E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2023; 11(6): 50-56

www.fisheriesjournal.com
Received: 20-09-2023
Accepted: 24-10-2023

Richard A Tossou
Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin

Diane NS Kpogue Gangbazo
[1] Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin
[2] Aquaculture Scool, National University of Agriculture, Bénin

Arnauld SM Djissou
Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin

Mouhamadou ND Liady
Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin

Zacharie Sohou
[1] Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin
[2] Benin Fisheries and Oceanographic Research Center, Benin

Emile D Fiogbe
Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin

Corresponding Author:
Richard A Tossou
Laboratory of Research on Wet Lands, LRZH/FAST/ University of Abomey-Calavi, Benin

Bibliography on the biology, ecology and breeding of the *Chrysichthys nigrodigitatus* (Lacépède, 1803)

Richard A Tossou, Diane NS Kpogue Gangbazo, Arnauld SM Djissou, Mouhamadou ND Liady, Zacharie Sohou and Emile D Fiogbe

DOI: https://doi.org/10.22271/fish.2023.v11.i6a.2878

Abstract
Chrysichthys nigrodigitatus, commonly known as the Jawfish, is classified in the *Claroteidae* family. It is present in tropical West Africa in lagoon and continental waters. It is easily recognizable from the other two species (*C. maurus, and C. auratus*) by its larger size and silvery gray coloration. There is a pronounced dimorphism between mature and immature individuals. Mature males can be recognised by their swollen heads and enlarged mouths, while mature females are overweight. *Chrysichthys nigrodigitatus* is a euryhalin fish with a preference for oligomesohaline waters. *Chrysichthys nigrodigitatus* has an omnivorous, insectivorous diet. Sexual maturity is reached in *Chrysichthys nigrodigitatus* around the age of 2 to 3 years. This fish is the subject of an intense fishery exploitation that threatens the stocks. Its domestication is the ultimate solution for its preservation in order to provide fish for consumption and reduce the import of frozen products.

Keywords: *Chrysichthys nigrodigitatus*, geographic distribution, diet, sexual maturity, threat

Introduction
Global aquaculture production reached a record 122.6 million tonnes in 2020, accounting for 57% of the world's total fish production estimated at 214 million tonnes in the same year (FAO, 2022) [1]. In Benin, domestic fish production has increased in recent years. Estimated at 52,250 tonnes in 2017, it reached 76,925 tonnes in 2021. Despite this increase in domestic fish production, domestic aquaculture production was down 12.6% from 2020. Estimated at 3,031 tonnes in 2020, it fell to 2,649 tonnes, or 3.44% of national fish production (Direction de la Statistique Agricole, 2022) [2]. This low domestic aquaculture production has resulted in increased imports of aquaculture products. This creates a dependence of the country on the outside and leads to significant foreign exchange losses through imports of fish products.
Human consumption of fish is estimated globally at 20.5 kg per capita in 2018. At regional and continental levels, fish consumption per capita is lowest in Africa, peaking at 10.5 kg in 2014 before falling back to 9.9 kg in 2018 (FAO, 2020) [3]. Low fish consumption in sub-Saharan Africa is the result of several interconnected factors, including a population that is growing at a faster rate than fish supply, stagnation of fish production due to pressure on catch fishery resources and a poorly developed aquaculture sector (Belco *et al.*, 2020) [4]. Indeed, according to FAO (2010) [5], aquaculture remains the most dynamic sector of food production of animal origin. In Benin, although numerous studies have proven the strong aquaculture potential of the country (topography and adequate infrastructure, availability of efficient aquaculture species, availability of qualified human resources, etc.), Beninese aquaculture is subject to constraints that hinder its development despite the multiple efforts of various actors (state, donors, NGOs, researchers, producers, etc.). (Abou *et al.*, 2007) [6]. These include the limited number of species farmed in aquaculture (*Clarias, Tilapia)* (Belco *et al.*, 2020) [4]. In the local markets and along the roads of Benin, several species of fresh fish from catches in inland waters are sold. This shows that apart from *Clarias gariepinus* and *tilapia*, the only species raised in Benin, the Beninese population gives a price to the variation of its fish dish. To meet this increased demand, these species are overexploited.

This gradually leads to their disappearance. It would therefore be important to domesticate these species of great aquaculture interest, so that Beninese farms are diversified into farmed fish, thus contributing to the reduction of overexploitation of these species in the aquatic environment. The *Chrysichthys nigrodigitatus* is a locally highly valued fish of great commercial value. It is a very widespread species in the lagoon environment, but less hardy. It adapts well to livestock conditions and is a prime choice for Beninese populations (Belco *et al.*, 2020) [4]. In Benin, little scientific work has focused on this species, although it could be an alternative to raising locally controlled fish. Therefore, it is necessary to take stock of the literature on geographical distribution, biology, ecology, natural feeding, reproduction in natural environment and diseases of the species to know it well and promote its breeding.

