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Full Length Research Paper

Food habits of two species of *Pseudotolithus* (Sciaenidae) off Benin (West Africa) nearshore waters and implications for management

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Food habits of *Pseudotolithus senegalensis* and *Pseudotolithus typus* in Benin nearshore waters were investigated for 18 months because of the importance of croakers in artisanal catches. Frequency of occurrence, numerical abundance and gravimetric composition were utilized in computing the percent index of relative importance of each food item. The major dietary components of the two species were shrimps. The food composition of *P. senegalensis* and *P. typus* did not show any variation with season. The diet composition of the two species of *Pseudotolithus* portray them as specialized feeders depending on similar food sources with low number of dietary prey items. Shrimps and to some extent juvenile fishes which constitute the important preys of *Pseudotolithus* spp., remain an essential link of the trophic system off Benin nearshore waters. Therefore, the dynamics of the abundance of these shrimps and juvenile fishes must be assessed for sustainable production of their predators.

Key words: Benin, diet composition, feeding intensity, food habits, *Pseudotholithus*, shrimps.

INTRODUCTION

Knowledge on fish feeding habits and fish nutritional needs are required for understanding food exploitation and foraging strategies among organisms in the marine environment. Investigation on the feeding regime of commercial fishes may help to identify habitats or sites of higher fish abundance for successful commercial capture. The Sciaenids constitute a large and varied family of fishes closely related to snappers but differing in that the spinous dorsal fin is short and the adipose tissue is much longer than the anal fin, which has only one or two spines (Edwards et al., 2001). They are made up of croakers, drums, meagres and weakfishes; about 70 genera and 270 species are known, with 14 species occurring along the Gulf of Guinea in the coast of West Africa (Edwards et al., 2001).

The species of genus *Pseudotolithus* (Family: Sciaenidae) (croakers) constitute an abundant and commercially important fish in Benin near shore waters (Gbaguidi, 2000, 2001; Sossoukpe, 2011; Sossoukpe et al., 2013) and indeed throughout the Atlantic coast of West Africa (Bayagbona, 1963). They account for about 21.75%, of the total marine landings from artisanal catches of Benin near shore waters (Gbaguidi, 2003). *Pseudotolithus senegalensis* and *Pseudotolithus typus* are widely distributed along the coast of tropical West Africa from Senegal to Angola (Edwards et al., 2001).

P. senegalensis and *P. typus* are common in Benin nearshore waters but there is a dearth of information on the food habits of these species. Anyanwu and Kusemiju (1990) reported on food of two species off the coast of Lagos, aspects of feeding ecology of three species of *Pseudotolithus* in the inshore waters southeastern Nigeria

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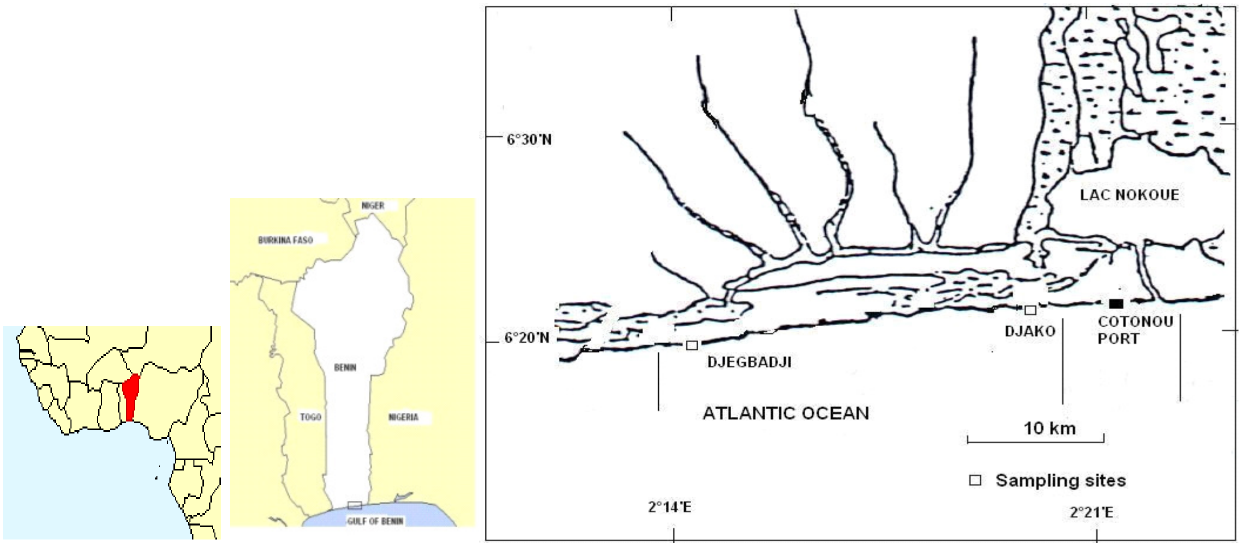

