European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 157 No 4 October, 2020, pp.440 - 449
http://www. europeanjournalofscientificresearch.com

# Exploitation Level of the Four Major Cichlid Fish from the Solomougou Dam Lake (Korhogo, Côte D'Ivoire)

**Moustapha Diaby**
*Corresponding Author, Institut de Gestion Agropastorale*
*Université Peleforo GON COULIBALY, Côte d'Ivoire*
E-mail : diae50@yahoo.fr
Tél: (+225) 59 12 91 92

**Koffi Dongo Kouassi**
*Unité de Formation et de Recherches des Sciences Biologiques*
*Université Peleforo GON COULIBALY, Côte d'Ivoire*

**Corinne Manuella Anet Akadje**
*Unité de Formation et de Recherches en Ingénierie Agronomique*
*Forestière et Environnementale, Université de MAN, Côte d'Ivoire*

**Konan N'DA**
*Unité de Formation et de Recherches des Sciences de la Nature*
*Université Nangui ABROGOUA, Côte d'Ivoire*

## Abstract

In Côte d'Ivoire, inland fisheries remain subject to little studies while contributing to major sources of animal proteins and income. This study has been conducted on the Solomougou Dam Lake to assess the stocks of the four cichlid fish most exploited. Fishes were collected monthly from January 2019 to December 2019. Each specimen was counted and its total length measured in cm. For each stock, growth parameters, mortality and exploitation rates and length at first capture have been determined. For *Hemichromis fasciatus* and *Oreochromis niloticus*, 56.46% and 65.45% of the catches belong to the sizes classes [12-15[ and [16-21[, respectively. For *Sarotherodon galilaeus*, the two size classes more abundant are [10-12 [(26.51%) and [16-17 [(10.84%). For *Tilapia mariae*, specimens with lengths between 10 and 13 cm (62.13%) are dominant. The highest value of asymptotic length is for *Sarotherodon galilaeus* (25.2 cm) while the minimum is for *Tilapia mariae* (18.9 cm). *Oreochromis niloticus* has the minimum growth rate (0.42 / year) while *Hemichromis fasciatus* has the highest one (0.96 / year). Total mortalities for the species range from 1.26 to 2.69, natural mortality from 1.06 to 1.92 and fishing mortality from 0.20 to 0.77. All the exploitation rates remain inferior to 0.5, suggesting the under exploitation of different fish stocks. As for lengths at first capture, 50% of the specimens of *Oreochromis niloticus* are captured at 17.77 cm and at 10.36 cm, 9.12 cm and 8.59 cm respectively for *Hemichromis fasciatus*, *Tilapia mariae* and *Sarotherodon galilaeus*.

**Keywords:** Exploitation level, Cichlid fish, Lake Solomougou, Côte d'Ivoire

# 1. Introduction

Inland capture fisheries represent major sources of animal proteins and income in developing countries (Welcomme et al., 2010), while they generally receive little consideration in water resource allocation decisions (Cooke et al., 2013). The lack of awareness is because information about these fisheries is inherently difficult to acquire because they are diverse, often small-scale and highly dispersed (FAO, 2010). However, in the absence of a rational management policy, fishing could lead to a state of overexploitation of the exploited stocks.

The use of analytical models in fisheries management has many advantages. These models take into account the size or age structure of the exploited stocks and their components such as reproduction, growth or mortality. Thus, they make it possible to predict a production by varying the parameters over which we have control, such as nets mesh size (Laurec and Le Guen, 1981). Today, FAO-ICLARM FISAT II program represents a stock assessment tool, allowing users to formulate management options for fisheries, especially in tropical contexts where data is not always available. The present study used this tool to assess the stocks of some cichlid fish from the Solomougou Dam Lake.

This fishery is exploited during all periods of the year. Different fishing gear types are also used there (Kouassi et al., 2019). It also plays an important role in supplying local markets with animal proteins. Therefore, the continuous assessment of the main specie's stocks caught deserves to be made for the optimal exploitation of this fishery. Such studies have not yet been conducted there and the present one is therefore a first.

