Journal of
Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 9 (4): 157-169, 2014
ISSN 1816-4927 / DOI: 10.3923/jfas.2014.157.169

The Biology of Gladiator Swim Crab (*Callinectes pallidus*) from Ojo Creek, Southwestern Nigeria

A.A. Jimoh, P.E. Ndimele, I.P. Lemomu and U.A. Shittu
Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos

Corresponding Author: P.E. Ndimele, Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos Tel: +234(0)8038205109

ABSTRACT

The food and feeding habit of the gladiator swim crab, *Callinectes pallidus* was investigated in Ojo Creek, Lagos, Southwestern Nigeria between April and June, 2010. The stomach content analysis was carried out using the frequency of occurrence method, numerical method and further confirmed using the Geometric Index of Importance (GII). Forty two (representing 14%) of the 300 specimens of the crabs examined had empty stomachs. The crabs fed on a variety of food items which included fishes, molluscs, crustaceans, higher plant materials, algae and diatom. Fishes were the most important food item constituting 48.2 by number, 75.6% by occurrence and 87.5% using the GII. This was closely followed by mollusc accounting for 36.5 by number, 71.3% by occurrence with a GII of 76.2%. The least item consumed was diatom with 0.7 by number, 11.6 by occurrence and 8.7% using GII. Fishes still remained the most important feed item relative to size and sex; however there was slight variation in food and feeding habit relative to size. The smaller crabs (carapace width <3.99 cm) fed more on algae and diatom than medium size (4.00, 4.99 cm carapace width) and large crabs (carapace width >5.00 cm). There was also a slight variation in food and feeding habit relative to sex with males consuming more fishes (with 53.3 by number, 82.4 by occurrence and 96% using GII), than females (41.4 by number, 70.9% by occurrence and 79.4 using GII). Using the frequency of occurrence method the females (with 53.4%) consumed higher plant materials than the males (38.2%). This study revealed that *Callinectes pallidus* is an omnivore and an opportunistic feeder.

Key words: Crabs, fishes, *Callinectes pallidus,* omnivore

INTRODUCTION

Nigeria has a wide variety of shellfish resources ranging from the molluscs such as the clams, cockles and periwinkles to the crustaceans which include the shrimps, prawns, crabs and lobsters. Globally and in many parts of Nigeria, shellfishes have been a popular food item in diets. It constitutes one of the main sources of animal protein most especially among coastal dwellers in some parts of Nigeria and crab is one of the most important of them.

Crabs have a high ash, mineral and crude fibre content (Oduro *et al*., 2001), serve as a source of minerals consumed either wholly and partially by sick folks (Akin-Oriola *et al*., 2005) and is often recommended for pregnant women (Adeyeye and Kenni, 2008). Crab is caught in creeks, lagoons and adjacent inshore marine waters. It supports a major artisanal fishery in the Badagry, Lagos and Lekki Lagoons in Southwestern Nigeria where it is fished mainly by women. Swimming crabs are important in trophic relationship of fish and organisms of sand and sandy mud bottoms and

provide an important potential link, transferring energy between benthic and pelagic food chains within the estuarine system (Longhurst, 1957; Scott, 1966; Pillay, 1967; Van Kul and Hongpromgad, 1972; Warner, 1977; Baird and Ulanowicz, 1993).

The Gladiator swim crab *Callinectes pallidus* (De Rocheburne, 1883) is a decapod crustacean. Most literatures give information on the crabs composition (Idoniboye-Obu and Ayinla, 1991; Alfred-Ockiya, 2000; Oduro *et al*., 2001; Siddiqui and Zafar, 2002; Nlewadim *et al*., 2009 and Enzeross *et al*., 1997), ecology (Okafor, 1988; Lawal-Are and Kusemiju, 2000; Arimoro and Idoro, 2007), morphometric and meristic characteriatics (Anetekhai *et al*., 1994; Akin-Oriola *et al*., 2005) biology and food and feeding habit (Lawal-Are and Bilewu, 2009; Chindah *et al*., 2000; Lawal-Are, 2009; George *et al*., 2009). However, there is a dearth of information on the food and feeding habits of this particular species *Callinectes pallidus* (De Rocheburne, 1883).

The aim of this investigation therefore is to provide baseline information on the food and feeding habits of *Callinectes pallidus* (De Rocheburne, 1883) from Ojo Creek, Southwestern Nigeria.

