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Aquaculture of *Heterotis niloticus* in Sub-Saharan Africa: Potentials and Perspectives

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Abstract

The review was carried out during the months of October 2019 to July 2020. The goal was to carry out a literature review on aquaculture of *Heterotis niloticus* in order to contribute to a better knowledge of the breeding of commonly named *African bonytongue* in Africa. The review, based on 41 published papers starting from 1980 to 2020 concerning common fish and *Heterotis niloticus* farming research in Africa. The most farmed fish species documented were in order of importance; *Oreochromis niloticus*, *Clarias gariepinus*, *Cyprinus carpio* and the less documented was *Heterotis niloticus*. *Heterotis niloticus* is microphagous and omnivorous species. The standard and total length of male and female are statistically close but their body weight is different according to gender. The fingerlings of *H. niloticus* grows rapidly with a diet 36% of protein and 6% of lipids. In Africa, the Specific Growth Rate (SGR) of *Heterotis niloticus* varies between 3.22g/day to 4g/day. The GonadoSomatic Index (GSI) varies to 0.003% -0.6% and to 0.2%-2.2 % respectively for male and female, which is correlated with period of spawning. The aquaculture of *Heterotis niloticus* has huge potentials in high fish demanding environment and therefore needs accurate data.

Keywords: *Heterotis niloticus*, fresh water aquaculture, opportunities, Sub-Saharan Africa.

Introduction

In 2017 for instance, world fish production from fish caught was 92.5 million tons, compared to 80.1 million tons from aquaculture (FAO, 2019). In Africa, fish production represents 3.64 % of world fish production. This production is very low and insufficient for Africa population, which is estimated at 1.3 billion; because fish production is insufficient, its consumption is less than 20.3 kg per capita (FAO, 2018). To meet this demand, local supply depends on frozen fish imports in many countries. Aquaculture is most often done by species introduction in local production systems. All over the world, the introduction of new fish species in the fresh waters is often undertaken with the aim of improving the ichtyological production (Economidis *et al.*, 2000). In Africa, some species of fish like *Heterotis niloticus* were introduced in different countries. Its common name is African bonytongue. *Heterotis niloticus* is a native fish to many countries of Africa: Cameroon, DRC, Nigeria, Burkina-Faso, Benin (Moreau, 1982). Since this introduction, *H. niloticus* was reared by fish farmers in Africa, because of its omnivorous diet, good meat quality and relative high commercial value. The aquaculture of these resources is very important for Scientist, fishermen, fish farmers and consumers. However, its use for aquaculture is limited by the difficulty in the massive production of fingerlings (Monentcham, 2009). In Africa, many authors studied this species on various aspects such as reproduction, feeding,

biology and ecology. The current review aims at giving insight to aquaculture of *Heterotis niloticus* in Africa for better research approach.

Material and methods

This study was based on wide consultation of 41 published papers starting from 1980 to 2020 to different study on *Heterotis niloticus* in Africa and America. PubMed, Google Scholar and African Journals Online databases were used to search articles published in English and French in accordance with the PRISMA guidelines. Retrieval and screening of articles was done using a structured search string with strict inclusion and exclusion criteria. Exclusion criteria include duplication, none compatibility of some articles and articles published before 1980, while inclusion criteria are biology, reproduction, feeding, and genetics of *Heterotis niloticus*. Free-text and grey literature were obtained by contacting the authors directly. No limit on publication dates was set. Literature search started on October 1st 2019, with an update on July 31th, 2020. Reference list of relevant articles were checked for additional titles for inclusion in the review. Software R was used to analyze some data using Chi-square to separate mean.

Results

Biology of Heterotis niloticus

Heterotis niloticus is the only african species of Osteoglossidae family. African bonytongue is a large freshwater fish native to the Sahelo-sudanese region in northwest Africa. It is found in rivers and lakes of Nilo-soudanian area, Central and West Africa (Moreau, 1982). This species lives at 21.50-30.10°C water temperature, and where oxygen is at 4.8-7.78 mg/l (6.20±2.10 mg/l of water), pH 6.70-7.25 (Sene, 2006; Monentcham, 2010a).

Spatial distribution of Heterotis niloticus

African bonytongue been introduced in many rivers, lakes and trough aquaculture.

Heterotis niloticus is found in West, East and Central Africa and in America. Because of its relative rapid growth, some other country like Central Africa Republic, Gabon, Ivory Cost and Madagascar imported this species from Cameroon around respectively 1956, 1959, 1959 and 1963 (Moreau, 1982) as from Table 1.

