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Full Length Research Paper

Nutrient utilization and growth of *Clarias gariepinus* fed four different commercial feeds

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Several studies had been conducted on the nutritional requirements of African catfish, *Clarias gariepinus*. Nevertheless, currently there is a gap about the gross composition of feed ingredients required for formulation of commercial feeds. The aims of this feeding trial were to investigate whether fish fed four different commercial feeds have a significant growth rate and nutrient utilization. A total of 120 fish samples were stocked for a triplicate feeding trial (10 fish for each replication) in 4 separated tanks with 4 different feeds: Euro, Melick, Coppens and Durante (T1), (T2), (T3) and (T4) respectively. During all the trial, the water quality and growth parameters were determined according to standard methods and no significant differences were found among the water quality parameters determined. The mean weight gain (MWG) and specific growth rate of T3 were significantly higher than those of other treatments. Statistics showed that protein efficiency ratio (PER) of T3 was significantly higher than other treatments. Contrary to the above trend, the feed conversion ratio (FCR) of T2 was significantly higher than other treatments. According to the results of this study, fish fed with Coppens feed showed a significant growth rate and nutrient utilization.

Key words: Feeding trial, treatments, growth, nutrient utilization, commercial feeds.

INTRODUCTION

Fish nutrition is critical in fish farming because feed represents 40-50% of production cost (Craig and Helfrish, 2002). Growth performance and nutrient utilization of fish is determined by gross composition of the feed ingredients, processing and storage of the feed products. Globally, there is a great decline in aquaculture production, due to fish feed manufacturers substituting vital feed ingredients with alternative feed stuffs that cannot achieve fish nutritional requirements. One of the critical challenges faced by aquaculture is the high cost of fish feeds and more than 50% of the total cost of production is intensified in culture system (Ali et al., 2004). Fish feed enhances optimum growth and resistance to diseases when it contains proper proportion of proteins, carbohydrate, lipids, vitamins and minerals. Nevertheless, nutrients in fish feeds are optimally utilized when the feed stuffs are acceptable and palatable to the fish.

Cost of production can be reduced if growth performance and feed efficiency are increased in commercial

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Table 1. Proximate compositions of the four commercial feeds.

Parameter	T1	T2	T3	T4
Moisture content (%)	8.53	8.07	8.67	8.67
Protein (%)	46.36	45.64	48.10	47.67
Ether extract (%)	28.50	29.63	30.37	27.73
Ash (%)	9.38	8.53	8.67	7.77
Crude fibre (%)	7.23	8.13	6.83	7.57
Energy (Cal/kg)	209.24.23	190.12	250.67	230.45

aquaculture (Dada and Olugbemi, 2013).

In an attempt to go into feed mill business, many fish nutritionists have formulated and supplied fish feeds to fish farmers without disclosing the gross composition of the fish feeds formulated. In order to ensure optimum growth performance of cultured fish, there is need for farmers to know the proximate composition of the formulated feed. Global attention is needed to address the impacts of various commercial feeds produced by feed millers. However, the culture of African catfish, *C. gariepinus* has produced optimum crude protein required for growth of the populace. In Nigeria, the farming systems of *C. gariepinus* have produced means of livelihood for many people in the local communities and have equally generated revenue for the government. Little or no information has been known and reported on gross composition of fish feeds in Nigeria. The aim of this study was to investigate the effects of four commercial feeds on growth and nutrient utilization of African catfish, *C. gariepinus*.

MATERIALS AND METHODS

A total of one hundred and twenty *C. gariepinus* with average weight of 20.20±2.68 g were purchased from Fatutek fish farm, Ashi-Bodija, Ibadan, Nigeria. The fish samples were stocked inside experimental bowl of 40 litres capacity at thirty fish per treatment with ten in each replicate. Before the feeding trial experiment, the fish samples were acclimatized for 14 days in the laboratory. The fish were fed at 5% body weight with Euro (FEFAC aisbi Rue de la Loi, 223 Bte 3 B-1040 Bruxelles Belgium), Melick (75 Orchard Drive Catawissa, PA 17820), Coppens (Dwarsdijk 4 5705 DM Helmond, The Netherlands) and Durante (Nigerwest building, old Lagos road, challenge, Ibadan, Oyo State, Nigeria) and they were allotted treatments (T1), (T2), (T3) and (T4) respectively. The feeding rates of the fish samples were adjusted weekly after weight measurement of each treatment. The proximate composition of the feed (Table 1) was determined according to the methods described by AOAC (2005).

The experimental bowls were aerated using an electronic aerator of model PAI. Water samples were collected weekly to determine water quality parameters (water temperature, dissolved oxygen, ammonia and pH). The pH of the water was determined using a digital pH meter Suntex (model TS-2). Water temperature was measured with mercury in glass thermometer. The reading was taken by dipping the thermometer in water to a depth of 0.5 m. Other water quality parameters were determined according to the standard methods of American Public Health Association (1992).