Origin and location of the species

According to Daget, (1965) [7], *Chrysichthys nigrodigitatus* is reported in most coastal rivers, from Senegal to Gabon, and frequents the brackish waters of coastal lagoons. It is common in the basins of Senegal, Gambia, Bandama and Niger. This species is captured in the upper, middle and lower parts of rivers (Roman 1974; Blache 1964; Loubens 1964) [8-10]. This species is known in most basins from Senegal to Angola (Risch 1992) [11]. *Chrysichthys nigrodigitatus*, absent from Chari and Lake Chad, is found in all watersheds of West Africa (Daget, 1962) [12]. It is found in Nigeria in the Cross River (Ndome *et al.*, 2018; Dele *et al.*, 2016; Ajang *et al.*, 2013; Ama-Abasi *et al.*, 2019) [13-16] in the Calabar River (Francis *et al.*, 2012) [30] and in the Epe Lagoon River (Muyideen *et al.*, 2010) [17]. It is present in Ghana in the Pra River (Okyere *et al.* 2020) [18] and in Côte d'Ivoire in the Ebrié lagoon (Bédia *et al.*, 2017) [19] and several rivers of these countries. In Benin it is found in lakes Nokoué and Ahémé, in the lagoon of Porto-Novo and in many rivers of Benin. *Chrysichthys nigrodigitatus* has marked genetic and morphological variations across regions.

Taxonomy

The genus *Chrysichthys* originally considered to belong to the family Bagridae is currently classified in the family Claroteidae. Nelson's classification (1994) shows that *Chrysichthys nigrodigitatus* (Lacépède, 1803) is Phylum: Chordata; Subphylum: Craniata; Super-class: Gnathostomata; Class: Ostheichthyus; Subclass: Actinopterygili; Subclass: Teloeostei; of the Order: Siluriforms; of the Family: Claroteidae; of the Genus: Chrysichthys; of the Subgenus: melanodactylus; of the Species: *Chrysichthys nigrodigitatus*.

Habitat

Chrysichthys nigrodigitatus is a euryhalin fish that colonizes brackish lagoons where it is often abundant, with a preference for oligomesoohalin waters (salinity ranging from 0 to 20 g. l -1) (Albaret, 1994; Hem *et al.*, 1994) [23]. In the wild, the population of *C nigrodigitatus* decreases as turbidity increases (Okyere *et al.* 2020) [18]. According to Ama-Abasi *et al.* (2019) [16], *Chrysichthys nigodigitatus* engages in local freshwater wanderings during the breeding season, giving the species a potamodrome status.

Morphological trait

According to Hem *et al.* (1994) [23], the name "mâchoiron" includes all three species of the genus *Chrysichthys (C. maurus, C. auratus and Chrysichthys nigrodigitatus).* Fish of the genus *Chrysichthys* commonly referred to as "machoiron" have a naked body characterized by the presence of four pairs of barbels, of which those of the lower jaw are unbranched and barely exceed the humeral spine (Lévêque *et al.*, 1992; Gourène *et al.*, 1995) [10, 25]. They have a pair of dorsal fins: the first is radiated and has 5 to 6 gill rays, the first is ossified and used for age determination. In the absence of scales, the second fin is small, fat and never has a radiated structure. A pair of pectoral fins of 8 to 11 soft rays, preceded by a strong spine, well denticulate on the posterior edge. A pair of ventral fins, implanted approximately in the middle of the body; a medium-sized anal fin comprising 3 to 5 single rays and 9 to 10 branching rays. The eyes with free edges, are lateral and large. The body is moderately elongated, 4 to 6 times as long as high (Risch, 1992) [11]. In fish of the genus *Chrysichthys*, a black spot is observed behind the operculum. There is a pronounced dimorphism between mature and immature individuals. The mature male is recognizable by its swollen head and enlarged mouth and the mature female by its overweight (Ouattara *et al.*, 2010) [26]. The *Chrysichthys* chew has 2n = 70 chromosomes. *Chrysichthvs nigrodigitatus* is recognizable by its large size, its pointed muzzle and a rather small mouth. Long and thin mandibular barbels have well separated insertion points. The occipital process is wide and the nostrils are well separated. The number of branchiospines on the first branchial arch varies from 14 to 18. The upper lobe of the caudal fin is much longer than the lower lobe (Ouattara *et al.* 2010) [26]. *Chrysichthys nigrodigitatus* is easily distinguished from the other two species (*C. maurus*, and *C. auratus*) by its larger size, silvery-gray coloration (while the other two are yellowish) and rapid growth. The head and back are dark brown or grey, the belly is white; the fat is often blackish (Hem *et al.*, 1994) [23].

Fig 1: Mature male and female of *Chrysichthys nigrodigitatus* (Yougone, 2008) [45]

Dele *et al.* (2016) [14] showed that the total lengths of *Chrysichthys nigrodigitatus* ranged from 11.00 to 30.20 cm (average size 19.67±4.56 cm), while the standard lengths ranged from 8.30 to 24.50 cm (average size 15.09±3.39 cm), the length-to-length relationship weight being described by the equation: Log W = 1.5389±2.8168 Log L. The value of the regression coefficient "b" for this species was nearly 3, indicating isometric growth. The average condition factors ranged from 1.68 to 1.76. Oluwale (2019) [29] showed that *Chrysichthys nigrodigitatus* has negative allometric growth with the regression coefficient of the relationship length – weight b=2. Francis *et al.* (2012) [30] showed that *Chrysichthys nigrodigitatus* has an Lmax (113.8 cm), (116.8 cm), Lm (60 cm), Lopt (75.9 cm).