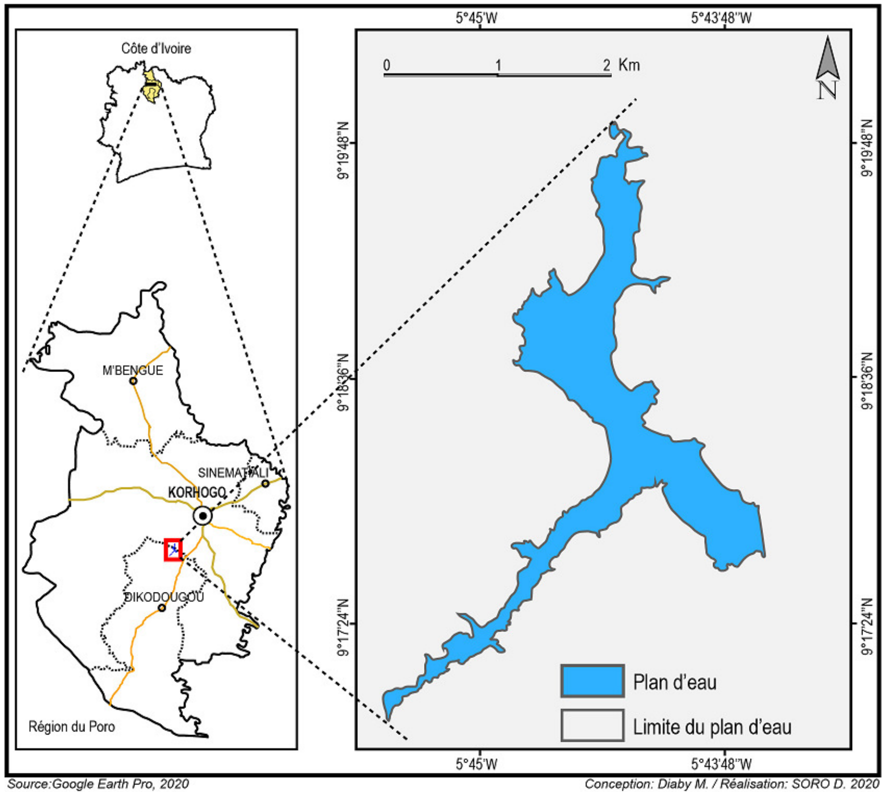
Preliminary studies we have conducted in this waterbody showed a great representativeness of four cichlid fish in catches, represented by *Hemichromis fasciatus*, *Oreochromis niloticus*, *Sarotherodon galilaeus* and *Tilapia mariae*. So, this study aims to assess the stocks of these four species. As for the specific objectives, they will make it possible to determine for the stock of each species, growth parameters, mortality parameters, exploitation rate and length at first capture. These results will provide an indication of the level of exploitation of their stock and, possibly, provide appropriate management measures.

# 2. Materials and Methods

## 2.1. Study Area

This study was conducted in the Solomougou Dam Lake located in the north of Côte d'Ivoire (Figure 1). Its watershed is located between the meridians 5°30' and 6° W and the parallels 9° and 9°30' N (Anonymous, 1962). This hydrosystem represents the fifth largest Dam Lake in the North of the country. It was originally built for agricultural purposes since 1973. But today, it's also now exploited for fisheries purposes throughout the year. In terms of size, it has an area of 500 hectares of water (Traoré, 1996). The climate is of the Sudanese type with an alternation of dry and rainy seasons. The dry season lasts from November to April. It is marked by the harmattan, hot and dry wind blowing from north to south. As for the rainy one, it extends from May to October with maximum rainfall in July and August. Average annual rainfall varies between 1,200 mm and 1,400 mm (Tanguy, 2004).

**Figure 1**: Geographical location of the Solomougou Dam Lake in the north of Côte d'Ivoire




## 2.2. Data Collection

Fish were collected monthly from local fishermen's catches, from January 2019 to December 2019. All captured specimens were taken into account during sampling to the extent possible. Otherwise, a representative sample of the catches was analyzed. Fish were identified to the species level using identification keys of Stiassny et al. (2008). Each specimen was counted and measured in cm for its total length.

## 2.3. Data Processing

### 2.3.1. Growth Parameters Estimation

Fish growth has been studied using Von Bertalanffy growth equation $Lt = L_\infty (1- e^{-k(t-to)})$ (Sparre et Venema, 1996). In this relation, Lt is the predicted length at age t, $L_\infty$ the asymptotic length, K the growth coefficient and $t_0$ age at which fish would have had zero length. The asymptotic length and growth coefficient were estimated using The ELEFAN routine in FISAT II. The theoretical age at length zero was estimated using Pauly's (1982) empirical equation: $\log_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$. Growth performance index ($\phi'$) was calculated using the equation $\phi' = \log_{10} K + 2 \log_{10} L_\infty$ (Pauly and Munro, 1984) and longevity ($t_{max}$) from the relation $t_{max} = 3/K$ (Pauly, 1984).

### 2.3.2. Mortality Parameters Estimation

The total mortality coefficient (Z), which represents the sum of fishing mortality (F) and natural mortality (M), was estimated using the length converted catch curve analysis (Pauly (1984). The equation used in this analysis is $\ln(Ni/\Delta ti)=a+b\times ti$. In this relation, Ni is the number of fish in length class i, Δti is the time needed for the fish to grow through length class i, ti is the age corresponding to the mid length of class i, and b is the slope that estimates total mortality Z after change of sign. The natural mortality (M) was estimated using the equation of Pauly (1980):

$Log_{10}M = 0.0066 - 0.279 \, Log_{10} \, L_\infty + 0.6543 \, Log_{10} \, K + 0.4634 \, Log_{10} \, T$, where $L_\infty$ and K are growth parameters in Von Bertalanffy growth equation and T the annual mean water temperature of the Dam Lake (27.2 ºC calculated in this study according to monthly recordings). Then, Fishing mortality (F) was calculated using the formula F = Z – M.

