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ORIGINAL ARTICLE

Occurrence and food habits of the bagrid catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) in the Pra River Estuary, Ghana

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ABSTRACT
This study assessed how environmental parameters such as salinity, dissolved oxygen (DO) and turbidity influenced occurrence of the bagrid catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) population in the Pra Estuary, their food habits, and how food preferences varied amongst the sizes. Fish were sampled from January to April 2017 using cast net. Physicochemical parameters were measured *in situ* using multi-parametric water quality checker. Length and weight of fish were determined, and with the aid of dissecting microscope, stomach contents were examined using the frequency of occurrence and 'points' methods. Salinity showed a general downward trend with the highest of 30‰ in January and lowest of 1‰ in April, DO fluctuated between 4 mg/L and 5 mg/L, while turbidity increased progressively from 8 NTU in January to 207 NTU in April. The number of fish caught decreased as turbidity increased and salinity decreased. A total of 282 specimens measuring 8.0 cm to 42.5 cm (TL) were sampled of which fish smaller than 17 cm were dominant. The catfish fed on detritus, insects, polychaetes, oligochaetes, bivalves, amphipods, shrimps, crabs and fish, with detrital matter being the most consumed food item. Recommendations are made for management considerations to address illegal mining activities which silt the estuary as well as regulate fishing practices such as the use of small meshed-nets that capture juveniles and bottom drag nets that deplete the food of the catfish.

Keywords: Pra Estuary, Water quality, Bagrid catfish, Food habits, Fisheries Management

Introduction

One economically important group of fish that utilize estuarine ecosystems are species of the genus *Chrysichthys* Bleeker, 1858 (see Froese & Pauly, 2020), in the family Claroteidae. There are five species belonging to the genus *Chrysichthys* in freshwaters of Ghana namely *C. walkeri* Günther, 1899, *C. auratus* (GeoffroySaint-Hilaire, 1809), *C. johnelsi* (Daget, 1959), *C. maurus* (Valenciennes, 1840) and *C. nigrodigitatus* (Lacepède, 1803) (Dankwa et al., 1999). Of the five, *C. nigrodigitatus* is known to be characteristically hardy and tolerant of different ecological conditions which has facilitated its culture in some countries (Pangni et al., 2008a; Pangni et al., 2008b), and the fish is well consumed for its nutritional value. The species is distributed in most basins from Senegal to Angola, occurring over mud and fine sand bottoms in shallow waters of lakes, rivers, estuaries and swamps where they are of great importance to aquaculture and fisheries (Paugy et al., 2003). Given the importance of this bagrid catfish to the fisheries in African basins, it is important to understand the ecology of the various populations in the different systems in which they occur in order to identify system-specific management strategies for the stocks.

Through the USAID-Ghana Sustainable Fisheries Management Project (a five year project focused on rebuilding Ghana's fish stocks) a community based fisheries co-management committee has been inaugurated to commence management planning for the fisheries resources of the River Pra estuary, the second largest estuary in Ghana after the Volta estuary. With *C. nigrodigitatus* being abundant in the estuary (Okyere, 2015), knowledge of the biology and ecology of this species in the ecosystem is critical as prerequisite for making sound management decisions. This research pertinently contributes information on the occurrence and food habits of the *C. nigrodigitatus* population in the Pra estuary.

Understanding the food habits of *C. nigrodigitatus* in the estuary is important because fishes appear to be dynamic in their feeding in different water bodies as indicated by Welcomme (1985). *C. nigrodigitatus* in particular is reportedly an opportunistic feeder that feeds on different food items in different systems. For instance, whereas Reed et al. (1967) reported the species as omnivorous opportunist capable of feeding on a variety of dietary items including seeds, insects, bivalves and detritus, Ajani (2001) described it as a carnivore that feeds throughout the water column. In Nigeria, while some populations fed widely on fish, crustaceans, molluscs, rotifers, phytoplankton and plant materials (Offem et al., 2008; Lawal et al., 2010), others consumed mainly molluscs (Ikusemiju and Olaniyan, 1977). Furthermore, feeding may become specialized with age and size of the fish and large individuals may feed on decapods and fish whereas relatively small individuals prefer zooplankton including copepods, ostracods and cladocerans (Idodo-Umeh, 2003; Laleye, 1995). This trophic variability makes it imperative to understand the food habits of local populations for management purposes.