After the feeding trial experiment, the following nutrient utilization and growth parameters were determined: Mean weight gain was calculated by subtracting mean initial weight (g) from mean final weight (g). Specific growth rate= $(\ln W_2 - \ln W_1) / T_2 - T_1 \times 100$, where W_2 is the mean final weight, W_1 is the mean initial weight and T_2 is the final day of the feeding trial and T_1 is the initial day of the feeding trial. Feed conversion ratio=Feed consumed (g)/Weight gain (g). Protein efficiency ratio=Weight gain (g)/Protein intake. Survival rate=Fish quantity at the end of the experimental period/Fish quantity at the beginning of the experimental period × 100.

The data collected were analyzed using Statistical Package for Social Sciences (SPSS), Version 11, 2001 and Statistical Analysis Software (SAS), Version 8, 2001. Duncan's Multiple Range Test was used to compare the differences among the means. The significant level was set at 5%.

RESULTS AND DISCUSSION

The water quality parameters investigated in this study are presented in Table 2. All parameters (water temperature, dissolved oxygen, ammonia and pH) determined were not significantly different among groups ($p>0.05$). Moreover the values recorded for these parameters were within the recommended ranges for the culture of African catfish, *C. gariepinus* and experimental fish (Viveen et al., 1986; Loiselle, 1994). Table 3 shows the growth performance and nutrient utilization of *C. gariepinus* fed different commercial feeds. The results showed that the MWG by T3 was significantly higher ($p<0.05$) than other treatments. The SGR showed similar level of significance. The SGR of T3 was significantly higher ($p<0.05$) than other treatments. Dietary crude protein is vital in fish feeds and must be supplied for rapid growth (Jauncey 1982; Lovell, 1989).

The findings of this study revealed that increased crude protein levels and caloric content of the diet had a significant effect on the MWG and SGR. Tabachek (1986) reported similar findings while investigating the influence of dietary protein and lipid levels on growth, body composition and utilization efficiencies of Arctic charr, *Salvelinus alpinus* L. Statistics further showed that PER of T3 was significantly higher ($p<0.05$) than other treatments. The significant value of PER in this study was as a result of the level of fat in the diet. This trend was also reported by Murat and Ibrahim (2013) who studied

Table 2. Physico-chemical parameters of water in tanks during the feeding trial period.

Parameter	Initial	T1	T2	T3	T4
Water temperature (°C)	29.77±0.25	30.00±0.20	30.27±0.25	29.50±0.30	30.00±0.50
Dissolved oxygen (mg/l)	6.04±0.05	6.04±0.02	6.08±0.01	5.90±0.20	6.08±0.01
pH	6.67±0.06	6.90±0.01	6.80±0.10	6.83±0.06	6.67±0.06
Ammonia (mg/l)	0.01	0.02	0.01	0.01	0.02

Means with same superscript were not significantly different (p>0.05).

Table 3. Nutrient utilization and growth of *Clarias gariepinus* fed four different commercial feeds.

Parameter	T1	T2	T3	T4
MIW (g)	19.70±3.64	19.59±3.82	20.23±2.68	21.28±2.09
MFW (g)	36.98±1.58	28.69±9.29	48.05±8.68	41.01±7.85
MWG (g)	$17.28±2.06^{c}$	$9.10±1.13^{d}$	$27.82±6.18^{a}$	$19.73±9.94^{a}$
SGR (%)	$1.15±1.05c^{b}$	$0.69±2.64^{c}$	$1.56±0.46^{a}$	$1.18±1.85^{b}$
PER	$0.20±0.89^{b}$	$0.14±4.63^{c}$	$0.24±2.67^{a}$	$0.20±4.36^{b}$
FCR	$0.11±0.03^{b}$	$0.16±0.03^{a}$	0.09±0.05c	$0.10±0.04^{b}$

Means with same superscript were not significantly different (p>0.05). Key: MIW, mean initial weight, MFW, mean final weight, MWG, mean weight gain, SGR, specific growth rate, PER, protein efficiency ratio, FCR, feed conversion ratio.

the effects of different dietary protein and lipid levels and oil sources on the growth performance and body composition of rainbow trout (*Oncorhynchus mykiss*, w.).

In contrary to the above trend, the FCR of T2 was significantly higher (p<0.05) than other treatments and T3 was significantly lower than other treatments. It was very clear in this study that FCR decreased with increased crude protein level. This assertion supported the findings of El-Dahhar et al. (2000) reporting the effect of protein and energy levels in commercial diets on growth performance of juvenile nile tilapia (*Oreochromis niloticus*). In the investigation of the growth parameters of the fish samples in this study, it was very apparent in the values recorded that Coppens (T3) gave the best growth performance and nutrient utilization compared with other treatments. This report also agreed with Jamabo et al. (2013), who also reported Coppens to give the best growth performance among other commercial feeds.

