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# Trophic food web in a small African tropical reservoir.

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**ABSTRACT**

Feeding of fish species andnycthemeral cycle of phytoplankton andchlorophyll a (chla) of Adzopé reservoir haveconducted between 06:00 and 03:00 h in intervals of 3 hours at the deepest point (S)from May 2008 to February 2009. To analyze phytoplankton community, species richness and total density(TD) were used, whereas,chla were obtained with Lorenzen method (Lorenzen, 1967). Feeding based bothTD and chla, were calculated from MAXIMS software to determine evacuation and ingestion rates (E.R. and I.R.), daily ration(D.R.) and infinite stomach content (I.S.C.)of fish active species.Similar variation of feeding and stomach content weight based bothTD and chla were observed. Generally, at all seasons, peaks of feeding resulting bothTD and chla were obtained during the day at 9h.Daily ration based on chla were highest than those based on TD. D.R. observed between 15h and 17h, highest I.R. resulting of chla at all seasons indicated higherfood contribution of *Oreochromisniloticus* (Linnaeus, 1758) which had represented 60% of fisheries.Using MAXIMSsoftware on total density and chla contributed to understanding of food web from Adzopé reservoir.

**KEYWORDS:**Phytoplankton, fish, MAXIMS software,West Africa.

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## I. INTRODUCTION

The development of efficient management programs of the reservoir water quality and their functioning requires enough knowledge about the ecological metabolism of the system. Understanding this metabolism means studying the processes involved and the energy transfer of the diverse trophic levels. Trophic interactions between primary producers and consumers are mediated through numerical predation but also through indirect pathways, such as nutrient regeneration [1; 2; 3]. In interactions between primary producers and grazers, nutrient recycling plays an important role for primary production [4].In effect, relationships between production rates of the primary producers and fishes, the two endpoints of the food web, have been described [5]. Thus, food chain theory predicts that with increasing nutrient levels, algal biomass does not necessarily increase as a greater part of the algal biomass production is removed by a growing herbivorous zooplankton community. However, if planktivorous fishes are present, algal biomass will increase proportionately, as the planktivorous will keep the herbivorous at a low level [6; 7; 8; 9; 10]. This theory has predicted natural dynamics reasonably well with respect to broad system variables such as total abundance and biomass [10; 11].

Adzopéreservoir situated in full locality plays a vital role in commercial fisheries and main drinking water reservoir of the city. Sound ecological management is necessary and it is necessary to study their fundamental ecosystem dynamics to assure their proper utilization and conservation. Phytoplankton productivity and

chlorophyll a biomass along with related parameters can be used as indices of trophic status and fisheries resource potential. The aim of this survey is to study nycthemeral variability of phytoplankton, chlorophyll a biomass and energy transfer from primary producers to fish, as a general approach to the energy flow along a simplified food-web.

## II. LITERATURE REVIEW

In Côte d'Ivoire few studies on trophic level have been conducted [12; 13; 14; 15].However, never studies were conducted in nycthemeral variation seems to respond to chemical, physical and biological parameters with regard of food web of fish based on total density and on chlorophyll a. Nevertheless, this is important to understanding aquatic environment alterations. Top predators can have substantial effects on specieslower down in the food web [16; 17; 18], either through numericalpredation or through indirect pathways. Predators ingestprey and recycle nutrient, thereby increasing the nutrientavailability of primary producers [19]. Furthermore, how different species are influencedby top predators depends also very much on theheterogeneity and shape of the food web [20]. Some consumer species can be reduced throughdirect consumption by predators, thus resulting inpositive effects on primary producer species, while other consumers increase in abundance through competitiverelease [21; 22].

## III. MATERIALS

Study area and sampling site

Adzopé Reservoir (6°10'52" and 6°12'15" N and 3°85'65" and 3°86'73" W) (Fig. 1), is located in the south-east of Côte d'Ivoire that belongs to the subequatorial zone [23]. This locality is characterized by four climatic seasons: Long rainy season (March-July); Short dry season (August); Short rainy season (September - November); Long dry season (December-February). Adzopé Reservoir, connected with temporary rivers inflow, receives direct run-off during the rainy season. The dwelling sewage flows though permanently into the reservoir. The total area of the reservoir is estimated at 61.44 hectares. The reservoir is characterized by a mean depth of 4.91 m and a length of about 2 km. The banks of the reservoir are occupied by residential dwellings and market gardening. The hydrological regime of this reservoir depends on precipitations.Sampling station (S), characterized by 6.3m average depth, is located a central zone of Adzopé'reservoir. This station, strongly influenced anthropogenically and relatively invaded floating macrophytes (*Fuirenaumbellate*Rottb. (Cyperaceae) and *Cyclosorusdentatus* (Forssk.)Ching (Thelypteridaceae), is located near a turbulence zone (6.5m average depth) characterized by the presence of dam.

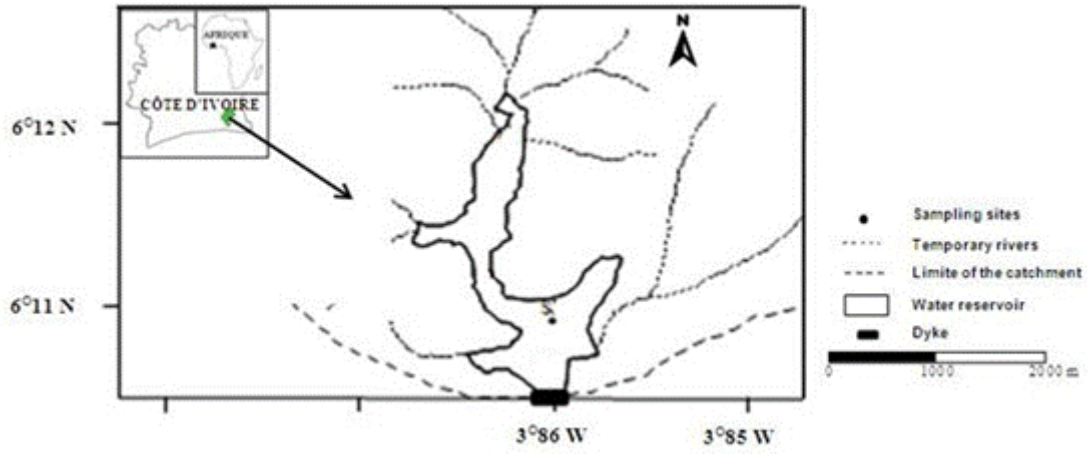


**Figure 1: Adzopé reservoir showing the sampling site (UTM, Universal Transverse Mercator) [24]**

**Environmental parameters**

Aqualitic pH 24 used for pH value, Aqualitic OX24 for dissolved oxygen, and, Aqualitic CD24 for conductivity (CND) and transparency (Tr).

