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# ANGLING AT LAVONONKAHA RESERVOIR (Department of Korhogo, Côte d'Ivoire): ICHTHYOLOGICAL COMPOSITION OF CATCHES AND EXPLOITATION PARAMETERS OF *Oreochromis niloticus* (Linnaeus, 1758)

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**ABSTRACT**

Many small reservoirs in Northern Côte d'Ivoire are used for crop irrigation, livestock rearing or fishing. They generate moderated ichthyological catches for local populations. Thus, strategies for their sustainable exploitation should be put in place. This study was conducted to provide the first data on fishing activity on the Lavononkaha Dam Lake. From June 2020 to July 2021, field studies were undertaken with the objectives of characterising fishing gears used, studying catch composition, and evaluating exploitation parameters of the *Oreochromis niloticus* stock. Results obtained stated the practice of recreational fishing by 41 anglers. These fishermen used a total of 380 fishing lines, 92.11% of which were single fishing rod. Ten fish species were identified in catches with a particular abundance of *Oreochromis niloticus* (48.33%). In the fishery, this species has a longevity tmax of 3.7 years and grows towards asymptotic length $L_\infty$=24.68 cm at a growth rate K=0.810/year. Despite the high number of fishing gears used, the stock of the species is underexploited (E=0.34) and half of the specimens are caught after reaching sexual maturity. Thus, the possibilities of increasing fishing effort to increase yields of this species exist within certain limits to be specified.

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## INTRODUCTION

Northern Côte d'Ivoire has hundreds of dam lakes built since the 1970s. They have always been the driving force behind agriculture and livestock sectors, often supplying surrounding localities with domestic drinking water. Nowadays, many of them are used for fishing purposes (Cecchi *et al*., 2009). Because of their small areas, some of these reservoirs are only used by few fishermen. They are therefore not very attractive. The low catches they generate are generally not considered in statistics. However, this situation should not obscure the important role they play in supplying fish to many households in these localities. The present study examines fishing activity on one of them in the department of Korhogo, specifically in the sub-prefecture of Karakoro. Like other rural localities in the country, prevalence of poverty (56.8% nationally) remains higher than in urban areas (ONP, 2019). As for many low-income populations, fish is often the only accessible source of protein according to Micha and Frank (2004). Moreover, according to FAO (2020), in West Africa, imported fish remains insufficient on national markets where the demand remains higher than the supply. In rural markets, far from coastal areas, this gap is even more marked with prices three to five times higher. Therefore, study of fishing activities in these small reservoirs should be a concern for their long-term exploitation.

In addition, studies on the ichthyological composition of Northern Côte d'Ivoire's dam lakes show the presence of several species. The Cichlidae family is one of the most represented with a particular abundance of *Oreochronis niloticus* species (DA Costa, 2003; Da Costa *et al*., 2004; Kouassi *et al*., 2020). This could be related to its ability to reproduce throughout the year and its varied diet, allowing it to easily colonize many continental aquatic environments. Despite all these potentialities of the species, some bad practices are likely to reduce its stock in each fishery. Consequences are, among others, a reduction in the species lifespan, the capture of smaller specimens or a decrease in fishing yields (Ouattara *et al*., 2006). This work was undertaken at Lavononkaha Dam Lake to provide the first data on fishing activity. The objectives were to characterize fishing gears used, to identify fish species caught and to assess level of exploitation of *Oreochromis niloticus* in this fishery. Results obtained can be used for any rational management policy for this activity.

## MATERIALS AND METHODS

### Study area

#### Lavononkaha Dam Lake

This study was conducted in Northern Côte d'Ivoire, specifically in the Korhogo department. Climate, of the tropical sudanese-guinean type, is marked by two seasons. The rainy season extends from April to October and the dry season from November to May (Jourda, 2009). The department has sixteen (16) sub-prefectures including Karakoro (INS, 2015) where the Lavononkaha Dam Lake is located. This dam has an area of 3 hectares. It was built in 1989 for livestock watering (Silué, 2012).

#### Data collection

The study was conducted from June 2020 to July 2021 over a period of eight months when fishing was most practiced. Fishing gears used by fishermen were observed and characterised. Also, fish species caught were identified *In situ* according to identification keys for West Africa fresh and brackish waters fish species (Stiassny *et al*., 2007) and using Côte d'Ivoire freshwater fish directory (Ouattara *et al*., 2016). For *Oreochromis niloticus* stock study, exploitation parameters were estimated using length frequency method (Gayanilo *et al.,* 2005). For this purpose, on each sampled specimen, total length and body mass were measured using respectively an ichthyometer graduated to the nearest cm and electronic balance branded SCA-301, with a precision of 1 g and a range of 7 kg. Finally, water temperature was also recorded with one reading taken in the morning and a second in the afternoon to obtain the daily average.