Conclusion

In the study, it was established that Coppens gave the best nutrient utilization and growth performance in *Clarias gariepinus.* By the results, it emerged a need for feed manufacturers to provide information on gross composition of fish feeds. The information provided should be used by farmers to choose the best feed for their fish.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Selectivity studies on beach seine deployed in nearshore waters near Accra, Ghana

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Beach seine is known to be biologically and ecologically destructive. Over the years there have been increased concerns from fishery managers and stakeholders in West Africa and beyond to reduce this destruction of fish resources by the gear. Total bans for periods in the year or the use of a bigger mesh size (25 mm) at the cod end have been investigated. A covered cod end experiment was conducted in the nearshore waters at Tsokome near Accra (Ghana) during June and September 2012 to contribute to find a solution to the management problem posed by the gear. The temporal variability of effort, catch, species composition of the 10 mm and 25 mm cod ends; the gear selectivity; and the revenue of each bag were studied and compared. A total of 60 species belonging to 35 families was recorded. The four dominant taxonomic families were: Penaeidae, Carangidae, Haemulidae and Trichiuridae in order of importance. The selection factors were high and almost the same for the dominant species *Brachydeuterus auritus*, *Chloroscombrus chrysurus* and *Peneaus notialis.* This suggests the need to raise the L_c through adoption of increased mesh size regulation. The use of the 25 mm bag was 25% more financially rewarding than that of 10 mm bag. The 10 mm bag was found to catch species of smaller size. Educational programmes for all relevant stakeholders about the gains of using a bigger mesh size at the cod end and immediate strict enforcement of the relevant provisions of the Fisheries Law 2002, Act 625 of Ghana are among the recommendations to help save fish resources from further degradation.

Key words: Beach seine gear, cod end, fish resource, fisheries management, gear selectivity, Ghana.

INTRODUCTION

Fish in Ghana is the most important non-traditional export commodity (Directorate of Fisheries, 2004). The fisheries sector is estimated to account for about 3% of the agricultural gross domestic product (GDP) and employs about 10% of the nation's economically active population (Amador et al., 2006). Average per capita consumption is 25 kg per annum (Directorate of Fisheries, 2004).

Ghanaian fisheries comprise the artisanal, semi-industrial, and industrial sub-sectors. The artisanal sector is the most important and accounts for 70 to 80% of the national fish production (Amador et al., 2006).

Beach seine is one of the dominant marine artisanal gears used in Ghana and along the coast of West Africa. Nunoo et al. (2006) stated that beach-seine fisheries

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contribute 12% to the total Ghanaian artisanal fisheries production and has quantitatively described fish assemblages associated with the nearshore environment in Sakumono, Ghana. According to Nunoo (2003), beach seining is a common mode of fishing, which is widely practised on the sandy beaches of Ghana and other West African coastal countries. There are 1074 beach-seine units operating from 315 landing beaches along its coastline (Akyempon et al., 2014).

However, beach seining is considered to be destructive and contributes to the reduction of the spawning potential of small pelagic stocks shared by countries bordering the western Gulf of Guinea (Nunoo, 2003; Nunoo et al., 2006). Along the West African coast, fishermen have complained about the scarcity of some fish species, and the reduction in weight and abundance of the catch even though fishing effort is increasing through the use of finer methods and techniques of fishing. Thus beach seining is considered to have a destructive impact (both biologically and ecologically) on fisheries. Because of its mode of operation, a beach seine always surrounds a range of species and sizes that occur together. When encountered by the net during hauling, they are captured. The use of a mesh size of 10 mm increases the potential non-selective character of the gear by catching more juvenile fishes. To show the destructive impact of the beach seine on fisheries, Payet (1997) stated that the beach seine acts as a trawl as it is dragged through the bottom of shallow waters, which causes the capture of some commercially important juvenile fish species; when dragged through the bottom of the water body (fishing ground) the lead line of the net also destroys fish spawning grounds.

A key definition of selective fishing refers to a fishing method's ability to target and capture organisms by size and species during the fishing operation allowing non-targets to be released unharmed (Pope et al., 1975). No gear is known to be one hundred percent selective for a given species or size range of individuals (Pope et al., 1975). Two types of selectivity, namely species selectivity and size selectivity can be distinguished. Species selectivity is the property of a fishing gear to capture a certain species rather than others. A generally important technical measure for fishing gears is the size selectivity which is defined as the probability of fish being retained in a fishing gear as a function of the length of the fish (Misund et al., 2001). Meanwhile, the size selectivity is defined as the property of the gear to retain, for a given species, individuals above a certain size (King, 1995).