**Phytoplankton**

Van Dorn bottle of 2.5 L of capacity was used for phytoplankton and chlorophyll a

Lugol's solution was used for phytoplankton conservation

Olympus BX40 microscope equipped with tracing and measuring devices was used for phytoplankton analysis.

Standard works [25;26] and more specific literature [27; 28; 29; 30; 31; 32; 33; 34] were used for the species classification.

DIAVERT inverted microscope was used for phytoplankton density

Whatman GF/C filters was used for chlorophyll a
Coolbox and freezer were used storingfor samples chlorophyll a. Acetone was used as extraction solvent,and the DR 2010 spectrophotometer was used to measure absorbance of the centrifuged extract

**Fish**
Purchase of fish with fishermen

**Food web**
MAXIMS EXCEL 5.0 software was used for food web interactions

## IV. METHODOLOGY

### 4.1 Environmental parameters

Temperature, pH, dissolved oxygen, conductivityand transparency were determined in situ between 06:00and 03:00 h in intervals of 3 hours at the deepest point of Adzopé Reservoir (S).The Aqualitic CD24 was used to assess water temperature and conductivity. Dissolved oxygen was measured with the Aqualitic OX24 instrument, while pH was measured using Aqualitic-pH24 equipment. These measures were carried out in order to represent the four climatic seasons.

### 4.2 Phytoplankton sampling and analysis

Sub-samples of 50 mL were gathered with Van Dorn bottle and preserved with 200 µLLugol's solution for phytoplanktonat the same station (S) and sampling hours of physical-chemical parameters. These samples were examined in the laboratory using an Olympus BX40 microscopeequipped with tracing and measuring devices. Before microscopic identifications, organic substances on the samples were removed using $HNO_3^-$ for diatoms [35]. Aliquots were settled in 5 or 10 ml settling chambers and density of phytoplankton was estimated using the method [36] as modified[37], with a DIAVERT inverted microscope. To analyze phytoplankton community structure, species richness and population density (cells/L) were used.

### 4.3 Sampling and analysis of chlorophyll a

Water samples for chlorophyll a were collected at the same station and sampling hours of physical-chemical parameters. Samples were taken in the euphotic zone and pooled before filtration. For chlorophylla concentrations, 500 mL of water were filtered through Whatman GF/C filters, and filters with phytoplankton were transported to the laboratory in a coolbox and stored in a freezer for not more than one day. Acetone was used as extraction solvent; the absorbance of the centrifuged extract was measured spectrophotometricallybefore and after acidification [38]. The results are given by the following formula:

$$chla(\mu g/l) = \frac{26{,}7 \times (E_1 - E_2) \times V}{l \times V_g}$$

E1: absorbance before acidification ($DO_{665}$-$DO_{750}$); E2: absorbance after acidification ($DO_{665}$-$DO_{750}$); V: volume of acetone (ml); Vg: volume of water filtered; l: length of the optic journey of the vat (cm).

### 4.4 Fish of Adzopé reservoir

During the study periods, sampling the fish were realized by fisher in Adzopé reservoir. The fish were identified with standard works [39; 40]. Correct taxonomic species names was obtained with www.fishbase.org.

### 4.5 Food web interactions

Food web parameters of fishes, based on phytoplankton density and chlorophyll awas calculated from MAXIMS EXCEL 5.0 software[41; 42]. The nycthemeraldata of total density and chla were tested in the MAXIMS software which calculate during the finding periods, evacuation and ingestion rates, sum of squared residuals, daily ration and infinite stomach content of fishactive species of Adzopéreservoir for each sampling period.

## V. RESULTS AND DISCUSSION

**Result 1:**Nycthemeral patterns of temperature, conductivity, pH and dissolved oxygen were shown by figure 2. During the day, between 6 and 15 h, values of temperature were highestwith a peak at 12 h at all seasons. However, at the 18 h, these values decrease and become minimal in the night. Kruskal-Wallis test indicated that temperature varied significantly ($p < 0.05$) between 12 and 3 h. Conductivity were maximum (> 180 µS/cm) at all hours during LDS. In contrast, minimum values (< 180 µS/cm) were recorded during LRS, SDS and SRS at all hours. With regard to the pH, the values ranged between 8.11 and 8.22 were basic and presented very lower variations of data observed at all hours during LRS. pH values were neutral during the day between 6 and 12 h (7.21-7.41) and acid during the night between 18 and 3h (6.02-6.25) in SDS. Moreover, pH values wereacid at

all hours during SRS (6.17-6.69) and LDS (5.24-6.57). Higher concentrations of dissolved oxygen were observed between 9 and 18 h and at 3h during SDS(6.1-7.6 mg/L and 6mg/L), between 12 and 3h during SRS(6.16-8.48 mg/ L) and between 9 and 3h during LDS (6.1-7.87 mg/ L). Lower concentrations of dissolved oxygen were notedatall hours during LRS, at 21h, at 24h and at 6h (4.5; 4.2 and 5.6mg/L) during SDS, between 6h and 9h (5.34 and 5.9 mg/L) in SRS, and at 6h (4.89 mg/L) during LDS. Differences in variation of dissolved oxygen were 1.10, 3.40, 3.14 and 3.11 mg/l for LRS, SDS, SRS and LDS respectively.

**Discussion 1:**Higher values of temperature observed during the day between 6h and 15h with a peak recorded at 12h at all season promote the photosynthetic activity of the phytoplanktonic community involving highest values of pH and dissolved oxygen concentrations. These results reveal some similarities with the situation observed bysome authors [43].