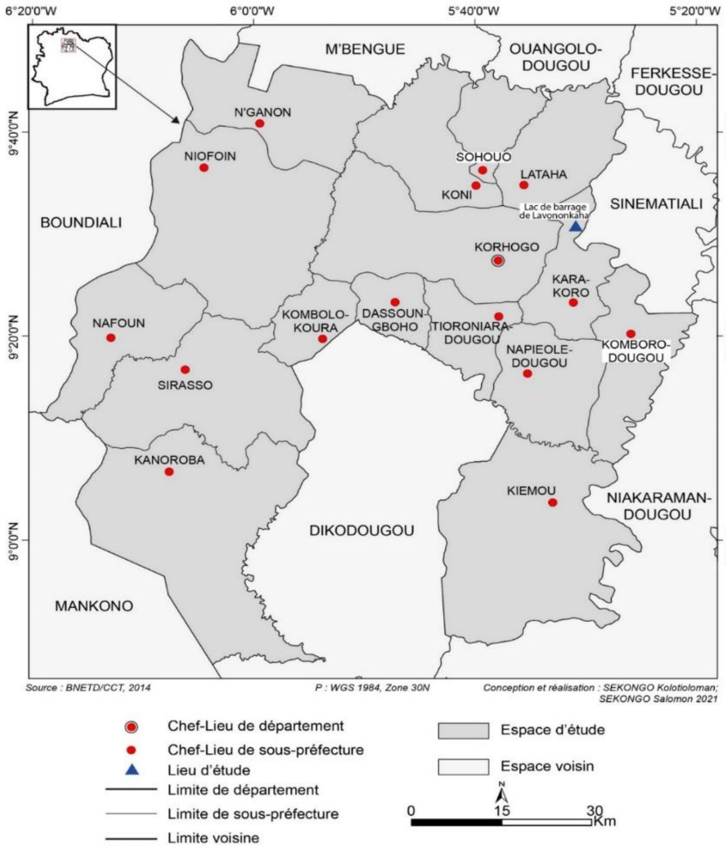



**Figure 1:** Location of the Lavononkaha Dam Lake in Northern Côte d'Ivoire

## Data processing

### Characterisation of fishing gears types

The numbers of each fishing gear type were calculated to determine the respective percentages.

### Catch composition

The fish sampled were grouped by species and family. The parameters determined were specific richness (total number of species), specific or family abundances (number of specimens of a given species or family) and finally relative abundances by species and family (percentage ratio of the number of specimens of a given species or family to the total number of fish sampled).

## Exploitation parameters of Oreochromis niloticus stock

### Length-weight relationship

The relation $Wt=a*Lt^b$ was used for this purpose with Wt corresponding to weight in g, Lt to total length in cm, a to constant and b to allometry coefficient. Isometric growth is observed when b=3 while allometric growth in favour of weight when b>3 and in favour of body length when b<3. The value of b was compared to the theoretical value 3 using Student's t-test (Ben Abdallah *et al*., 2003).

### Length-age relationship

In this study, the age structure of *Oreochromis niloticus* population was estimated from length-frequency data. The Von Bertalanffy (1938) model was used to describe the relationship between the total length and the age: $Lt = L_\infty (1-e^{-K(t-t_0)})$. In this equation, Lt is the predicted length at age t, $L_\infty$ the asymptotic length, K the growth coefficient and $t_0$ the age at which fish would have had zero length. $L_\infty$ and K have been estimated using the ELEFAN I method (Gayanilo *et al*., 2005) and $t_0$ calculated from Pauly's equation (1982): $\log_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038\log_{10}K$. They were used to calculate longevity tmax=3/K (Pauly, 1984) and growth performance index $Ø'=\ln K+2\ln L_\infty$ (Pauly and Munro, 1984).

### Mortality parameters and exploitation rate

Growth parameters estimated previously were used to calculate the total mortality (Z), the natural mortality (M) and the fishing mortality (F). The total mortality was estimated by the length converted catch curve method (Pauly, 1984).
The natural mortality (M) was generated using the equation $Log_{10}M = 0{,}0066-0{,}279xLog_{10}L_\infty+0{,}6543xLog10K+0{,}4634Log_{10}T$ (Pauly, 1980). Finally, the fishing mortality was deduced from the relationship Z=M+F with F=Z-M. Once mortality parameters are known, exploitation rate (E) is calculated from the formula E=F/Z. If E > 0.5 the stock is overexploited, if E < 0.5 the stock is under-exploited and finally if E = 0.5 the stock is optimally exploited (Gayanilo *et al*., 2005).