Fishing communities where beach seining is practiced are dependent on a fragile natural asset base under stress from over-harvesting of juvenile fish with nets of small mesh sizes. Across West African countries, the mesh size of the bunt of the beach seine nets range between 5 and 25 mm (25 mm is rare) (Yeboah, 2003). This method of fishing is used both in the sea and in inland waters in many parts of the world. It constitutes an important endeavour in such areas as India (Alikunhi, 1957), Africa (Lowe, 1956; Koranteng, 2001; McClanahan and Mangi) and Ceylon (Fernando, 1967).

Beach seine fishers mostly operate in small-scale fisheries often reliant on seasonal and fluctuating fisheries. Small-scale fisheries are highly dynamic, labour intensive and usually well integrated with local marketing arrangements. Small-scale fishers, their families and communities are critically dependent on fish for their food and livelihood security and are extremely vulnerable to external pressures and shocks (Drammeh, 2000). At the present rate of depletion of the fish stock and destruction of the fishing ground in affected West African nations such as Cote d'Ivoire, Togo, and Benin, there is an urgent need to manage the beach seine fisheries sustainably for posterity.

Managing beach seine fisheries in West Africa has become a daunting task because of its artisanal and multispecies nature, its importance to local fishermen, and the lack of integrated strategies and law enforcement. In Ghana, the Fisheries Law, 2002 Act 625 and Fisheries regulations L.I. 1968 (2010) contains provisions that seek to regulate beach seining. These laws tackle concerns such as: prohibition of fishing in specified zones, closed season for fishing, manufacture, importation or sale of fishing nets, prohibition of use of seine nets in inland waters, prohibition of seine nets the mesh size of which is less than 25 mm in stretched diagonal length in coastal waters, use of seine nets for tuna fishing, and penalties. A number of these provisions remain unmonitored and unenforced. The little active semblance of any management of beach seining in Ghana is done traditionally by local communities and the few active community-based fisheries management committees (CBFMC) in the coastal areas.

Considering the precautionary principle as enshrined in the Food and Agriculture Organization (FAO) of the United Nation (UN) Code of Conduct for Responsible Fisheries (FAO 1995), and the objectives of the United Nations Convention on Biodiversity (United Nations,1994), many West African nations have seriously considered some management strategies. These strategies are: seasonal closure, mesh-size restrictions, and use of square-mesh nets and outright banning of beach seining (Nunoo et al., 2006). The FAO under its Nansen Project is spearheading the search in West Africa under the Ecosystem based Approach to Fisheries (EAF) management for sustainable fishing using the beach seine gear.

The aim of this study is to provide science-based information that will contribute to sustainable management of the beach seine fishery in the nearshore environment of West African nations. The specific objectives are to: (1) determine temporal variability of effort, catch and species composition of 10 mm and 25 mm bags in both the lean and fishing seasons of the year in Ghana; (2) establish the species and length selectivity for abundant species using the covered cod end