MATERIALS AND METHODS

Sampling location: The Ojo Creek (Fig. 1) in Badagry environ of Lagos State is an extension of Badagry creek, which is one of the marginal estuaries that characterizes the West African coastline (Amadi, 1990). It is surrounded by many fishing villages and is a central point for the sales of fin

Fig. 1: Sampling location (Ojo Creek), Lagos, Southwestern, Nigeria

and shell fish. During the off-season, mats, ropes, palm oil and coconuts brought from nearby villages are sold predominantly. The surrounding vegetation is composed of mainly herbs and shrub plants dotted by raffia palm (*Raphia sudanica*), oil palm (*Elaeis guineensis*) and coconut palms (*Cocos nucifera*). Floating plants such as the water lettuce (*Pistia stratoites*), duckweed (*Lemna* sp.) and water hyacinth (*Eichhornia* sp.) often cover some parts of the water surface.

Collection of specimens: Twenty five specimens of the crabs {Fig. 2 (*Callinectes pallidus*)} were obtained weekly for 12 weeks between April and June 2010 from Ojo Creek, Lagos. The crabs which were collected live from fish mongers in Ojo Creek were packed in sacs and transferred into a deep freezer (-20°C) in the laboratory prior to analysis. A total of 300 specimens of the crab were collected and analysed. The crabs were identified based on the methods described by Schneider (1992) for *C. pallidus* (De Rocheburne, 1883).

Meristic and morphometric data: In the laboratory, using the venier calliper, the Carapace Length (CL), Left Chelae Diameter (LCD), Right Chelae Diameter (RCD) and Carapace Width (CW) were determined to the nearest 0.01 cm while the Body Weight (BW) was measured using the mettle balance (Model PM400) to the nearest 0.01 g.

Sex determination: *Callinectes pallidus* was sorted according to sex using the method described by Sachs and Cumberlidge (1991), the size of the abdomen distinguishes sexes. In males, it is triangular and inset into the underside (Fig. 3). In females (Fig. 4), it is broad, round and sometimes brownish in colour. The specimens of *C. pallidus* `were sorted into male and female to estimate the sex ratio.

Food analysis: The stomach lies on the anterior wall of the carapace. The cardiac stomach was removed and dissected for each specimen. The stomach content was immediately transferred into a petri dish and little water was added to it and viewed under a binocular microscope for examination.

The contents were identified using the keys given by Ward and Whipple (1950), Pennak (1953) and Prescott (1962). All items in the stomach including skeletal material were classified as food item. The stomach content was analysed using the numerical and percentage frequency of occurrence methods (Kwei, 1978; Hyslop, 1980; Williams, 1981).

The frequency of occurrence of different food items belonging to a certain category is counted, divided by the total number of individuals with a non-empty stomach and multiplied by 100 in order to obtain the frequency of occurrence. However in the numerical method the number of individuals in each food category was recorded for all stomachs and the total is expressed as a proportion (percentage) of the total individuals in all food categories.

The percentage frequency of occurrence is calculated (Ndimele *et al.*, 2010) by the formula:

$$F_i = \frac{N_i}{N} \times 100$$

Where:

Fig. 2: Dorsal view of *Callinectes pallidus*

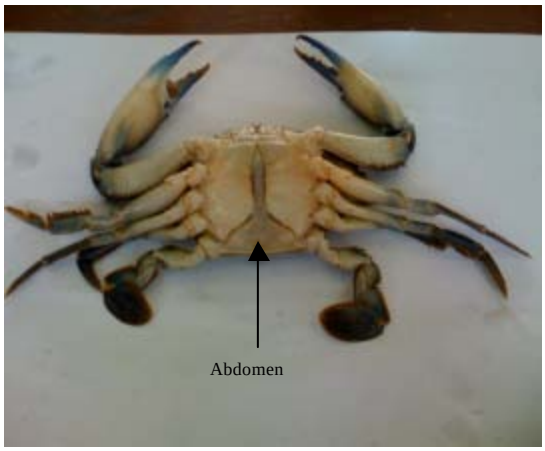

Fig. 3: Ventral view of *Callinectes pallidus* (male)

Fig. 4: Ventral view of *Callinectes pallidus* (female)

F_i: Frequency of occurrence of the ith food items in the sample
N_i: Number of stomachs in which the ith item was found
N: Total number of stomachs with food in the sample

While the Numerical item of each food item is calculated using:

$$N_i = \frac{F_i}{F} \times 100$$

Where:
N_i: Numerical percentage of the ith food item in the sample
F_i: Total number of ith food item
F: Total number of all food items

The numerical and frequency of occurrence methods however has some shortcomings (Gumus *et al*., 2002), therefore the Geometric Index of Importance (GII) was used in this study to measure the relative importance of the food items. The GII is easy to compute, each parameter involved is weighed equally and food items are ranked according to their overall importance in the stomach.

The GII, in its simplified form (Gumus *et al*., 2002), may be calculated as:

$$GIIj = \frac{\left[\sum_{i=1}^{n} Vi\right]j}{\sqrt{n}}$$

Where:
V_i: The value of the ith measure of food item category j and
n: The measure used in the analysis of each food item

The percentage of total number and percentage of frequency of occurrence are the relative measures of food items used in the estimation of GII.

