Food and feeding habits of the silver fish *Raiamas senegalensis* (Steindachner, 1870), Cypriniformes, Cyprinidae in a West African River (Bandama River, Côte d’Ivoire)

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Abstract: The feeding habits of *Raiamas senegalensis* (Steindachner, 1870) in Bandama River were investigated by examining the stomach contents of 172 fish collected monthly from the experiment catch from October 2008 to September 2009. Observation of the digestive tract morphology and the index of preponderance (Ip) calculated by combining the corrected frequency of occurrence with the total weight percentage of preys showed that *R. senegalensis* is carnivore with an insectivore tendency. They are also included fish and plants as second preys. Juveniles (LS ≤ 100 mm) and adults (LS > 100 mm) consumed insects principally but they consume plants and fish as second preys respectively. Juveniles of *R. senegalensis* preferentially consume insects during dry and raining seasons. However, adults eat preferentially insects during the rainy season and fish in dry season.

**Key words**: Cyprinidae - *Raiamas senegalensis* - Feeding habits - Bandama River - Côte d’Ivoire

Introduction

The study of diets and feeding habits of freshwater fish species is a subject of continuous research and it constitutes the basis for the development of the successful fisheries management program on fish capture and culture (Oronsaye & Nakpodia, 2005). Also, studies of feeding ecology are useful and fundamental to an understanding of the functional role of the fish within their ecosystems (Blaber, 2000; Cruz-Escalona, et al., 2000). There is great diversity of organisms that are consumed by fish and these differ in size and taxonomic group (Meye, et al., 2008). Several studies have been undertaken on the food and feeding habits with the aim of determining their dietary requirements.

Fish species studied in the present work belong to the family Cyprinid. It is the largest family of freshwater fish with about 2450 species distributed in about 318 genera. Members of this species-rich family are found in the fresh waters of Europe, Asia, Africa, and North and Central America. Many species are important economically, primarily for fisheries and aquaculture, and secondary, some small species are kept in aquaria and ponds. In Africa about 25 genera are recognized, occurring from the Maghreb and throughout tropical and subtropical regions (De Weerd, et al., 2007). Despite the large distribution of this family, ecology and biology of *Raiamas* species are virtually unknown. This study therefore aims at providing further information on the nourishment and abundance of natural food needed by *R. senegalensis* in a fluvial Bandama River.

Materiel and methods

The Bandama River is located entirely in Côte d’Ivoire between 3°50 and 7° W and 5° and 10°20 N (Figure 1). This basin have a surface area of 97 500 km² and 1050 km long. The Bandama River rises on north of country between Korhogo and Boundiali and enters Grand-Lahou lagoon at sea level. The man-made Lakes Kossou (drainage area: 900 km²) and Taabo (drainage area: 69 km²) originated from the building of a hydroelectric dam on the main course of the Bandama River (Traoré, 1996; Kouassi, 2007). Its two mains tributaries rivers are the N’Zi on the left bank (725 km) and Marahoué on the right bank (550 km). In the study area, the general characteristics of watershed area described by Lévêque, et al. (1983) indicate that the stream through different vegetation and climate zones (area of Sudan and Guinea) and hydrological regimes (tropical regime transition, equatorial regime transition attenuated, equatorial regime transition), 17 study sites along Bandama River were selected based on: (1) a geographical position in the strait; (2) a possibility for conducting a sampling program; and (3) not being a restricted area for military purposes.

Sampling and laboratory examination

Fish specimens (*n* = 172) were collected every month during October 2008 to September 2009. Gears employed included 19 gill nets (mesh sizes between 8 to 80 mm, 1.5 m deep and 30 m long) and a backpack electrofisher Smith Root Inc., Model 12-B Pow. This combination of capture methods was employed to reduce size selection. Sampling was carried out at various day periods in various areas of Bandama River. Day sampling...
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with nets was done between 7.00 – 12.00h while the night sampling was between 17.00 – 7.00h. Electrofishing was done at each station by using the same catch effort. Fifteen minutes of fishing was applied.

In the laboratory, each specimen was weighed to the nearest 0.01 g using a top loading Satorius balance (model BP 310S) and standard length was measured in centimeter using measuring board. Specimens were dissected to remove the stomach. Stomachs were preserved in 5% formalin solution. Subsequently, each stomach was slit open and its contents were sorted, counted under a binocular microscope Olympus SZ51 (0.80 – 4x). All prey items were weighed to the nearest 0.001 g and identified to the lowest taxonomic level possible according to Dejoux, et al. (1981), Needham (1962), Durand & Lévêque (1980, 1981), Dussart (1980) and Rey & Saint-Jean (1980).

\[
VC = \frac{\text{NES}}{\text{NSE}} \times 100
\]

with NES = number of empty stomachs. NSE = number of stomachs examined

For each fish, intestinal coefficient (IC), defined as the ratio of the length of the intestine (\(L_i\)) by the standard length (SL), was calculated according Paugy (1994).