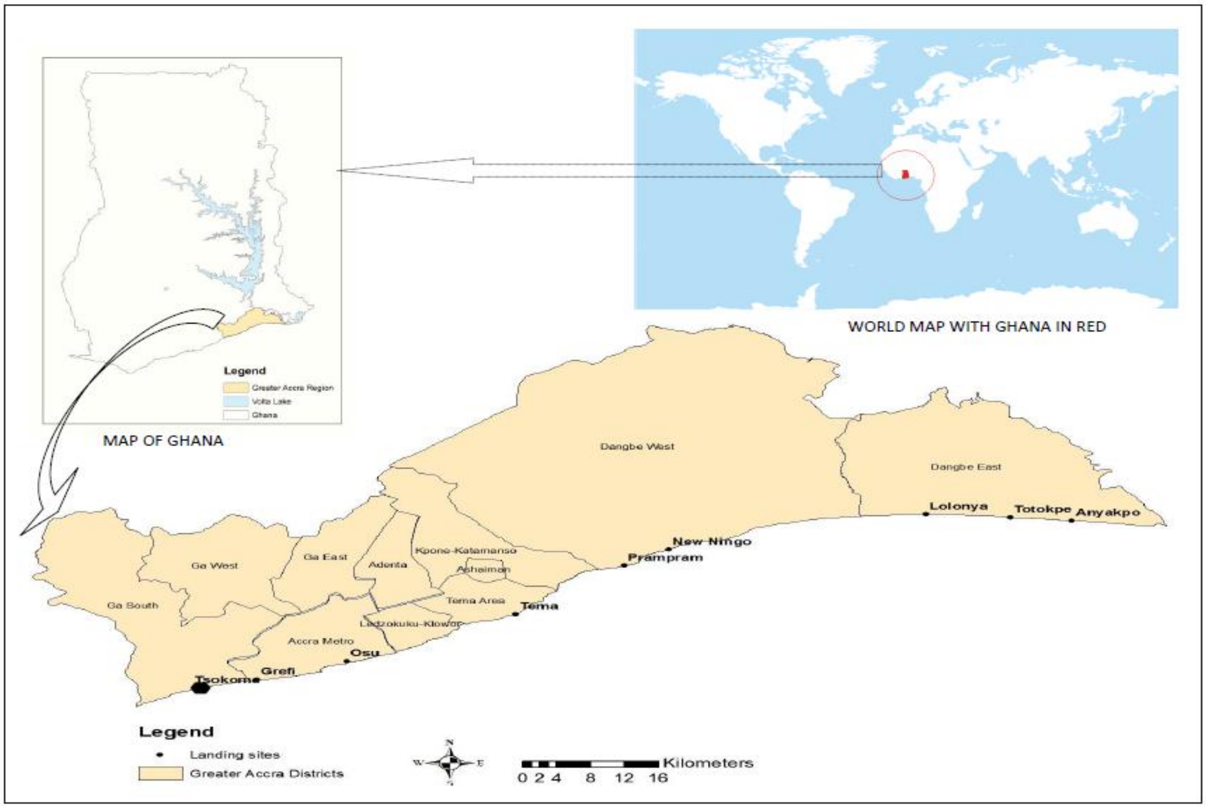

Figure 1. Location of the Tsokome fish landing beach.

experiment; and (3) establish revenue from catches of the two bags of different mesh sizes.

METHODS

The study site was Tsokome fish landing beach (GPS location: 05° 30' N, 00° 19' W) which is situated near Botianor, west of Accra township and off the main Accra-Winneba road in Greater-Accra, one of the coastal regions of Ghana in West Africa) (Figure 1). The beach is sandy with a gentle slope and is used for both fishing activities and leisure. The fish landing beach is also used as a tourist site operated by the Bojo Beach Resort. Tsokome is located adjacent to the Sakumono I wetlands and is itself an estuarine area. The Densu River enters the sea at Tsokome, near the fish landing beach.

The near shore fish community was sampled weekly between June and September. While June and July period falls within the lean beach seine fishing season because of attendant high energy wave action at beaches, and August to September was considered to fall within the peak fishing season in Ghana.

The beach seine gear used for this study was specifically designed for the purpose. It comprised a main net, wings and two bags. Each of these three parts of the net had different mesh dimensions. The net used is described as follows: the length of the net itself is 532.5 m, the length of the towing rope length is 400 m, hence, 932.5 m as a total length. The net was used in a covered cod end experiment. The covered cod end experiment involves fitting the cod end of a beach seine with a cover made of smaller mesh netting. The cod end in this experiment measures 12 m length and 3 m width, with a mesh size of 25 mm, while the cover has a mesh size of 10 mm and measured 17 m length and 3.7 m width. The net was designed in such a way that whenever fish escapes from the bigger meshed cod end the fish will at least be retained by the cover net (Plate 1).

Sampling on the field consisted of taking fish samples from the cod end and the covered end (cover net) after marine litter was removed and the catch washed with seawater. Fish samples were taken (with bucket weighing 0.620 kg) proportionally to the total catch, at least 10% by weight of catch. Bulk weight was taken on the field and also the identity, weight and length of bigger fish were recorded as part of total catch. During fishing, the number of fishers was recorded as fishing effort. They were counted at the beginning and at the end of the hauling, and the average taken. Fishing effort was also recorded in terms of time spent fishing from the laying of the net till its total haulage of catch to land.

As the total catch from the individual hauls were large, sub-samples were taken and sorted by species or species group, individuals were counted and weighed. The identification was done using fish taxonomic identification guides (Fischer et al., 1984; Schneider, 1990). The total length and weight of individual specimens of the dominant species (*Brachydeuterus auritus* Bigeye grunt*; Chloroscombrus chrysurus,* Atlantic bumper*; Penaeus notialis,* Southern pink shrimp *and Selene dorsalis;* African lookdown) were taken, when possible, at least up to 200 individuals. Dominant species was defined as species that contributed to at least 5% of the total catch by weight.

Fluctuations in the assemblage were analyzed in terms of abundance, biomass and diversity (Lasiak, 1984). Percent numerical abundance and biomass were determined for each bag (Figures 2 and 3). All sampled data were raised to total catch by

Plate 1. Fish catch in the two bags.