### 2.3.3. Exploitation Rate Estimation

Once mortality parameters are determined, the exploitation rate (E) was calculated from the equation: E = F/Z (Gulland, 1971). The stock is underexploited if $E < 0.5$, overexploited when $E > 0.5$ and optimally exploited when E = 0.5.

### 2.3.4. Probability of Capture

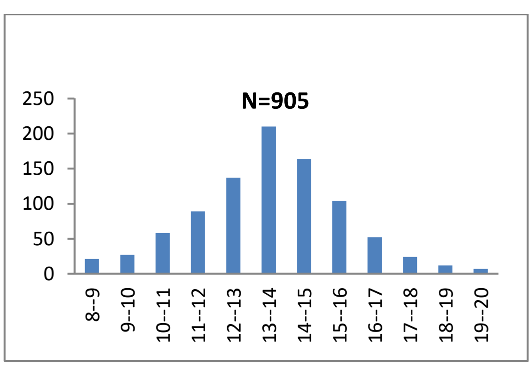
The ascending part of the length converted catch curve is used to generate probability of capture. This parameter is calculated by the ratio of the numbers actually caught with those that "ought" to have been caught for each length group class. The length at capture at probabilities 25%, 50% and 75% corresponds respectively to the length at which 25% ($L_{25}$), 50% ($L_{50}$ called length at first capture) and 75% ($L_{75}$) of the fish entering the gear are retained (Gayanilo et al., 2005).

## 3. Results

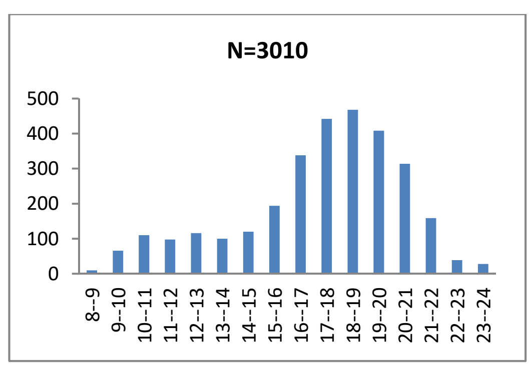
### 3.1. Size Composition of the Catches

The widest length class size is observed for *Sarotherodon galilaeus* ([8-25[), followed by *Oreochromis niloticus* ([8-24[), *Hemichromis fasciatus* ([8-20[) and *Tilapia mariae* ([8-19[) (Figure 2). However, in *Hemichromis fasciatus*'s catches, specimens belonging to the interval length class [13-14 [ are the most abundant, representing 23.20% of the specie's capture. For *Oreochromis niloticus*, catches are dominated by specimens of sizes varying between 16 and 21 cm with an abundance peak observed in the interval length class [18-19[ (15.55% of the capture). *Sarotherodon galilaeus*'stock is characterized by two observable modal length classes. The first peak is for specimens belonging to the interval length class [10-11[(13.60% of the capture), very close to the abundance level of the length class [11-12[ and the second class corresponding to the interval length class [16-17 [ (10.84%). For *Tilapia mariae*, catches are dominated by specimens from the interval length class [11-12[, representing 25.52% of its total catches.

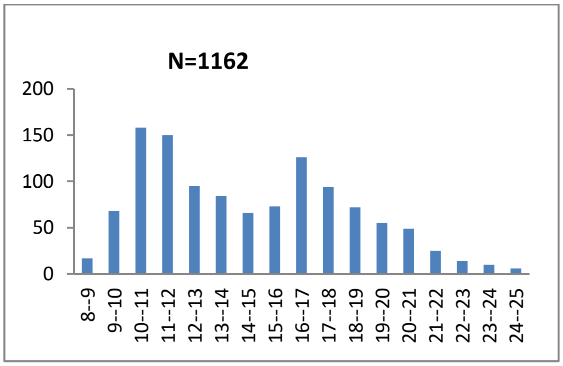
**Figure 2**: Length frequency distribution of the four cichlid fish in catches