Visual estimate of the degree of fullness of the stomach was estimated subjectively and expressed as follows:

Class 1: Empty stomach
Class 2: Half-full stomach
Class 3: Full stomach

Stomach contents were identified into 8 groups namely; fishes, mollusc, crustaceans, diatom, algae, higher plant, sand grains and unidentified mass.

RESULTS

A total of 300 specimens of *Callinectes pallidus* were examined and 42 (representing 14%) of the crabs had empty stomach. The crabs fed mainly on 6 food items made up of fishes, molluscs, crustaceans, higher plant materials, algae and diatom. Other items found in the stomach and thus classified as food include sand grains and unidentified mass. The fishes consisted mainly of fish

parts, fish scales and fish spines and bones since they were macerated. The crustaceans consisted mainly of shrimp appendages and juvenile crab appendages, while the mollusc was comprised mainly of bivalves and barnacles. The diatom was comprised majorly of *Melosira varians* and *Cyclotella comta* while the algae consisted of *Asterionella gracillima, Trachelomonas* and *Ankistrodesmus falcatus* (Chlorophyta). Other items found in the stomach include sand grains and unidentified mass.

Table 1 shows the visual estimate of the degree of fullness of the crab stomach. It was observed that 42 cabs had empty stomachs, 177 had half-full stomach while 81 crab samples had full stomach, representing 14, 59 and 27%, respectively.

The summary of the stomach contents is given in Table 2. Fishes were the most important food items constituting 48.2% by numerical approch, 75.6% by occurrence and 87.5% using the Geometric Index of Importance (GII). This was closely followed by mollusc accounting for 36.5, 71.3 and 76.2% by numerical, occurrence and geometric index of importance respectively. The analysis also revealed that diatom constituted the least item consumed accounting for 0.7 by numerical, 11.6 by occurrence and 8.7% using the geometric index of importance.

GII: Geometric Index of Importance: According to Fig. 5, the feed in relation to carapace width revealed fishes still remain the most important food item as evident in its geometric index of importance value of 77.2, 84.8 and 94.1% for small, medium size and large crabs, respectively. However, the smaller crabs tend to feed on more algae and diatom which tend to reduce with increase in size, as shown in the GII of 14.4, 9.5, 6.2% for diatom and 33.8, 25.8 and 16.1% for algae for small, medium and large crabs, respectively.

Figure 6 shows that algae and diatom had higher values by occurrence in small crabs than the medium and large crabs. Fishes had higher values by occurrence in large crabs than medium and small crabs, respectively. However, mollusc had the same value (72.3%) by occurrence in medium and large crabs although lower (56.3%) in small crabs.

Table 1: Summary of the degree of fullness of stomach contents of *Callinectes pallidus* from Ojo Creek, Lagos (April-June 2010)

Degree of fullness	No. of crabs	Percentage (%)
Empty stomach	42	14
Half-full stomach	177	59
Full stomach	81	27
Total	300	

Table 2: Summary of stomach contents of *Callinectes pallidus* from Ojo Creek, Lagos (April-June 2010)

	Numerical		Occurrence		
Food item	Number	(%)	Number	(%)	GII (%)
Fishes	6438	48.2	195	75.6	87.5
Molluscs	4878	36.5	184	71.3	76.2
Crustaceans	1755	12.8	136	52.7	46.3
Algae	186	1.4	66	25.6	19.1
Diatom	90	0.7	30	11.6	8.7
Higher plant	-	-	94	36.4	36.4
Sand grains	-	-	75	29.1	29.1
Unidentified mass	-	-	25	9.7	9.7

GII: Geometric index of importance

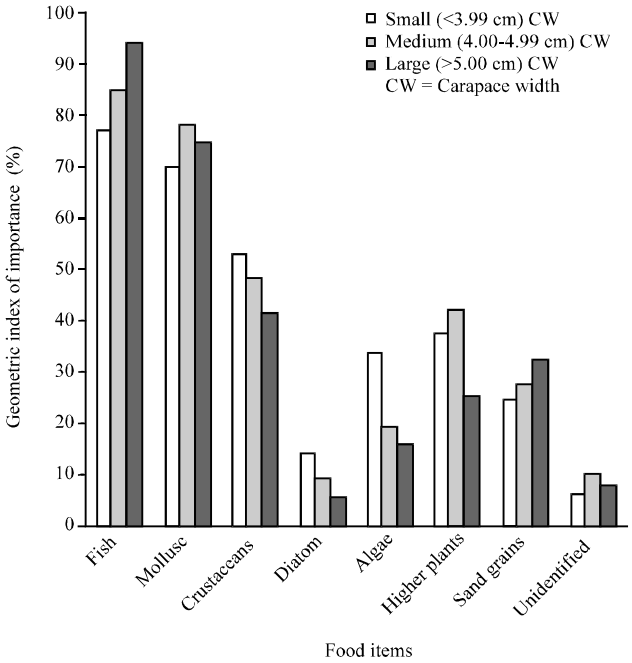

Fig. 5: Stomach contents of *Callinectes pallidus* (by size groups) using geometric index of importance