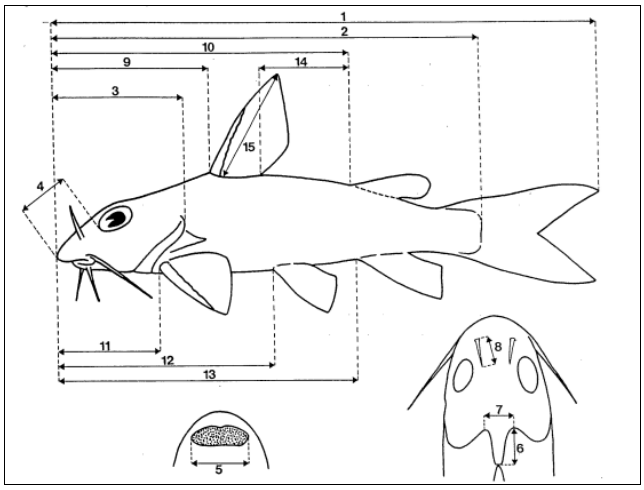

Fig 2: Morphometric characters studied on specimens of *Chrysichthys nigrodigitatus* (Ouattara *et al.*, 2010) [26]

1, total length; 2, standard length; 3, head length; 4, muzzle length; 5, premaxillary band width; 6, occipital process length: 7, occipital process width; 8, nasal barb length; 9, pre-dorsal length; 10, preadipose length; 11, prepectoral length; 12, prepelvian length; 13, preanal length; 14, distance between dorsal and adipose fins; 15, dorsal fin length.

Diet and population dynamism

Chrysichthys nigrodigitatus has an omnivorous diet (Oramadike 2015; Kouamé 2009) [31, 32]. Muyideen *et al.* (2010) [17] indicate that food organisms consisted of phytoplankton, crustaceans, molluscs, plant matter and parts of fish. According to Okyere *et al.* (2020) [18], catfish feed on detritus, insects, polychaetes, oligochaetes, bivalves, amphipods, shrimp, crabs and fish, with detritus being the most consumed food product. According to Oluwale (2019) [29], stomach content analysis based on the Relative Importance Index revealed that juvenile *Chrysichthys nigrodigitatus* were omnivorous and feed primarily on algae, chironomid larvae, amphipods, rotifers, plants and fry. The estimated relative length of the intestine was greater than 1 (> 1), validating the omnivorous feeding habit. The feeding strategy diagram represented the species as generalist with an insectivorous tendency. In the wild, the diet of *Chrysichthys nigrodigitatus* varies with individual size (Yao 2006) [33]. Ndome *et al.* (2018) [13] reveal seven (07) identified foods and an unidentified mass distributed by size of individuals of *Chrysichthys nigrodigitatus*. Unidentified mass, algae, insect parts, fish bones, and mud are the main food sources for *Chrysichthys nigrodigitatus*, which ranged in size from 36, 0 to 56.5 cm standard length while in *C. Nigrogitatus* individuals ranging in size from 56, 6 to 77.0 cm standard length the main feeds consist of unidentified mass, algae and fish parts. Larvae and juveniles are zooplankton and insectivorous respectively (Konan 1983; Yao 2006) [34 33]. Adults feed on organic detritus and invertebrates: insect larvae (chironomas, dipterans), planktonic crustaceans, molluscs, in particular the bivalve *Corbula trigona* present in abundance in the benthos (Ikusemiju and Olaniyan, 1977) [35]. According to Lalèyè *et al.* (1995) [20], *Chrysichthys nigrodigitatus* tends to specialize during its growth, with the appearance of a more predatory tendency towards juvenile fish and decapod crustaceans in adulthood. The season also influences the diet of *Chrysichthys nigrodigitatus*. During the rainy season, the fish feed mainly on Chirominidae, Oligochaetes and gastropods while the prey consumed in the dry season are Chirominidae and Odonates, mainly Neurogomphus sp. (Yao, 2006) [33]. According to Dele *et al.* (2016) [14] *Chrysichthys nigrodigitatus* was captured both during the dry season (October - March) and the wet season (April - September), with the highest abundance observed in June. The decline in the population density of the species has been attributed to the interaction of many factors such as habitat and breeding location, low reproductive rate, overexploitation of the species and migratory behaviour of the species.

Reproduction in the natural environment

Research on controlling the reproduction of Jawfish in the broad sense began in 1977. They relied on the particular behaviour of these fish during the breeding season. The morphology of adult's changes, creating a very clear sexual dimorphism. Then the couples look for crevices (dead wood, bamboo), to deposit the eggs to which they give parental care (custody and ventilation of the laying), (Hem *et al.*, 1987) [36]. According to Legendre and Albaret (1991) [37], sexual maturity is reached around the age of 2 years for individuals larger than 200 mm. Dia (1975) [38] estimates that *Chrysichthys nigrodigitatus* reproduces from the height of 330 mm which is equivalent to 3 years of age. According to Legendre and Albaret (1991) [37], the maximum breeding size is 650 mm (fork length). On the other hand, the smallest mature female for reproduction measured 195 mm (Albaret, 1982) [39].

