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Population dynamics of *Clarias gariepinus* (Burchell, 1822) in Lake Mai-Ndombe, Democratic Republic of the Congo

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Abstract

This study consisted of studying the population dynamics of *Clarias gariepinus* in Lake Mai-Ndombe in the Democratic Republic of Congo. Length frequency data was collected from May 2020 to February 2021 at the Inongo located in the Mai-Ndombe Province. These data were compiled and analyzed using Microsoft Excel, FISAT software and R Studio. The growth coefficient (K), the asymptotic length (L_∞), the theoretical age at which the species measures zero centimeters (t_0) were respectively: 0.28/year; 55.56 cm and -0.50 years. Natural mortality, fishing mortality and total mortality were also estimated and their values were respectivelly: 0.35/year; 0.7/year and 1.05/year. The average length at first capture was 23 cm. The results of yield per recruit (Y/R) analyzes showed that the maximum fishing mortality rate (Fmax) was 0.8/year and the optimal length at first capture (L_{op}) was 31 cm. these results show that this fishery is still good. But, to avoid any sudden change in stock status, fishing quota regulations are recommended for this fishery. Furthermore, advanced stock assessment model like Ecosystem Approach to Fisheries would be very necessary to determine other parameters such as: Biodiversity, environmental and socioeconomic factors which are very important for sustainable resource management fisheries in this Lake.

Key words: *Clarias gariepinus, Stock assessment, Fisheries ecological parameters, Lake Mai-Ndombe*

1. Introduction

The Democratic Republic of the Congo (DRC) has a hydrographic network made up of several water bodies, these include: Inland and Marine waters. The total area of inland waters is around 86,000 sq.km (FAO, 2022). Fishery is very important in this country, because it creates jobs opportunities and contributes to food security and the well-being of Congolese people (FAO, 1995).

Nowadays, it is globally recognized that several species of fish are at risk of extinction (Zhang, 2020). The percentage of fish stocks at the biologically unstable level increased from 10% to 33.1% between 1974 and 2015

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(FAO, 2018). This constitutes a major alert for all governments in the world in the management and protection of fisheries resources.

Sustainable Development Goal 14 emphasizes the sustainable exploitation of fisheries resources by combating the overexploitation of these resources (FAO, 2018). Population dynamics and stock assessment of a fishery resource are very important as this information allows fisheries sector managers to make responsible decisions for the sustainability their fisheries.

According to MRAC (2018), population dynamics is the study of marginal and long-term changes in the number, length, individual weight and age composition of individuals in one or more populations, and of the processes biological and environmental influences influencing these changes.

In the DRC, researches in the fishery sector are very rare. Published scientific papers in the field of stock assessment are extremely rare. So, this study might be the starting point for the implementation of the method that will be shown in this study. Nurul *et al*. (2002) as reported that the population dynamic is very necessary for the formulation of policies and laws for sustainable management of fisheries.

Research in the field of fisheries is an official commitment of all member countries of the United Nations as stipulated in the Code of Conduct for Responsible Fishing (FAO, 1995). Thus, the results of this study will be useful in the Literatures for some large-scale studies in the DRC.

This study consists of studying the Population Dynamics of Clarias gariepinus in Lake Mai-Ndombe. The choice of this species is justified by the fact that it is primarily commercial species and it is among those most caught by fishermen. In addition, *C. gariepinus* commonly called 'Ngolo' in the local language (Russell *et al*., 2007) is one of the main predators in this river. Length frequencies data was collected for a sample of 2001 fishes from artisanal fishermen in different sites in the Lake Mai-Ndombe from May 2020 to February 2021.

2. Materials and methods

This study was carried out in Lake Mai-Ndombe. This lake is a body of water located in the central basin of the DRC and towards the western part of the country. This river measures 2,300 km^2 (Russel *et al.,* 2007) and its surface area can even reach 10,000 km^2 during the rainy season.