(a) (b) (c)

Figure 1. Maps showing Benin in Africa (a), Republic of Benin (b) and the two sampling sites (Site 1 (Djako) and Site 2 (Djègbadji) (c).

were reported by Akpan and Isangedighi (2004). This paper presents additional information on the food habits of the species off Benin near shore waters in view of their economic importance in artisanal catches.

MATERIALS AND METHODS

Study area

The study was carried out in the near shore waters of Benin (West Africa) (Figure 1). Two sampling sites were considered. The first (Site 1, 06° 20' 51'' N, 2° 21' 58'' E) is located in the fishing camp of Djako at Cotonou city. This Site is situated at 500 m from the International Airport of Cotonou and about 2 km from the Port of Cotonou which can provide some risks of chemical pollution because of tar rejection by oil tankers and residues of phosphate. The second sampling site (Site 2, 06° 20' 36'' N, 02° 14' 56 E) without any apparent risk of pollution is located in the fishing village of Djègbadji at Ouidah city about 30 km from the former site.

Fish sampling

Samples of *Pseudotolithus* spp. were obtained from beach seine hauls at two terminals (Sites 1 and 2) and collection was done biweekly for eighteen consecutive months (March 2008 to August 2009). The nomenclature of the species conformed to those of Schneider (1990) and Edwards et al. (2001). A total of 1343 specimens of *P. typus* and 936 specimens of *P. senegalensis* from both sampling sites were examined. Specimens were weighed to the nearest 0.1 g after blotting dry with filter paper. Total length (TL) and standard length (SL) were measured to the nearest 0.1 cm.

Food composition

Three methods were used to assess the food composition *viz.* frequency of occurrence, numerical abundance and gravimetric composition. The stomachs were removed, slit open, and the contents displayed in Petri dishes with a few drops distilled water added to agitate them and examined microscopically. Prey items were identified to the lowest possible taxonomic level using appropriate taxonomic guides. The percentage frequency of occurrence (FO) which expresses the population-wide food habits (Cailliet, 1977) was based on the number of stomachs in which a food item was found as percentage of the total number of non-empty stomachs while percentage numerical abundance (Cn) was the number of each prey item in all non-empty stomachs in a sample, expressed as the number of the total number of food items in all stomachs (Hyslop, 1980). The percentage of gravimetric composition (Cw) which reflects dietary nutritional value (Macdonald and Green, 1983) was based on the weight of a particular food item in all non-empty stomachs as percentage of the total weight of all food items in all non-empty stomachs. The principal food items were then determined using the index of relative importance (IRI) which represents a modified version of Labropoulou et al. (1997), embracing the three methods as follows(Pinkas et al., 1971 cited in Hyslop, 1980):

$$IRI = (Cn + Cw) \times FO$$

Where IRI = Index of relative importance; Cn = percentage numerical abundance; Cp = percentage point and F = Percentage frequency of occurrence. The IRI was further expressed as percentage as follows (Cortés, 1997):

$$\%IRI = 100\ IRIi / \sum_{i=1}^{n} IRIi$$

Where, n is the total number of food categories considered at a given taxonomic level.

The incorporation of the three methods of stomach analysis in computing the %IRI is more representatives (Windel, 1971; Hyslop, 1980) and reduces to the barest minimum. The bias associated with the independent interpretation of results from each analytical

Table 1. Food items identified in stomach contents of *Pseudotolithus senegalensis* and *Pseudotolithus typus*.