Oocyte maturity generally begins with the beginning of the rainy season and reaches its peak during periods of high flooding of lagoons and rivers where temperature and salinity are declining (Nuñez-Rodriguez *et al.*, 1995) [49]. According to the same authors, vitellogenesis begins between April and May and reaches its peak between June and August. According to Otémé (1993a) [42] the final phase of gonadal maturation occurs in August with oocytes whose average diameter is between 2.5 and 3 mm. On the other hand Nuñez Rodriguez *et al.* (1995) [49] estimate that the spawning begins towards the end of August, reach their maximum frequency between September and October and they decrease towards the end of November to end in early December.

The same female of *Chrysichthys nigrodigitatus* reproduces only once in the year. But Hem *et al.*, (1994) [23] observed that in low-salt or low-salinity areas, reproductive activity may extend year-round in some females of *Chrysichthys nigrodigitatus*. According to Otémé (1993a) [42], the absolute fertility of *Chrysichthys nigrodigitatus* is between 9805 and 40587 oocytes, or on average a relative fertility of 15 oocytes per gram of female body weight, with extreme values of 6 and 24 oocytes per body weight. Kouassi (1973) [41] and Lalèyè *et al.* (1995) [20] estimated relative fertility of 24 and 11±5.12 eggs per gram of body weight in the wild, respectively. The age of *Chrysichthys nigrodigitatus* brood stock has a significant effect on reproductive performance. Indeed, according to Yougone *et al.* 2008 [45], larval growth in weight and length and survival rate are better in 4-year-old females than in 2- and 3-year-old females.

Diseases of *Chrysichthys nigrodigitatus*

There are two monogenes and three intestinal parasites in *Chrysichthys nigrodigitatus*. The two species of monogenes are: *Protoancylodiscoids chrysichthes* and *Protoancylodiscoids sinonchium* (Kritsky *et al.*, 1999) [43].

The first cited carries an onchium while the second does not (Bilong-Bilong *et al.*, 1997) [44]. The intestinal parasites identified in *Chrysichthys nigrodigitatus* are *Nephrocephalus sessilis*, *Siphodera ghanensis* and *Pleistophora sp* (Kouamé A., 2009) [32]. *Nephrocephalus sessilis* and *Pleistophora sp* were detected in the intestine while *Siphodera ghanensis* was encountered both in the intestine and in the stomach.

Current knowledge on *Chrysichthys nigrodigitatus* breeding

The breeding of *Chrysichthys nigrodigitatus* has been effective in Côte d'Ivoire for several years. It is done in the country's lagoons. The methods used for the breeding of *Chrysichthys nigrodigitatus* are as follows:

Controlled reproduction

Controlled reproduction of *Chrysichthys nigrodigitatus* was achieved by «forced marriage», confining sexually mature couples for 2 to 4 weeks in spawning receptacles formed by a PVC tube (Hem, 1986) [46]. This method has been gradually refined to currently achieve egg laying in more than 80% of females. Reproduction of free-ranging pairs in ponds with open egg-laying receptacles is also possible (Otémé, 1993b) [47]. However, for practical reasons, the first method is currently used in production context.

Jawfish breeding cycle

Larval rearing and fry rearing

Larval rearing of *Chrysichthys nigrodigitatus* now poses no particular problem, due to the large size of the larvae at hatching and the size of their vitelline reserve. Hatching takes place five days after fertilization at a temperature of 27-29 °C. The resulting larvae weigh 25 to 30 mg. They have a large yolk sac (approx. 3 mm), which takes around ten days to be completely resorbed at a temperature of 28-30 °C. From this stage onwards, the fish accept directly a compound feed containing 45% crude protein, presented in the form of meal (Dia and Otémé, 1986) [48]. After around twenty days of rearing in circular tanks fed with lagoon water, the fry reach a weight of 80 to 150 mg and can then be transferred to ponds (Hem *et al.*, 1994, 1995) [23].

Pre-fattening

It has two stages

The first stage takes place in ponds. Post-larvae receive an artificial food and they also benefit from the nutritional supplement of planktonic biomass that develops there. This semi-intensive pre-magnification allows to produce juveniles of 5 - 7 g in three months. The second stage is carried out in lagoon cages with small mesh (about 8 mm) and it lasts three months. This pre-magnification allows to obtain juveniles or fingerlings of about 15-20 g. The density of 100 fish per m^2 seems to be optimal for this phase (Hem *et al.* 1994) [23].