Fig.1 shows in red the source location of African bonytongue in Africa and in gray non-source location for African bonytongue (Sanders *et al*., 2014; GFIB Secretariat, 2018).

Table 1: Distribution of *Heterotis niloticus* in West and Central Africa

Year	Native country	Host country	Zone of migration
1952	North Cameroon	South Cameroon	Swamp of Nyong
1956	Cameroon	Republic of Central Africa	Fish farming+ Oubangui river
1959	Cameroon	Ivory Coast	Fish farming Bouake, artificial lakes Ayame, Kossou
1959	Cameroon	Gabon	Ogoue river
1963	Cameroon	Madagascar	Fish farming ivoloina, Pangalane and high plateau
1966	Congo	Zaïre	Congo river, Toumba lake

Source : Moreau (1982)

Importance and interest of Heterotis niloticus

Information concerning the chemical composition of the fishes is necessary to ensure that they meet the requirements of man's diet (Romharsha *et al*., 2014) because, biochemical composition of fish is a good indicator for quality (Hernandez *et al*., 2001).

The range of mineral contents in *H. niloticus* indicates that the species is a good source of minerals. His chemical composition is 16.54 ±3.24 % sodium, 1.68±0.18 % of calcium, 5±1,65% of potassium, 0.65±0.12 % of iron and 0.68±0.15 % of magnesium (Olanrewaju *et al*., 2016). These mineral

products are the essential elements important for proper functioning of blood (Hays, 1989). The mean value of approximate composition of *Heterotis niloticus* are: moisture content (62.95%), ash (2.40%), protein (20.60), fat (12.20%), carbohydrate (1.85%) (Olanrewaju *et al*., 2016).

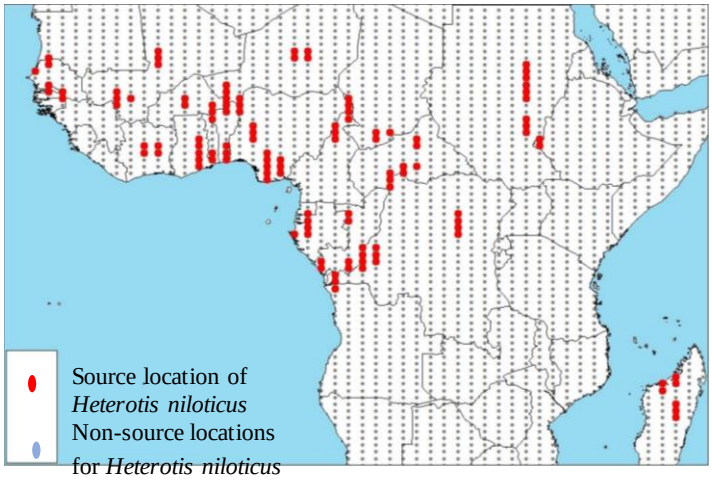

Figure 1. Map of location of *Heterotis niloticus* in Africa
Source: Froese and Pauly (2018)

The mean value of proximate composition of *Heterotis niloticus* in Nigeria are: moisture content (62.95%), ash (2.40%), protein (20.60), fat (12.20%), carbohydrate (1.85%) (Olanrewaju *et al*., 2016). In Cameroon, Monentcham, *et al*. (2010a) found that the body composition of *Heterotis niloticus* rearing in ponds have the following respective composition: moisture content (80.50%), ash (4%), proteins (13.60), total lipid (1.10%), and carbohydrates (1.85%).

Heterotis niloticus farming

- *Housing*

In Africa, African bonytongue are reared at tank, happa and ponds (Monentcham, 2009) (Photos 1, 2, 3 and 4).

- *Growth and feeding*

In Nigeria, Odo *et al*. (2009) found that *Heterotis niloticus* have a microphagous diet plus insect larvae. The fingerlings of *H. niloticus* grows rapidly with a diet who have 36% of protein and 6% of lipids (Monentcham *et al*., 2010b). In Africa, the Specific Growth Rate (SGR) of *Heterotis niloticus* varies between 3.22g/day to 4g/day. For artificial feeding, in Cameroon, the fingerlings of *H. niloticus* grows rapidly with a diet who have 36% of protein and 6% of lipids (Monentcham, 2010a).

