allows them to adapt quickly to changes in environmental and hydrological conditions that exist in stagnant waters (**Okogwu, 2010**). Most of the rotifer species found in Taabo reservoir such as *Anuraeopsis fissa*, *Anuraeopsis navicular*, *Brachionus angularis*, *Brachionus caudatus*, *Brachionus falcatus*, *Keratella cochlearis*, *Keratella Lenzi*, *Keratella tropica*, *Hexathra intermediaire*, *Trichocerca cylindrique*, and *Trichocerca similis* are associated with high trophic state and alkaline water (**Chalkia and Kehayias, 2013**; **Ochocka and Pasztaleniec, 2016**).

The proportion of very frequent taxa are the most numerous at all the sampling sites, and Sorensen similarity indexes between these sites are higher than 80 %. The spatial invariability of environmental variables could explain the high similarity of zooplankton community between the sampling sites in Taabo reservoir and the predominance of common taxa. According to **Sharma et al.** (**2017**); water temperature, nutrient, pH, transparency are essential factors in shaping zooplankton community composition.

The highest values of zooplankton abundances were recorded in dry seasons at all the sampling sites. The high abundance of zooplankton observed in dry season could be explained by the fact that environmental variables such as water temperature, transparency, and pH are more stable in dry seasons than rainy seasons. According to **Pal et al.** (**2015**); zooplankton species have their life cycle influenced by temperature, feeding and photoperiod.

Shannon-Weaver diversity and Pielou Evenness indices were lower in long rainy season than the others seasons. The low values of these indices in this season indicates a disturbance in zooplankton community of Taabo reservoir. This disturbance recorded during the rainy season could be explained by the input of rainfall rich in nutrients and mineral elements coming from the catchment area which favours the proliferation of polluo-resistant taxa (**Ochocka and Pasztaleniec, 2016**).

The results of the redundancy analysis (RDA) highlight the relationships between the environmental variables and the abundance of the mains zooplankton taxa in Taabo reservoir. **Williamson et al.** (**2011**) and **Pinel-Alloul et al.** (**2013**) have demonstrated a positive relationship between the zooplankton community and environmental variables. The abundances of zooplankton taxa such as *Mesocyclops* sp., *Thermocyclops* sp., *Ceriodaphnia cornulata* and *Diaphanosoma excisum* were positively affected by conductivity, water depth, pH, TP, and TN. However, water transparency and temperature had positively influenced the abundances of zooplankton taxa such as *Anuraeopsis fissa*, *Brachionus angularis*, *Brachionus caudatus*, *Brachionus falcatus*, *Keratella Lenzi*, *Keratella tropica*, *Hexathra intermediaire*, *Epiphanes macrourus*, *Filinia opoliensis*, *Lecane leontine,* and Nauplii. The same result have be reported by **Devetter** (**2011**) in Slapy reservoir in Czech Republic, **Chalkia and Kehayias** (**2013**) in Ozeros lake in Greece, **Brito et al.** (**2016**) in two tropical reservoirs in Brazil.

Conclusion:-

This study has made a first inventory of the zooplankton community of Taabo reservoir. The results for abiotic parameters reveal significant temporal variation. The taxonomic composition of zooplankton shows the presence of 77 taxa. Rotifers group are most diversified and abundant. Analysis of the seasonal variability of zooplankton density shows that zooplankton densities are higher in dry seasons than in rainy seasons. The result of diversity and Evenness indices showed that the Taabo reservoir was unstable and poorly organised during the long rainy season. Analysis of correlations between physical and chemical parameters and zooplankton indicates that the faunal distribution was more influenced by environmental parameters such as conductivity, temperature, pH, transparency and water depth.