Mai-Ndombe (1° 53' south, 18° 14' east) and its tributaries belong to the hydrographic system of the central Congolese basin as shown in the Figure 1. The latter is a vast depression of floodable rainforest covering 7,500

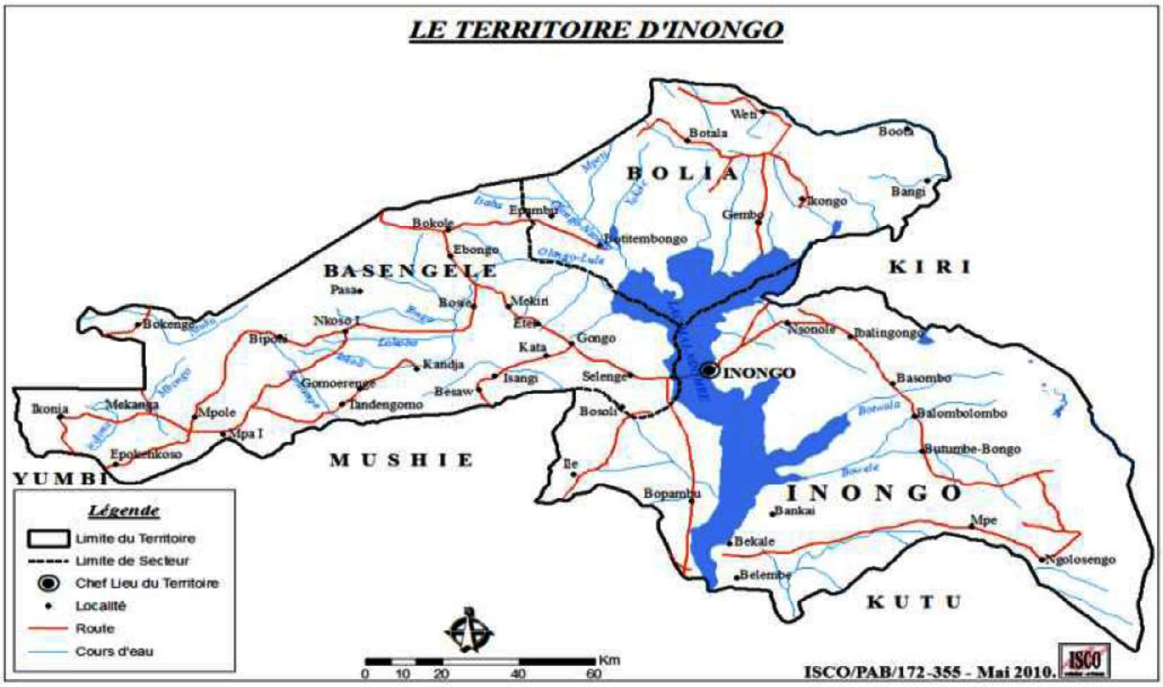

Figure 1: Localization the Lake Mai-Ndombe in the territory of Inongo (Micha *et al.*, 2018)

km². It is administratively located in the territory of Inongo, belonging to the new province of Maï-Ndombe (formerly one of the four districts of the province of Bandundu). The climate is equatorial: rainfall greater than 1,900 mm, average daytime temperature of around 25 °C. Inongo Territory has a climate with two rainy seasons with two dry seasons interspersed with rain (Micha *et al.*, 2018).

The length of this Lake is approximately 130 km and its average width is 14 km (4 to 30 km). It is shallow (maximum 10 m, average 5 m). It is located at an altitude of 320 m and flows south into the Congo River via the Fimi and Kasaï rivers (Bongeba and Micha, 2013; Micha *et al.*, 2018). According to Kutshukina and Micha, (2013), many species including: *Gephyroglanis congicus; Channalabes apus; Clariallabes attemsi; Schilbe mystus; Citharinus gibbosus; Citharinus macrolepis; Distichodus* spp.; *Mastacembelus* spp.; *Hydrocynus goliath*; *Auchenoglanis occidentalis; Labeo lineatus; Synodontis* spp; *Parachanna obscura* and *Clarias gariepinus* are sold at the markets of Maï-Ndombe.

3. Data Collection

A random sample consisting of 2001 fresh fish taken from artisanal fishermen in Inongo, Maï-Ndombe were measured (length) and weighed (weight) per individual. The samples were taken between May 2020 and February 2021 in Lake Maï-Ndombe, in the DRC. A plastic measuring tape was used to measure fish size and a small electronic scale was used to weigh their weights. Measurements were taken in centimeters (cm) for length and in grams (g) for the weight of the fish or individual.

4. Methods

The process of this work was as follows:

- The use of some literature including lecture notes, scientific papers and country reports on the fish species, study area, stock assessment process.
- Preparation of form's survey for data collection.
- Compilation of length frequencies data.
- Data analysis using Microsoft Excel, fisheries statistics software including FiSAT II and R Studio.