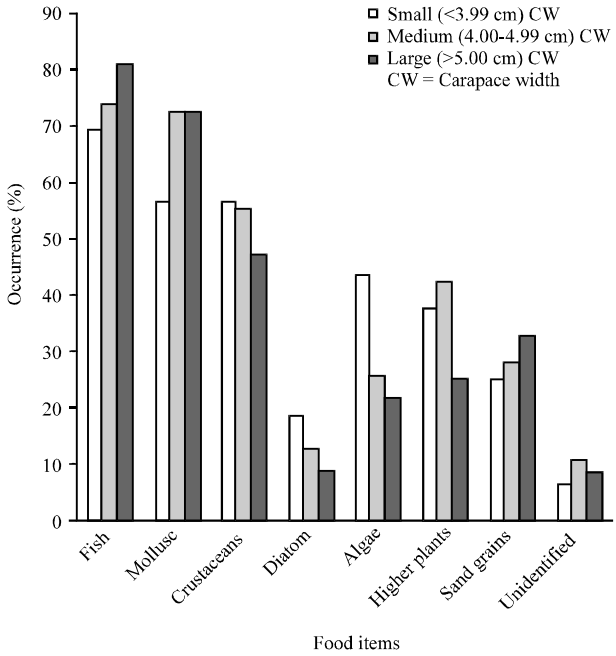

Fig. 6: Stomach contents of *Callinectes pallidus* (by size groups) using percentage frequency of occurrence

Using the numerical method as represented in Fig. 7, crustaceans, diatom and algae had higher value by number in small crabs than medium and large crabs, respectively but fishes had higher values in large crabs than medium and large crabs, respectively.

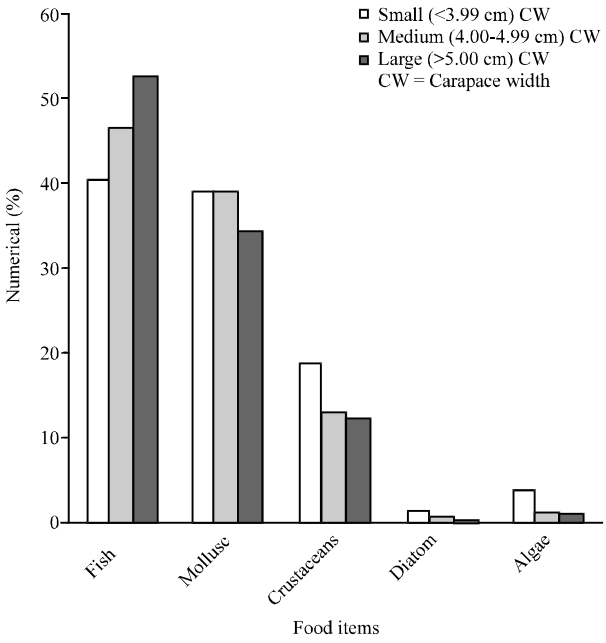

Fig. 7: Stomach contents of *Callinectes pallidus* (by size groups) using numerical method

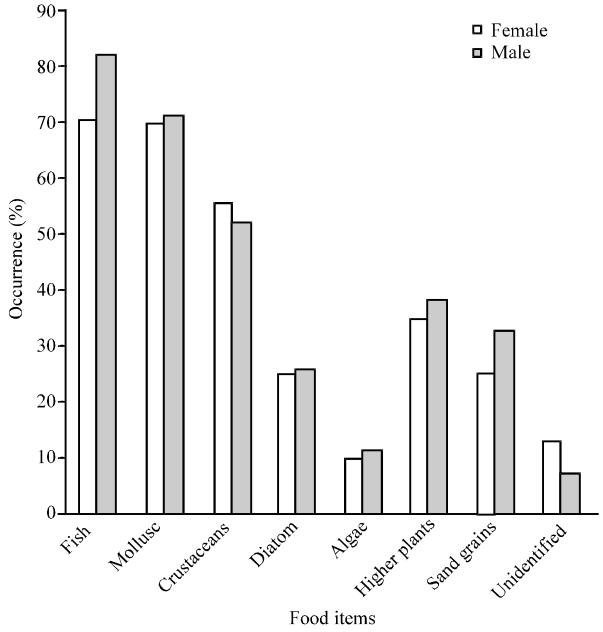

Fig. 8: Stomach contents of *Callinectes pallidus* (by sex) using percentage frequency of occurrence

Fishes are the most important food item in the females with 41.4 by number and 70.9% by occurrence which was further confirmed by its geometric index of importance of 70.9%. Fishes were also the most important food item for the males with 53.3 by number, 82.4 by occurrence and 96% using the geometric index of importance. As shown in Fig. 8, the females fed on more crustaceans (55.1%) than males (51.9%) by occurrence, but the males fed on more of all other food items than the females using the percentage frequency of occurrence method.