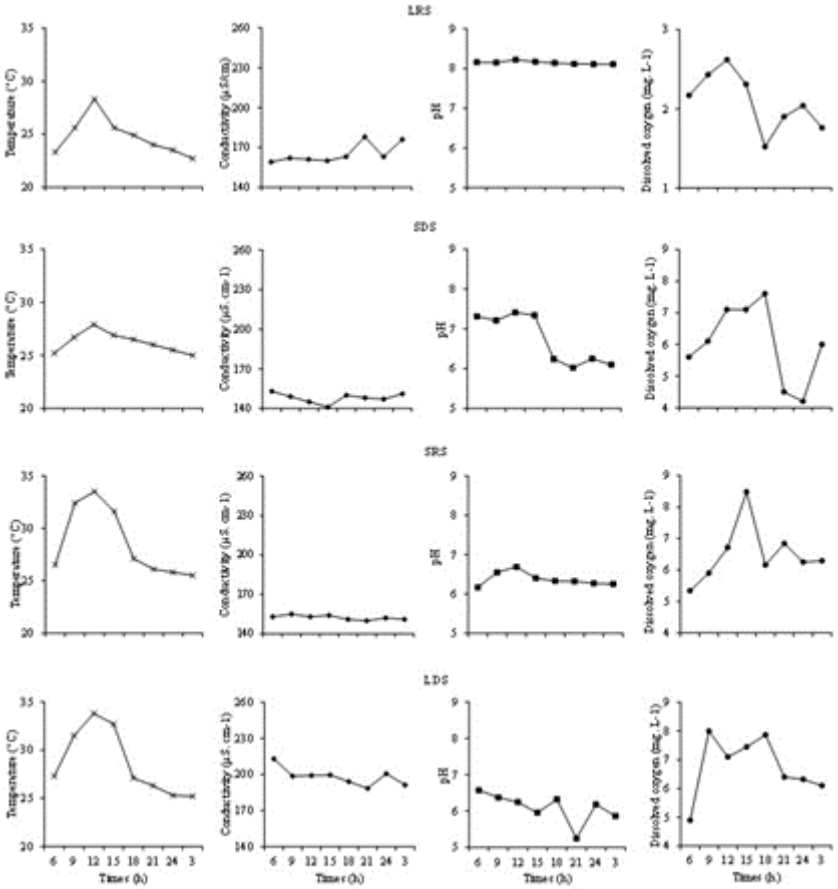


**Figure 2: Nycthemeral variations of temperature, conductivity, pH and dissolved oxygen during the study period. h: hours**

**Result 2:**A total of 190 taxa, consisting of the Chlorophyta (74 taxa), Euglenophyta (53 taxa), Bacillariophyta (33 taxa), Cyanobacteria (21 taxa), Pyrrhophyta (5 taxa) and Xanthophyta (4 taxa) were observed. During the four seasons, significant oscillation were recorded in number of taxa at each hours (Fig. 3). Number ranged between 17 taxa at 12h and 91 taxa at 18h. Highest number were noted during SDS at 9h (61 taxa), SRS at 18h (91 taxa) and 21h (59 taxa) and during LRS at 6h (60 taxa), 12h (62 taxa) and at 24h (61 taxa). In contrast, lower number was recorded during LRS at 12h with 17 taxa.

**Discussion 2:**During the night, higher pH values observed on the surface at all seasons were associated to photosynthesis of phytoplanktonic algae characterized by highest number at 21h (59 taxa) during SRS and at 24 h (61 taxa) in LRS. According [44], phytoplankton and other aquatic vegetation remove carbon dioxide, which significantlyinfluences the pH, from the water during photosynthesis. The small pH variations indicate high buffering capacity for the lake, which may be supported by the elevated alkalinity observed. Environments with elevated alkalinity present small variations of pH, even with the occurrence of high photosynthetic rates, when the consumption of $CO_2$ is immediately compensated by the $HCO_3^-$ dissociation. These results were similar with the results obtained by some author[45].

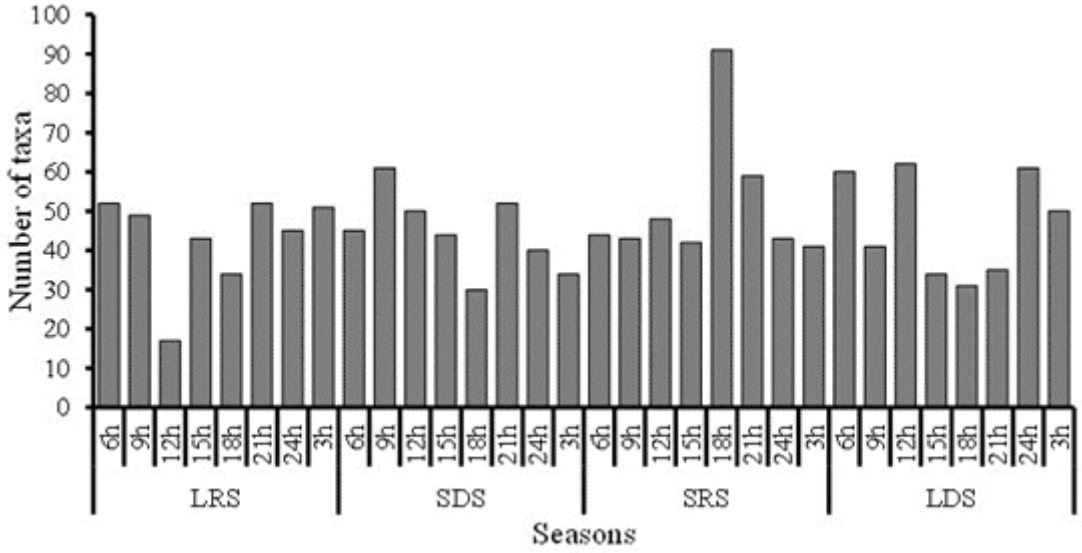


**Figure 3: Temporal patterns in number of taxa at the deepest point of Adzopé Reservoir. LRS: long rainy season; SDS: short dry season; SRS: short rainy season; LDS: long dry season.**

**Result 3:**Figure 4 presentsnycthemeral cycle of each phylum duringsampling seasonsat the deepest point of Adzopé Reservoir. This number specie was characterized by highest number of taxa in the Euglenophytaand Chlorophyta during LRS at 6h and 9h (18 and 18 taxa; 18 and 15 taxa) and at 21h (13 and 26 taxa), during SDS between 6h and 15h (14 and 15 taxa; 22 and 15 taxa; 24 and 14 taxa; 16 and 15 taxa), during SRS between 6h and 12h (18 and 14 taxa; 19 and 15 taxa; 12 and 21 taxa) and at 18h with 26 and 25 taxa and at 21h with 17 and 24 taxa respectively, and during LDS between 6h and 12h (18 and 22 taxa; 15 and 14 taxa; 23 and23 taxa). Moreover, higher number of taxa in Bacillariophyta were noted at 9h (19 taxa) during SDS, at 18h (27 taxa) during SRS and during LDS at 24h (27 taxa) and 3h (18 taxa) respectively. The number, observed in each phyla during different hours and seasons, was following by Cyanobacteria at 6h (9 taxa), 18h (10 taxa) and 21h (8 taxa) during LRS, at 12h (8 taxa) and at 18h (9 taxa) in SRS respectively.