Analyses of stomach contents were done using (1) the corrected frequency of occurrence (\(F_c\)) and (2) the weight frequency (W) as described by (Rosecchi & Nouaze, 1987) and Hyslop (1980) for each prey item and category to describe the diet of *R. senegalensis*.

\[
(1) \% F_c = \frac{F_i}{\sum F_i} \times 100,
\]

with \(F_i = \frac{N_i}{N_t}\), where \(N_i\) is the number of stomachs containing prey item i, and \(N_t\) the total number of full stomachs examined.

\[
(2) \% W = \frac{W_i}{W_t} \times 100,
\]

Where \(W_i\) is the total weight of prey item i, and \(W_t\) is the total weight of all prey.

In order to synthesize these two indexes, we calculated (3) the index of preponderance (\(I_p\)) accordingly to Natarajan & Jhingran (1961).

\[
(3) \quad I_p = \frac{\% F_c \times \% W}{\sum (%F_c \times \% W)} \times 100
\]

The index of preponderance (\(I_p\)) varies from 0 to 100%. Different prey taxa were arranged according to the classification scale of Simenstad (1979). For that purpose, items were arranged in decreasing order of \(I_p\). The cumulative values of these items with a \(I_p\) of at least 50% were considered preferential. Those with a cumulative value reaching 75% were the secondary prey and the others were incidental preys.

The size at first maturity of *R. senegalensis* being 100 mm (Paugy, et al., 2006), to study diet variation with fish size, specimens were divided into two categories according to gonad maturity: juveniles (LS ≤ 100 mm) and adults (LS > 100 mm). The description of the digestive tract included 37 individuals whose size was between 71 and 151 mm (SL).

**Statistical analysis**

Spearman’s correlation coefficient (Fritz, 1974) was used to compare the diet between species within size fish and seasons of the year (max probability retained: \(p\)-level = 0.05). This analysis was performed with the software Statistica version 7.1.

**Data treatment**

Vacuity coefficient (VC) was calculated to evaluate feeding intensity (Hureau, 1970):

**Figure 1: Position of sampling sites (●) within the Bandama Basin (Côte d’Ivoire) (October 2008 to September 2009)**

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Results

Digestive tract morphology

The digestive tract morphology of *Raiamas senegalensis* species showed a thick-walled esophagus followed by an elongated stomach, thick-walled with the anterior part larger than the posterior. The poorly developed pyloric caeca are present at the pylorus. A relatively short intestine extends more or less linearly to the fish anus. There is a linear relationship \( y = 0.41x - 10.82 \) between the length of intestine and the standard length of the fish. The correlation coefficient \( r = 0.86 \) indicates a high link between intestine length and standard length (SL). The intestinal coefficient (IC) for all individuals analyzed varies between 0.21 and 0.44 with an average of 0.31.

General diet composition

The summary of the food composition with the indices of importance in the stomach of *R. senegalensis* is presented in table 1. A total of 172 stomachs of *R. senegalensis* with a standard length of 27.0 – 153.0 mm were examined. Hundred and twenty four (124) specimens had food item in their stomach and 48 stomachs were empty, indicating vacuity coefficient of 27.91 %.

Food items are assigned into five taxonomic groups: Insects, fish, algae, diatoms and plants. An important sedimentary fraction composed of sand and mud was noted in all stomach. Although sand and mud may be very important in abrading exoskeleton, this fraction has no nutritional value. It was therefore excluded from all the quantitative values. Insects (n = 8 families: Chironomidae, Leptoceridae, Hydropsychidae, Ecnomidae, Baetidae, Ephemerellidae, Elmidae and Libellulidae) were the most frequent food item found in stomach, representing 79.10 %, followed by fish \( n = 2: Barbus \) sp. and fish detritus \( (Fc = 4.48 \%) \) and plants \( n = 1: Organics \) debris \( (Fc = 16.42 \%) \). Among insects, detritus had the highest \% \( Fc \) (50.75), followed by Baetidae (7.46 %), Chironomidae (4.48 %), Leptoceridae (4.48 %) and Ephemerellidae (4.48 %).

In terms of weight percentage \( (W \%) \), the most food items in *R. Senegalensis* stomach are fish (41.20 %), following by plants (32.47 %) and insects (26.33 %).

According to the index of preponderance, insects \( (Ip = 79.94 \%) \) were classified in the category of preferential preys, while plants \( (Ip = 15.75 \%) \) were the secondary preys. All the other taxa represented incidentally ingested by this species.