Fattening

Grow-out takes place in lagoon enclosures on sandy bottoms about 1 m deep. During this phase, fish of 26 cm or 250 to 300 g are obtained from juveniles of 10 and 15 g after eleven months of rearing (Van Opstal and Coton, 1981; Hem, 1982) [51, 50]. Market-sized fish (350 g to 450 g) are obtained after around 18 months of rearing. Stocking densities are typically 10 to 20 fingerlings per square meter. Survival rates at the end of the grow-out cycle are generally over 90%. (Hem *et al.*, 1994) [23].

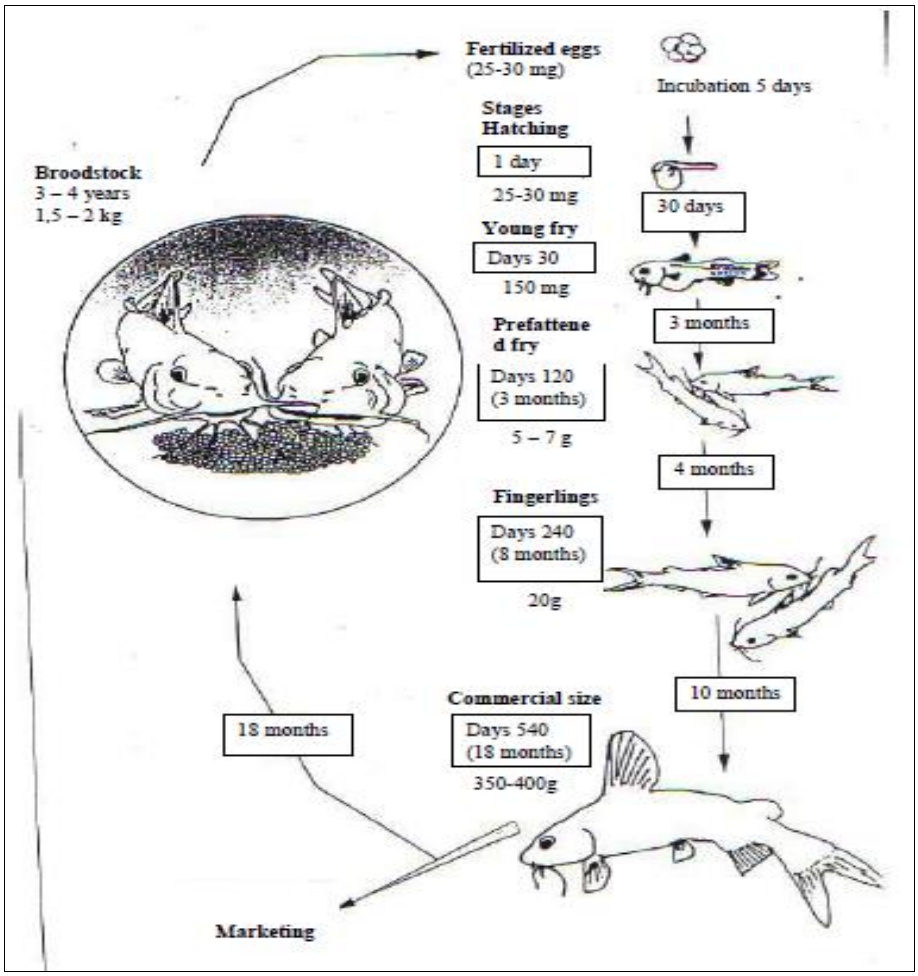

Fig 3: Jawfish rearing cycle at the Layo aquaculture experimental station (Côte-d'Ivoire), (Yougone, 2008) [45]

Feeding in a breeding environment

Several studies carried out on the feeding of *Chrysichthys nigrodigitatus* in captivity have led to the development of diets that promote better growth and survival rates (Dia and Otémé, 1986; Cissé *et al.*, 1995; Erondu *et al.*, 2006) [48, 52, 53]. Individual food requirements vary according to development and physiological stage. After resorption of the yolk vesicle, larvae accept artificial food containing 30% crude protein. This food can be either in the form of flour, or based on fresh sheep brains (Dia and Otémé, 1986) [48]. Whatever the feed, larvae are fed *ad libitum* for an average of three weeks. Juveniles and adults are fed a compound feed in the form of pellets of varying sizes, depending on the age of the individuals. In juveniles, the feed used contains between 30 and 40% protein and is presented in the form of 3 mm diameter pellets (Hem *et al.*, 1987; Erondu *et al.*, 2006) [36, 53], whereas the feed distributed to adults is titrated at 35% crude protein (Hem *et al.*, 1994) [23]. Several dietary protein sources were used to manufacture experimental feeds formulated with 35% crude protein for *C nigrotigitatus.* In these feeds, the major proteins are provided either by *Artemia salina*, beef brain meal or maggot meal. The best growth rates are obtained with bovine brain meal, while the lowest growth rates are recorded with maggot meal (Kouadio, 2014) [54].

Polyculture of *Chryschthys nigrodigitatus*

Otémé (1991) [55] polycultured machoiron *Chryschthys nigrodigitatus* with *Oreochromis niloticus* in ponds. Stocking densities were 6,700 jawfish per hectare on the one hand, and 6,700 jawfish with 3,350 *tilapia* per hectare on the other. The daily feed ration was set at 6% of the estimated jawfish biomass. The results showed that tilapia appear to have contributed to an improvement in water quality. Their presence did not affect jawfish growth or production. However, it did significantly increase total fish production by 23.5%. The average survival rate of jawfish did not differ from one production system to another.