Figure 9 shows that the male crabs fed more on fishes (53.3%) than the females (41.4%) in terms of the numerical method. However the females fed more on mollusc, crustacean, diatom and algae. As shown in Fig. 10, the male tend to feed on more fishes than the female as evident in its GII of 96 for male and 79.4% for females. Both sexes had similar GII for diatom of 18.9 and 19% for female and male, respectively. The females however, fed on more mollusc, crustaceans and higher plant materials.

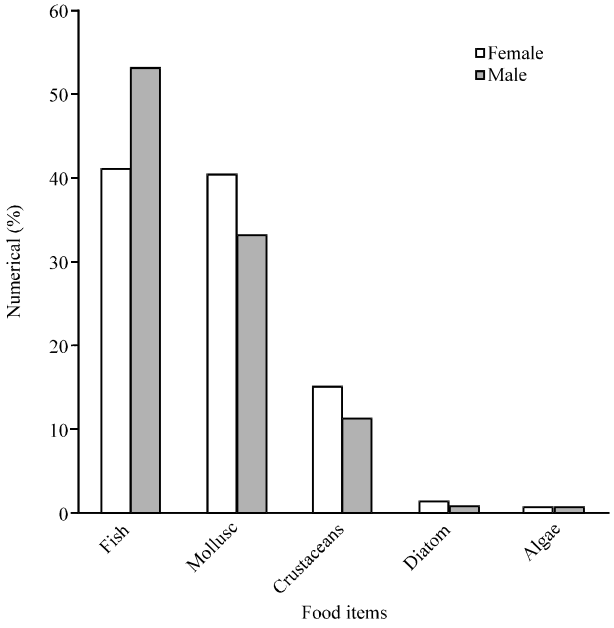

Fig. 9: Stomach contents of *Callinectes pallidus* (by sex) using numerical method

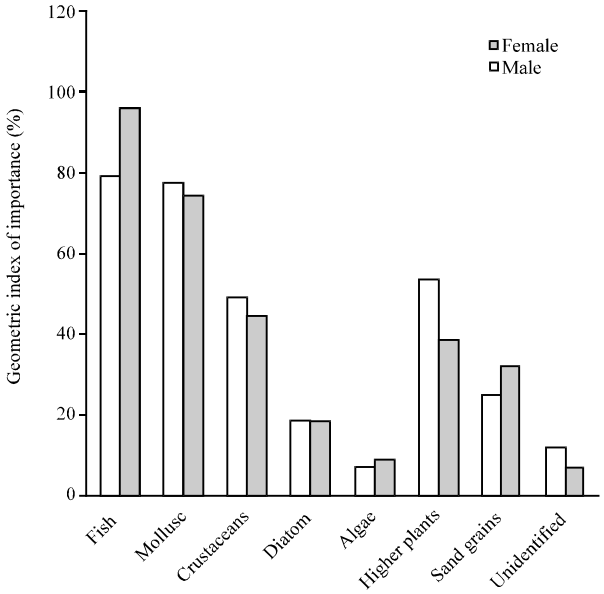

Fig. 10: Stomach contents of *C. pallidus* (by sex) using geometric index of importance

DISCUSSION

The knowledge of the diet of a species in nature is important for the establishment of its nutritional needs and of its interaction with other organisms (*Albertoni et al.*, 2003). According to Wootton (1992), food and feeding habits are indispensable part of biological and taxonomic studies because it is an essential function of an organism as growth, development and reproduction are all dependent on energy that enters in the form of food. The food items of *Callinectes pallidus* consisted of fishes, molluscs, crustaceans, higher plant material, algae, diatom, sand grains and unidentified mass. According to Guillory (1996a), crabs are generally opportunistic predators. Their diets may include a wide range of taxa including bivalves, crustaceans and fish. The number and variety of food items found in the individual stomach of *Callinectes pallidus* in this study showed that the crab is an omnivore and opportunistic benthic predator. Food habits of the crab in Ojo Creek was therefore similar to previous reports for crabs of the genus *Callinectes* (Lawal-Are and Kusemiju, 2000; Arimoro and Idoro, 2007; Lawal-Are, 2009; Chindah *et al.*, 2000; Emmanuel, 2008; George *et al.*, 2009). Juvenile and adult crabs were characterized as opportunistic benthic omnivores, detritivores, cannibals and scavengers, with food habits determined by local abundance and availability of prey (Guillory, 1996b; McConaugha and McConaugha, 1996).