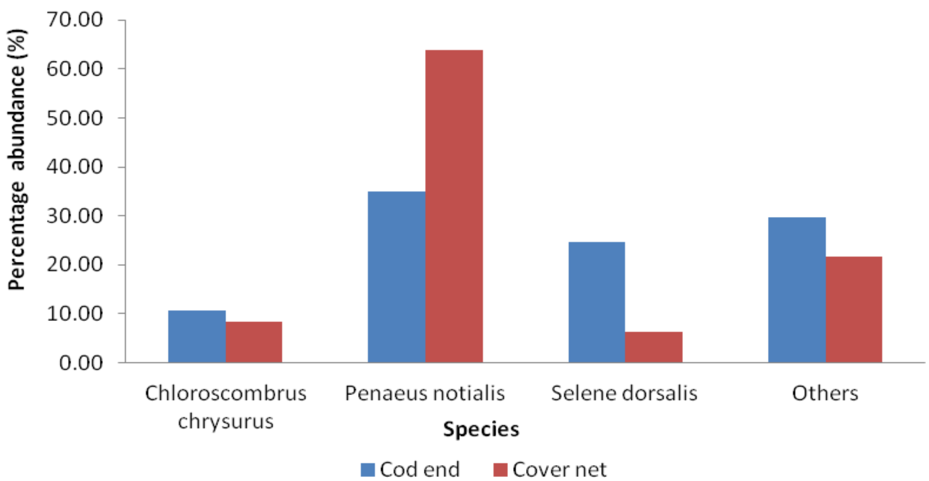

Figure 2. Percentage abundance of dominant species caught in the codend and cover net.

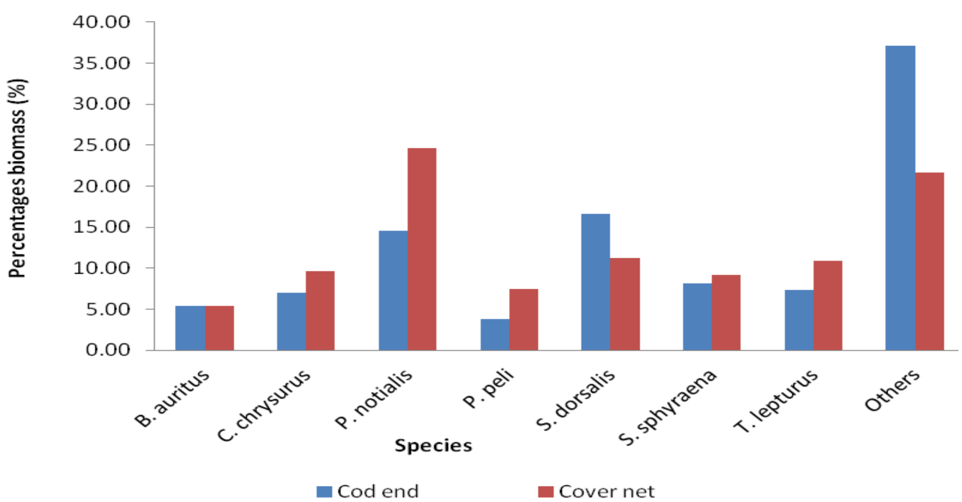

Figure 3. Percentage biomass of dominant species caught by the cod end and cover net.

Table 1. Size ranges of dominant species according to the mesh size.

Evaluation parameters		*Brachydeuterus auritus*	*Chloroscombrus chrysurus*	*Selene dorsalis*	*Penaeus notialis*
Cod end	Range (cm)	6.5 - 12.4	4.5 - 20	4 - 13.2	3 - 16.7
	Mean (cm)	8.55	8.15	6.66	8.37
	± Standard error	0.04	0.08	0.06	0.05
Covered cod end	Range (cm)	3.9 - 12.4	1.3 - 12.8	4.2 - 12.5	2.4 - 12.8
	Mean (cm)	7.68	6.17	6.4	8.71
	± Standard error	0.05	0.06	0.06	0.06

multiplying them by the appropriate raising factor (total number of bowls in a catch).

The catch per unit effort (CPUE), the length frequency, the weight and length relationship and the gear selectivity were determined to comparatively assess community characteristics in order to determine if the cod end and the cover were sampling similar fish assemblage. Catch per unit effort (CPUE) was estimated using time and number of men. When time is used, the total weight of the catch (kg) was divided by time interval *t* (minutes) between deployment and retrieval of the gear. And when using the number of men, the total weight of the catch (kg) is divided by the total number of men involved in the fishing activity. CPUE (kg/min and kg/man) were plotted against weeks to determine the trends. Fishing effort (minutes and number of men) were also plotted against weight of total catch to determine which one gave the best correlation.

Weekly length data for each of the measured species were compiled and placed in size classes of one cm range. Histograms were then plotted (frequency against length) to determine size distribution. The same length and weight data were also used to assess the growth of the species. Log_{10} (weight) was plotted against Log_{10} (length) to establish weekly weight and length relationships.