Aspects not yet covered

To this day

- The transfer and storage of fry and adults of *Chrysichthys nigrodigitatus* is not controlled.
- At present, there are no studies reporting precise nutritional requirements for *Chrysichthys nigrodigitatus*.
- The optimum stocking density and feeding rate for *Chrysichthys nigrodigitatus* fry reared in a controlled environment have not been precisely determined.
- As all available data on *Chrysichthys nigrodigitatus* rearing in Côte-d'Ivoire are recorded in lagoon rearing, it would be interesting to carry out these studies in freshwater rearing to enable fish farmers in Benin, wherever they may be in the country, to breed this species.

Development involvement

Numerous studies have already been carried out on the biology, ecology and rearing of *Chrysichthys nigrodigitatus* in many countries, making it an interesting target for attempts at aquaculture rearing. However, it has not been domesticated in freshwater, although it could be adapted to local conditions for fish farming in Benin. Research to develop its captive breeding proved necessary. To achieve this, it is important to carry out scientific work in order to determine the conditions of transfer and storage of fry, the optimal stocking density of larvae and fry, optimal rationing of larvae and fry and nutritional requirements (proteins, lipids, carbohydrates) of *Chrysichthys nigrodigitatus.*

In the long term, it would be useful to consider studies on the exploitation and the impact of the degradation of water bodies on the survival and growth of *Chrysichthys nigrodigitatus* in order to lead to the implementation of a participatory development plan including the various stakeholders in the fisheries sector in Benin.

References

1. FAO. Résumé de la Situation mondiale des pêches et de l'aquaculture: Vers une transformation bleue. Rome, FAO; c2022. p. 32.
2. Direction de la Statistique Agricole. Les chiffres de la campagne agricole 2021-2022 et les prévisions de la campagne agricole 2022-2023; c2022. p. 28.
3. FAO. Résumé de la situation mondiale des pêches et de l'aquaculture: la durabilité en action; c2020. p. 28.
4. Belco AL, Imorou T, Elegbe HA, Pelebe ROE, Tougan PU, Boni AR, *et al.* Les Produits Halieutiques au Bénin: Sources d'Approvisionnement et Statistiques. 2020;21(1):152-167.
5. FAO. La situation mondiale des pêches et de l'aquaculture; Département de Pêches et Aquaculture, FAO (Ed), Rome (Italie); c2010. p. 244.
6. Abou Y, Fiogbé ED, Micha JC. Effects of stocking density on growth, yield and profitability of farming Nile tilapia, Oreochromis niloticus, fed Azolla diet, in earthen ponds. Aquaculture Research. 2007;38:595-604.
7. Daget J. Poissons de Côte d'Ivoire (Eaux douces et saumâtres), Mémoire de l'IFAN. 1965;(1174):385.
8. Roman B. Complément d'information sur les poissons des hauts-bassins du fleuve Volta. Notes et Documents Voltaïques. 1974;(7):123-152.
9. Blache J. Les poissons du bassin du Tchad et du bassin adjacent du Mayo kebbi. Etude systématique et biologique. Mémoire orstom. 1964;(4):483.
10. Loubens G. Travaux en vue du développement de la pêche dans le bassin inférieur de l'Ogone. Parie, Centre Technique Forestier Tropical; c1964. p. 27.
11. Risch LM. Bagridae. In Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Vol. 2. Edited by Lévêque C, Paugy D, and Teugels GG. Collection Faune Tropicale XXVIII, ORSTOM, Paris, and Musée Royale de l'Afrique Centrale, Tervuren, Belgium; c1992. p. 395-431.
12. Daget J. Poissons du Fouta Dialon et de la basse Guinee. Mem. Inst. Fr. Afr. Noire. 1962;65:210.
13. Ndome CB, Udo IU. Food, feeding habit and condition factor of Silver Catfish (*Chrysichthys nigrodigitatus*) (Geoffrey Saint Hilaire, 1808) from Cross River estuary, Nigeria JFLS. 2018;3(2):20-25.
14. Dele M, Alinko SA, Ali HG. Declining population density of Silver Catfish, *Chrysichthys nigrodigitatus* in Cross River State, Nigeria Advances in Agriculture and Agricultural Sciences ISSN 2381-3911. 2016;2(3):092-098.
15. Ajang RO, Ndome CB, Ekwu, A, Uttah EC, Iboh CI. Population dynamics and gillnets selectivity of *Chrysichthys nigrodigitatus* (Lalepede 1803) in lower reaches of the cross river estuary, Nigeria. Ethiopian