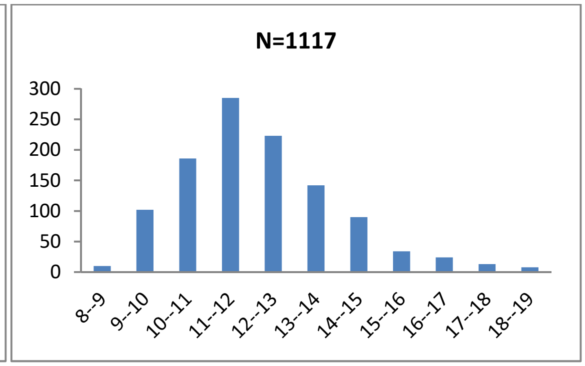

*Hemichromis fasciatus*




*Oreochromis niloticus*




*Sarotherodon galilaeus*




*Tilapia mariae*

### 3.2. Growth Parameters

The Table 1 indicates that the highest value of asymptotic length $L_\infty$ is observed for *Sarotherodon galilaeus* (25.2 cm) with an average growth rate (K) of 0.84 / year and the age of $t_0$ at -0.013 years. At the opposite, the minimum asymptotic length $L_\infty$, corresponding to 18.9 cm, is for *Tilapia mariae*, with an average growth rate (K) of 0.64 / year and the age of $t_0$ at -0.011 years. The two last species, *Oreochromis niloticus* and *Hemichromis fasciatus*, have intermediate asymptotic length ($L_\infty$), but *Oreochromis niloticus* has minimum growth rate (K) in the group (0.42/year) while *Hemichromis fasciatus* has the highest one (0.96/year). As for growth performance index, they remain between 2 and 3 with the highest value observed for *Sarotherodon galilaeus* (2.727) and the minimum for *Tilapia mariae* (2.359). Longevity recorded varies from 3.13 for *Hemichromis fasciatus* and 7.14 for *Oreochromis niloticus*. The two other species have intermediate values.

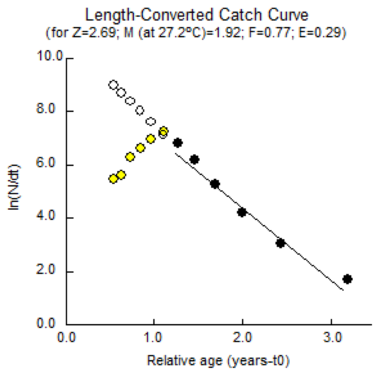
**Table 1:** Growth parameters of species studied in comparison to populations from other fisheries

| Species | Locality | L∞ | K | $t_0$ | Ø' | tmax | References |
|---|---|---|---|---|---|---|---|
| | Solomougou Dam Lake – Côte d'Ivoire | 19.95 | 0.96 | -0.015 | 2.582 | 3.13 | Current study |
| *H. fasciatus* | Lake Ayame I – Côte d'Ivoire | 27 | 0.57 | - | 2.62 | - | Tah et al. (2010) |
| | Okpara stream- Benin | 18.8 | 0.88 | -0.67 | 2.40 | - | Sidi Imorou et al. (2019) |
| | Solomougou Dam Lake – Côte d'Ivoire | 24.15 | 0.42 | -0.006 | 2.389 | 7.14 | Current study |
| *O. niloticus* | Lake Ayame I – Côte d'Ivoire | 35.5 | 0.48 | - | 2.78 | | Tah et al. (2010) |
| | Lake Buyo – Côte d'Ivoire | 32.77 | 0.60 | -0.26 | 2.81 | 5 | Goli Bi et al., (2019) |
| | Solomougou Dam Lake – Côte d'Ivoire | 25.2 | 0.84 | -0.013 | 2.727 | 3.57 | Current study |
| *S. galilaeus* | Lake Doukon - Benin | 26.2 | 0.73 | - | 2.70 | - | Lederoun et al. (2016) |
| | | 17.8 | 0.79 | - | 2.4 | - | Abobi et al. (2019) |
| | Solomougou Dam Lake – Côte d'Ivoire | 18.9 | 0.64 | -0.011 | 2.359 | 4.69 | Current study |
| *T. mariae* | Nigeria | 30.4 | 0.4 | - | - | - | King and Etim (2004) |

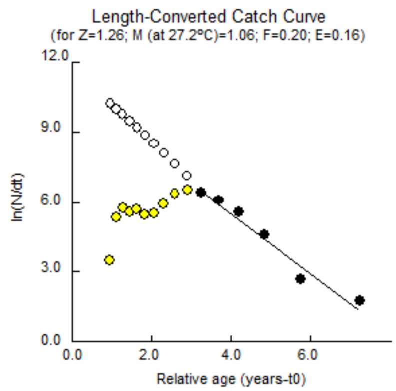
### 3.3. Mortality and Exploitation Rates

Among the four species, the highest values of total mortality rate (Z), natural mortality rate (M) and fishing mortality rate (F) are obtained for *Hemichromis fasciatus* with respective values of 2.69, 1.92 and 0.77 (Figure 3). At the opposite, the minimum values of theses parameters are observed for *Oreochromis niloticus* with total mortality rate (Z) of 1.26, natural mortality rate (M) of 1.06 and fishing mortality rate (F) of 0.2. The two other species, *Sarotherodon galilaeus* and *Tilapia mariae*, have intermediate values, with respectively total mortality rate (Z) of 1.94 and 1.73 and fishing mortality rate (F) of 0.29 and 0.23. As for exploitation rates, values registered for the four species remain inferior to the reference point of 0.5. However, the highest value of this parameter is observed for *Hemichromis fasciatus* (0.29) while the minimum is for *Tilapia mariae* (0.13).