5. Data analysis

The length frequencies data analysis were done using Microsoft Excel and FAO FISAT software (Gayanilo *et al.*, 2005) as well as R software for estimating the fisheries ecological parameters and other indicators of C. gariepinus of Mai-Ndombe.

Von Bertalanffy growth parameters (K and L∞) were determined from ELEFAN in the FiSAT II software (Gayanilo *et al.*, 2005). The theoretical age at which the species measures zero cm (t_0) was estimated using the empirical equation (Pauly, 1983).

$$\log10\ (-t_0) = -0.3922 - 0.275 * \log10 L_\infty - 1.038 * \log10 K$$

The length-weight (L-W) relationship of the individual was estimated by applying the traditional formula:

$$W = a*L^b$$

where W is the weight of the individual expressed in grams (g); L is the total length of the fish or individual, 'a' is the intercept and 'b' is the slope of this relationship, both are coefficients extracted from this relationship (MRAC, 2018).

The Natural mortality (M) was estimated using the equation of Zhang and Megrey (2006), $M = \beta * K/\exp(K*(ci*t_{max}-t_0) -1$.

where 'β' or 'b' = is the coefficient coming from the weight and length relationship of our data. 'Ci' is the quotient used for a value of 0.302 for pelagic species 0.440 for demersal species (Zhang and Megrey, 2010).

The growth performance index (ø) was calculated by the following equation: ø = Log10K+2Log10L∞ (MRAC, 2018c).

The predicted average total length (L_t) showing the maximum age of *C. gariepinus* in Mai-Ndombe was estimated by the Van Bertalanffy equation: $L_t = L_\infty\ (1-\exp\ (-k\ (t-t_0)))$.

The total mortality (Z) was estimated using the method of Beverton and Holt (1956) cited by Zhang (2020): $Z= K*((L_\infty - \bar{L})/ (\bar{L} - L'))$.

where $\bar{L}$ is the mean length of this fish; L' is the lower limit of the first length interval of the fish which is fully vulnerable to the fishing gear; L_∞ = the infinite length or the asymptotic length of the fish (Zhang, 2020).

Fishing mortality (F) was estimated by the following relationship: $F= Z-M$ (Zhang, 2020), where Z is the total mortality and M is the natural mortality of the species.

The length of the individual at first capture (L_c) was estimated from the logistic curve of the following equation: $SL = 1/(1+\exp(a-b*L_\infty)$ (Sparre and Venema, 1998; Tirtadanu and Umi, 2019). Where: 'a' is the intercept of this curve and 'b' is the slope of the same curve. 'SL' is the logistic curve and 'L_c' was determined by dividing 'a' by 'b' and 'L_∞' which is the average length (Tirtadanu and Umi, 2019).

The yield per recruitment (Y/R) model of Zhang and Megrey (2006) was used to determine the maximum fishing mortality (F_{max}) and the optimal length at first capture (L_{opt}).

$$\frac{Y}{R} = F.\left(\alpha L_\infty^{\beta}\right)\left(\frac{L_\infty - l_c}{L_\infty - l_r}\right)^{\frac{M}{K}} . \sum_{n=0}^{3} \frac{U_n\left(\frac{L_\infty - l_c}{L_\infty}\right)^n}{F + M + nK}$$

where K is the Von Bertalanffy growth coefficient; L_∞ =Asymptotic length of the species; t_0 = the theoretical age at which the fish measures zero cm; l_c = length at first capture; l_r = length at recruitment; U_n = Integration coefficient; n = number of summation ($U_0 = 1$, $U_1 = -3$, $U_2 = 3$, and $U_3 = -1$); F= fishing mortality; α and β are the coefficients of the length-weight relationship and M= natural mortality of the species.

6. Results

The results of this study are grouped into two: ecological parameters of the population and reference points or management indicators.

The Fisheries Ecological Parameters of *C. gariepinus*

The results of fisheries ecological parameters are shown in Table 1.