Figure 2. Concrete tank

Figure 3. Hapas

Figure 4. Barrage pond

Figure 5. Diversion pond

❖ *Reproduction*

The reproduction of a species of fish, in a given environment is indeed a set of biological traits such as age and size at first sexual maturity, the fertility, gonad development and behavior including the availability of reproductive health care and the reproduction season (Paugy et Leveque, 1999). The maturation of gonads *Heterotis niloticus* in the Nyong depends of rainy season and the presence of abundant aquatic vegetation on the zones riverbanks (Nguenga and Brummet, 2010).

Table 2 shows the first sexual maturity for *Heterotis niloticus*. At 19 months old, African bonytongue is mature and its standard length is 30 cm and 33 cm respectively for male and female.

Table 2: Minimal size at first sexual maturity of *Heterotis niloticus*

Gender	Standard length **(cm)**	**Age (month)**	**Weight (kg)**
Male	30	19	0.8
Female	33		

Source: Kouakou et al., (2016).

By this figure (6), the Gonad Somatic Index (GSI) of the females of *Heterotis niloticus* was significantly higher than males. The pic of GSI become at the raining season and it declined progressively throughout the dry season. These indicated that the reproduction period of bonytongue was restricted to the wet and flood period margins (Adite *et al.*, 2006; Adite *et al.*, 2017; Kiloso, 2016; Kouakou *et al.*, 2016).

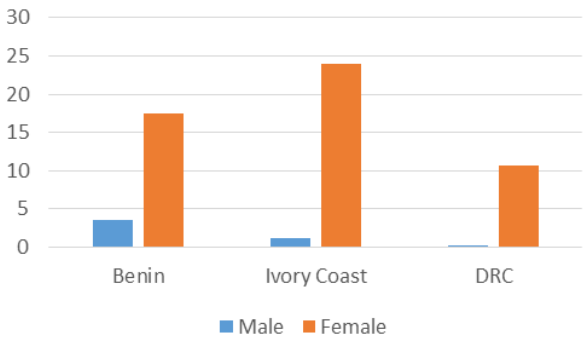

Figure 6. Variation of GonadoSomatic Index (GSI) according to the countries.
Source: Adite et al, 2017; Kouakou et al., 2016 ; Kiloso, 2016. DRC=Democratic Republic of Congo

Table 3 illustrates the periods of reproduction of *Heterotis niloticus* in some countries in Africa

Table 3: Reproduction period of *Heterotis niloticus* in Africa

Country	Reproduction period	References
Centrafrique (fish farming)	May to September	(Tillon, 1959)
Côte d'Ivoire (Agneby river)	June to August November to December	(Kouakou *et a*l., 2016)
Benin (Sô river)	May to August	(Adite *et al*., 2006)
Cameroon (Nyong river)	April to June September to October	(Depierre et Vivien, 1977)

Source: Koua (2020)

Many authors agree to recognize a definite correlation between the reproduction of *Heterotis* and the season of the rainfall causing heavy flooding and flooding of surrounding. The Gonad Somatic Index (GSI) of *Heterotis niloticus* varies between 0.52% to2.19% and 0.0035% to 0.35% respectively for females and males. The Gonad Somatic Index (GSI) of the females *Heterotis niloticus* was significantly higher in males at 5 % level according to the countries. The peak of GSI arises during the raining season and it declines progressively throughout the dry season. These indicated that the reproduction period of bonytongue was restricted to the wet and flood period margins. Many authors agree to recognize a definite correlation between the reproduction of *Heterotis niloticus* and the season of the rainfall causing heavy flooding and flooding of surrounding grassy areas which constitute preferred spawning grounds (Seme, 2006; Kiloso, 2016; Kouakou *et al*., 2016; Adite et al, 2017). There are therefore two reproduction periods April to June and September to November Nguenga and Brummet, 2010).

Genetics of Heterotis niloticus in Africa

- *Genetic diversity and sexing of Heterotis niloticus*

In 2020, Koua was study the reproductive trait of *Heterotis niloticus* and Arapaima Gigas. Following mitochondrial gene, he found six haplotypes of Cyt b gene and two haplotypes of NADH1 gene. None haplotypic differentiation between fish stocks and wild population belonging to the same basin, but haplotype differentiation between watersheds. ELISA Test and proteomic approach were used to sex the mature *Heterotis niloticus*.

- *Morphobiometric measurements of Heterotis niloticus in Africa*

In Cameroon, no study is done about diversity of this species, but the recent study by Djouatsa (2020) shows that in bimodal zone the diversity of *Heterotis niloticus* is very low but we have two types of

color patterns of body, grey and brown (Fig. 7 and 8); the dominant color of eye is golden. These results are similar to those got by Moreau (1982) in Africa.