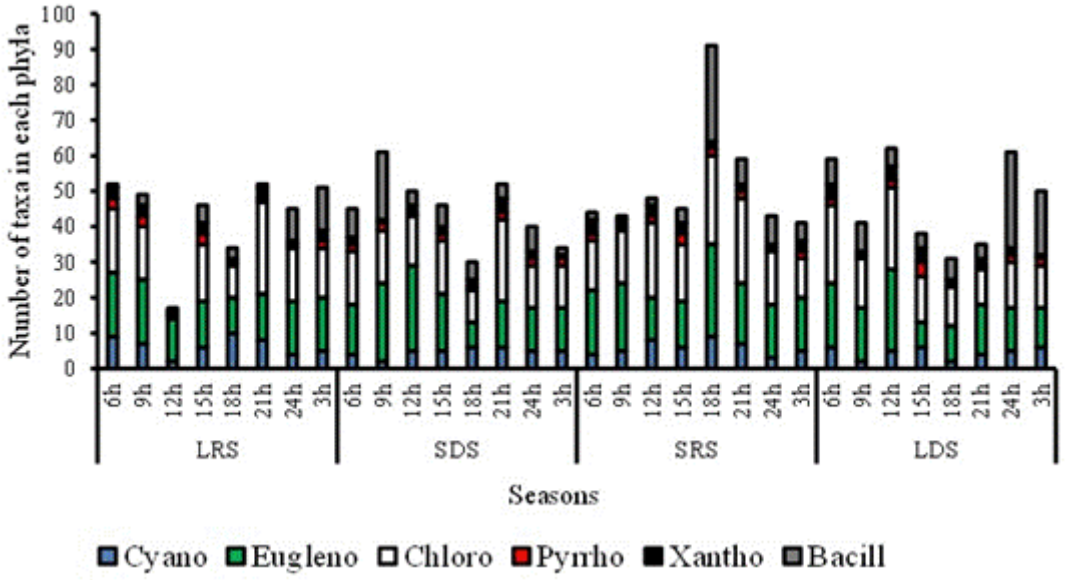


**Figure 4: Nycthemeral variation of species richness at the deepest point of Adzopé Reservoir during study period. h: hours; Cyano: Cyanobacteria; Eugleno: Euglenophyta; Chloro: Chlorophyta; Pyrrho: Pyrrhophyta; Xantho: Xanthophyta; Bacill: Bacillariophyta; LRS: long rainy season; SDS: short dry season; SRS: short rainy season; LDS: long dry season.**

**Discussion 3:**At peak times, where the highest values of temperature were noted, number of taxa recorded in Adzopé reservoir where highest with 61 taxa and increasing total density (531 $10^5$ cell/L) in SDS at 9h

characterized by a highest number of Euglenophyta and Chlorophyta (22 and 15 taxa), 60 and 62 taxa during LRS characterized by a highest number of them at 6h (18 and 18 taxa), lowest number at 12h (12 and 1 taxa) and lower total density at all hours. During these seasons at these hours, pH values were neutral (7.21-7.41) and basic (8.11-8.22) respectively, whereas increasing dissolved oxygen concentration observed during the day was related to the metabolism of the Adzopé reservoir.Thus, highest number of taxa recorded at 18h (91 taxa) during SRS were characterized by the same phylum observed during highest temperature values with 26 and 25 taxa at 18h. The phylum were following by high number of Bacillariophyta (27 taxa) and Cyanobacteria (9 taxa) at 18h during SRS. The result will due to according to some authors [46] at the resident time of the algae within the euphotic zone and water movements, although light attenuation depends chiefly upon the phytoplankton density, the growth success of individual species is related not only to the photosynthetic capacity of the algae, the nutrient status of the cells, and respiration losses. For this author, the interaction between excess density and water movement was manifested by the observed patterns of vertical phytoplankton distribution.

**Result 4:**During the hours of collection, seasonally variation of phytoplankton density in Adzopéreservoir were comprised between 50 $10^5$ cell/L and 939410$^5$ cell/L (Figure 5). Minimum of phytoplankton density were recorded at 24h and 15h during LRS and SRS respectively, whereas maximum total density was noted at 15h in SDS. Increasingof the total densityduring the day in SDS between 6h (86 $10^5$ cell/L) and 9h (531 $10^5$ cell/L),whereas a decreasing of the total density between 9h (531 $10^5$ cell/L) and 12h (390 $10^5$ cell/L),following by an increasing of total density between 12h (390 $10^5$ cell/L) and 15h (9394 $10^5$ cell/L), and a decreasing abruptly of total density between 15h (9394 $10^5$ cell/L) and18h (82 $10^5$ cell/L),with an increasing abruptly of total density during the night between 18h (82 $10^5$ cell/L) and 21h (274 $10^5$ cell/L),and a decreasing abruptly of total density between 21h (274 $10^5$ cell/L) and 24h (87 $10^5$ cell/L)and increasing slightly of total density between 24h (87 $10^5$ cell/L) and 3h (105 $10^5$ cell/L).During SRS, increasingtotal density were registered between 9h (99 $10^5$ cell/L) and 12h (431 $10^5$ cell/L) and between 15h (50 $10^5$ cell/L) and 21h (429 $10^5$ cell/L).At this period, the highest decreasing of total density was noted between 21h (429 $10^5$ cell/L) and 24h (49 $10^5$ cell/L). During LDS, total density decreased abruptly between 6h (215 $10^5$ cell/L) and 9h (73 $10^5$ cell/L) and increased abruptly between 9h (73 $10^5$ cell/L) and 12h (258 $10^5$ cell/L). In same season, between 15h (79 $10^5$ cell/L) and 21h (101 $10^5$ cell/L), total density were low and increased abruptly between 21h (101 $10^5$ cell/L) and 24h (376 $10^5$ cell/L). At this season, between 24h (376 $10^5$ cell/L) and 3h (116 $10^5$ cell/L), total density decreased abruptly. In contrast, the lower total density were observed at all hours (66 - 199 $10^5$ cell/L) during LRS.