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References:-

1. **Adandedjan, D.; Makponse, E.; Hinvi, L.C. and Laleyé, P.** (2017). Données préliminaires sur la diversité du zooplancton du lac Nokoué (Sud-Bénin). Journal of Applied Bosciences, 115: 11476-11489. https://dx.doi.org/10.4314/jab/v115i1.7
2. **Adhikari, P.L.; Shrestha, S.; Bam, W.; Xie, L. and Perschbacher, P.** (2017). Evaluation of spatial-temporal variations of water quality and plankton assemblages and its relationship to water use in Kulekhani Multipurpose Reservoir, Nepal. Journal of Environmental Protection, 8(11): 1270.
3. **Adon, M.P.; Ouattara, A. and Gourène, G.** (2012). Limnological characteristics inferred from physical-chemical patterns of a tropical shallow reservoir (Adzopé, Côte d'Ivoire). Journal of Agriculture and Biological Sciences, 3(2): 262 - 270.
4. **Aka, E.N.A.; Edia, O.E.; Doumbia, L. and Ouattara, A.** (2020). Diversity and distribution of aquatique macroinvertebrates in Faé dam lake (South-West of Côte d'Ivoire). International Journal of Science and Research, 9(2): 864-875.
5. **Aka, M.; Pagano, M.; Saint-Jean, L.; Arfi, R.; Bouvy, M.; Cecchi, P.; Corbin, D. and Thomas, S.** (2000). Zooplankton variability in 49 shallow tropical reservoirs of Ivory Coast (West Africa). International Review of Hydrobiology: A Journal Covering all Aspects of Limnology and Marine Biology, 85(4): 491-504.
6. **Anoh, K.A.; Jourda, J.P.; Koua, T.J-J.; Eba, A.E. and Lazar, G.** (2012). Damarcation of protection perimeters for surface waters of Taabo (Ivory Coast) watershed using gis and multicriteria analysis. Environmental Engineering and Management journal, 11: 2123-2131.
7. **Aliko, N.G.G.; Da Costa, K.S.; Dietoa, Y.M.; Ouattara, A. and Gourène, G.** (2010). Caractéristiques de la population de Distichodusrostratus Günther, 1864 (pisces: Distichodontidae) du lac de barrage de Taabo (bassin du Bandama, Côte d'Ivoire). Implications pour une gestion rationnelle du stock. Tropicultura, 28: 50-56.
8. **Brito, S.L.; Maia-Barbosa, P.M. and Pinto-Coelho, R.M.** (2016). Secondary productivity of main microcrustacean species of two tropical reservoirs in Brazil and its relationship with trophic state. Journal of Limnology, 75:320329DOI 10.4081/jlimnol.2016.1267.
9. **Chalkia, E. and Kehayias; G.** (2013). Zooplankton community dynamics and environmental factors in Lake Ozeros (Greece). Mediterranean Marine Science, 14(3): 32-41. http://dx.doi.org/10.12681/mms.541
10. **Cooke, S.J.; Allison, E.H.; Beard, T.D.; Alinghaus, R.; Arthington, A.H.; Barttey, D.M.; Cowx, I.G.; Fuentevilla, C.; Leonard, N.I.; Lorenzen, K.; Lynch, A.J.; Nguyen, V.M.; Yoren, S-J.; Taylor, W.W. and**

Welcomme, R.L. (2016). On the sustainability of inland fisheries: Finding a future for the forgotten. Ambio, 45(7):753-764. https://doi.org/10.1007/s13280-016-0787-4