Dietary changes with fish size

Food preferences of *R. Senegalensis* were almost similar in juveniles and adults (Figure 2). Insect and plants constituted always the principal food items. Nevertheless, the importance of these preys decreased with increasing size of specimens. In juveniles, insects \( (Ip = 81.01 \%) \) were a main ingested food and plants \( (Ip = 18.99 \%) \) were considered as secondary preys. In adults, the preferential preys were represented by insects \( (Ip = 55.15 \%) \) while, fish \( (Ip = 29.55 \%) \) constituted the secondary preys and plants \( (Ip = 15.30 \%) \) an incidental preys.

Spearman rank order correlation analysis showed no significant correlation, at the 0.71 \( p \)-level, between diets composition of juveniles and adults (Table 2).

Table 1. General diet composition of *Raiamas senegalensis* (n = 172) from Bandama River (October 2008 - September 2009). \( Fc \) = correct occurrence percentage; \( W \) = Weight percentage; \( Ip \) = index of preponderance.

<table>
<thead>
<tr>
<th>Food items</th>
<th>( Ip %)</th>
<th>%W</th>
<th>% Fc</th>
</tr>
</thead>
<tbody>
<tr>
<td>FISHES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyprinidae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Barbus</em> sp</td>
<td>3,845</td>
<td>38.83</td>
<td>1.49</td>
</tr>
<tr>
<td>Fish parts</td>
<td>0,469</td>
<td>2.37</td>
<td>2.99</td>
</tr>
<tr>
<td>INSECTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diptère</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chironomidae</td>
<td>0,110</td>
<td>0.37</td>
<td>4.48</td>
</tr>
<tr>
<td>Leptoceridae</td>
<td>0,006</td>
<td>0.02</td>
<td>4.48</td>
</tr>
<tr>
<td>Hydropsychidae</td>
<td>0,043</td>
<td>0.44</td>
<td>1.49</td>
</tr>
<tr>
<td><em>Cheumatopsyche</em></td>
<td>0,043</td>
<td>0.44</td>
<td>1.49</td>
</tr>
<tr>
<td>Ecnomidae</td>
<td>0,021</td>
<td>0.11</td>
<td>2.99</td>
</tr>
<tr>
<td><em>Ecnomus sp</em></td>
<td>0,021</td>
<td>0.11</td>
<td>2.99</td>
</tr>
<tr>
<td>Ephéméroptère</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baetidae</td>
<td>0,807</td>
<td>1.63</td>
<td>7.46</td>
</tr>
<tr>
<td>Ephemerellidae</td>
<td>0,005</td>
<td>0.02</td>
<td>4.48</td>
</tr>
<tr>
<td>Odonate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Libellulidae</td>
<td>0,002</td>
<td>0.02</td>
<td>1.49</td>
</tr>
<tr>
<td>Coleoptère</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elmidae</td>
<td>0,030</td>
<td>0.30</td>
<td>1.49</td>
</tr>
<tr>
<td>Insects detritus</td>
<td>78,92</td>
<td>23.44</td>
<td>50.75</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Food items</th>
<th>Food items</th>
<th>Ip %</th>
<th>%W</th>
<th>% Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANTS</td>
<td>Plants detritus</td>
<td>15,75</td>
<td>32,47</td>
<td>16,42</td>
</tr>
<tr>
<td>TOTAL</td>
<td>FISHES</td>
<td>4,31</td>
<td>41,20</td>
<td>4,48</td>
</tr>
<tr>
<td></td>
<td>INSECTS</td>
<td>79,94</td>
<td>26,33</td>
<td>79,10</td>
</tr>
<tr>
<td></td>
<td>PLANTS</td>
<td>15,75</td>
<td>32,47</td>
<td>16,42</td>
</tr>
</tbody>
</table>

**Table 2.** Spearman correlation to compare similarity of diet between adults and juveniles of *Raiamas senegalensis* caught from October 2008 to September 2009

<table>
<thead>
<tr>
<th>Sizes compared</th>
<th>N</th>
<th>R of Spearman</th>
<th>t(N-2)</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults / Juveniles</td>
<td>11</td>
<td>0,125902</td>
<td>0,380735</td>
<td>0,712231</td>
</tr>
</tbody>
</table>

**Figure 2.** Index of preponderance (% Ip) in juveniles (Ls ≤ 100 mm) and adults (Ls >100 mm) of *Raiamas senegalensis* caught from October 2008 to September 2009 in Bandama River

**Seasonal variation in the diet composition**

Figure 3 shows seasonal variations in the diet composition of *R. Senegalis*. In raining season, the fish fed insects (Ip = 80.94 %) preferentially and plants (Ip = 18.43 %) secondary. Whereas during dry season, dominated prey became fish (Ip = 67.86 %) following by insects (Ip = 28.98 %) as secondary prey. During this period, plants (Ip = 3.16 %) were the most important prey rarely eaten. The spearman analysis test showed significant different (*p*-level = 0.03) between feeding habit of *Raiamas senegalensis* during dry and raining season (Table 3).