Food items	*Pseudotolithus senegalensis*	*Pseudotolithus typus*
Shrimps	*Penaeus atlantica* *Nematopalaemon hastatus*	*Penaeus atlantica* *Nematopalaemon hastatus*
Fishes	*Trichiurus lepturus* *Brachydeuterus auritus*	*Sardinella maderensis* *Ilisha africana*
Crabs	*Callinectes spp*	*Dorripe arinata*
Cephalopods	*Lolliguncula mercatoris*	*Lolliguncula mercatoris*
Total	6 prey species	6 prey species

Table 2. Percentage contribution and variations in the overall food composition of *P. senegalensis* at Site 1.

Prey category	Cn (%)	Cw (%)	FO (%)	IRI	IRI (%)
Crustacean					
Parapenaeopsis atlantica (Shrimp)	48.6	42.9	52.2	4777.9	75.6
Nematopalaemon hastatus (Shrimp)	21.5	17.0	23.0	883.3	14.0
Callinectes spp. (Crabs)	4.7	2.7	5.2	38.3	6.3
Unidentified partially digested shrimps	18.7	15.8	11.5	396.4	0.6
Total	88.8	75.7	86.7	14254.8	97.7
Pisces					
Trichiurus lepturus	5.4	17.2	9.6	218.2	3.5
Brachydeuterus auritus	0.7	4.2	1.5	7.3	0.1
Unidentified partially digested fish	0.0	0.2	1.1	0.2	0.0
Total	6.2	21.6	12.2	339.4	2.3
Cephalopod					
Lolliguncula mercatoris	0.4	0.5	0.7	0.7	0.0
Number of stomachs examined	370				
Number of non-empty stomachs	270				

method and consequently gives a more accurate picture of dietary importance (Hyslop, 1980).

Feeding intensity

Many authors used the vacuity index which expressed the number of empty stomachs as a percentage of the total number of stomachs examined to study the feeding intensity. In the present study, the repletion index (RI) of Aoyama Yasuda (1960) cited by Cavadevall et al. (1994) based on the weight of stomach content as percentage of fish ungutted weight was used to determine feeding intensity. This choice was made as many "empty" stomachs had become so as a result of the drastic change of pressure during hauling operations causing stomach content regurgitation.

Indeed, follow up the monthly repletion index does not only describe the feeding cycle, but also evaluates the quantitative fluctuation of the food consumed by the fish during the year (Anato, 1999). Ontogenic, monthly and seasonal variations in feeding intensity based on the repletion index were examined.

RESULTS

Diet composition

Food items identified for *P. senegalensis* and *P. typus* from both sites are reported in Table 1. The diet of the two fish species at both sites consisted mainly of shrimps and fishes including crabs and cephalopods. The two fish species fed on the same species of shrimps, but on different species of fish and crabs.

The relative importance of the different prey groups and species are given in Tables 2 and 4 for *P. senegalensis* and in Tables 3 and 5 for *P. typus*. For *P. senegalensis*, crustaceans constituted the most important prey group in samples from both sites making up 97.7% of the total IRI in Site 1 and 94.3% in Site 2. Among the crustaceans, *P. atlantica* had the highest %IRI (Site 1 = 75.6%, Site 2 =

Table 3. Percentage contribution and variations in the overall food composition of *P. typus* at Site 1.

Prey category	Cn(%)	Cw(%)	FO (%)	IRI	IRI (%)
Crustacean					
P. atlantica (Shrimp)	0.6	36.8	54.2	2025.7	70.6
N. hastatus (Shrimp)	11.7	6.0	16.1	285.3	9.9
D. arinata (Crabs)	2.8	1.5	3.3	14.1	14.1
Unidentified partially digested shrimps	21.0	8.7	13.6	403.5	0.5
Total	91.1	51.5	83.9	11957.1	98.0
Pisces					
S. maderensis	4.4	13.3	7.3	129.3	4.5
I. africana	0.9	3.6	1.8	7.8	0.3
Unidentified partially digested fish	0.1	2.1	1.0	2.2	0.1
Total	5.4	18.9	10.1	245.2	2.0
Cephalopod					
L. mercatoris	0.8	0.5	1.3	1.5	0.1
Number of stomachs examined	618				
Number of non-empty stomachs	375				

Table 4. Percentage contribution and variations in the overall food composition of *P. senegalensis* at Site 2.