11. **Dajoz, R.** (2000). Précis d'écologie, 7 ème édition, Dunod, Paris, 615p.
12. **Dembowska, E.A.; Napiórkowski, P.; Mieszczankin, T. and Józefowicz, S.** (2015). Planktonic indices in the evaluation of the ecological status and the trophic state of the longest lake in Poland. Ecological Indicators, 56: 15-22. https://doi.org/10.1016/j.ecolind.2015.03.019
13. **Devetter, M.** (2011). Seasonal development of planktonic rotifers in Slapy Reservoir (Czech Republic). Biologia, 66 (4): 662-668. 10.2478/s11756-011-0062-x
14. **Dotchemin, K.; Idrissa, C.A.; Edia, E.O.; and Allassane, O.** (2021). Macroinvertebrate community structure and spatial distribution in the lower section of Kossou Lake (Côte d'Ivoire). International Journal of Tropical Insect Science, 41(1): 629-642.
15. **Doulka, E. and Kehayias, G.** (2008). Spatial and temporal distribution of zooplankton in Lake Trichonis (Greece). Journal of Natural History, 42(5-8): 575-595. doi:10.1080/00222930701835555
16. **Fan, Y.; Fang, C. and Zhang, Q.** (2019). Coupling coordinated development between social economy and ecological environment in Chinese provincial capital cities-assessment and policy implications. Journal of Cleaner Production, 229: 289-298. https://doi.org/10.1016/j.jclepro.2019.05.027
17. **Fofana, N.M.; Etilé, R.N. and Goore, Bi.G.** (2019). Répartition saisonnière du zooplancton en relation avec les caractéristiques environnementales dans le lac Kaby (Bongouanou, Côte d'Ivoire). Journal of Applied Biosciences, 140: 14256-14267. https://dx.org./10.4314/jab.v140i1.5
18. **Groga, N; Ouattara, A.; Da Costa, S.; Dauta, A.; Beauchard, O.; Moreau, J.; Gourene, G. and Laffaille, P.** (2012). Water quality and water-use conflicts in Lake Taabo (Ivory Coast). Open Journal of Ecology, 2: 38-47. http://dx.doi.org/10.4236/oje.2012.21005.
19. **Hill, M.P.; Coetzee, J.A.; Martin, G.D.; Smith R. and Strange, E.F.** (2020). Invasive alien aquatic plants in South African freshwater ecosystems. In Biological Invasions in South Africa. Springer, Cham, 97-114.
20. **Idris, B.A.G.** (1983). Freshwater zooplankton of Malaysia (Crustacea: cladocera). Universiti Pertanian Malaysia Press.
21. **Ismail, A.H. and Adnan, A.A.M.** (2016). Zoopankton composition and abundance as indicators of eutrophication in two small man-made lakes. Tropical Life Sciences Research, 27(1): 31-38. http://dx: doi.org/10.21315/tlsr2016.27.3.5
22. **Jeppesen, E.; Noges, P.; Davidson, T.A.; Haberman, J.; Noges, T.; Blank, K.; Lauridsen, T.L.; Sondergaard, M.; Sayer, C.; Laugaste, R.; Johansson, L.S.; Bjerring, R. and Amsinck, S.L.** (2011). Zooplnkton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia, 676(1): 279-297. Doi: 10.1007/s10750-011-0831-0
23. **Kouassi, K.L; Goné, D.L.; Mélèdje, N.H.; Wognin, A.V.I. and Aka, K.** (2007). Hydrologie et évolution spatio-temporelledes charges solides en suspension dans le lac du barrage hydroélectrique de Taabo (Côte d'Ivoire). European Journal of Scientific Research, 18: 463-476.
24. **Kouassi, K.L.; Kouame, K.I.; Konan, K.S.; Angulo, M.S. and Deme, M.** (2013). Two-dimensional numerical simulation of the hydro-sedimentary phenomena in Lake Taabo, Côte d'Ivoire. Water resources management, 27: 4379-4394. https://doi.org/10.1007/s11269-013-0417-x
25. **Kuczyńska-Kippen, N. and Joniak, T.** (2016). Zooplankton diversity and macrophyte biometry in shallow water bodies of various trophic state. Hydrobiologia, 774(1): 39-51. https://doi.org/10.1007/s10750-015-2595-4
26. **Ma, C.; Mwagona, P.C.; Yu, H.; Sun, X.; Liang, L.; Mahboob, S. and Al-Ghanim, K.A.** (2019). Seasonal dynamics of zooplankton functional group and its relationship with physico-chemical variables in high turbid nutrient-rich Small Xingkai Wetland Lake, Northeast China. Journal of Freshwater Ecology, 34(1): 65-79. https://doi.org/10.1080/02705060.2018.1443847
27. **Makwinja, R.; Mengistou, S.; Kaunda, E. and Alamirew, T.** (2021). Spatial distribution of zooplankton in response to ecological dynamics in tropical shallow lake: Insight from Lake Malombe, Malawi. Journal of Freshwater Ecology, 36(1): 127-148.
28. **Mama, D.; Deluchat, V.; Bowen, J.; Chouti, W.; Yao, B.; Gnon, B. and Baudu, M.** (2011). Caractérisation d'un Système Lagunaire en zone tropicale: cas du lac Nokoué (Bénin). European journal of scientifique research, 56(4): 516-528.
29. **Mwagona, P.C.; Chengxue, M. and Hongxian, Y.** (2018). Seasonal dynamics of Zooplankton functional groups in relation to environmental variables in Xiquanyan Reservoir, Northeast China. Annales de Limnologie - International Journal of Limnology, 54 : 33. doi:10.1051/limn/2018024