It was observed that 14% of the crabs examined had empty stomachs. This is similar with the studies of Lawal-Are and Kusemiju (2000) and Lawal-Are (2009) where they reported percentage empty stomach of 17.6 and 11.7%, respectively but slightly different from that of Arimoro and Idoro (2007) that reported 20.8%. The differences could be due to the difference in season, locality or that crabs feed intermittently and/or have a high rate of digestion as some food items may be quickly digested, thus making identification difficult. Moreover, with high rates of digestion, some food particles may be difficult to observe and identify and as such the presence of unidentified mass in stomach contents.

The analysis of the stomach content revealed that although *C. pallidus* feed on a wide variety of food items, they showed preference for fishes and molluscs. Fishes had the highest value by number and occurrence and was further confirmed by the Geometric Index of Importance (GII). It was closely followed by molluscs and then crustaceans, higher plants, sand grains, algae, unidentifed mass and diatom in that order. According to Arawomo (1976), numerical method is also not suitable for dealing with food items such as macroalgae and detritus which do not occur in discrete units. Therefore, the frequency of occurrence method was utilised and not numerical method for higher plant, unidentified mass and sand grains. The high percentage occurrence of sand grains may be incidental and as a result of the benthic nature of the crabs and associated with the bottom substratum to which some of their food item such as algae, mollusc and crustacean species are attached. This is in agreement with reports of Nikolsky (1963), Allison (2006), Chindah *et al.* (2000) and George *et al.* (2009).

The results also showed significant changes in food habits relative to size of crabs. This variation in food habit was also reported by Lawal-Are (2001) and Chindah *et al.* (2000) for *Callinectes amnicola*. However, Emmanuel (2008) observed no distinct changes in the food habit relative to size in the same species (*C. amnicola*). The small crabs consumed more algae and diatom than the medium and large crabs using the Geometric Index of Importance (GII). Fishes had higher values in large crabs compared to the medium and female crabs. The medium crabs consumed more mollusc than large and small crabs. The smaller crabs however, consumed more crustaceans than the medium and larger crabs. The observed changes in feeding habit relative to size differences may be due to food selection resulting from the absence of suitably sized prey in the

environment (Moore and Moore, 1976). George *et al.* (2009) concluded that the small crabs feeding more on algae and diatom than medium and large (adult) crabs may have resulted from the fact that the juveniles being less active forage more on algae and slow moving fauna.

Fish and other animals are more common in large crabs than the smaller ones; this may be as a result of the digestive system of adults being more developed than the juveniles (Warner, 1977; Chindah *et al.*, 2000). Furthermore, Warner (1977) and Paul (1981) had observed in their studies that the organism forage more on algae during their early stages and at maturity depends largely on fauna such as shrimps, brachyuran, bivalves, gastropods, fish, polychaetes and others.

Fish was still the most preferred food item for both sexes. However fishes had higher values by number, occurrence and confirmed by the geometric index of importance in males than females. The females fed on relatively higher plant than males.

CONCLUSION

From the results of the analysis of the stomach contents of the gladiator swim crab *Callinectes pallidus* (De Rocheburne, 1883), it could be concluded that the species is an omnivore and opportunistic predator, feeding mainly on fishes and mollusc and to a lesser extent. They exhibit a carnivorous way of feeding by feeding on fishes, mollusc and to a lesser extent on crustaceans, higher plant materials, algae and diatom. Furthermore, with the number and variety of the food organisms found in the stomach, the crab may be considered as euryphagus feeding on any food item it could readily come across. This is particularly important for the culture of this organism since this crab species have been reported to possess high demand and command good market price.

REFERENCES

Adeyeye, E.I and A.M. Kenni, 2008. The relationship in the amino acid of the whole body, flesh and exoskeleton of common West African fresh water male crab *Sudananautes africanus africanus*. Pak. J. Nutr., 7: 748-752.

Akin-Oriola, G., M. Anetekhai and K. Olowonirejuaro, 2005. Morphometric and meristic studies in two crabs: *Cardisoma armatum* and *Callinectes pallidus*. Turk. J. Fish. Aquat. Sci., 5: 85-89.

Albertoni, E.F., C. Palma-Silva and F.A. Esteves, 2003. Natural diet of three species of shrimp in a tropical coastal lagoon. Braz. Arch. Biol. Technol., 46: 395-403.

Alfred-Ockiya, J.F., 2000. Nutritional changes in traditionally preserved shellfishes from the Niger-Delta, Nigeria. J. Aquat. Sci., 15: 9-11.