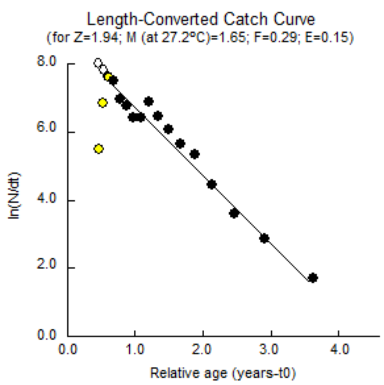
**Figure 3:** Linearized length-converted catch curves for estimation of Mortality parameters and current exploitation rates for the four species.



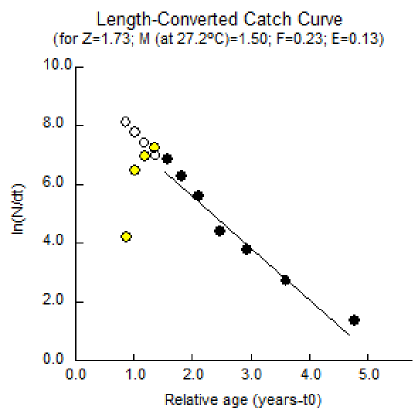

*Hemichromis fasciatus*




*Oreochromis niloticus*




Sarotherodon galilaeus

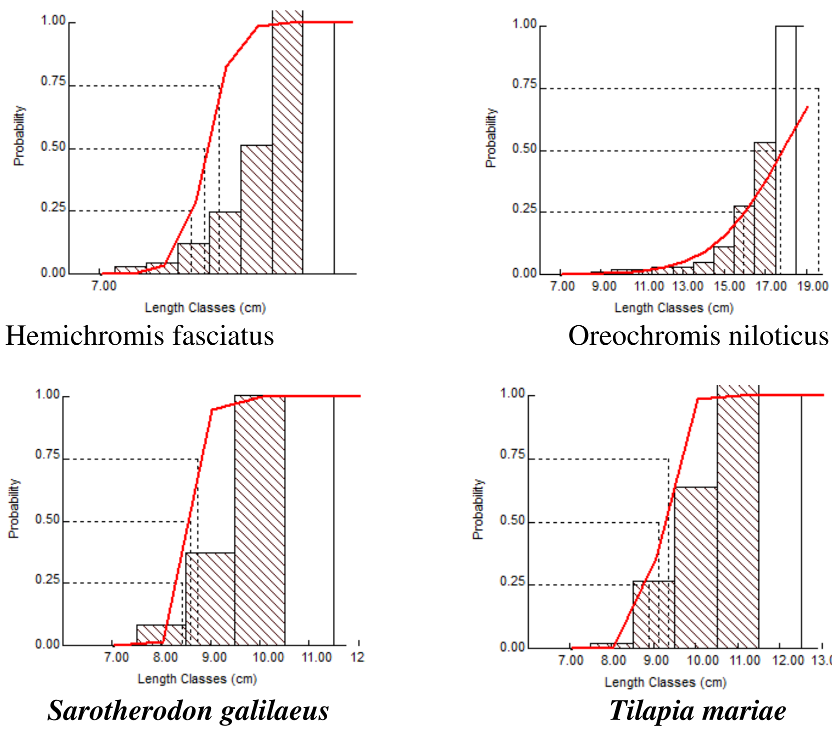



Tilapia mariae

### 3.4. Probability of Capture

Length at first capture (L50), representing length at which 50% of specimens are captured by fishing gear, was estimated at 17.77 cm for *Oreochromis niloticus*. As for *Hemichromis fasciatus*, *Tilapia mariae* and *Sarotherodon galilaeus*, they were respectively 10.36 cm, 9.12 cm and 8.59 cm. Values for lengths of capture at probabilities 25% and 75% correspond respectively to 9.91 cm and 10.82 cm for *Hemichromis fasciatus*, to 15.95 cm and 19.6 cm for *Oreochromis niloticus*, to 8.43 cm and 8.75 cm for *Sarotherodon galilaeus* and to 8.89 cm and 9.35 cm for *Tilapia mariae* (Figure 4).