Prey category	Cn(%)	Cw(%)	FO (%)	IRI	IRI (%)
Crustacean					
P. atlantica (Shrimp)	43.1	31.3	37.3	2775.8	61.7
N. hastatus (Shrimp)	31.5	18.7	22.0	1103.4	24.5
Callinectes spp. (Crabs)	4.0	2.9	5.0	34.4	5.4
Unidentified partially digested shrimps	12.9	12.2	9.7	242.7	0.8
Total	87.5	62.1	69.0	10323.5	94.3
Pisces					
T. lepturus	5.9	27.7	9.3	313.6	7.0
B. auritus	2.1	5.5	3.7	28.0	0.6
Unidentified partially digested fish	0.0	0.1	2.0	0.2	0.0
Total	8.0	33.4	15.0	620.1	5.7
Cephalopod					
L. mercatoris	0.6	1.6	0.7	1.4	0.0
Number of stomachs examined	469				
Number of non-empty stomachs	303				

61.7%); Unidentified partially digested shrimps had the lowest %IRI (Site 1 = 0.6%; Site 2 = 0.8%). Pisces contributed the second highest dietary materials making up 2.3% in Site 1 and 5.7% in Site 2 specimens. At Site 1, *Trichiurus lepturus* was the main fish prey (%IRI = 3.5%) while *Brachydeuterus auritus* had the very low %IRI. Other dietary items encountered included *L. mercatoris* which had zero %IRI could be considered as an incidental food prey.

The diet of *P. typus* did not show great difference from that of *P. senegalensis*. Crustaceans had the greatest %IRI (Site 1 = 98.0%; Site 2 = 98.0%) and *P. atlantica* was the main crustacean (Site 1 = 70.6%; Site 2 = 75.0%). *Dardanelle maderensis was* the main fish prey (%IRI = 4.5 and %IRI = 2.2) while *Illisha africana* had the very low %IRI.

Table 5. Percentage contribution and variations in the overall food composition of *P. typus* at Site 2.

Prey category	Cn%	Cw%	FO (%)	IRI	IRI (%)
Crustacean					
P. atlantica (Shrimp)	52.7	43.8	40.5	3910.3	75.0
N. hastatus (Shrimp)	19.3	17.1	21.2	772.3	14.8
D. arinata (Crabs)	1.7	2.1	3.0	11.5	7.5
Unidentified partially digested shrimps	21.6	13.7	11.0	389.4	0.2
Total	93.6	74.7	72.7	12240.8	98.0
Pisces					
S. maderensis	3.6	17.3	5.5	115.0	2.2
I. africana	1.1	5.7	2.2	15.0	0.3
Unidentified partially digested fish	0.0	0.2	1.1	0.2	0.0
Total	4.7	23.2	8.8	245.9	2.0
Cephalopod					
L. mercatoris	0.0	0.0	0.0	0.0	0.0
Number of stomachs examined	570				
Number of non-empty stomachs	359				

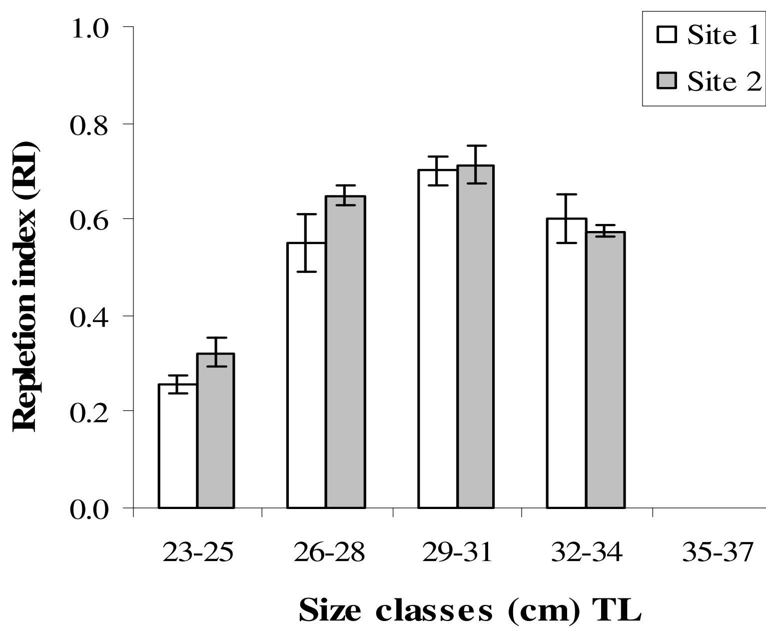

Figure 2. Variation in repletion index of *P. senegalensis* as a function of fish size.