Table 1: The fisheries ecological parameters

α	B	W_∞ (gr)	K(y^{-1})	L_∞ (cm)	M(y^{-1})	ϕ	F(y^{-1})	Z	$l_{c\ (cm)}$	$l_{r\ (cm)}$	t_0	T_{max} (years)
0.026	2.939	3551	0.28	55.65	0.35	2.9	0.7	1.05	23	7	-0.5	11

α and β are the coefficients coming from the length-weight relationship. Where W_∞ is the infinite weight of *C. gariepinus* expressed in grams; K is the growth coefficient; L_∞ is the asymptotic length expressed in centimeters;

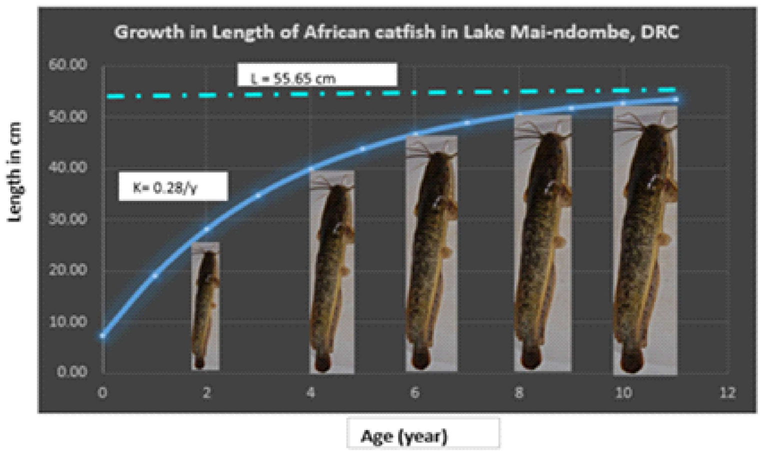

Figure 2: Growth in length showing the maximum age of *C. gariepinus* in Lake Mai-Ndombe

ϕ is the performance index of growth; M is the natural mortality of the species; F is the fishing mortality; Z is the total mortality; L_c is the length at the first capture; L_r is length at recruitment; t_0 is the theoretical age where the species measures zero centimeters; T_{max} is the maximum age of the species.

7. Management indicators

Figure 3 was plotted using the increment of length at first capture data against fishing mortality data. Point 'H' shows the optimal length (L_{opt}= 31 cm) which gives the maximum yield per recruit (Y/R= 255.95 g/recruit) at the current fishing mortality (F_c = 0.7 y^{-1}). The line 'L' shows the length at first capture (L_c = 23 cm) and the maximum Fishing mortality (F_{max} = 0.8 y^{-1}).

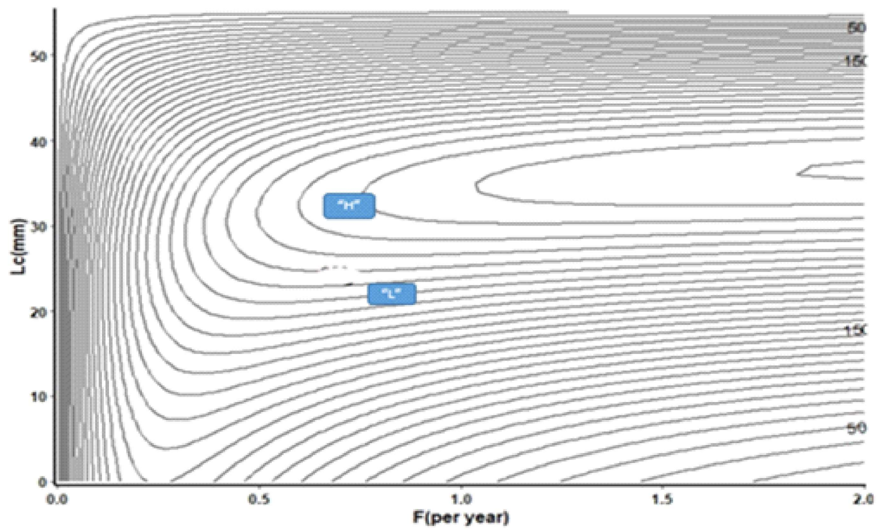

Figure 3: Yield per Recruit diagram indicating the stock status of *C. gariepinus* in Lake Mai-Ndombe

8. Discussion

The results from ecological parameters of the *C. gariepinus* population show that the *C. gariepinus* of Lake Mai-Ndombe has a maximum lifespan of 11 years as shown in Figure 2. The length at recruitment (L_r = 7 cm) is lower than the length at first capture (L_c = 23 cm). This means that fishing regulations in Lake Mai-Ndombe are too weak, because this species is fished before the maturity age. This confirm what Micha *et al.* (2018) reported that in Lake Mai-Ndombe, the selectivity of most of the fishing gears does not meet the international regulation.