Journal of Environmental Studies and Management. 2013;1:31-40.
16. Ama-Abasi D, Mfon U, Aniedi EU, Bassey J, James E, Sandra U. The migration status of silver catfish, *Chrysichthys nigrodigitatus* (Siluriformes: Claroteidae) of the cross river, Nigeria. International Journal of Fisheries and Aquatic Studies. 2019;7(5):536-541.
17. Muyideen OL, Oluwabamise JS, Bola MS. Morphometry and diet of *Chrysichthys nigrodigitatus* (Lacépède) in Epe Lagoon, Nigeri African Journal of Biotechnology. 2010;9(46):7955-7960.
18. Okyere I, Boahemaa-Kobil EE. Occurrence and food habits of the bagrid catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) in the Pra River Estuary, Ghana, Journal of Fisheries and Coastal Management; c2020. p. 29-34.
19. Bédia AT, N'doua ER, Goore GI, Essetchi KP, N'douba V. Paramètres de croissance et d'exploitation de *Chrysichthys nigrodigitatus* (Lecepede, 1803) (Siluriforme, Bagridae) dans une lagune tropicale: lagune Ebrié (Secteur I: lagune Potou, Côte d'Ivoire) Tropicultura. 2017;35(4):253-261.
20. Lalèyè PA, Philippart JC, Poncin P. Biologie de la reproduction de deux espèces de Chrysichthys (Siluriformes; Bagridea) au lac Nokoué et à la lagune de Porto-Novo au Bénin. J Afr. Zool. 1995;109(3):213-224.
21. Nelson JS. Fishes of the world. 3rd edition Wiley and sons; c1994. p. 600.
22. Albaret JJ. Les poissons: Biologie et peuplement. In: Environnement et ressources aquatiques de Cote d'Ivoire. Tome II. Les milieux lagunaires. J.R. Durand, P. Dufour, D. Guiral, SGF Zabi, Ed. Editions de l'ORSTOM, Paris; c1994. p. 239-279.
23. Hem S, Legendre M, Trebaol L, Cisse A, Otémé ZJ, Moreau Y. L'aquaculture lagunaire. In: Environnement et ressources aquatiques de Côte-d'Ivoire. Tome II. Les milieux lagunaires. Durand JR, Dufour P, Guiral D, Zahi SGF. Ed. Edition de l'ORSTOM, Paris; c1994. p. 455-505.
24. Lévêque C, Paugy D, Teugels GG. Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest. Edition orstom Tome; c1992. p. 468-495.
25. Gourène G, Teugels GG, Thys Van Den Audenaerde DFE. Manuel pratique d'identification des poissons du lac d'Ayamé Rivière de Bia (Côte d'Ivoire). Archives Scientifiques. Edition CRO / ORSTOM, Abidjan. 1995;14(1):5-11.
26. Ouattara TAS, Atseb C. Identification morphologique des espèces de chrysichthys (Bleecker, 1862) F. Tech. & Doc. Vulg; c2010. p. 19-23.
27. Adéno AB. Différenciation génétique des populations naturelles de poissons d'intérêt aquacole en Afrique de l'ouest. Doctorat de troisième cycle d'Hydrobiologie. Université de Cocody, Abidjan (Côte d'Ivoire); c1996. p. 106.
28. Yougone DBI. Contribution à l'étude des effets de l'âge sur les performances de reproduction du mâchoiron (*Chrysichthys nigrodigitatus*) élevé à la station expérimentale d'aquaculture de layo en côte d'ivoire, thèse de doctorat; c2008. p. 85.
29. Oluwale FV. Aspect of the neglected biology of a juvenile catfish from the wild, Int. J Res. 2019;7(4):1422-1432.
30. Francis A, Elewuo U. Aspects of the biology of trap caught *Chrysichthys nigrodigitatus* (Lacepede: 1803) from the New Calabar River, Nigeria; International Journal of Fisheries and Aquaculture. 2012;4(6):99-104.
31. Oramadike CE. Proximate Composition and Technological Properties of Wild African Catfish *Chrysichthys nigrodigitatus* (Lacépède1802) American Journal of Agricultural Science. 2015;2(2):54-58.
32. Kouamé A. Parasitisme et productivité en élevage du mâchoiron *Chrysichthys nigrodigitatus* (Lacepede, 1803) en Côte d'Ivoire; Thèse de Doctorat; c2009. p. 174.
33. Yao SS. Contribution à l'étude de la diversité biologique et de l'écologie alimentaire de l'ichtyofaune d'un hydrosystème ouest-Africain: cas du bassin de la Comoé (Côte d'Ivoire) thèse de Doctorat, Université de Cocody Abidjan (Côte d'Ivoire); c2006. p. 222.
34. Konan A. Régime alimentaire de deux espèces de Chrysichthys en lagune (Côte d'Ivoire). Mémoire cycle Ingénieur ENSA (Rennes), France; c1983. p. 28.
35. Ikusemiju K, Olaniyan CIO. The food and feeding habits of the catfishes. Chrysichthys walkeri (Giinthcr), Chrysichthys filamentorns (Boulengcr) and *Chrysichthys nigrodigitatus* (Lacepedc) in Lekki lagoon. Nigeria. J Fish Biol. JO; c1977. p. 105-115
36. Hem S, Bard FX, Otémé ZJ, Moreau Y. Recherches sur l'aquaculture du machoiron. In: Recherches en aquaculture sur les principales espèces de poissons lagunaires en Côte-d'Ivoire. (1984-1986). Rapp. CEE/ORSTOM/CRO, TSD A. 1987;082:11-39.
37. Legendre M, Albaret JJ. Maximum Observed Length (MOL) as an indicator of growth rate in tropical fishes. Aquaculture. 1991;94:327-341.
38. Dia AK. Détermination de l'âge des machoirons (*Chrysichthys nigrodigitatus*). Premières estimations de la croissance. Due. Scient. Cent. Rech. Oceanogr. Abidjan. 1975;6:139-151.
39. Albaret JJ. Reproduction et fécondité des poissons d'eau douce de Côte d'Ivoire. Rev. Hydr. Trop. 1982;15(4):283-404.
40. Nuñez-Rodriguez J, Otémé Z, Hem S. Comparative study of vitellogenesis of two African catfish species *Chrysichthys nigrodigitatus* (Claroteidae) and Heterobranchus longifilis (Clariidae). Aquatic Living Resources. 1995;8(4):291-296.
41. Kouassi NJ. Note sur la biologie de *Chrysichthys nigrodigitatus* et de Chrysichthys velifer. Développement de la pêche du lac de Kossou Projet PNUD/FAO. IVC. 1973;(526):8.
42. Otémé ZJ. Reproduction et fécondité du mâchoiron *Chrysichthys nigrodigitatus* en élevage. Journal. Ivoire. Océanologie. Limnologie. Abidjan. 1993a;2(1):53-59.
43. Kritsky DC, Stephens JF. Haliotrema abandon n. sp. (Monogenea, Dactylogyridae) from the gills of wild and maricultured west Australian dhufish Glucosoma hebraicum (Teleostei: Glaucosomatidae) in Australia. J. Paraditol. 1999;(87):749-754.
44. Bilong-Bilong CF, Birgi E, Le Brun N. Protoancylodiscoides malapteruri n. sp. (Monogenea, Dactylogyridae, Ancyrocephalidea), parasite branchial de Malapterurus electricus Gmelin (siluriformes, Malapteruridae), au Cameroun. Systematic parasitology. 1997;38:203-210.
45. Yougone DBI. Contribution à l'étude des effets de l'âge sur les performances de reproduction du mâchoiron (*Chrysichthys nigrodigitatus*) élevé à la station