**Figure 4:** Probability of capture for the four species




## 4. Discussion

In a fishery, length classes analyse of the catches provides information on the demographic structure of the exploited fish stocks. In this study, analyse of Interval length size of catches showed that the smallest length retained in fishing gear was 8 cm of total length for each species. This is the consequence of using small mesh size nets in this fishery. Our study also showed that, in length frequency distribution of different species, peaks of length class are [13-14[ for *Hemichromis fasciatus*, [18-19[ for *Oreochromis niloticus*, [10-11[ and [16-17[ for *Sarotherodon galilaeus* and [11-12[ For *Tilapia mariae*. These peaks can be divided into two main length classes which are [10-14[ and [16-19[. This should be the consequence of using two main groups of gillnets by fishermen. Indeed, the section of our studies on the typology of fishing gear used on this Dam Lake showed that, according to gillnets, seven different mesh sizes were used by fishermen with a predominance of nets 20mm (22.92%) and 30mm (31.94%), representing together 54.86% of this gear type.

Growth comparison results in Table 1 showed that growth parameters values vary from one fishery to another. However, the asymptotic lengths obtained for cichlids from the Solomougou Dam Lake are generally lower than those obtained in other areas. As for the growth coefficients, those registered for our species are generally close to other values or greater. Many reasons could explain difference between growth parameters for the same species from different localities, among which variations in environmental conditions as well as sampling techniques and computations (Hernandez, 1986).

Asymptotic length calculated for a species is always correlated with the largest size of specimens during sampling. So, low values of asymptotic lengths estimated for Slomougou's species could be due in part to the escape of fish from fishing gear. In fact, fishermen usually evoked the presence of tree's trunks submerged since the creation of the Dam Lake, thus limiting their accessibility to many places of the reservoir. This phenomenon is also responsible for the recurrent renewal of their gillnets due to tears.

Growth performance index (Ø') registered in this study vary from 2.359 to 2.727. Baijot and Moreau (1997) have defined for this purpose an interval between 2.65 and 3.32 for most fish species in Africa. With the exception for *Sarotherodon galilaeus*, values obtained in this study for other species are less than 2.65. This slight difference could be explained by certain environmental factors, notably water temperature, which affects not only on food production, but also on the physiology of fish (Fritsch, 2005). Northern Côte d'Ivoire is characterized by Harmattan period, lasting from three to five months (Eldin, 1971), responsible for a considerable drop in the temperature of the environment. For King and Etim (2004), temperature is the most important factor limiting the growth of fish.

Mortality parameters registered for the four species indicated that total mortality for *Hemichromis fasciatus* (2.69) is the highest, while values for *Oreochromis niloticus* (Z=1.26), *Sarotherodon galilaeus* (Z=1.94) and *Tilapia mariae* (Z=1.73) are below 2. This is the indication that *Hemichromis fasciatus* stock is most affected by mortality in this fishery. For each of the species, natural mortality values remain higher than the fishing mortality. The ratio M/*K* relationship is 2.00 for *Hemichromis fasciatus*, 2.52 for *Oreochromis niloticus*, 1.96 for *Sarotherodon galilaeus* and 2.34 for *Tilapia mariae*. Beverton and Holt (1956) mentioned that species M/*K* relationship should be in the range values from 1.5 to 2.5. Therefore, the M values obtained in our study should be considered as appropriate. So, high values of natural mortality over fishing mortality observed in this study imply that populations of these fish are more prone to naturally mortality situations than fishing gears. Reasons mentioned above with regard to the possibilities for fish escaping from fishing gear or the use of gillnets with small mesh sizes not able to enmesh specimens of large size could explain this fact.

Pauly (1983) indicated a reference exploitation rate (E) value, allowing to classify overexploited, underexploited or optimal exploited fish stocks, based on the assumption that the optimal value of E is 0.5 for optimal exploited stocks. Values of this parameter for the four species remain inferior to 0.5. However, the highest value of this parameter is observed for *Hemichromis fasciatus* (0.29) while the minimum is for *Tilapia mariae* (0.13). So, the stock of each species is underexploited in the Solomougou waters. The low level of exploitation rates calculated could be linked to the exploitation regime of this fishery. In fact, Kouassi et al. (2019) indicated that fishing on the Solomougou Dam Lake is practiced throughout the year. However, fishing activity is practically absent there from August to October with the presence of only 4 to 7 fishermen. The recolonization of the fishery by fishermen after this period is done gradually but slowly. This situation could be assimilated to a fishery closure period, allowing better renewal of stocks. In addition, the reproductive biology of these species could be a factor in preserving their stocks. In fact, these species breed many times in a year contrary to other fish species with only one breeding period a year. Results reported by Traoré (1996) for *Oreochromis niloticus* and *Sarotherodon galilaeus* in Côte d'Ivoire, by Sidi Imorou *et al.* (2020) in Benin for *Hemichromis fasciatus* or by Anene and Okorie (2008) in Nigeria for *Tilapia mariae* are some examples. This represents a great advantage for them for continuous recruitment throughout the year.