In addition, the calculated weight (W_∞ = 3.55 kg) is much greater than the maximum weight of the species in the sample. As shown in Figure 4.

These results are can be used by fisheries managers of DRC for improving the fisheries management system in order to ensure the sustainability of the fisheries resources of the Lake Mai-Ndombe.

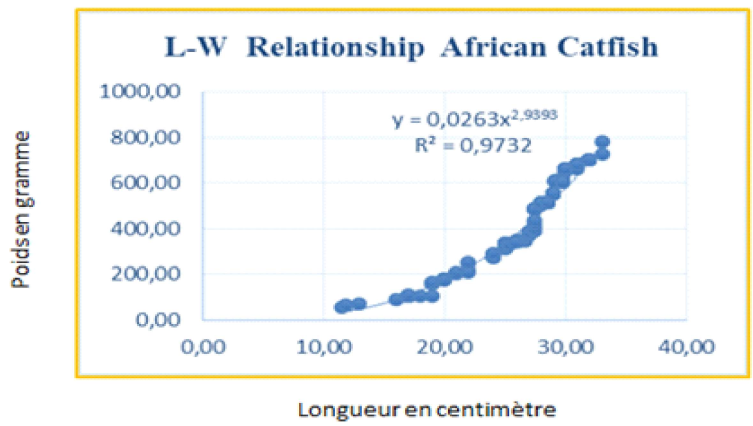

Figure 4: Weight-length relationship of the data sample collected for *C. gariepinus* in lake Mai-Ndombe

The population (ecological) parameters of *C. gariepinus* from Lake Mai-Ndombe were compared with those of other countries as indicated in the Table 2. The asymptotic length of the current study was the smallest than in other studies. However, the growth coefficient (K) in this study was larger than that of Malawi and Ethiopia (Tweddle et al., 1979). On the other hand, those from South Africa and Zambia were much larger than all. Of all the exploited items, the L_∞ of Zambia was the largest (Wudneh, 1998) than all others.

In terms of weight, *C. gariepinus* from DRC weighed more than those from South Africa, Ethiopia and Malawi. This may be because of the ecosystem and the richness of food. Since the Lake Mai-Ndombe is located in the equatorial forest and is fed by several rivers and streams which can contain a lot of plant debris and making the aquatic environment favorable for the fast growth of fishes.

However, the temperature of the environment can also have a very significant influence on the weight of the fish. Because, in Malawi where the average temperature is equal to 26.5 gives the W_∞ equal to 4 kg, which is slightly higher than that of the DRC where the average temperature was 26 °C.

As for the Yield per recruit analysis (Y/R), the results show that the stock level of this species is still stable or underexploited. Because the F_c or current fishing mortality (F_c = 0.7 y^{-1}), is still lower than the maximum fishing mortality (F_{max} = 0.8 y^{-1}).

Table 2: Population parameters of *C. gariepinus* in Lake Mai-Ndombe vs. other studies

Study Number	Parameters							Reference
	L_∞ (cm)	Length type	K (y^{-1})	W_∞ (kg)	Sex	T °C Celsius	Country	
Curent	55.65	TL	0.28	3.6	Mixed	26	DRC	Curent
1	67.2	TL	0.517	1.9	Female		South Africa	Bruton and Allanson (1980)
2	85	TL	0.2	4.9	Female	22	Ethiopia	Wudneh (1998)
3	90	TL	0.2	5.8	Male	22	Ethiopia	Wudneh (1998)
4	67.5	TL	0.51		-	23.5	Zambia	Kolding *et al.* (1996)
5	79	TL	0.17	4	Female	26.5	Malawi	Tweddle *et al.* (1979)

9. Conclusion

1. As Nurul *et al.* (2002) said that, the knowledge of population dynamics is very important for the good management of fisheries resources. Knowing that fishery in Mai-Ndombe is very important and it has been reported that some commercial species were declined. So, it was necessary to conduct a stock assessment for this fishery to know if it was still stable or overfished.
2. Then, we found out that the stock level of *C. gariepinus* called 'Ngolo' is still good or underexploited, because the current fishing exploitation rate is still lower than the maximum fishing mortality.
3. However, it is necessary to carry out another type of Stock Assessment such as the Ecosystem Approach to Fisheries to determine additional parameters of biodiversity, habitat quality and socioeconomic factors, which are also important to understand for the fishery management.