Allison, M.E., 2006. The ecology and fisheries of *Parailapellucida* (Boulenger, 1901) (SCHILBEIDAE) in the lower nun river of the Niger Delta, Nigeria. Ph.D. Thesis, University of PortHarcourt, Port Harcourt, Nigeria.

Amadi, A.A., 1990. A comparative ecology of estuaries in Nigeria. Hydrobiology, 208: 27-38.

Anetekhai, M.A., F.G. Owodeinde and E.G. Ogbe, 1994. Meristic and mophormetric features, Age and growth pattern in *Cardosoma armatum* (Herklots) from Lagos Lagoon, Nigeria. Niger. J. Sci., 19: 12-18.

Arawomo, G.A.O., 1976. Food and feeding of three *Citharinііs* species in Lake Kainji, Nigeria. J. Fish Biol., 9: 3-10.

Arimoro, F.O. and B.O. Idoro, 2007. The ecological studies and biology of *Callinectes armnicola* (Portunidae) in the lower reaches of Warri River, Delta State, Nigeria. World J. Zool., 2: 57-66.

Baird, D. and R.E. Ulanowicz, 1993. Comparative study on the trophic structure, cycling and ecosystem properties of four tidal estuaries. Mar. Ecol. Prog. Ser., 99: 221-237.

Chindah, A.C., C.C.B. Tawari and K.A. Ifechukwude, 2000. The food and feeding habits of the swimming crab, *Callinectes amnicola* (Portunidae) of the New Calabar River, Nigeria. J. Applied Sci. Environ. Manage., 4: 51-57.

De Rocheburne, A.T., 1883. Diagnoses d'arthropodes nouveaux propres a la Senegambie [Diagnoses of new arthropods specific Senegambia]. Buletin de la Societe Philomathique de Parie, 7: 167-182 (In French).

Emmanuel, B.E., 2008. The fishery and bionomics of the swimming crab, *Callinectes amnicola* (De Rocheburne, 1883) from a tropical Lagoon and its adjacent creek, Southwest, Nigeria. J. Fish. Aquat. Sci., 3: 114-125.

Enzeross, R., L. Enzeross and F. Bingel, 1997. Occurrence of blue crab, *Callinectis sapidus* (Rathbun, 1896) (Crustaceae, Brachyura) on the Turkish mediterranean and its size distribution in the bay of Iskenderun. Turk. J. Zool., 21: 113-122.

George, A.D.I., J.F.N. Abowei and M.B. Inko-Tariah, 2009. The composition in different size groups and Index of Relative Importance (IRI) of *Callinectes amnicola* (De Rocheburne, 1883) food from Okpoka Creek, Niger Delta, Nigeria. Int. J. Anim. Vet. Adv., 1: 83-91.

Guillory, V., 1996a. A Biological and Fisheries Profile of the Blue Crab, *Callinectes sapidus*. Louisiana Department of Wildlife and Fisheries, Office of Fisheries, USA., Pages: 210.

Guillory, V., 1996b. A management profile of the blue crab, *Callinectes sapidus*. Louisiana Department of Wildlife and Fisheries, Fisheries Management Plan Series 8, Part 2, pp: 34.

Gumus, A., M. Yilmaz and N. Polat, 2002. Relative importance of food items in feeding of *Chondrostoma regium* Heckel, 1843 and its relation with the time of annulus formation. Turkish J. Zool., 26: 271-278.

Hyslop, E.J., 1980. Stomach contents analysis: A review of methods and their application. J. Fish Biol., 17: 411-429.

Idoniboye-Obu, T.I.E. and O.A. Ayinla, 1991. Prospholipid and fatty acid composition of two brachyuran decapod crustacea *Callinectes latimanus* (Rathbun) and *Cardisoma armatum* (Herklots). Technical Paper No, 73, African Regional Aquaculture Centre, Nigerian Institute for Oceanography and Marine Research, Port-Harcourt, Nigeria, October 1991, pp: 1-17.

Kwei, E.A., 1978. Size composition, growth and sexual maturity of *Callinectes latimanus* (Rath.) in two Ghanaian lagoons. Zool. J. Linnean Soc., 64: 151-175.

Lawal-Are, A.O. and B. Bilewu, 2009. The biology of the smooth swim crab, *Portunus validus* (Herklots) off Lagos Coast, Nigeria. Eur. J. Sci. Res., 30: 402-408.

Lawal-Are, A.O. and K. Kusemiju, 2000. Size composition, growth pattern and feeding habits of the blue crab, *Callinectes amnicola* (DeRocheburne) in the Badagry lagoon, Nigeria. J. Sci. Res. Dev., 4: 117-126.