Probability of capture study showed that length at first capture (L50) is 17.77 cm for *Oreochromis niloticus*, and 10.36 cm, 9.12 cm and 8.59 cm for *Hemichromis fasciatus*, *Tilapia mariae* and *Sarotherodon galilaeus*, respectively. However, Pauly and Soriano (1986) conclude that in the situation for *Sarotherodon galilaeus* with the ratio $Lc/L_\infty$ ($Lc/L_\infty$=0.3) lower than 0.5 and exploitation rate below 0.5, many small sizes specimen are within the catch. However, for *Hemichromis fasciatus*, *Oreochromis niloticus* and *Tilapia mariae* with ratios $Lc/L_\infty$ of 0.5, 0.7, and 0.5, respectively, and values of exploitation rate below 0.5, large fish are caught at low effort levels.

## 5. Conclusion

The present study analyzed fishermen's catches from the Solomougou Dam Lake in order to assess the level of exploitation of the four cichlidae species most exploited. The sizes of the specimens during samplings were ranged from 8 cm to 25 cm. The exploitation rates registered indicated that the stock of each species is underexploited in this fishery. In addition, the decrease of their stocks is more due to natural mortality which remained higher than the fishing mortality for all the species. Therefore, the possibilities of increasing fishing effort in order to increase the catches are conceivable. However, this study deserves to be supplemented by studies on selectivity of fishing gear and the size at first sexual maturity of the different species. These results will make it possible to associate the increase in fishing effort with regulation of fishing gear types.

## Acknowledgements

Authors acknowledge, on the one hand, administrative authorities in charge of monitoring fishing activities in the Department of Korhogo for facilitatng collaboration with fishermen and, on the other hand, fishermen exercising on the Solomougou Dam Lake for their conviviality.

## References

[1] Abobi, S. M., Mildenberger, T. K., Kolding, J. and Wolff, M., 2019. Assessing the exploitation status of main fisheries resources in Ghana's reservoirs based on reconstructed catches and a length-based bootstrapping stock assessment method. Lake & Reservoir Management, 35(4), 415-434.

[2] Anene, A. and Okorie, P. U., 2008. Some aspects of the reproductive biology of *Tilapia mariae* (Boulenger 1901) in a small lake in south-eastern Nigeria. African Journal of Biotechnology, 7(14), 2478-2482.

[3] Anonymous, 1962. Étude hydrologique du Solomougou. Résultats de la Campagne 1961. Document ORSTOM, 79p.

[4] Baijot, E. and Moreau, J., 1997. Biology and demographic status of the main fish species in the reservoirs of Burkina Faso. In: Baijot E, Moreau J, Barry J, Bouda S, Eds. Hydrological aspects of fisheries in small reservoirs in the Sahel Region, Technical Centre for Agricultural and Rural Cooperation, Commission of the European Communities, Wageningen, Netherlands, 79-109.

[5] Beverton, R. J. H. and Holt, S. J., 1956. A review of methods for estimating mortality rates in fish populations, with special reference to sources of bias in catch sampling. Rapports et Procès-Verbaux des Réunions Conseil International pour l'Exploration de la Mer, 140, 67–83.

[6] Cooke, S. J., Lapointe, N. W. R., Martins, E. G., Thiem, J. D., Raby, G. D., Taylor, M. K., Beard, T. D. Jr. and Cowx, I. G., 2013. Failure to engage the public in issues related to inland fishes and fisheries: strategies for building public and political will to promote meaningful conservation. J. Fish Biol., 83(4), 997-1018.

[7] Eldin, M., 1971. Le climat. In: Le milieu naturel de la Côte d'Ivoire. Avenard JM, Eldin E, Girard G, Sircoulon J, Touchebeuf P, Guillaumet JL, Adjanohoun E, Perraud A, Eds. ORSTOM, Paris, 73-108.

[8] FAO, 2010. The State of World Fisheries and Aquaculture - 2010 (SOFIA). Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

[9] Fritsch, M., 2005. Traits biologiques et exploitation du Bar commun *Dicentrarchus labrax* (L.) dans les pêcheries françaises de la Manche et du Golfe de Gascogne. Thèse de Doctorat, Université de Bretagne occidental, France, 314p.

[10] Gayanilo, F. C., Sparre, P. et Pauly, D., 2005. Outils d'evaluation des stocks II (FISAT II). Version révisée. Guide d'utilisation. FAO Série informatique, Pêche No. 8, Version révisée, Rome, FAO, 190p.