30. **NF EN ISO 10304-1** (2009). Qualité de l'eau – Dosage des anions dissous par chromatographie ionique des ions en phase liquide – Partie 1 : Dosage du bromure, chlorure, fluorure, nitrate, nitrite, phosphate et sulfate, p 16.
31. **Ochocka, A. and Pastaleniec, A.** (2016). Sensitivity of plankton indices to lake trophic conditions. Environment Monitoring assess, 188: 622. 10.1007/s10661-016-5634-3
32. **Odjohou, E.; Amani, M.; Soro, G. and Monde, S.** (2020). Caractérisation physico-chimique des eaux d'un eaux d'un système lacustre du cordon littoral ivoirien : cas du lac Labion. International Journal of Biolocial and chimical Sciences, 14(5): 1878-1892. Doi :https://doi.org/10.4314/ijbcs.vL4i5.30
33. **Okogwu, O.** (2010). Seasonal variations of species composition and abundance of zooplankton in Ehoma Lake, a floodplain lake in Nigeria. Revista de biología tropical, 58(1): 171-182.
34. **Okoro, J.O.; Nnamonu, E.I.; Okoye, C.I.C.; Onyishi, G.C.; Obiezue, R.N. and Ozioko, K.U.** (2017). Ecology of the Class Insecta in Opi Lake, Nigeria. International Journal of Research in Pharmacy and Biosciences, 4(6): 24-30.
35. **Ouattara, I.N.; Ouattara, A.; Koné, T.; N'douba, V. and Gourène, G.** (2007). Distribution Du Zooplancton Le Long De Deux Petits Bassins Côtiers Ouest Africains (Bia et Agnebi; Côte D\'Ivoire). AgronomieAfricaine, 19(2): 197-210.
36. **Pal, S.; Patra, A.K. and Chakraborty, K.** (2015). Prospect of Brachionuscalyciflorus, a holoplankton, for its potential bio-indicator property: A review. International Journal of Recent Scientific Reserch, 6(11): 7603-7608.
37. **Patil, J.V.; Ekhande, A.P. and Padate, G.S.** (2011). Study of Lotus Lake: Its abiotic factors their correlation with reference to seasonal changes and altitude. Annals of Biological Research, 2(4): 44-56.
38. **Pinel-Alloul, B.; André, A.; Legendre, P.; Cardille, J.A.; Patalas, K. and Salki, A.** (2013). Large-scale geographic patterns of diversity and community structure of pelagic crustacean zooplankton in C anadian lakes. Global Ecology and Biogeography, 22(7): 784-795. https://doi.org/10.1111/geb.12041
39. **Pontin, R.M.** (1978). A key to the freshwater planktonic and semi-planktonic Rotifera of the British Isles (No. 38). Hyperion Books.
40. **Pourriot, R.** (1980). Les Rotifères. In Flore et Faune aquatique de l'Afrique Sahélo-soudanienne; Durand, JR.and Lévêque C., (Eds.) ; ORSTOM, Paris, 219-244.
41. **R Core Team** (2013). R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria, Available online at: http://www.R-project.org/.
42. **Razak, A.S.B. and Sharip, Z.** (2019). Spatio-temporal variation of zooplankton community structure in tropical urban waterbodies along trophic and urban gradients, Ecological Processes, 8 (44): 2-12. https://doi.org/10.1186/s13717-019-0196-2
43. **Rey, J. and Saint-Jean, L.** (1980). Branchiopodes (Cladocères). In Flore et Faune aquatique de l'Afrique Sahélo-soudanienne; Durand, J.R. & Lévêque, C. (Eds.) ; ORSTOM, Paris, 307-332.