Species diversity was calculated using the Shannon-Wiener function as modified by Pielou (1966). Species richness and equitability were estimated according to Margalef (1958) and Pielou (1969) respectively. Shannon-Wiener's Diversity Index is given as, $H' = (n\log_{10}n - f_i \log_{10} f_i) / n$. Species richness (Margalef) given as, $d = (S-1) / \log_{10} n$ and represents the measure of the number of species present for a given number of individuals (Clark and Warwick, 1994). Finally Pielou's expression of evenness, homogeneity or relative density is given as, $J' = H' / H'_{max}$. It expresses how evenly the individuals are distributed among the different species (Clark and Warwick, 1994). N is a measure of the number of species present for a given number of individuals; n, the number of individuals represented in a species; S, the total number of species; H_{max}, the maximum possible diversity which would be achieved if all species were equally abundant and is given as $H'_{max} = \log_{10} S$ and f_i the number of observations in category "i". PRIMER (Plymouth Routines in Multivariate Ecological Research) 2000, version 6.2 software was used to calculate the diversity indices. The species occurrence percent similarity using Bray-Curtis similarity test was performed to see how similar the samples of the different bags were. PRIMER was also used for the purpose.

An ANOVA (Analysis Of Variance) single factor was also performed to see if the difference among the lengths of the species in the two bags was significant. Significance was taken at 95% confidence level ($P<0.05$). The Lc (mean length at first capture) and SF (Selection factor), were calculated for four of the dominant species. To achieve these objectives ln [(1-P)/P] was plotted against total length in centimetres for each of the measured species (P representing the fishes in cod end as fraction of the total). Lc = a / r (where 'a' is the intercept and 'r = -b' is the slope) and SF = Lc / mesh size. SF is the constant of proportionality. They were used to assess the gear selectivity.

RESULTS

Comparison of the species composition and diversity in the two bags

Species composition of catch included groups such as bony fishes, crustaceans, gastropods, cephalopods and elasmobranches. Tables 2 and 3 show the average species composition in abundance and in biomass of the catch after fifteen weeks of study. A total of 67 species belonging to 35 taxonomic families were recorded for both bags throughout the study period. The cod end had 59 species belonging to 32 families and the cover net had 48 species belonging to 25 families. The major families and dominant species were not really identical in the two bags. In common the four major families were the Penaeidae, Carangidae, Haemulidae and Trichiuridae; while the five dominant species were *P. notialis, C. chrysurus, B. auritus, S. dorsalis* and *Trichiurus lepturus* (Largehead hairtail).

The dominant species varied in terms of abundance and biomass, according to the mesh size of the bag and the season. But in both nets the dominant species in terms of numbers and in decreasing order were three: *P. notialis, C. chrysurus, S. dorsalis*, Meanwhile in terms of catch and and in decreasing order they were seven: *P. notialis, T. lepturus, C. chrysurus, , B. auritus, S. dorsalis* and *Sphyraena sphyraena* (Barracuda).

The taxonomic and ecological details of species encountered during the study period showed that among the species encountered; about 50% were residents of the coastal waters and the adjacent estuary, about 28% could be found either in coastal waters or offshore, and about 22% were mainly offshore species. *Lobotes surinamensis* (Atlantic tripletail), a very rare offshore species was also recorded in the catch.

A weekly length frequency was computed for the dominant species using the catch of the two bags (Figure 4). Species caught in the cod end are generally bigger than those caught in the covered cod end (Table 1). Significant difference was found between the lengths of

Table 2. Average species composition of catch in numbers.