To this end, this work investigates how abiotic parameters such as salinity, dissolved oxygen (DO) and turbidity influence the occurrence of the catfish *C. nigrodigitatus* in the Pra estuary. It also examines the dietary food items consumed by the population and how food preferences differ between different sizes of the fish as a contributory research for the Pra estuarine fisheries management planning.

Materials and methods

Sampling site

The study was carried out in River Pra estuary (Figure 1) located in Shama District in the Western Region of Ghana, West Africa (5° 01’ 00” N, 5° 03’ 30” N and 1° 36’ 30”W, 1°38’ 00” W). The estuary provides fish resources for communities along its banks mainly Shama, Anlo Beach and Krobo. As described by Okyere (2018), the main vegetation are mangroves of the genera *Avicennia*, *Rhizophora* and *Laguncularia* which fringe the banks of the estuary, and extend over three kilometers on both sides. The system receives tidal inflow from the Gulf of Guinea of the Atlantic Ocean. Environmental conditions are reported to vary widely in the estuary within the year, with salinity ranging from below 3 ‰ in the wet season (June-July) to 23 ‰ in the dry season (October - March), and turbidity being persistently high with peak in June-July although could be reduced in January-February (Okyere, 2018).

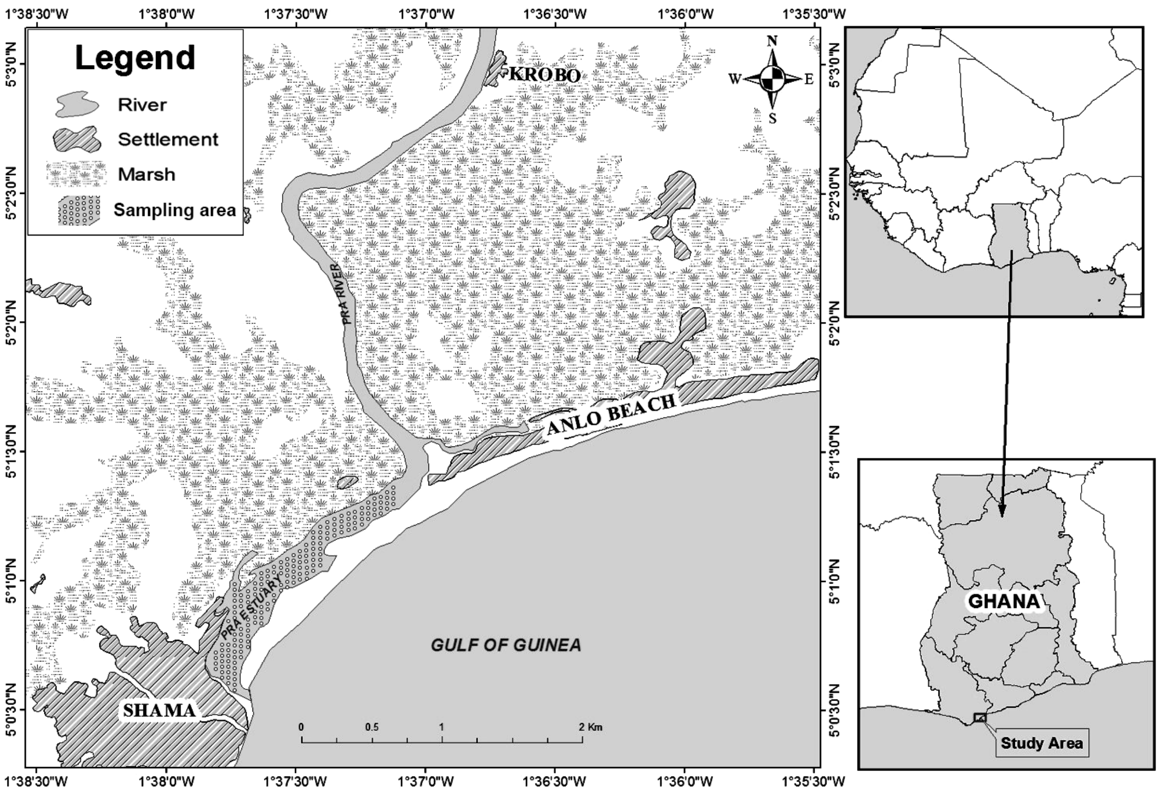

Figure 1: Map of the Study area

Sampling of water quality parameters and fish specimens

Sampling was carried out twice in a month from the dry season in January to early rainy season in April 2017. Three replicates of salinity, dissolved oxygen concentration and turbidity were measured *in situ* with a multi-parametric water quality checker (Hanna instrument multi-parametric probe HI 9829) from (10) random locations in the estuary on each sampling date. These were used to compute monthly means for each parameter. Fish were caught with cast net where a standard of 25 casts were deployed on each sampling day, and number of fish caught were recorded and preserved immediately in 10% formalin for further laboratory analysis. The weight (W) to the nearest 0.01 g and total length (TL) to the nearest 0.1 cm of the fish specimens were determined using an electronic balance and a fish measuring board, respectively.

Stomach content analysis