44. **Sharma, A.S.; Gupta, S. and Singh, N.R.** (2017). Zooplankton community of KeibulLamjao National Park (KLNP) Manipur, India in relation to the physico-chemical variables of the water. Chinese journal of oceanology and limnology, 35(3): 469-480. https://doi.org/10.1007/s00343-017-5341-0
45. **Sharma, B.K. and Sharma, S.** (2020). Zooplankton diversity of a subtropical reservoir of Meghalaya, northeast India with remarks on spatial and temporal variations. Opuscula Zoologica Budapest 50(1) : 67-86.
46. **Shiel, R.J.** (1995). A guide to identification of rotifers, cladocerans and copepods from Australian Inland Waters. Cooperative Research Centre for Freshwater Ecology Identification Guide no. 3. Albury: Murray Darling Freshwater Research Centre.
47. **Tahir, S.M.; Otchoum, B.B.; Ibrahim, M.A.; Siméon, T.; Achuo E.D. and Hubert, Z.T.S.** (2020). Spatio-temporal dynamics of zooplankton communities (Rotifers, Cladocerans, Copepods) and water quality of Lake Léré (TCHAD). International Journal of Environment, Agriculture and Biotechnology, 5(3).
48. **Van Tongeren, O.F.R.; Van Liere, L.; Gulati, R.D.; Postema, G. and Boesewinkel-De Bruyn, P.J.** (1992). Multivariate analysis of the plankton communities in the Loosdrecht lakes: relationship with the chemical and physical environment. Hydrobiologia, 233: 105-117. https://doi.org/10.1007/BF00016100
49. **Vei, K.N.** (2005). Suivi et évaluation de l'impact socio-temporel d'un projet d'aménagement du territoire en Afrique de l'Ouest. L'exemple du barrage de Taabo en Côte d'Ivoire. Apport de la télédétection et des SIG. Thèse de doctorat, Université de Cocody. 155P.
50. **Vincent, K.; Mwebaza-Ndawula, L.; Makanga, B. and Nachuha, S.** (2012). Variations in zooplankton community structure and water quality conditions in three habitat types in northern Lake Victoria. Lakes & Reservoirs: Research & Management, 17(2): 83-95.

51. **Wang, L.; Shen, H.; Wu, Z.; Li, Y.; Su, H.; Zheng, W.; Chen, J. and Xie, P.** (2020). Warming affects crustacean grazing pressure on phytoplankton by altering the vertical distribution in a stratified lake. Science of the Total Environment, 734: 139195. https://doi.org//10.1016/s.scitotenv.2020.139195
52. **Williamson, C.E.; Fischer, J.M.; Bollens, S.M.; Overholt, E.P. and Breckenridge, J.K.** (2011). Toward a more comprehensive theory of zooplankton diel vertical migration: integrating ultraviolet radiation and water transparency into the biotic paradigm. Limnology and oceanography, 56(5): 1603-1623.
53. **Zébazé Togouet, S.H.; Tuekam Kayo, R.P.; Boutin, C.; Nola, M. and Foto Menbohan, S.** (2011). Impact de la pression anthropique sur l'eau et la faune aquatique des puits et sources de la région de Yaoundé (Cameroun, Afrique Centrale). Bulletin de la Société d'Histoire Naturelle de Toulouse, 147: 27-41.