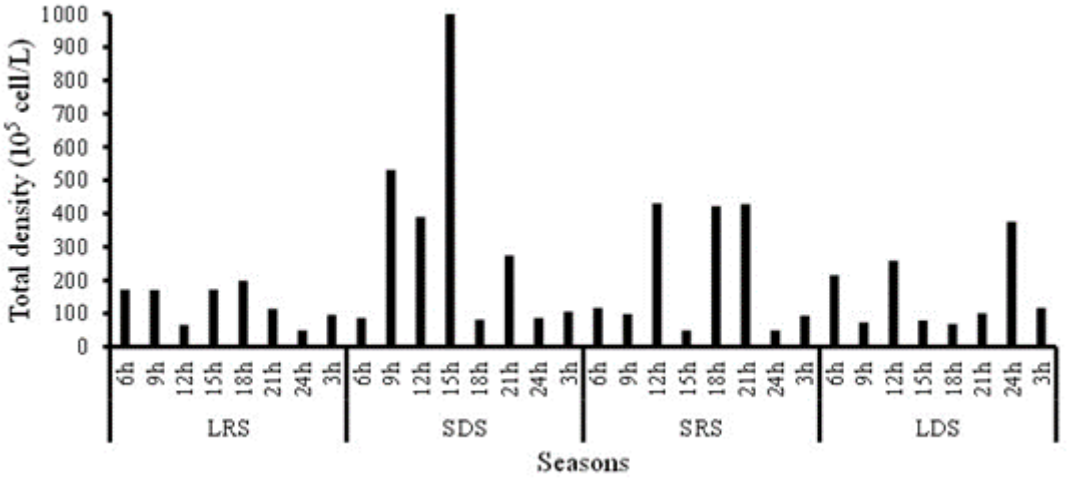


**Figure 5: Temporal patterns of total density at the deepest point of Adzopé Reservoir. h: hours; LRS: long rainy season; SDS: short dry season; SRS: short rainy season; LDS: long dry season.**

**Discussion 4:**The peak of temperature noted at 12h did not coincide with the highest phytoplankton density (9394 $10^5$ cell/L) as observed in this study during SDS. This was attributable to rainy season influx of nutrients from land drainage and the effect due to phytoplankton flushing.

**Result 5:**Nycthemeral phytoplankton contribution during each season were presented in figure 6. Most of the abundance was represented by only 3 of the 6 phylums: the Cyanobacteria, the Chlorophytaand the Euglenophyta. Phytoplankton analysis indicated that Cyanobacteria were dominant above 44% of the samples during sampling hours and seasons, whereas at these periods, Chlorophytaand Euglenophytawere dominant

above 18% and 9% of them, respectively. In samples where the latter were dominant, Cyanobacteria were generally subdominant.The group dominated most of sampling hour and season periods by 6 taxa that are *Microcystisaeruginosa* (Kütz.) (Kütz.), *Merismopediapunctata*Meyen, *Pseudanabaena* cf. *limnetica* (Lemmerm.) Komárek, *Anabaena constricta* (Szafer) Lauterborn, *Anabaena*sp and *Lyngbyamartensiana*Menegh. exGomont.Species of *Trachelomonasvolvocina*Ehrenb.was the only taxa which contributed the largest proportion to Euglenophyta abundance. Chlorophyta was characterized by species of *Crucigeniellacrucifera*(Wolle) Komárekand *Dictyosphaeriumpulchellum*H.C.Wood. Other important phytoplankton species observed were the *Peridiniumcinctum* (Müller) Ehrenbg and *Karenia*sp. 2 in Pyrrhophyta,*Tetraëdriellagigas*(Pascher) G.M.Sm. and *Acanthoceraszachariasii*(Brun) Simonsenfrom Xanthophyta and Bacillariophytarespectively.

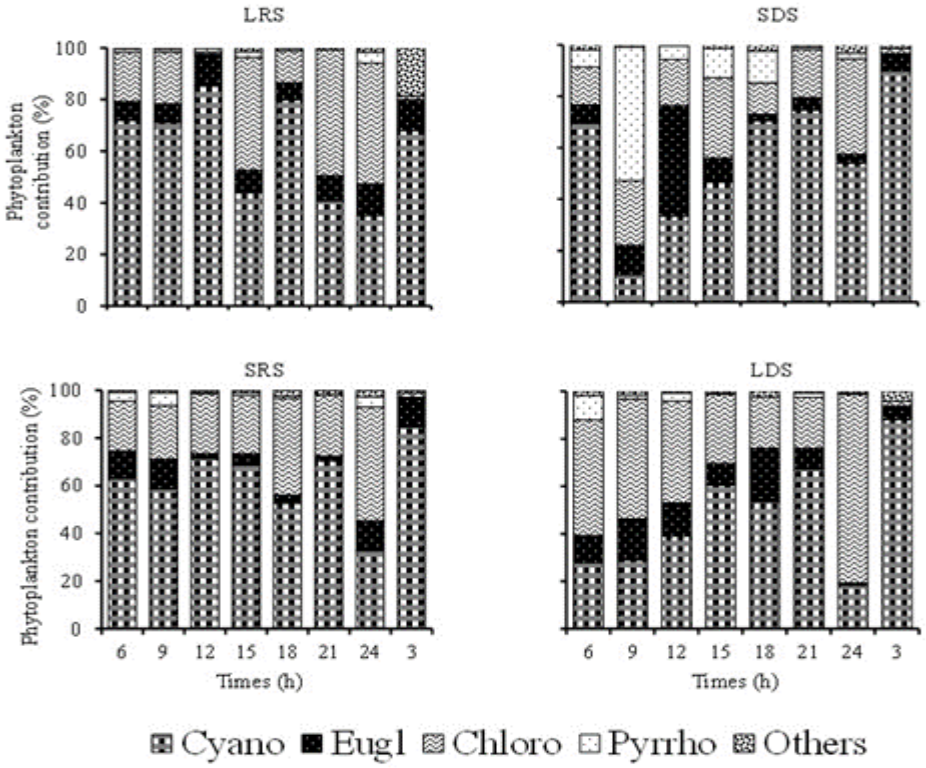


**Figure 6: Community succession at the deepest point of Adzopé Reservoir during hours (h) and seasons sampling. Cyano: Cyanobacteria; Eugl: Euglenophyta; Chloro: Chlorophyta; Pyrrho: Pyrrhophyta; LRS: long rainy season; SDS: short dry season; SRS: short rainy season; LDS: long dry season.**

Nycthemeral patterns of food web bothtotal density and chlorophyll a,and stomach content weight from fishcalculeted by MAXIMS software were presented in figures7 and 8. In general, similar variation of food webbasedontotal density and chla (Fig. 7), and stomach content weight resultingon total density and chla (Fig. 8) were observed.