To examine the food items consumed and how food preferences differ between the different size groups, the specimens were separated into three groups; specimens smaller than 10 cm, specimens between 10 cm and 20 cm, and specimens longer than 20 cm TL to arbitrarily represent small, medium and large specimens respectively. Stomachs of the fish were extracted into a petri dish and ingested food items examined using dissecting microscope. Due to the difficulties in counting most of the food items, the frequency of occurrence and "points" methods were adopted in analysing the stomach contents. The frequency of occurrence method involved counting the number of times a particular food item occurred in the stomachs examined and expressed as a percentage of the total number of stomachs with food excluding empty stomachs (Hynes, 1950; Windell, 1978; Bowen, 1980). This was expressed as:

$$\%\ \text{ccurence of food items} = \frac{\text{No. of stomachs with a particular food item}}{\text{No. of stomachs with food}} \times 100$$

The "points" method (Hyslop, 1980; Lima-Junior and Goitein, 2001) was based on arbitrary five- point scale: 40 points for full stomach, 30 for three-quarters, 20 for half, 10 for quarter-filled, and 0 for empty stomach. Points were awarded to stomachs based on the extent of their fullness, and the percentage composition of each food item was calculated as:

$$\text{Percentage composition} = \frac{\text{Total points of particular food item}}{\text{Total points of all food items}} \times 100$$

The samples were combined for analyses of size distribution and length-weight relation. The size distribution was analysed using a length-frequency distribution at 2 cm interval while the length-weight relation was established with a regression analysis using the least-squares method (Zar, 1999). The choice of using 2 cm class interval for the length-frequency distribution is because for *Chrysichthys nigrodigitatus*, 2 cm class interval is a reasonable size to represent a cohort as individuals in a cohort may vary in size by 2 cm or more.

Results

Water salinity, dissolved oxygen and turbidity

Results of monthly means of the physico-chemical parameters recorded over the four month period, along with number of fish caught are presented in Table 1. Salinity of the estuary declined from 30.3 ‰ in January to 1.3 ‰ in April, with some fluctuations in-between. Dissolved oxygen also fluctuated between 3.6 mg/L and 5.6 mg/L during the period while turbidity increased progressively from the lowest of 8 NTU in January to 207 NTU in April. The abundance of fish trended inversely with turbidity, declining progressively from 118 fish in January to 33 per 25 casts in April as turbidity increased.