expérimentale d'aquaculture de layo en côte d'ivoire, thèse de doctorat; c2008. p. 85.
46. Hem S. Premiers résultats sur la reproduction contrôlée de *Chrysichthys nigrodigitatus* en milieu d'élevage. In: Aquaculture research in the African region. Proc. African seminar on aquaculture. E. A. Huisman ed. PUDOC, Wageningen, Neth; c1986. p. 189-205.
47. Otémé ZJ. Cycle sexuel et fécondité du mâchoiron *Chrysichthys nigrodigitatus* en lagune Ebrié (Côte d'Ivoire). Journal. Ivoire. Océanologie. Limnologie. Abidjan. 1993b;2(1):61-67.
48. Dia AK, Otémé ZJ. Etude de la qualité de l'aliment et de la densité sur le taux de survie des alevins de *Chrysichthys nigrodigitatus*. In: Aquaculture research in the African region. Proceedings of the African seminar on aquaculture. E. A. Huisman Ed. PUDOC, Wageningen (Hollande); c1986. p. 169-174.
49. Hem S, Nunez Rodriguez J, Otémé ZJ. L'aquaculture du machoiron en Côte-d'Ivoire. ORSTOM actualités. 1995;48:28-33.
50. Van Opstal Y, Coton P. Efficacité comparée de différentes formules alimentaires sur la croissance en élevage de Chrysichthys walkeri et *Chrysichthys nigrodigitatus*. Doc. Scien. Cent. Rech. Océanogr. Abidjan. 1981;12(1):79-89.
51. Hem S. L'aquaculture en enclos: adaptation en milieu lagunaire ivoirien. Aquaculture. 1982;21:261-272.
52. Cissé A. Nutrition *et al.*imentation des poisons. Programme de formation, module1, Document Scientifique, Centre de Recherche Océanologiques; c1995. p. 24.
53. Erondu ES, Bekibele D, Gbulubo AT. Optimum crude protein requirement of the catfish, *Chrysichthys nigrodigitatus*. Journal of Fisheries International. 2006;1(1-2):40-43.
54. Kouadio NJ. Influence de la source de protéines alimentaires et de la densité de mise en charge sur les performances zootechniques des post-larves de machoiron *Chrysichthys nigrodigitatus* (lacepede, 1803), Mémoire de master; c2014. p. 85.
55. Otémé ZJ. Polyculture du machoiron Chrysichthys nixrodigitatus avec Oreochromis niluticus en étang. J lvoir. Oceannl. Limnol. 1991;1:9-15.
56. Otémé ZJ. Polyculture du machoiron *Chrysichthys nixrodigitatus* avec *Oreochromis niloticus* en étang. J. lvoir. Oceannl. Limnol. 1991;1:9-15.