Beginning food web of fish on total density (Fig. 7a) was noted between 6h (0.317 g of weigth of total density obtained in stomach content (Fig. 8a)) and12h (0.428 g of weigth of total density obtained in stomach content (Fig. 8a)) with a peaks observedat 9h (0.399 g of weigth of total density obtained in stomach content (Fig. 8a)) and at 12hduring SRS. At this season, beginning food web of fish on chla (Fig. 7b) was observed between 3h (0.77 g of weigth of chla obtained in stomach content (Fig. 8b)) and 9h (8.60 g of weigth of chla obtained in stomach content (Fig. 8b)) with a peaks recorded at 6h (7.80 g of weigth of chla obtained in stomach content (Fig. 8b)) and at 9h.During LDS, beginning consumption of total density (Fig. 8a) and chla(Fig. 7b) were registered between 21h (0.101 g of weigth of total density found in stomach content (Fig. 8a) and 0.3 g of weigth of chlafound in stomach content (Fig. 8b))and 9h (0.273 g of weigth of total density found in stomach content (Fig. 8a) and 4.5 g of weigth of chla found in stomach content (Fig. 8b)) with the peaks were observed at 6h (0.228 g of weigth of total density obtained in stomach content (Fig. 8a),9h and18h (0.296 g of weigth of total density found in stomach content (Fig. 8a)) for total density and at 9h for chla.In SDS, beginning consumption of total density was registered between 24h (0.083 g of weigth of total density found in stomach content (Fig. 8a)) and 9h (0.531 g of weigth of total density obtained in stomach content (Fig. 8a)) with the peakswere noted at6h (0.519 g of weigth of total density noted in stomach content (Fig. 8a)) and at 9h. At this

period, beginning consumption of chla was registered between 24h (0.9 g of weigth of chlafound in stomach content (Fig. 8b)) and 9h (3.9 g of weigth of chlafound in stomach content (Fig. 8b)) with the peaks noted at 6h (3.7 g of weigth of chlaobtained in stomach content (Fig. 8b)) and at 9h. During LRS, beginning consumption of total density was registered between 9h (0.171 g of weigth of total density noted in stomach content (Fig. 8a)) and 15h (0.201 g of weigth of total density found in stomach content (Fig. 8a)) with the peaks noted at 12h (0.199 g of weigth of total densitynoted in stomach content (Fig. 8a)) and at 15h. At this season, beginning consumption of chla was registered between 3h (0.4 g of weigth of chlafound in stomach content (Fig. 8b)) and 9h (9.7 g of weigth of chla found in stomach content (Fig. 8b)) with the peak obtained at 9h.

**Discussion 5:**In general, similar nycthemeral patterns of food web of fish based both total density and chla were shown by MAXIMS software. During study period, chlorophyll a concentrations increased from the onset of the photoperiod until its termination before peak biomass was achieved. According to [47; 48], this apparent circadian component of chlorophyll production is consistent with observations on natural communities elsewhere, and the change in the pattern following bloom collapse agrees with the nutrient-induced modification of cell-division patterns described for some species [49]. Ingestion rate (I.R.) based on chla were more highest than I.R. based on total density at hours daily ration between 15h and 17h. Chlorophyll a, although a useful index of total phytoplankton biomass, does not give information on behavior of individual species [46], because chlorophyll a of microscopic macrophytes were included in this chlorophyll a biomass. The concentrations of chlorophyll a above 10 µg/L were typical of eutrophic environments [50], confirming the reservoir Adzopé classification. In effect, Adzopé reservoir was characterized by concentrations of chlorophyll a comprised between 0.4 mg/L (400 µg/L) and 9.7 mg/L (9700 µg/L), an enhanced total density (50-9394 $10^5$ cell/L), dominant Cyanobacteria above 44 % of samples during hours and seasons and stable number of fish production explained thus presence of six taxa of fish (personal observations).

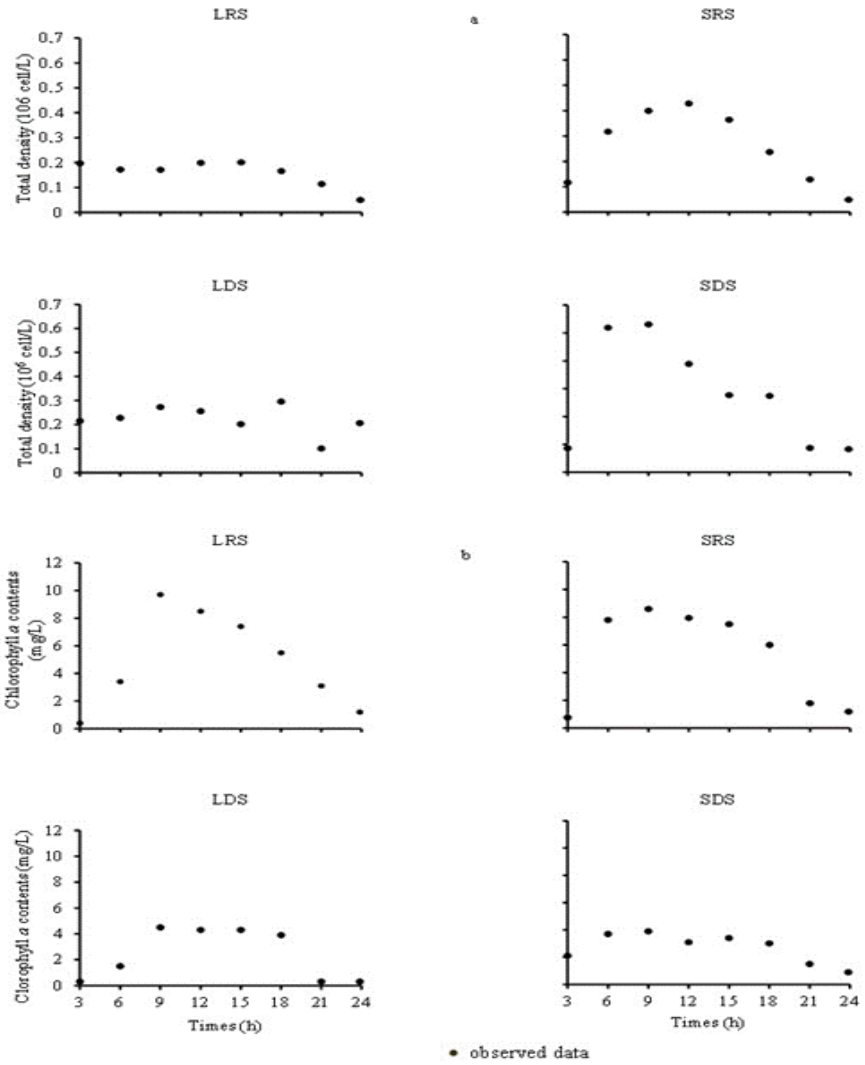


**Figure 7: Nycthemeral pattern of the food web of fish based on total density (a) and chla (b) at the deepest point of Adzopé Reservoir. (•): values observed.**