Ontogenic variation in feeding intensity

Figures 2 and 3 show the variation in repletion index (FI) with size groups of *P. senegalensis* and *P. typus*, respectively. The 29 to 31 cm (TL) group had the highest repletion index (0.70) among specimens of both sites. Similar results were reported for *P. typus* (the 29 to 31 cm group, RI = 0.76). Feeding intensity increased as the fish for both species got bigger at Sites 1 and 2 up to the 29 to 31 cm (TL) group but reduced in very large fish (32 to 34 cm).

Monthly variation in feeding intensity

Figures 4 and 5 show the monthly variation in repletion

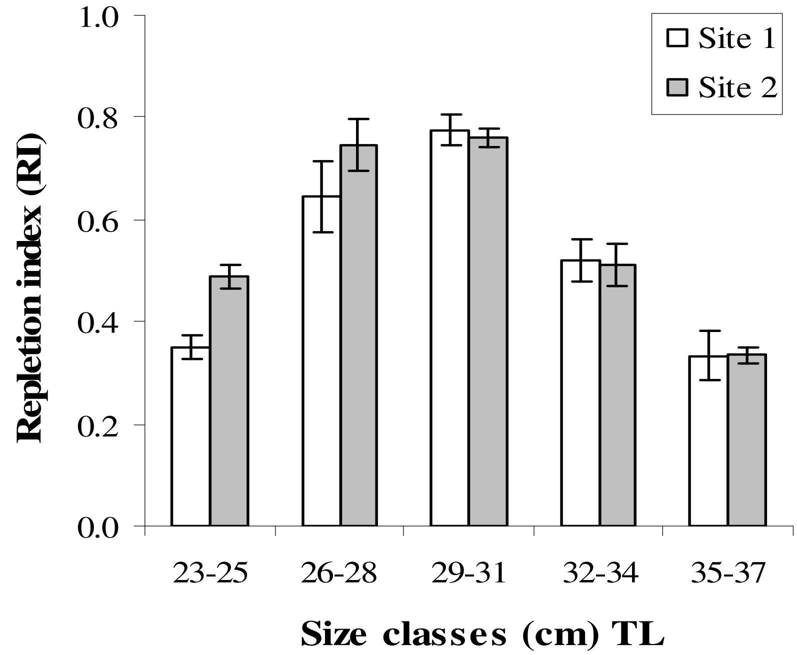

Figure 3. Variation in repletion index of *P. typus* as a function of fish size.

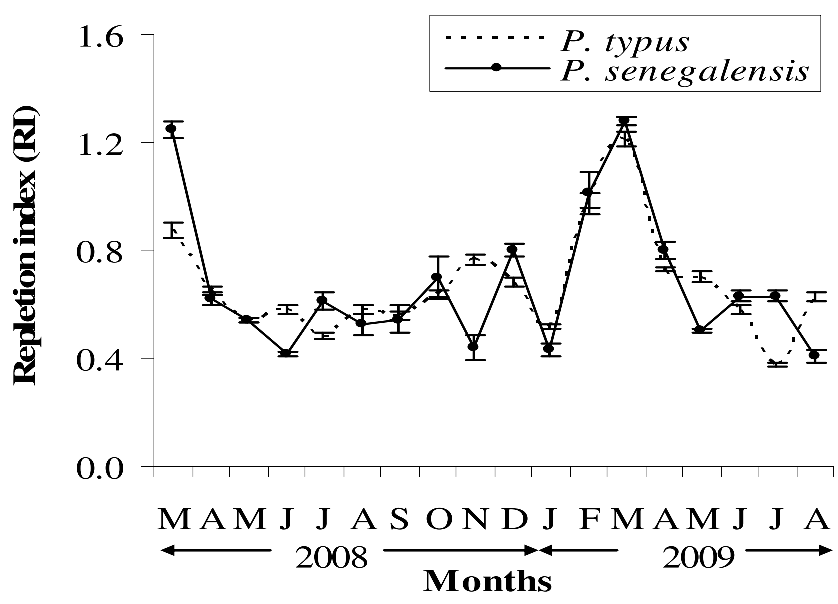

Figure 4. Monthly variation in repletion index of *P. senegalensis* and *Pseudotolithus typus* for Site 2.