### Lengths at probabilities of capture

The ascending part of the length converted catch curve that allowed the determination of total mortality represents specimens partially captured by the fishing gear. In addition, it allows the calculation of lengths at which 25%, 50% and 75% of specimens are captured (Gayanilo *et al*., 2005).

### Virtual Population Analysis (VPA)

The FISAT II software allowed the Virtual Population Analysis study. For each length class, output parameters are fishing mortality (F) and average biomass, as well as population reconstructed in numbers (Gayanilo *et al*., 2005).

### Reference points for relative yield and relative biomass per recruit

The ogive selection tool of the FISAT II software uses the Beverton and Holt model modified by Pauly and Soriano (1986). It uses as input data $L_\infty$, K and M. In turn, by varying fishing mortality F, it calculates different values of relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) to draw the corresponding curves and determine the reference points Emax, E0.1 and E0.5. Emax is the exploitation level which maximizes Y'/R, E0.1 is the level of exploitation at which the marginal increase in the relative yield per recruit is 10% of its value at E = 0, and E0.5 is the exploitation rate of reducing stock to half its virgin biomass (Gayanilo *et al*., 2005).

## RESULTS

### Fishing gears: Types and relative percentages

Only angling is practised on the Lavononkaha reservoir using a single fishing rod (Figure 2A), a fishing reel (Figure 2B) and a bottom fishing rig (Figure 2C). Forty-one (41) fishermen had been recorded in the fishery. Most of them set up wooden seats in shallow areas of the reservoir to hold more fishing gears. A total of 380 fishing lines have been listed, 92.11% of which were single fishing rod (Table 1).

**Table 1.** Relative percentages of fishing gears types

| Fishing gears | Numbers | Percentages (%) |
|---|---|---|
| Single fishing rod | 350 | 92.11 |
| Fishing reel | 9 | 2.36 |
| Bottom fishing rig | 21 | 5.53 |
| Total | 380 | 100.00 |

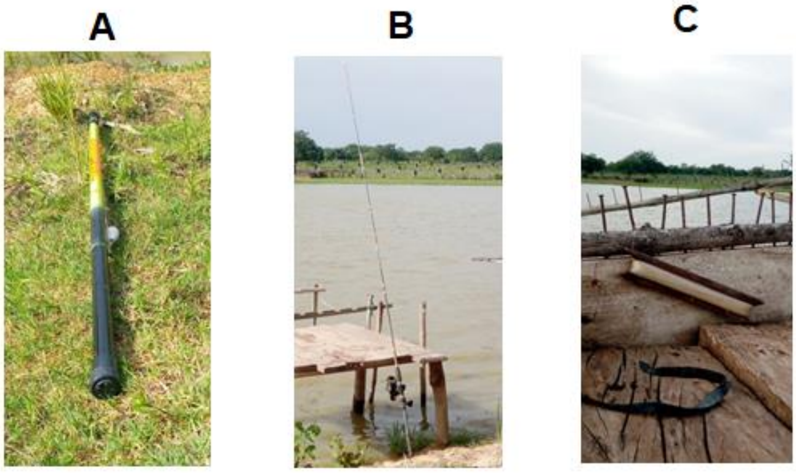



**Figure 2. Pictures of fishing gear types used by anglers**
**A:** Single fishing rod; **B:** Fishing reel; **C:** Bottom fishing rig

**Ichthyological composition of captures**

In total, ten (10) fish species belonging to eight families have been identified in catches. Cichlidae had three species compared to only one for the other families (Table 2). These species are *Oreochromis niloticus, Sarotherodon galilaeus, Sarotherodon melanotheron, Clarias gariepinus, Heterotis niloticus, Schilbe intermedius, Malopterurus electricus, Synodontis schall, Brycinus imberi* and *Chrisychthys nigrodigitatus*. In terms of abundance, Cichlidae constituted more than half of total catches (54.73%). *Oreochromis niloticus* represented 88.31% of the Cichlidae and 48.33% of the total catches, followed by *Clarias gariepinus* (15.86%) and *Heterotis niloticus* (12.10%). These three species represented 3/4 (76.29%) of the fish caught.