Table 1: Monthly changes in physico-chemical parameters and number of *Chrysichthys nigrodigitatus* caught in the Pra Estuary from January to April 2017

Month	Mean physico-chemical parameters (± standard error)			Total no. of fish specimens per 25 net casts
	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	
January	30.3 (±0.02)	5.0 (±0.3)	8.5 (±3.8)	118
February	7.3 (±0.3)	4.5 (±0.7)	18.5 (±1.3)	78
March	18.4 (±3.9)	3.7 (±0.2)	48.6 (±1.3)	53
April	1.3 (±0.3)	5.6 (±0.1)	207.3 (±23.2)	33

Size distribution and length-weight relation of the fish

The 282 *Chrysichthys nigrodigitatus* specimens sampled ranged from 8.0 to 42.5 cm TL (Figure 2a). The population exhibited a unimodal distribution skewed towards smaller sizes, with fishes measuring 9.0 cm to 16.0 cm highly dominating the catch and together constituting over 70% of the sample while bigger individuals measuring 17 cm to 42.0 cm made up less than 30% of the catch. The fish length correlated positively and strongly with the weight (r = 0.96) in a power relationship (Figure 2b), with a growth coefficient (b) of 2.99 indicating that the population exhibited isometric growth.

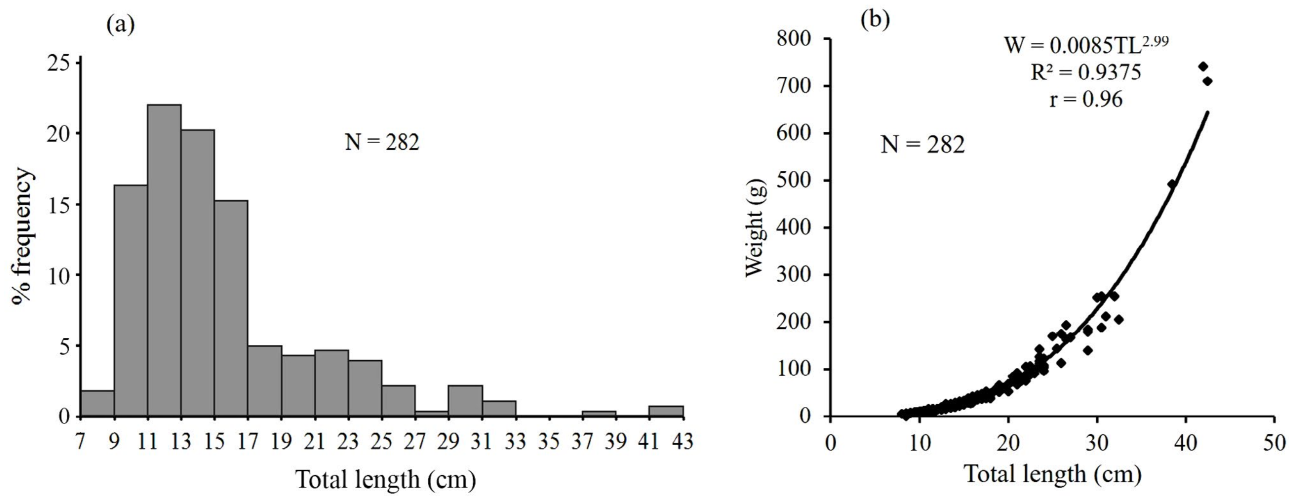

Figure 2: (a) Length–frequency distribution and (b) length-weight relationship of *Chrysichthys nigrodigitatus* sampled from the Pra estuary