Figure 7. Grey *Heterotis niloticus*

Figure 8. Brown *Heterotis niloticus*

The scales of *Heterotis niloticus* are cycloid and its caudal fin is rounded.

Table 4: Standard lengths according to countries

	Standard Length (cm)				
Country	**Benin**	**Ivory Coast**	**DRC**	**Nigeria**	**Cameroon**
M	63.25a	42.15b	16.24c	25.45c	52.55a
±SE	1.90	4.72	2.25	6.29	7.11
CV	3.01	11.21	13.86	24.72	13.52

Source : Adite et al., (2017) ; Kouako et al., (2016) ; Kiloso (2016) ; Odo et al., (2009) ; Djouatsa (2020). DRC= Democratic Republic of Congo, SE= Standard Error, CV= Coefficient of Variation, M=Mean; Numbers with the same letters are not statistically different at 5%.

The standard lengths (cm) varies across the countries: Benin (63.25±1.90), Cameroon (52.55±7.11), DRC (16.24±2.25), Ivory Coast (42.15±4.72) and Nigeria (25.45±6.29) (Adite *et al.*, 2017; Kiloso, 2016; Kouako *et al.*, 2016; Mohammed *et al.*, 2019; Djouatsa, 2020).

Following the Tab. 4, the standard length of *Heterotis niloticus* in DRC and Nigeria is the same statistically at 5%, and Benin and Cameroon have the same standard length. *Heterotis niloticus* of Ivory Coast have a different standard length with another country. Cameroon and Benin have a highest standard length in Africa.

- *Body weight of Heterotis niloticus in Africa*

Table 5 shows the different body weight of *Heterotis niloticus* in Africa.

Table 5: Comparison of body weight (g) with countries

Measurement	Body weight (g)					
	Benin	Ivory Cost	Senegal	Nigeria	Cameroun	DRC
M	2812.72a	595b	900c	252.7d	4505e	621.50f
±SE	106.94	21.21	141.42	176.21	4292.13	84.14

Source : Adite et al., (2017) ; Kiloso, (2016) ; Kouakou et al., (2016); Odo, et al., (2009) ; Djouatsa (2020) ; Sene (2006) Mohammed et al., (2019). Numbers with the different letters are statistically different at 5%. M=Mean, SE=Standard Error, DRC=Democratic Republic of Congo

In West Africa, the body weight of *Heterotis niloticus* varies from 252.7 g to 2812.72g, whereas in Central Africa the body weight varies from 621g to 4505g. In Benin and DRC, males are heavier than females and there is a significant difference in weight between females and males of *Heterotis niloticus* (Adite *et al.*, 2017; Kiloso, 2016; Djouatsa, 2020).

❖ *Diseases*

The presence of crustaceans of the genus *Lernaeogiraffa* and *Lernaea* that parasitize the gills of *Heterotis niloticus* has been noted and 40% of the stock may be contaminated (Mica, 1973 cited by Moreau (1982)). All species of *Lernaea* occur in Africa (Except *L. cyprinacea*) and the genera *Opistholernaea, Afrolernaea, Lernaeogiraffa* and *Dysphorus* are endemic in Africa (Moreau, 1982).

Conclusion

Aquaculture of *Heterotis niloticus* in Africa is much diversified because of varied rearing and fisheries patterns of this species. The said species is of nutritive importance for human and their diet in captivity is simple. The feed conversion is good for this species. The standard length and body weight vary with the environment conditions (climate, feeding…). The aquaculture of *Heterotis niloticus* has huge potentials in high fish demanding environment and therefore needs accurate data.

In this review, some core difficulties of *Heterotis niloticus* aquaculture in Africa are not clearly documented. Suggestions therefore focus on following aspects using appropriate tools and methods, including nuclear-derived techniques: cartography of *Heterotis niloticus* in Africa*;* morphobiometric characterisation of *Heterotis niloticus* in some countries (DRC, Ivory Cost, Cameroon); exploitation of *Heterotis niloticus* in Africa; genetic diversity of *Heterotis niloticus* in Africa; sex determination of *Heterotis niloticus* from controlling reproduction (artificial or semi-artificial reproduction), and actualisation of fish statistics in Africa.

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Author's contribution

Wikondi and **Meutchieye** designed the study; **Wikondi** collected, analysed the data and led manuscript steps**; Tomedi** and **Meutchieye** were revised and improved the paper contents.

Ethics

Authors declare that there are no ethical issues that my arise after the publication of this manuscript.

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