[11] Goli Bi, B. E. P., Kamelan, T. M., Berté, S., Kien, K. B., Ndiaye, S. and Kouamelan, E. P., 2019. The first data on the population parameters of the main fish species in man-made Lake Buyo (River Sassandra, Côte d'Ivoire). Egyptian Journal of Aquatic Biology & Fisheries, 23(2), 585-597.

[12] Gulland, J. A., 1971. The fish resources of the oceans. West by the fleet, Survey. Fishing News Books, Ltd., Surrey, England, 225p.

[13] Hernandez, A. H. V., 1986. Study on the age and growth of bogue (*Boops boops*) from the central Adriatic Sea. Cybium, 13, 281-288.

[14] King, R. P. and Etim, L., 2004. Reproduction, growth, mortality and yield of *Tilapia mariae* Bouleger, 1899 (Cichlidae) in a Nigerian rainforest wetland stream. Journal of Applied Ichthyology, 20(6), 502–510.

[15] Kouassi, K. D., Diaby, M., Amon, Y. N. and N'da, K., 2019. Dynamic of fishing activity on the Solomougou Dam Lake (Korhogo, Côte d'Ivoire). International Journal of Agriculture, Environment and Bioresearch, 4(6), 298-307.

[16] Laurec, A. et Le Guen, J-C., 1981. Dynamique des populations marines exploitées. Concepts et méthodes. Rapport Scientifique et Technique, CNEXO/ Centre Océanographique de Bretagne, Tome1, nº45, 108p.

[17] Lederoun, D., Vandewalle, P., Brahim, A., Moreau, J. and Laleye, P., 2016. Population parameters and exploitation rate of *Sarotherodon galilaeus galilaeus* (Cichlidae) in Lakes Doukon and Togbadji, Benin. Afr. J. Aquat. Sci., 41, 151–160.

[18] Pauly, D., 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stock. Journal du Conseil international pour l'Exploration de la Mer, 39(3), 175-192.

[19] Pauly. D., 1982. Une sélection de méthodes simples pour l'estimation des stocks de poissons tropicaux. FAO, Circulaire sur les pêches, nº729, 63p.

[20] Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper, 52p.

[21] Pauly, D., 1984. Fish population dynamics in tropical waters. A manual for use with programmable calculators. ICLARM contribution, nº143, 325p.

[22] Pauly, D. and Munro, J. L., l984. Once more on growth comparisons of fish and invertebrates. Fishbyte, 2(1), 1-21.

[23] Pauly, D. and Soriano, M. L., 1986. Some practical extensions to Beverton and Holt's relative yieldper-recruit model. In: Maclean JL, Dizon LB, Hosillo LV, Eds. The first Asian fisheries forum,Philippines, Asian Fisheries Society, Philippines, 491-496.

[24] Sidi Imorou, R., Adite, A., Arame, H. and Sonon, P. S., 2020. Aspects of life history patterns of the cichlid fish *Hemichromis fasciatus* Peters, 1857 from Okpara Stream, Northern Benin, West Africa. Aquatic Research, 3(2), 110-123.

[25] Sidi Imorou, R., Adite, A., Sossoukpe, E., Adjibade, K. N., Arame, H. and Sonon, S. P., 2019. Demographic parameters and exploitation rate of five key fishes of Okpara Stream, Ouemé River, Benin, West Africa. Int. J. Aquat. Biol., 7(6), 332-341.

[26] Sparre, P. et Venema, S. C., 1996. Introduction à l'évaluation des stocks de poissons tropicaux. Première partie: Manuel FAO. Document technique sur les pêches, 306(l), 401p.

[27] Stiassny, L. J., Teugels, G. G. et Hopkins, C.D., 2008. Poissons d'eaux douces et saumâtres de basse Guinée, ouest de l'Afrique centrale. IRD Éditions, 800p.

[28] Tah, L., Joanny, T. G., N'Douba, V., Kouassi, N. J. and Moreau, J., 2010. Preliminary estimates of the population parameters of major fish species in Lake Ayamé I (Bia basin; Côte d'Ivoire). Journal of Applied Ichthyology, 26(1), 57-63.

[29] Tanguy, L. G., 2004. Le développement agricole et pastoral du Nord de la Côte d'Ivoire: problèmes de coexistence. Les Cahiers d'Outre-Mer, Revue de géographie de Bordeaux, 226-227, 259-288.

[30] Traoré, K., 1996. État des connaissances sur les pêcheries continentales ivoiriennes. Rapport de consultation Avril 1996, PROJET FAO TCP / IVC / 4553.

[31] Welcomme, R. L., Cowx, I. G., Coates, D., Béné, C., Funge-Smith, S., Halls, A. and Lorenzen, K., 2010. Inland capture fisheries. Phil. Trans. R. Soc. Lond. Ser. B, Biol. Sci., 365(1554): 2881-2896.