**Table 2.** Ichthyological composition of captures

| Families | species | Numbers | Relative abundances (%) | |
|---|---|---|---|---|
| | | | Per species | Per family |
| Alestidae | *Brycinus imberi* | 36 | 2.50 | 2.50 |
| | *Oreochromis niloticus* | 695 | 48.33 | |
| Cichlidae | *Sarotherodon galilaeus* | 36 | 2.50 | 54.73 |
| | *Sarotherodon melanotheron* | 56 | 3.89 | |
| Clariidae | *Clarias gariepinus* | 228 | 15.86 | 15.86 |
| Claroteidae | *Chrisychthys nigrodigitatus* | 21 | 1.46 | 1.46 |
| Malapteruridae | *Malopterurus electricus* | 33 | 2.29 | 2.29 |
| Mochokidae | *Synodontis schall* | 63 | 4.38 | 4.38 |
| Osteoglossidae | *Heterotis niloticus* | 174 | 12.10 | 12.10 |
| Schilbeidae | *Schilbe intermedius* | 96 | 6.68 | 6.68 |

**Exploitation parameters of *Oreochromis niloticus* stock**

The allometry coefficient calculated from length-weight relationship in the present study is b=2.804, significantly different from theoretical value 3. The Von Bertalanffy growth parameters correspond to an asymptotic length $L_\infty$=24.68 cm and a growth rate K=0.810/year. The resulting equation is therefore of the form $Lt = 24.68(1-e^{-0.810(t+0.693)})$. As for the longevity and the growth performance index, they are respectively tmax=3.7 years and $Ø'$= 2.693 (Table 3).

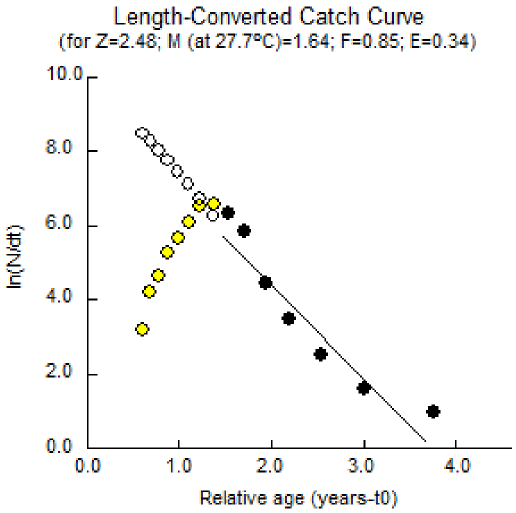
In the fishery, the species of *Oreochromis niloticus* die more from natural causes (M=1.64) than from fishing (F=0.85). The value of exploitation rate is E=0.34 (Figure 3A). However, results of Virtual Population Analysis indicate that size classes between 16 cm and 19 cm are more affected by fishing, with highest pressure on specimens belonging to interval [18 - 19 cm] (Figure 3C; Table IV). The lengths at Probabilities of Capture shows that 50% of specimens are vulnerable to fishing gear at size $L_{50}$ = 14.65 cm. As for the sizes at which 25% and 75% of specimens are captured, they correspond to 13.59 cm and 15.70 cm respectively (Figure 3B). Finally, reference points for relative yield and relative biomass per recruit indicate that exploitation rate likely to reduce the unexploited biomass by half is $E_{50}$=0.382 and that maximising relative yield per recruit is $E_{max}$=0.749 (Figure 3D).

**Table 3.** Exploitation parameters of *Oreochromis niloticus* in Lavononkaha reservoir. N, number of specimens; a, constant; b, allometry coefficient; $r^2$, determination coefficient; t, Student's t-test value; A, allometry; A-, negative allometry; $L_\infty$, asymptotic length; K, growth rate; $t_0$, theoretical age at length=0; Z, total mortality; M, natural mortality; F, fishing mortality; E, exploitation rate; $L_{25}$, $L_{50}$ and $L_{75}$, lengths at which 25%, 50% and 75% of specimens are captured; $E_{50}$, exploitation rate that reduces virgin biomass by half; $E_{10}$, exploitation rate at which the marginal increase in relative yield per recruit is 10% of its value at E=0; $E_{max}$, exploitation rate that maximises relative yield per recruit.