index of *P. senegalensis* and *P. typus* from Sites 1 and 2, respectively. For Site 1 the highest repletion index occurred in March 2009 for both species (1.21 and 1.27, respectively) while the lowest occurred in June 2008 (0.42 for *P. senegalensis*) and in July 2009 (0.38 for *P. typus*). Specimens from Site 2 yielded the highest repletion index in March 2009 (1.17 for *P. senegalensis* and 1.37 for *P. typus*) and lowest in June 2008 (0.44) for *P. senegalensis* and in July 2009 (0.37) for *P. typus*. Consequently, June and July were the months with lowest feeding activity for *P. senegalensis* and *P. typus*, respectively while peak feeding occurred in March for

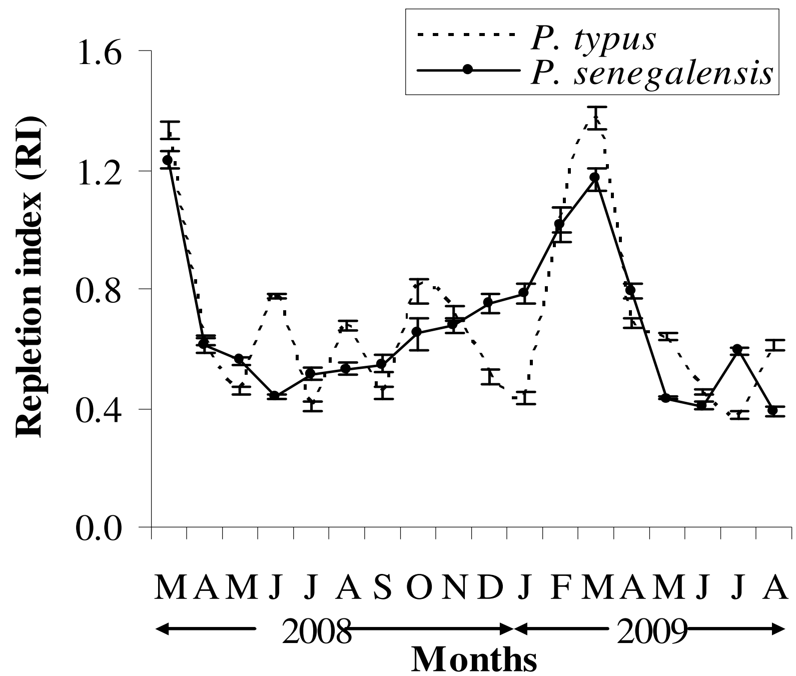

Figure 5. Monthly variation in repletion index *of P. senegalensis* and *P. typus* for Site 1.

Seasonal variation in feeding intensity

Four hydrological seasons occurs in the Gulf of Benin during a year. These are: a minor hydrological cold season (December to January), a major hydrological warm season (February to May), a minor hydrological season warm (November) and a major hydrological cold season (June to October) (Anato, 1999).

The seasonal variation in repletion index for the two sites (Figures 6 and 7) showed that the major hydrological warm season samples of *P. senegalensis* and *P. typus* had higher repletion index than other hydrological season samples at both sites. Consequently, feeding was more intense during the major warm season than during any other season.

DISCUSSION

The diet composition of the two species of *Pseudotolithus* portray them as specialized feeders depending on similar food sources with relatively low number of dietary items. Blay (2006) found that juveniles of *B. auritus* and *P. senegalensis* in Ghanaian coastal waters were stenophagous carnivores with high preference for juveniles of shrimps and other fishes including juveniles of *B. auritus.*

The principal food materials reported by the current study were shrimps (Crustaceans). These results confirmed those of Troadec (1971) who reported that four stomachs out of five contained shrimps (in this study a stomach out of two contained the Caridae *Nematopalaemon hastatus* and one out of five, the Penaeidae *Parapenaeopsis atlantica*). Baran (1995) also reported the importance of shrimps in the food regime of *Pseudotolithus elongatus* and *P. typus*. Sidibé (2003) obtained the same results while studying the community of Sciaenidae off the Guinean coasts. Tientcheu and Djama, (1994) noted that *P. typus* feeds mostly (80%) on shrimps whereas *P. senegalensis* feeds both on shrimps (47%) and on juvenile Clupeids (45%). Longhurst (1964) and Anyanwu and Kusemiju (1990) reported similar results from neighboring Nigeria. So did Blay (2006) from Cape Coast, Ghana. According to Troadec (1968), the food habits of *P. typus* is very close to those of *P. senegalensis* with stronger preference for *N. hastatus*. In contrast with Troadec (1971), the present study revealed that *P. atlantica* was the most important shrimps species fed on by *P. typus* and *P. senegalensis* off Benin nearshore waters. Tientcheu and Djama, (1994) reported similar results for these two Sciaenid fish species off Cameroon.