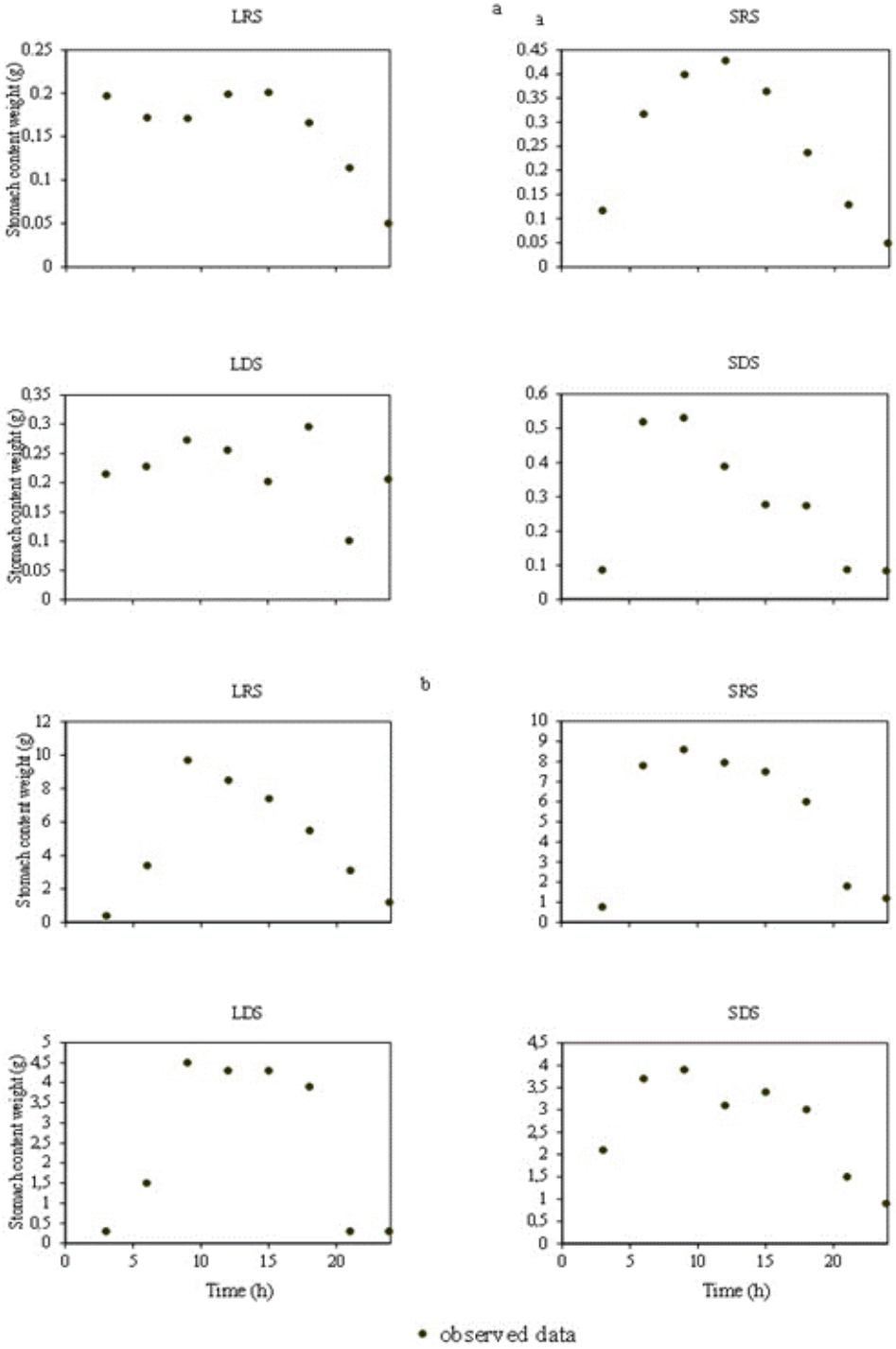


**Figure 8: Nycthemeral variation of the stomach content of fish based on total density (a) and chla (b) at the deepest point of Adzopé Reservoir. (•): values observed.**

Table 1 presents the list of fish recorded during this study. A total of 6 species belong to 6 genus and 4 families were noted. *Oreochromisniloticus* (Linnaeus, 1758), *Coptodonzillii* (Gervais, 1848), and *Hemichromisfasciatus* Peters, 1857 of Cichlidae family, *Clarias*sp. of Clariidae family, *Chrysichthysnigrodigitatus* (Lacépède, 1803) of Claroteidae family and *Heterotisniloticus* (Cuvier, 1829) of Osteoglossidae family.

**Table 1: Fish composition of Adzopé reservoir (personal observations)**

| Families | Species |
|---|---|
| Osteoglossidae | *Heterotisniloticus*Cuvier |
| Claroteidae | *Chrysichthysnigrodigitatus*(Lacépède, 1803) |
| Clariidae | *Clarias*sp. |
| Cichlidae | *Hemichromisfasciatus*Peters, 1857 |
| | *Coptodonzillii*(Gervais, 1848) |
| | *Oreochromisniloticus*(Linnaeus, 1758) |