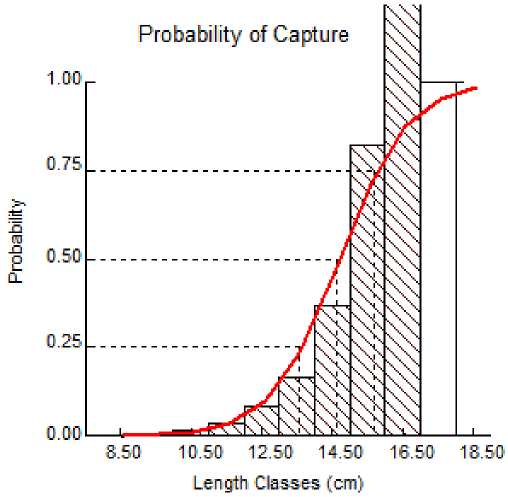
| **Exploitation parameters** | **Values** | | | | | |
|---|---|---|---|---|---|---|
| Length-weight relationship | **N** | **a** | **b** | **$r^2$** | **t** | **A** |
| | 234 | 0.037 | 2,804 | 0,985 | 3.957 | **A-** |
| Growth parameters | **$L_\infty$ (cm)** | **K ($an^{-1}$)** | **$T_0$ (an)** | **tmax (ans)** | | **Ø** |
| | 24,68 | 0,810 | - 0,693 | 3,7 | | 2.693 |
| Mortality parameters | **Z** | **M (à 27,7°C)** | **F** | | | |
| | 2,48 | 1,64 | 0,85 | | | |
| Exploitation rate (E) | **E =** 0,34 | | | | | |
| Lengths at probabilities of capture | **$L_{25}$ (cm)** | **$L_{50}$ (cm)** | **$L_{75}$ (cm)** | | | |
| | 13,59 | 14,65 | 15,70 | | | |
| Reference points at Y'/R B'/R | $E_{50}$ | $E_{10}$ | $E_{max}$ | | | |
| | 0,382 | 0.603 | 0,749 | | | |

**Table 4.** Numerical result of Virtual Population Analysis

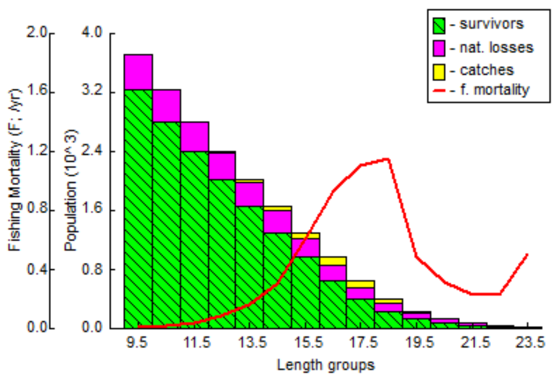
| **Mid-Length** | **Catch (in number)** | **Population (N)** | **Fishing mortality (F)** | **Biomass (tons)** |
|---|---|---|---|---|
| 9.5 | 2 | 3710.32 | 0.0071 | 0.01 |
| 10.5 | 6 | 3245 | 0.0228 | 0.01 |
| 11.5 | 10 | 2807.47 | 0.0411 | 0.01 |
| 12.5 | 20 | 2398.25 | 0.0897 | 0.01 |
| 13.5 | 32 | 2012.39 | 0.1587 | 0.01 |
| 14.5 | 55 | 1649.66 | 0.3085 | 0.01 |
| 15.5 | 92 | 1302.23 | 0.6082 | 0.01 |
| 16.5 | 112 | 962.16 | 0.9295 | 0.01 |
| 17.5 | 99 | 652.55 | 1.1055 | 0.01 |
| 18.5 | 72 | 406.69 | 1.1546 | 0.01 |
| 19.5 | 21 | 232.42 | 0.4819 | 0.01 |
| 20.5 | 10 | 139.95 | 0.3174 | 0.01 |
| 21.5 | 5 | 78.28 | 0.2301 | 0 |
| 22.5 | 3 | 37.65 | 0.2256 | 0 |
| 23.5 | 3 | 12.84 | 0.5 | 0 |