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References

Bongeba, C. and Micha J-C. (2013). State of fishing south of Lake Mai-Ndombe. *Scientific and Technical Journal of the Forest and Environment of the Congo Basin*, (1): 46-55. [French].

Bruton, M.N. and Allanson, B.A. (1980). Growth of *Clarias gariepinus* in Lake Sibaya, South Africa. Institute for Freshwater Studies, Rhodes University, Grahamstown.

FAO (1995). Report of the Expert Consultation on Guidelines for Responsible Fisheries Management. *FAO Fisheries Report No. 519*. FAO, Rome. [In Italy].

FAO (2009). Fisheries and Aquaculture Country Profiles, Democratic Republic of Congo. [French].

FAO (2018). The state of world fisheries and aquaculture 2018 - Meeting the sustaible development goals. Rome. Licence CCBY-NC-SA3.0 IGO. [In Italy].

FAO (1983). Some Simple Methods for the Assessment of Tropical Fish Stocks. A Technical Paper, 254 p. By Pauly Daniel, Associate Scientist International Center Living Aquatic Resources Management. Philippines.

FAO (2022). Profils des Pêches et de l'Aquaculture de la République Démocratique Du Congo.

Gayanilo, F.C., Sparre, P. and Pauly, D. (2005). Computerized information series fisheries No. 8. FAO-ICLARM. Stock Assessment Tools II User's guide.

Kolding, J., Ticheler, H. and Chanda, B. (1996). Assessment of the Bangweulu Swamps Fisheries. WWF Bangweulu Wetlands Project Final Report December.

Kutshukina, L.F., Micha, J.C. (2013). Analyse des modes d'exploitation des ressources halieutiques du Lac Mai-Ndombe en République Démocratique du Congo. *Geo-Eco-Trop*., 37(2): 273-284.

Micha, J-C., Nabwenge B., Babi-Levieux, Ibofa, R., Mumba, F., Mutambwe, S., Zanga N., Willem, E., Svennsson, Jan-Erik. and Wilander, A. (2018). An over-exploited resource, Nannothrissa stewarti, an endemic sardine from Lac Maï-Ndombe (DR Congo), an unforeseen result of the National Malaria Control Programme. [French].

MRAC (2018). Training FishBASE and the Taxonomy of Fishes. Population dynamics (46p.pdf 3.26 MB, anglais). Course material available on Google at: https://www.africamuseum.be/fr/research/training/fishbase/coursematerial.

Nurul, A.S.M., Rahman, M.A., Haldar, G.C., Mazid, M.A. and Milton, D. (2002). Population dynamics and stock assessment of *Hilsa shad, Tenualosa ilisha* in Bangladesh. *Asian Fisheries Science* 15 (2002):123-128. doi: https://doi.org/10.33997/j.afs.2002.15.2.003

Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. *FAO Fisheries Technical Paper*, 254 p.

Russell, A.J.M., Gordon, A., Bungubetshi, G. and Zanga, N. (2007). Preliminary assessment of the artisanal fishery sector around Lac Maï-Ndombe in the Lac Tele-Lac Tumba (LTL) CARPE Landscape. For a collaborative report produced by WorldFish Center and the Worldwide Fund for Nature (WWF) Corresponding Author: WorldFish Center Regional. Office for Africa and West Asia. PO Box 1261, Maadi 11728 Cairo, Egypt.

Sparre, P. and Venema, S.C. (1998). Introduction to tropical fish stock assessment. Part 1 Manual. FAO Fisheries Technical Paper. No. 306.1. Rev 2. Rome, FAO. 407p.

Tirtadanu,T. and Umi, C. (2017). Some population parameters and exploitation status of four finger threadfin (Eleutheronema tetradactylum Shaw, 1804) in Tarakan waters, North Kalimantan. Available online at: http://ejournal-balitbang.kkp.go.id/index.php/ifrj

Tirtadanu, T. and Umi, C. (2019). Fishery, population parameters and exploitation status of blue swimming crab (*Portunus pelagicus*) in Kwandang Waters, Indonesia. Research Institute of Marine Fisheries, Ministry of Marine Affairs and Fisheries Republic of Indonesia, Cibinong, Bogor, Indonesia.

