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

Wikondi J1, Tonfack DJ2, Meutchieye F2, Tomedi TM3

1: Department of Genetic and Biostatistic, School of Veterinary Medicine and Sciences, University of Ngaoundere, PO Box: 454 Ngaoundere-Cameroon
2: Biotechnology and Bioinformatics Research Unit, Department of Animal Science; University of Dschang, FASA, PO Box. 188, Dschang-Cameroon
3: Institute of Fisheries and aquatic Sciences of the University of Douala, Yabassi PO Box. 7236, Douala-Bassa

* Corresponding author: Wikondi Jeanne, Department of Genetic and Biostatistic, School of Veterinary Medicine and Sciences, University of Ngaoundere, Cameroon, E-mail: wikondi2013@gmail.com

Article history: Received: July 7th 2021; Revised: August 28th 2021; Accepted: September 2nd 2021

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 ichthyological 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 31st, 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+ Oubanguiriver |
| 1959 | Cameroon       | Ivory Coast | Fish farming Bouake, artificial lakes Ayame, Kossou |
| 1959 | Cameroon       | Gabon        | Ogoe 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).
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).
Table 3 illustrates the periods of reproduction of *Heterotis niloticus* in some countries in Africa.

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

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 areas. The Gonad Somatic Index (GSI) of *Heterotis niloticus* varies between 0.52% to 2.19% 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 haploptic 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***

![Grey Heterotis niloticus](image1)

**Figure 8. Brown *Heterotis niloticus***

![Brown Heterotis niloticus](image2)

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

**Table 4: Standard lengths according to countries**

| 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**
In West Africa, the body weight of *Heterotis niloticus* varies from 252.7 g to 2812.72 g, whereas in Central Africa the body weight varies from 621 g to 4505 g. 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.

**Acknowledgement**

Special thanks to the authors for their collaboration to this study.

**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 may arise after the publication of this manuscript.

**References**

Adite AK. Winemiller O. and Fiojgbe ED 2006. Population structure and reproduction of the African bonytongue *Heterotis niloticus* in the Sô River-floodplain system (West Africa): implications for management. Ecology of Freshwater Fishes 15:30-39. DOI: 10.1111/j.1600-0633.2005.00119.x

Adite A. Ediye MM. Toko II. Abou Y. Imorou RS. Sonon SP 2017. Morphological and meristic characterization of the African bonytongue, *Heterotis niloticus* (Cuvier, 1829), from Lake Hlan and Sô River, Southern Benin, West Africa: The need for habitat protection and species conservation. International Journal of Fisheries and Aquatic Research, 16-28p.
Kouakou FKI. Koné T. Soro Y. N'Da K 2016. Reproduction De Heterotis niloticus (Cuvier, 1829) De La Rivière Agneby(Côte d’Ivoire). European Scientific JournalFebruary2016 edition vol.12, No.6 ISSN: 1857 – 7881 (Print) - ISSN1857- 7431. doi: 10.19044/esj.2016.v12n6p83

Mohammed ZB. Diyaware MY. Umar HM. Agaji MI and Aliyu M 2019. Sex identification in Heterotis niloticus (Cuvier, 1829) using morphometric and meristic characters from Alau lake, Borno State Nigeria. FUDMA Journal of Sciences (FJS), ISSN online: 2616-1370 ISSN print: 2645 – 2944 Vol. 3 No. 3, September, 2019, pp 12 – 17.

Monentcham SE. Kouam J. Pouomogne V. and Kestemont P 2009. Biology and prospect for aquaculture of African bonytongue, Heterotis niloticus (Cuvier, 1829): A review. Aquaculture (289), 191–198 p. doi:10.1016/j.aquaculture.2009.01.019

Monentcham S-E. Kouam J. Chuba D. Whatelet B. Pouomogne V. and Kestemont P 2010 a. Partial substitution of fish meal with soybean with cottonseed meals in diet for African bonytongue, Heterotis niloticus (Cuvier, 1829) fingerlings: effects on growth, feed efficiency and body composition. Aquaculture research (41), e385-e392. doi: 10.1111/j.1365 - 2109.20.09.02461. x

Monentcham S-E. Pouomogne V. and Kestemont P 2010 b. Influence of dietary protein levels on growth performance and body composition of African bonytongue fingerlings, Heterotis niloticus (Cuvier, 1829). Aquaculture nutrition (16), 144–152. doi: 10.1111/j.1365-2095.2008.00646.x

Ngueenga D. et Brummet RE 2010. Facteurs d’adaptation et d’implantation du «Kanga» Heterotis niloticus (Cuvier, 1829) dans le fleuve Nyong (Cameroon). International Journal of Biological and Chemical Sciences, 4(2), 530-534. ISSN 1991-8631

Odo GE. Nwamba, HO. and Eyo J 2009. Aspects of the biology of Heterotis niloticus (Cuvier, 1829) (Osteoglossiformes: osteoglossidae) in the Anambra flood river system, Nigeria. Animal Research International 6(2):994-1002

Olanrewaju AN. Kareem OK. Nyaku R.E. and Tubo MT 2017. Length-Weight and Length-Length Relationships of Heterotis niloticus (Cuvier, 1829) and Rairamas senegalensis (Steindachner, 1870). J Aquac. Res. Development S2: 011. doi:10.4172/2155-9546.S2-0110. 1-5p

Romharsha H. Hei A. and Sarojinalini C 2014. Proximate composition and amino acid profile of some hill-stream fishes of Manipur. International Journal of Scientific Research, 3(8): 170 – 172.

Paugy D. et Lévêque C 1999. Les Poissons des Eaux Continentales Africaines : Diversité, Ecologie, Utilisation par l’Homme, (eds). Editions IRD: Paris; 351-364.

FAO 2019. Yearbook of fisheries and aquaculture for 2017.

Moreau. 1982. Exposé synoptique des données biologiques sur Heterotis niloticus (Cuvier, 1829). SAST 1,28(03).

Froese and Pauly 2018. African bonytongue (Heterotis niloticus); Ecological risk screening summary. U.S Fish and Wildlife Service, 1-14p. https://www.fishbase.de/summary/2388 (Accessed on June 16, 2020)

Djouatsa TJ 2020. Diversité phénotypique de Heterotis niloticus dans la zone forestière à pluviométrie bimodale du centre Cameroun. Mémoire de Master de Science, Département de Zootechnie, FASA, Université de Dschang. 63p.

Economidis Dimitriou E. Pagoni R. Michaloudi E N L 2000. Introduced and translocated fish species in the inland water of Greece. Fisheries Management and Ecology 7:239-250. DOI: 10.1046/j.1365-2400.2000.00197.x

Kiloso. MP 2016. Contribution à l’étude biologique d’Heterotis niloticus (Cuvier, 1829) du Congo Supérieur au Maniema (Cas du tronçon Kindu-Kowé). Mémoire de Diplôme d’Etudes Supérieures en Sciences Agronomiques, Faculté de gestion des ressources naturelles renouvelables, Université de Kisangani, 1-64p.

Koua 2020. Comparaison des traits de reproduction de deux espèces phylogénétiquement sœurs du groupe des ostéoglossoformes: Heterotis niloticus en Afrique et Arapaima gigas en Amérique du Sud. Thèse de Doctorat PhD, Normandine Université, 336p.

Sene ACG 2006. Étude des facteurs de développement de l’aquaculture d’Heterotis niloticus (Cuvier, 1829) : Caractérisation de la croissance en élevage extensif et premières observations de l’alimentation des jeunes stades. Mémoire de fin d’étude, Master II Sciences halieutique et aquacoles, Université de Cheikh Anta Diop, Sénégal.