This importance of shrimps in diet composition may be due to their abundance (Lagler et al., 1977) and nutritional profitability. The observed high trophic specialization may be attributed to the fact that the dietary sources are largely autochthonous. The disadvantage of such specialized foraging is that the fish is increasingly exposed to intra and interspecific competition. However, the presence in the stomach of other food items such as

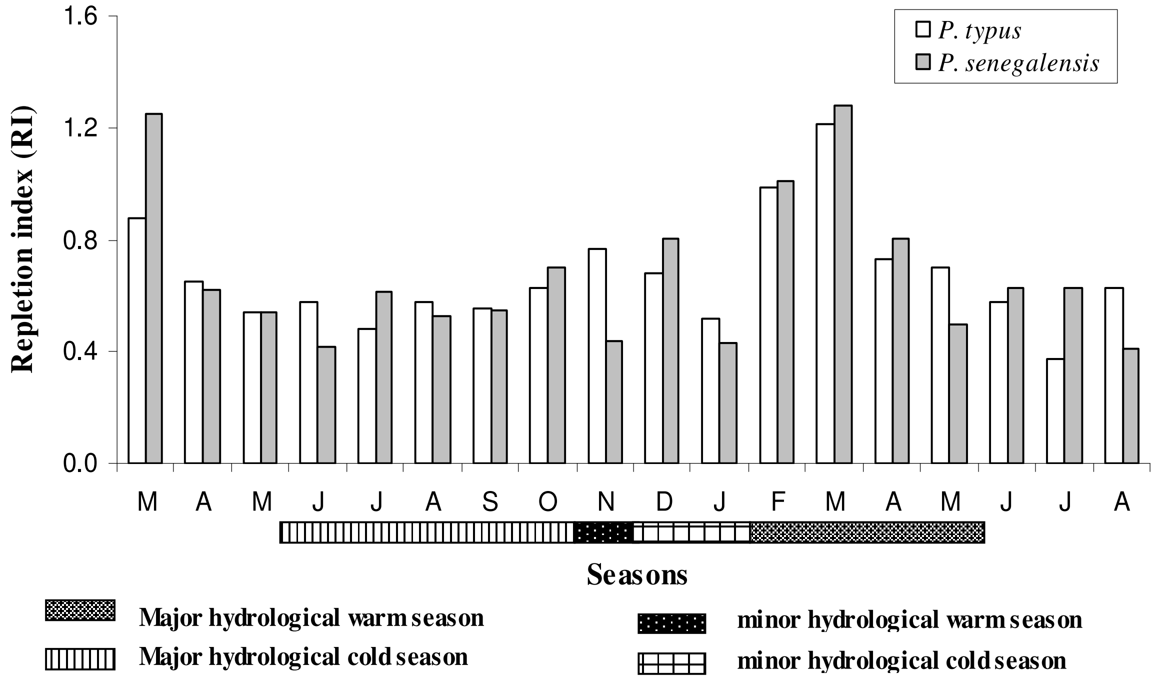

Figure 6. Seasonal variation in repletion index of *P. senegalensis* and *P. typus* for Site 1.