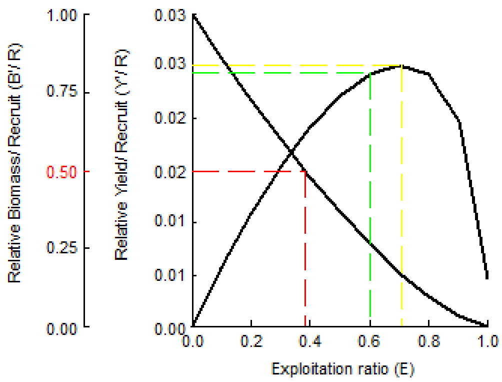

A- Mortality parameters and exploitation rate




B- Lengths at probabilities of capture




C- Virtual Population Analysis




D- Reference points at Y'/R and B'/R

**Figure 3.** Graphic results of *Oreochromis niloticus* exploitation parameters in Lavononkaha reservoir

## DISCUSSION

Only angling is practised on the Lavononkaha reservoir using mainly single fishing rod (92.11%) and the secondary fishing reel and the bottom fishing rig. This situation is particular. Indeed, fishing gears used in Ivorian continental fisheries are generally diversified including sparrow hawk, longline, trap, bamboo trap, seine net and gillnet (Da Costa *et al.* 1998; Diaby *et al*. 2020; Dogbo *et al.* 2020). According to the information collected, the exclusive use of fishing lines in this reservoir is a decision of the dam managers for only recreational fishing purpose. The great number of fishing lines listed, 380 in total in this 3 hectare fishery, could be explained by low catches generated by angling. These gears are of individual use with a small area of action (Attingli *et al.*, 2017). Therefore, to increase their catch, each fisherman has several lines.

Ten fish species, belonging to 8 families, were identified in the catches. Da Costa (2003) mentions specific richness ranging from 18 to 37 in small dams in Northern Côte d'Ivoire with areas ranging from 1 to 16 hectares. It should be noted that these fisheries were exploited by a wide fishing gear type. Attingli *et al.* (2017) also highlighted species richness in relation to use of fishing gear types. In this regard, sparrow hawks are known to capture species living more in surface waters than on the bottom, longlines preferentially capture siluriformes while gillnets and traps have wide range of selectivity. As for bamboo traps, they are very selective towards Chrysichthys (Traoré 1996; Legendre and Lévêque, 2006). Thus, exclusive use of fishing lines could be related to low species richness observed. Furthermore, catches are dominated by Cichlidae (51.31%) and by *Oreochromis niloticus* species (45.72%). Similar observations are regularly made in Ivorian continental fisheries (Shep *et al*., 2013, Kouassi *et al.,* 2020).

In relation to exploitation parameters of *Oreochromis niloticus* in the Lavononkaha reservoir, the allometry coefficient calculated from length-weight relationship is b=2.804, significantly different from the theoretical value of 3. This negative allometry means that weight gain is faster than growth in length (Ben Abdallah *et al*., 2003). The asymptotic length calculated ($L_\infty$=24.68 cm) is lower than those reported in different fisheries (between 28 cm and 58 cm) by Assefa *et al*. (2019). As for growth rates (K=0.810/year), it is on the contrary higher, Assefa *et al*. (2019) reporting K values between 0.4 and 0.7/year. Also, the recorded longevity is tmax=3.7 years while the species are reported to have a lifespan between 4 and 7 years (Ipungu *et al*., 2015). Sparre and Venema (1996) noted that growth of a species differed from stock to stock due to different environmental conditions.

Mortality parameters provide an exploitation rate (E=0.34) below the 0.5 threshold, reflecting under-exploitation of the specie's stock. In terms of prediction, this value of E=0.34 is below the exploitation rate that could reduce the unexploited biomass by half ($E_{50}$=0.382), a reference point below which stock renewal could be compromised (Gayanilo *et al*., 2005). It is also below the exploitation rate that maximises the relative yield per recruit ($E_{max}$ = 0.749) and $E_{10}$ = 0.619. Considering the observations of some authors considering $E_{max}$ as a "target" and "limit" reference point for short-lived species or advocating the use of $E_{10}$ as a more conservative measure for stock than $E_{max}$ (Cadima, 2003; Hoggarth *et al*., 2006), fishing effort for capturing *Oreochromis niloticus* in the reservoir could increase within certain limits without causing harm to its stock. In any case, length at first capture was estimated at $L_{50}$=14.65 cm while sexual maturity of the species in northern Côte d'Ivoire dam lakes is reached between 10.5 cm and 12.9 cm (Lévêque *et al.,* 2006). On this basis, more than half of *Oreochromis niloticus* specimens are caught after reaching sexual maturity.

## CONCLUSION

Fishing in the Lavononkaha reservoir is exclusively of is creational type and carried out with fishing lines and preferably with a single fishing rod. Ten fish species have been found in catches with a particular abundance of *Oreochromis niloticus*. Despite a great number of fishing lines used, the stock of this species is under-exploited and half of the specimens are caught after reaching sexual maturity. Possibilities of increasing fishing effort to increase yields of this species exist within certain limits to be specified.

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## CONFLICT OF INTEREST

There is no conflict of interest for this study.

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