Lawal-Are, A.O., 2001. Aspects of the biology of the Lagoon crab, *Callinectes amnicola* (De Rocheburne) in Badagry, Lagos and Lekki Lagoons, Nigeria. Proceedings of the 16th Annual Conference of the Fisheries Society of Nigeria, November 4-9, 2001, Fisheries Society of Nigeria, Apapa, Lagos, Nigeria, pp: 215-220.

Lawal-Are, A.O., 2009. Food and feeding habits of the blue crabs *Callinectes amnicola* (De Rocheburne) from three different interconnecting lagoons in South-West Nigeria. Eur. J. Sci. Res., 32: 88-94.

Longhurst, A.R., 1957. The food of the demersal fish of a West African Estuary. J. Anim. Ecol., 26: 269-387.

McConaugha, J.R. and C.S. McConaugha, 1996. Prey selection and feeding mechanism in brachyuran megalopae: The *Callinectes sapidus* model. Proceeding of the 24th Annual Conference on Benthic Ecology, March 7-10, 1996, Columbia, South Carolina, pp: 56-112.

Moore, J.W. and E.A. Moore, 1976. Environmental Chemistry. Academic Press Inc., London, UK., ISBN-13: 9780125050500, pp: 360-363.

Ndimele, P.E., C.A. Kumolu-Johnson, N.F. Aladetohun and O.A. Ayorinde, 2010. Length-weight relationship, condition factor and dietary composition of *Sarotherodon melanotheron*, Ruppell, 1852 (Pisces: Cichlidae) in Ologe Lagoon, Lagos, Nigeria. Agric. Biol. J. North Am., 1: 584-590.

Nikolsky, G.V., 1963. The Ecology of Fisheries. Academic Press, London, UK., pp: 200.

Nlewadim, A.A., C.O. Ofor and J.P. Udoh, 2009. Size composition and population characteristics of the swimming crab *Callinectes amnicola* (De Rocheburne, 1883) (crustacea, brachyura, portunidae) in the Imo River estuary, Nigeria. Niger. J. Agric. Food Environ., 5: 47-61.

Oduro, W., W.O. Ellis, I. Oduro and D. Tetteh, 2001. Nutritional quality of selected Ghanaian crab species. J. Ghana Sci. Assoc., 3: 37-40.

Okafor, F.C., 1988. The ecology of *Sudanonautes africanus* h. milne edwards crustacea decapoda in South-Eastern Nigeria. Trop. Ecol., 29: 89-97.

Paul, R.K.G., 1981. Natural diet, feeding and predatory activity of the crabs *Callinectes arcuatus* and *C. toxote* (Decapoda, Brachyura, Portunidae). Mar. Ecol. Prog. Ser., 6: 91-99.

Pennak, R.W., 1953. Freshwater Invertebrates of the United States. Ronald Press, New York, USA., Pages: 769.

Pillay, T.V.R., 1967. Estuarine Fisheries of West Africa. In: Estuaries, Lauff, G.F. (Ed.). AA Balkema Publishers, Rotterdam, Netherlands, pp: 639-646.

Prescott, G.W., 1962. Algae of the Western Great Lakes Area. W.M.C. Brown Co., Dubuque, Iowa, USA., pp: 946.

Sachs, R. and N. Cumberlidge, 1991. The dwarf river crab *Liberonautes latidactylus* nanoides Cumberlidge and Sachs, 1989, from Liberia-a new second intermediate host of *Paragonimus uterobilateralis*. Trop. Med. Parasitol., 42: 73-74.

Schneider, W., 1992. FAO species identification guide: Guide to the marine commercial resources of the gulf of Guinea. FAO, RAFR/FI, Rome, pp: 268.

Scott, J.S., 1966. Report on the fisheries of the Niger delta special area. Niger Delta Development Board, Port Harcourt, Nigeria, pp: 160.

Siddiqui, M.Z.H. and M. Zafar, 2002. Crabs in the chakaria sundarban area of Bangladesh. J. NOAMI., 19: 61-77.

Van Kul, P.S. and L. Hongpromgad, 1972. Preliminary Experiments in Pond Rearing and Some Biological Studies of *Syclla serata* (Fodskal). In: Coastal Aquaculture in the Indo-Pacific Region, Pillay, T.V.R. (Ed.). FAO, Rome, Italy, pp: 362-374.

Ward, H.B. and G.C. Whipple, 1950. Freshwater Biology. John Wiley, London, UK., Pages: 650.

Warner, G.F., 1977. The Biology of Crabs. The Biology of Crabs. London, UK., ISBN-13: 9780236400874, Pages: 202.

Williams, M.J., 1981. Methods for analysis of natural diet in portunid crabs (Crustacea: Decapoda: Portunidae). J. Exp. Mar. Biol. Ecol., 52: 103-113.

Wootton, R.J., 1992. Fish Ecology: Tertiary Level Biology. Blackie Publication, London, ISBN-13: 9780216931527, Pages: 212.