**Table 3.** Spearman correlation showed similarity of diet between rainy and dry season of *Raiamas senegalensis* catch from October 2008 to September 2009

<table>
<thead>
<tr>
<th>Season compared</th>
<th>N</th>
<th>R of Spearman</th>
<th>t(N-2)</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainy season / Dry season</td>
<td>10</td>
<td>0,678834</td>
<td>2,614806</td>
<td>0,030899</td>
</tr>
</tbody>
</table>
Food and feeding habits of the silver fish *Raiamas senegalensis* (Steindachner, 1870), *Cypriniformes*, *Cyprinidae* in a West African River (Bandama River, Côte d'Ivoire)

**Figure 3.** Seasonal variation of diet of *Raiamas senegalensis* in Bandama River based on the % Ip between October 2008 to September 2009

**Discussion**

**Digestive tract morphology**

Studies of the digestive tract morphology of fish showed that the length of the intestine is often an indicator of diet (Donald & Michael, 1995). Which is generally interpreted as reflecting the resistance of different foods to digestion (Herder & Freyhof, 2006). Digestion of animal prey being faster than plants prey (Kapoor, et al., 1975), carnivorous species has much shorter intestines than those of omnivores. Species what have elongated intestines are herbivores. Also, species who have undeveloped stomach, intestine is usually longer [Verighina, 1990; Kouamélan, et al., 1999; Hugueny & Pouilly, 1999]. In relation to the characteristics of the digestive tract, this study showed that, the intestine of *R. senegalensis* is relatively short, which is typical of carnivores. The walls of stomach are found to be more rigid, thick and resistant. This structure should be explained the presence of hard items, such as insects, in the stomach content. This digestive tract morphology appears to be an ecomorphological pattern and our result is in agreement with several other studies (e.g Paugy 1994, Norton, et al., 1995; Ward-Campbell, et al. 2005, Carla Ibañez, et al. 2007). Also, according to Paugy 1994, *R. senegalensis* is among species that the length of intestine is less than three times the standard length. Based on the intestine coefficient ($0.21 \leq IC \leq 0.44$), *R. senegalensis* appears as an invertivore. However, the values of intestinal coefficient obtained from this specie ($IC = 0.21-0.44$) is lower than those found by Paugy (1994) for some invertivores species ($IC = 0.73-0.93$).

**General diet composition**

Analysis of stomach contents of *R. senegalensis* during this study showed that insects were the most preferable food with an occurrence more than 79.10 % of the examined fish. *R. senegalensis* species are predators; they consume mainly insects but also include fish and plants as second preys in their diets. They should be considered as carnivore with an invertivore tendency. However, an important fraction of sedimentary was also found in their stomach. This should be understood as accidental, due to the voracious character of the species that swallows parts of sediment when attacking the prey in one side, and these species could field on substrata on other side. Diet of *R. senegalensis* in Bandama River could be compared to that of *R. moorii* in Kivu Lake in Zaire (Kaningini, 1999). According to this author, diet of *R. moorii* is composed of two categories of prey: fish and insects.

**Dietary changes with fish size**

In this study, juveniles and adults of *R. senegalensis* share insects and plants as primary and secondary prey. However, in addition, adults eat fish. The slight variations in the food items of adults and juveniles suggested age-specific dietary preferences in order to avoid intra-specific competition for available food. This is possibly an important strategy for survival and an advantage over the fish species competing for a specific food item. Also, as fish grow, they are able to eat larger prey, and bigger prey becomes more profitable (Wyckmans, et al., 2007). As Herrel, et al. (2005)
said, during fish growth, increasing prey size will usually lead to taxonomic changes and these changes are manifested as ontogenetic diet switches.

**Seasonal variation in the diet composition**

In tropical areas, it is shown that the availability of food for fish can vary greatly in quantity and quality depending on the season (Wootton, 1990). In juvenile *R. senegalensis*, the diet does not vary with the seasons. They preferentially consume insects during dry and raining seasons. However, adults preferentially eat insects during the rainy season and fish in dry season. These changes in the diet of adults are the fact that rainy drain allochthonous materials as it is known to most tropical rivers (Tejerina-Garro & Merrona, 2010). These foods composed of terrestrial insects and other aquatic insects from the decomposition of organic matter and hatching larvae. During the dry season, the reduction of food resources in the environment requires adults of *R. senegalensis* hunted and feed on other small fish.

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**References:**


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