**Result 6:**Feeding parameters and infinite stomach content based on total density and chladuring sampling seasons were presented in table 2. During the 1rstfeeding period (a), similar ingestion rate (I.R.) per hour based on total density was recorded in SDS (0.16 $g.h^{-1}$) at 8h and SRS (0.2 $g.h^{-1}$) at 9hfrom the end of this period. In contrast, highestI.R.per hour based on total density and onchlawere observed during LRS (2 $g.h^{-1}$) at 15h and SDS (3 $g.h^{-1}$)at 10h50 respectively.At this period, similar I.R. based onchla was recorded during LRS at 11h(0.85 $g.h^{-1}$) and SRS at 9h (0.75 $g.h^{-1}$).Lower I.R.based ontotal density (0.01 $g.h^{-1}$) was noted in LDS at 9h.Evacuation rate (E.R.) per hour based on total density were characterized by increasing of values during LRSat 5h (0.1 $g.h^{-1}$) to SRS at 3h (0.25 $g.h^{-1}$), with decreasing in SDS (0.17 $g.h^{-1}$) and LDS (0.05 $g.h^{-1}$) at 3h respectively at the beginning of the 1rst feeding period. At this period, E.R. per hour based onchla were similar between LRS and SDS (0.15$g.h^{-1}$) at 6h and 3h respectively, and between SRS (0.35$g.h^{-1}$) and LDS (0.3$g.h^{-1}$) at 3h respectively.The 2nd feeding period (b) was characterized at different hours (16h, 15h15, 10h and 15h) by similar values of sum of squared residuals (S.C.R.)based on total density at all seasons. Inversely, higher S.C.R.based onchla were noted during LRS and LDS at 14h50 (8.43 $g.h^{-1}$) and 12h50 (13.32 $g.h^{-1}$) respectively. At this period, lower S.C.R. onchla was recorded during SDS at 13h(2.70 $g.h^{-1}$). Daily ration (D.R.)values based on chla were highest than those obtained by total density. D.R.based on total density showed highest values during short seasons (SDS and SRS) at 16h15 (1.19 g) and 16h (1.47 g) respectively, whereas, lower values were noted in long seasons (LRS and LDS) at 17h with 0.36 g and 0.27 g respectively. In contrast, higher values of D.R. based on chla was registered at 15h20 (18.01 g) during LRS, at 17h (43.71 g) in SRS and during LDS at 15h(19.65 g), whereas lower value was obtained at 15h (9.69 g) during SDS.

**Table 2: Feeding parameters and infinite stomach content of fish based on total density and chlaat the deepest point of Adzopé Reservoir during nycthemeral cycle.**

| | 1rst feeding period | | 2nd feeding period | | ISC (g) | 1rst feeding period | | 2nd feeding period | | ISC (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Beginning | End | Beginning | End | | Beginning | End | Beginning | End | |
| | E.R. | I.R. | S.C.R. (g) | D.R (g) | | E.R. | I.R. | S.C.R. (g) | D.R (g) | |
| | TD | | | | | Chla | | | | |
| LRS | 5h | 15h | 16h | 17h | 0.2 | 6h | 11h | 14h50 | 15h20 | 9.99 |
| | 0.1 | 2 | 0.02 | 0.36 | | 0.15 | 0.85 | 8.43 | 18.01 | |
| SDS | 3h | 8h | 15h15 | 16h15 | 0.81 | 3h | 10h50 | 13h | 15h | 3.85 |
| | 0.17 | 0.16 | 0.01 | 1.19 | | 0.15 | 3 | 2.70 | 9.69 | |
| SRS | 3h | 9h | 10h | 16h | 0.43 | 3h | 9h | 11h50 | 17h | 8.60 |
| | 0.25 | 0.2 | 0.013 | 1.47 | | 0.35 | 0.75 | 6.82 | 43.71 | |
| LDS | 3h | 9h | 15h | 17h | 0.59 | 3h | 12h | 12h50 | 15h | 4.45 |
| | 0.05 | 0.01 | 0.02 | 0.27 | | 0.3 | 2 | 13.32 | 19.65 | |

I.R.: ingestion rate per hour ($h^{-1}$); E.R.: evacuation rate per hour ($h^{-1}$); S.C.R.: Sum of squared residuals (g); D.R.: Daily ration (g); I.S.C.: infinite stomach content (g); h: hours. LRS: long rainy season; SDS: short dry season; SRS: short rainy season; LDS: long dry season. TD: total density.

**Discussion 6:**The ichtyofauna characterized by above 60% of filter microphagous essentially planktivorous and various micro-detritus *Oreochromisniloticus* (Linnaeus, 1758) and others fish such as preferential benthophagous often planktivorous*Heterotisniloticus* (Cuvier, 1829),carnivorous with omnivorous tendency *Chrysichthysnigrodigitatus* (Lacépède, 1803) and *Clarias* sp., carnivorous *Hemichromisfasciatus* Peters, 1857,herbivorouswith omnivorous tendency *Coptodonzillii*(Gervais, 1848)[39; 40] was observed. According some authors [51; 52], natural food of freshwater fish culture contributed increasing of *Oreochromisniloticus* (Linnaeus, 1758) growth at the ratio comprised between 45 % et 74 %. Nycthemeral feeding parameters and infinite stomach content based on total density and chla during sampling seasons had reveal some similarities with the situation observed in laguna bay [53]and semi-intensive aquaculture [14]. These authors revealed that *Oreochromisniloticus* (Linnaeus, 1758) species showed diurnal feeding activity. Yet, according these authors, the fish showed night feeding. During this period, several fishkills (personal observations) and regular collapses of bluegreens were also observed. These result were similar than those obtained by [54] and [55]. Several studies have found that fish exert a top-down effect on phytoplankton through predation on herbivores, and

facilitate phytoplankton growth through nutrient recycling [56; 57]. Fish increased dissolved nutrient concentrations and phytoplanktonbiovolume in pelagic habitats [58]. However, this has grater importance in nutrient limiting conditions. In eutrophic lakes, fish predation on zooplankton may affect the structure and dynamics of plankton more than fish excretion [58]. Thus, in eutrophic Adzopé reservoir, where phytoplankton is nutrient limited during the study period, fish excretions were very less important for phytoplankton growth. Thus, trophic cascading effects on phytoplankton through fish predation are probably more important, although resistant colonial and filamentous Cyanobacteria species such as *Microcystisaeruginosa* (Kütz.) (Kütz.), *Pseudanabaena* cf. *limnetica* (Lemmerm.) Komárek, *Anabaena constricta* (Szafer) Lauterborn, *Anabaena*sp and *Lyngbyamartensiana*Menegh. exGomont dominating the phytoplankton community.

## VI. CONCLUSION

On the basis of the present experimental investigation, the following conclusions can be highlighted.

1. Similarnycthemeral patterns of phytoplankton and food web parameters of fish based on total density and on chlawere noted.
2. Total density, chlorophyll a concentrations and stomach content weight showed same variations during study period.
3. Ingestion rate (I.R.) based on chla were more highest than I.R. based on total density at hours daily ration between 15h and 17h showing highest contribution of *Oreochromisniloticus* which represent 60% of fisheries and microscopic macrophytes.4. The result showed qualitative contribution of Cyanobacteria, Chlorophyta and Euglenophyta in food web of fish recorded in Adzopé reservoir.

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