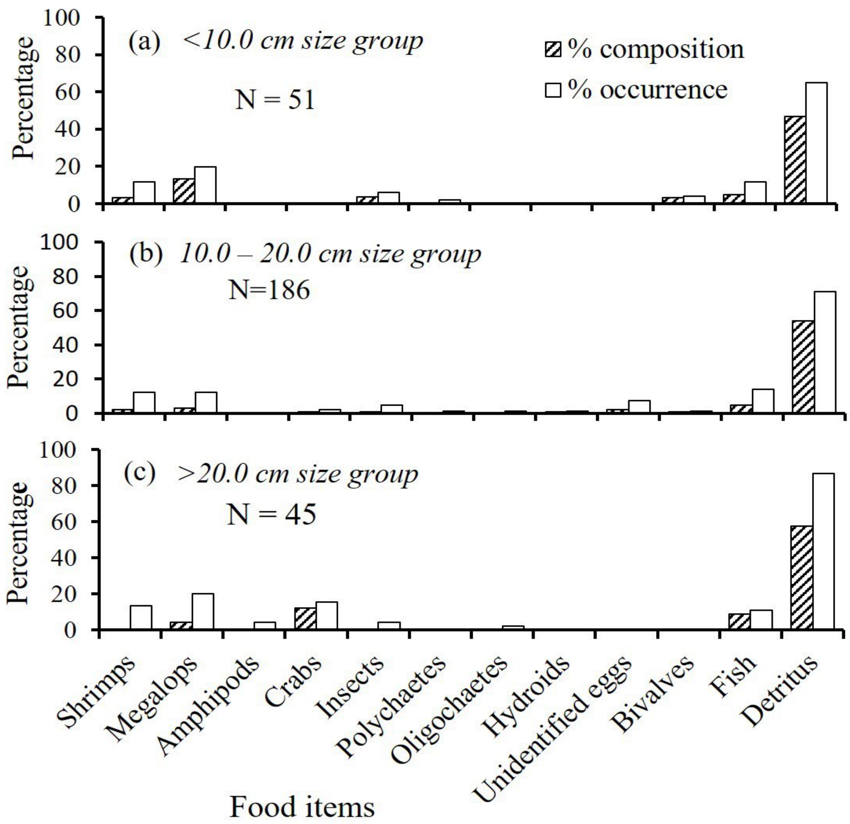

Figure 3: Occurrence and composition of the different food items in the diet of the three size groups of *Chrysichthys nigrodigitatus* sampled from the Pra estuary

Occurrence and composition of food items

The catfish fed widely on detrital materials, fish, crustaceans, molluscs, insects, annelid worms and cnidarians. Crustaceans comprised shrimps, amphipods and crabs at the megalop stage while molluscs consumed were exclusively bivalves. Insects encountered were mainly chironomid larvae, the worms were composed of polychaetes and oligochaetes, and the cnidarians were entirely hydroids.

Figure 3(a-c) compares the occurrence and composition of the different food items in the diet of the three size groups of the fish; less than 10.0 cm, 10.0 cm to 20.0 cm, and bigger than 20.0 cm TL. All size groups fed highly on detritus which made up over 50% of food consumed. Aside detritus, the catfish specimens less than 10.0 cm as well as the 10.0 - 20.0 cm group preferred crabs at megalop stage (> 20% composition) and shrimps (13%) with low preference for fish (< 5%) while specimens above 20 cm TL preyed considerably on fish (19%), crabs (17%) and bivalves (11%), but rarely on shrimps (< 1%). The catfish preyed sparingly on insect larvae, worms and the other food items.