Tweddle D., Lewis D.S.C and Willoughby N.G. (1979). An annotated checklist of the fish fauna of the river shire south of kapachira falls, malawi. Ichthyological bulletin of the J.L.B. Smith Institute of Ichthyology Rhodes University, Grahamstown, Malawi.

Wudneh, T. (1998). Biology and management of fish stocks in Bahir Dar Gulf, Lake Tana, Ethiopia. Wageningen University and ResearchProQuest Dissertations Publishing.28244481.

Zhang, C.I. (2020). Fisheries stock assessment. Lecture notes of world fisheries university-pilot program of ministry of oceans and fisheries of republic of Korea and FAO. 189 p.

Zhang, C.I. and Megrey, B.A. (2006). A revised alverson and carney model for estimating the instantaneous rate of natural mortality. *T. Am. Fish. Soc.*, 135, 620-633.

Zhang, C.I. and Megrey, B.A. (2010). A Simple biomass-based length-cohort analysis for estimating biomass and fishing mortality. *T. Am. Fish. Soc.* 139(3), 911-924.

Appendices

Appendix 1: Length Frequency Data on the Length of *C. gariepinus* 'Ngolo' in Mai-Ndombe in DRC

Table 1: Length frequencies data for *Clarias gariepinus* (LakeMai-Ndombe)

Class Interval		Mid Length	Frequencies (monthly)										Total
L1 (lower length)	L2 (Upper length)		May	June	July	August	Sept	Oct	Nov	Dec	Jan	Febrary	
4	6	5	0	0	0	0	0	0	0	0	0	0	0
6	8	7	1	0	7	0	0	0	0	0	0	0	8
8	10	9	2	0	12	0	0	0	0	1	0	0	15
10	12	11	2	2	25	0	0	0	8	10	2	1	50
12	14	13	2	1	7	0	0	0	0	1	1	3	15
14	16	15	7	1	17	10	4	1	4	5	0	4	53
16	18	17	7	17	16	1	18	30	0	4	15	11	119
18	20	19	20	5	10	25	58	19	47	35	7	8	234
20	22	21	38	9	8	39	41	17	17	13	10	10	202
22	24	23	32	4	6	62	50	6	58	51	3	4	276
24	26	25	27	45	19	61	10	14	11	14	32	30	263
26	28	27	10	31	16	0	7	9	0	3	43	43	162
28	30	29	10	15	22	0	9	12	1	2	45	43	159
30	32	31	5	14	14	2	2	47	52	50	28	27	241
32	34	33	9	25	5	0	1	45	2	3	14	16	120
34	36	35	3	31	12	0	0	0	0	2	0	1	49
36	38	37	7	0	2	0	0	0	0	0	0	0	9
38	40	39	4	0	1	0	0	0	0	0	0	0	5
40	42	41	4	0	1	0	0	0	0	1	0	0	6
42	44	43	2	0	0	0	0	0	0	1	0	0	3
44	46	45	3	0	0	0	0	0	0	1	0	0	4
46	48	47	2	0	0	0	0	0	0	1	0	0	3
48	50	49	1	0	0	0	0	0	0	1	0	0	2
50	52	51	1	0	0	0	0	0	0	1	0	0	2
52	54	53	1	0	0	0	0	0	0	0	0	0	1
Total			200	200	200	200	200	200	200	200	200	201	2001

Appendices (Cont.)

Appendix 2: Length-Weight Data January 2021		
Year: 2021	**Month: January**	
Species name	***Clarias gariepinus*(Ngolo)**	
N°	**Size (cm)**	**Weight (g)**
1	11,50	55,00
2	11,80	62,00
3	13,00	71,00
4	16,00	88,00
5	17,00	102,00
6	17,00	105,00
7	18,00	105,00
8	17,00	105,00
9	17,00	106,00
10	17,00	104,00
11	17,00	105,00
12	17,00	105,00
13	19,00	105,20
14	17,00	106,00
15	17,00	105,00
16	17,00	105,00
17	17,00	102,00
18	17,00	104,00
19	17,00	105,00
20	17,00	105,00
21	17,00	107,00

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