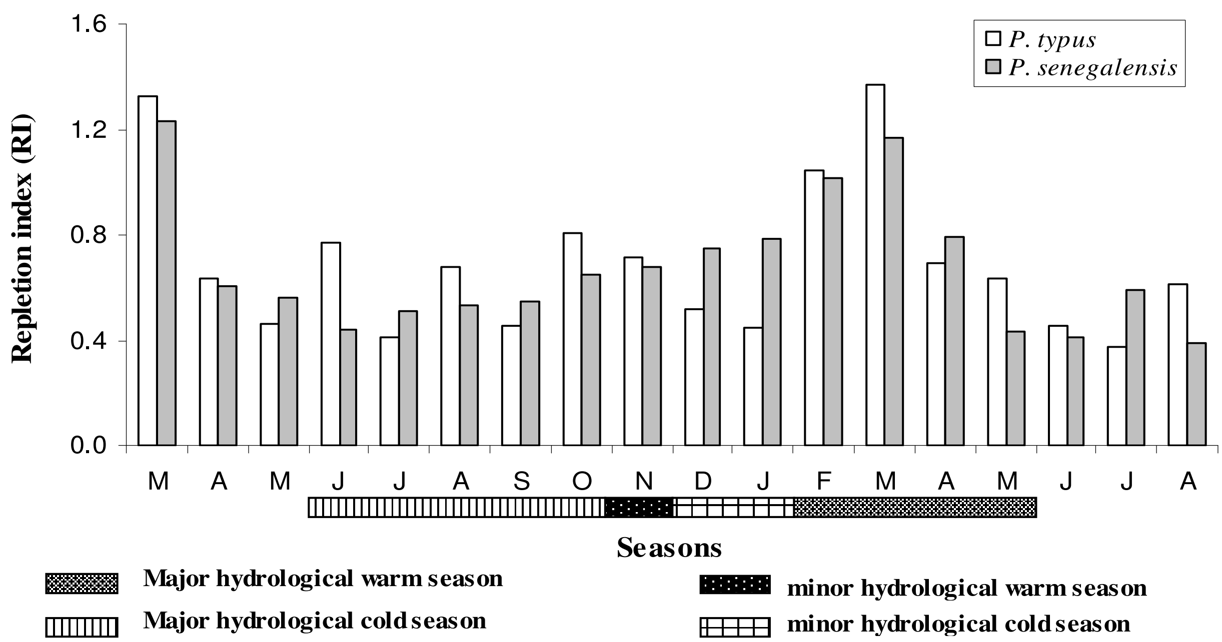

Figure 7. Seasonal variation in repletion index of *P. senegalensis* and *P. typus* for Site 2.

different fish species in *P. senegalensis* and *P. typus* attests to the inherent ability of these two species to expand their dietary options should there be any dramatic negative alteration in the availability of the favoured dietary items thereby checking competition. According to Labropoulou et al. (1997), large individuals exploit a broader range of prey than smaller ones due to the larger mouth gape of the former. Widening of dietary sources with fish sizes constitutes another means of reducing competition between smaller and larger individuals.

The seasonal variation in repletion index of *P. senegalensis* and *P. typus* showed a higher feeding activity in the major hydrological warm season which is the period of high production of shrimps in Benin. Troadec (1971) reported that *N. hastatus*, species of cold season, is the favourite food of *P. senegalensis* and *P. atlantica* constituted a replacement food. He made this conclusion because the consumption of *P. atlantica* was neither linked to their total abundance nor to small size of individuals. Their occurrence increases in stomachs while *N. hastatus* occurrence decreases in spite of the abundance of *N. hastatus* in the area at the beginning of minor warm season. He expressed that during the major warm season, abundance of *N. hastatus* and *P. atlantica* decreases, and then food items become diversified. According to Troadec (1971) decreases of feeding intensity observed at the end of upwelling would correspond to the minimum of oxygen that appears and reduces the population of most species of demersal fauna and particularly the food of Sciaenids.

Size-related repletion index exhibited a clear pattern at both sites. The 29 to 31 cm (TL) group had the highest repletion index (0.70) among specimens of both sites. Higher feeding activity in small individuals may be related to the fact that small prey items are digested much more rapidly than the larger fish ones found in the stomach of the larger fish (Labropoulou et al., 1997), while increased feeding activity in very large fish may be due to increased physiological demand associated with reproductive investment coupled with increased mouth gape and to the reduced vulnerability of the fish to predation while feeding.

Conclusion

With respect to the exploitation of near shore demersal fishes, it can be concluded that shrimps and to some extent juvenile fishes which constitute important preys of *Pseudotolithus* spp., remain an essential link in the trophic system off Benin nearshore waters. Therefore, the dynamics of the abundance of these shrimps and juvenile fishes must be assessed for sustainable production of their predators which constitute an essential proportion of exploited demersal resources in Benin. Reciprocally, it can be said that these fish species have an appreciable impact on the dynamics of populations of crustaceans, notably the shrimps. Their exploitation can also have some induced impacts and can occasion ecosystemic modifications.

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