Discussion

Over the past decade, the Pra estuary has been highly silted by illegal gold mining activities upstream rendering it turbid with murky colouration through most parts of the year and becoming clearer only between January and March in the dry season (Okyere, 2015). The low turbidity of 8 NTU recorded in January and the substantial rise to 207 NTU at the onset of the rainy season in April was therefore expected. Conceivably, the rains triggered runoffs which exacerbated the transport of silt and other fine particles into the estuary thereby increasing the turbidity. Turbidity caused by suspended silt has multiplicity of effects on the survival and abundance of fish. As pointed out by Bilotta and Brazier (2008) and Simenstad (1990), many fish need clear waters to spot their prey and the silt can also clog the gills of fish and irritate them. The rising turbidity of the Pra estuary during the study period therefore probably rendered the habitat unfavourable for the fish and could account for the observed decline in their abundance over time. It is unlikely that DO had any influence on the occurrence of species since the range of 3 – 6 mg/L recorded was within the optimum required by all catfishes including *C. nigrodigitatus* (Tetteh, 2016). The decline in salinity from 30 ‰ to 1 ‰ (due to freshwater inflows from the rains) also possibly had no effect on the occurrence of the catfish as the species is tolerant of both freshwater and brackish water conditions and inhabits estuaries and river basins in Africa (Paugy et al., 2003).

The length distribution of *C. nigrodigitatus* showed that fish smaller than 17.0 cm TL were dominant in the estuary, with specimens smaller than 11 cm making up about 18% of the sample. Offem et al. (2008) found males of the species in the Cross River, Nigeria to reach maturity at 11.5 cm and females at 16.7 cm TL. The entire fish below 11.0 cm which constituted 18% of the catch were therefore likely juveniles and females between 11.0 cm and 17.0 cm in the estuary were also conservatively not mature. The occurrence of such considerable quantities of juvenile fish in the estuary reiterates the need to enforce laws of the Ghana Fisheries Act 2003 which bans the use of undersized meshes (< 25.0 mm stretched mesh) in fishing from estuaries. The isometric growth exhibited by the current population is consistent with observations made on other populations (Offem et al., 2008; Lawal et al., 2010).

The abundance of a potential food item is a key factor that determines what a fish feeds on (Lagler et al., 1977). In Pra estuary, *C. nigrodigitatus* fed on a wide range of food items comprising fish, crabs mostly at the megalop stage, shrimps, amphipods, insect larvae, polychaetes, oligochaetes, bivalves and large amounts of detrital matter. This primarily suggests a considerable availability of diverse prey in the estuary. This also buttresses previous observations on the species as omnivorous detritivores (Oronsaye and Nakpodia 2005; Offem et al., 2008; Yem et al., 2009). Of a serious concern is that most of these prey are benthic organisms inhabiting bottom of the estuary and continuous use of dragnets over the bottom could destroy microhabitats of these prey organisms and deplete their populations thereby depriving the catfish of their food.

Apart from detrital materials which were highly ingested by catfish specimens of all sizes, those up to 20.0 cm long preferred crabs at megalop stage and shrimps with low preference for fish while specimens above 20.0 cm preyed considerably on fish, juvenile crabs and bivalves, but rarely on shrimps. This primarily suggests some form of resource partitioning in the population probably in avoidance of intraspecific competition as the smaller fishes may not have developed stronger jaws that could crush the shells of bivalves and juvenile crabs.

In conclusion, it could be possible that turbidity influenced the occurrence of *Chrysichthys nigrodigitatus* in the Pra estuary, since a rise in turbidity appeared to have coincided with a decline in abundance of the fish in the ecosystem. Also, a considerable proportion of the bagrid catfish population inhabiting the estuary were likely juveniles and the species is omnivorous detritivores preying on a wide range of food items from the bottom of the water body. Fishing with undersized meshed nets would therefore harvest the juveniles while deploying dragnets in the estuary could potentially deplete the populations of prey organisms from the bottom and deprive *C. nigrodigitatus* of their food. The combined effect of these could have dire consequences on the survival of the catfish population. Management plans should therefore consider addressing illegal mining activities within the catchment of the Pra River to reduce siltation of the estuary, and clamping down on the use of dragnets as well as small meshes below the legally prescribed size in the Ghana Fisheries Act 2003 (Act 625).

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