Taxonomic name	Taxonomic family	Cover end	%	Covered end	%
Ablennes hians	Belonidae	11	0.01	0	0
Alectis alexandrinus	Carandidae	180	0.14	91	0.03
Batrachoides liberiensis	Batrachoididae	0	0	5	0.00
Bothus podas africanus	Bothidae	5	0.00	0	0
Brachydeuterus auritus	Haemulidae	5151	3.89	7471	2.28
Callinectes amnicola	Portunidae	991	0.75	371	0.11
Caranx hippos	Carangidae	264	0.20	277	0.08
Caranx rhonchus	Carangidae	6	0.00	0	0
Chaetodon robustus	Chaetodontidae	1	0.00	12	0.00
Chloroscombrus chrysurus	Carangidae	14200	10.73	27233	8.33
Chloroscombrus rhoncus		0	0	8	0.00
Cynoglossus canariensis	Cynoglossidae	40	0.03	119	0.04
Cynoglossus monodi	Cynoglossidae	105	0.08	121	0.04
Cynoglossus senegalensis	Cynoglossidae	6	0.00	140	0.04
Daysatis margarita	Dasyatididae	12	0.01	0	0
Decapterus punctatus	Carangidae	63	0.05	40	0.01
Decapterus volitans		0	0	6	0.00
Dentex angolensis		1	0.00	0	0
Dentex canariensis		4	0.00	0	0
Drepane africana	Drepanidae	892	0.67	334	0.10
Engraulis encrasicolus	Engraulididae	16	0.01	18	0.01
Ephippion guttifer	Tetradontidae	9	0.01	18	0.01
Epinephelus aeneus	Serranidae	0	0	9	0.00
Ethmalosa fimbriata	Clupeidae	7171	5.42	3599	1.10
Eucinostomus melanopterus	Gerreidae	13	0.01	21	0.01
Exhippolysmata hastatoides	Hippolytidae	10	0.01	0	0
Galeiodes decadactylus	Polynemidae	2955	2.23	1953	0.60
Gerres melanopterus	Gerreidae	31	0.02	0	0
Hemiramphus brasiliensis	Hemiramphidae	210	0.16	117	0.04
Ilisha africana	Clupeidae	4490	3.39	10198	3.12
Lagocephalus laevigatus	Tetraodontidae	53	0.04	2015	0.62
Lagocephalus lagocephalus		26	0.02	0	0
Lobotes surinamensis		5	0.00	0	0
Mugil cephalus	Mugilidae	70	0.05	51	0.02
Panulirus regius	Palinuridae	23	0.02	0	0
Penaeus notialis	Penaeidae	46158	34.89	208728	63.82
Pentanemus quinquarius	Polynemidae	36	0.03	817	0.25
Pomadasys jubelini	Heamulidae	18	0.01	0	0
Polydactylus quadrifilis		16	0.01	25	0.01
Portunidae		20	0.02	32	0.01
Priacanthus arenatus		26	0.02	8	0.00
Pseudotholithus brachygnathus	Sciaenidae	106	0.08	616	0.19
Pseudotholithus senegalensis	Sciaenidae	311	0.24	1903	0.58
Pseudotholithus typus	Sciaenidae	1304	0.99	3684	1.13
Pteroscion peli	Sciaenidae	3540	2.68	10752	3.29
Raja miraletus	Rajidae	11	0.01	0	0
Remora nocrates	Echeneididae	0	0	16	0.00
Rhinobatos rhinobatos		0	0	1	0.00
Sardinella aurita	Clupeidae	25	0.02	161	0.05
Sardinella maderensis	Clupeidae	3431	2.59	2793	0.85
Scomberomorus tritor	Scombridae	387	0.29	42	0.01

Table 2. Contd.

Scorpaena scrofa	Scorpaenidae	11	0.01	0	0
Selene dorsalis	Carangidae	32648	24.68	20473	6.26
Sepia officinalis hierredda	Sepiidae	363	0.27	1990	0.61
Sepiella ornata	Sepiidae	28	0.02	863	0.26
Sphyraena sphyraena	Sphyraenidae	2547	1.92	6718	2.05
Squatina oculata	Squatinidae	1	0.00	0	0
Stromateus fiatola	Stromatidae	48	0.04	120	0.04
Torpedo torpedo		1	0.00	0	0
Trachinocephalus myops		0	0	6	0.00
Trachinotus goreensis	Carangidae	5	0.00	0	0
Trachinotus teraia	Carangidae	5	0.00	0	0
Trachinotus ovatus	Carangidae	472	0.36	428	0.13
Trichiurus lepturus	Trichiuridae	3752	2.84	12505	3.82
Umbrina canariensis	Sciaenidae	19	0.01	136	0.04
Species X		13	0.01	7	0.00
Species Z		0	0.00	15	0.00
Gastropod		1	0.00	0	0

the dominant species of the two bags (ANOVA, p = 1.4 E-274, df =7).

The hierarchical grouping of species by group-average clustering is presented in the form of dendograms (similarity measure according to Bray Curtis). For the cod end (25 mm mesh size bag), four different groups of similarity are observed; weeks 8 and 9 are the most similar at 80.48% followed by weeks 12 and 14. The first four weeks are similar to each other at 63.45% and also similar to the rest at 57.81%. Within the covered cod end (10 mm mesh size bag), the four groups of weeks were observed similar at 56.92% level to each other. The most similar weeks were weeks 12 and 13 (at 82.95%) followed by 6 and week 7 (at 79.76%). The similarity among the first four weeks is still confirmed, where weeks 2, 3 and 4 are similar at 69.65%, as in the covered cod end the two most similar weeks are week 6 and 7 (at 73.76 %). The catch in the cod end and the covered cod end are similar at 78.61% (Figure 5).

Diversity indices were assessed for Shannon-Wiener's species diversity (H'), Pielou's expression of evenness (J') and Margalef's species richness (d). Fluctuations in diversity indices were observed to occur in both bags over the study period. However, these fluctuations were observed to be relatively higher in the cod end than in the covered end (d: 3.53 against 3.03, J':0.53 against 0.44, and H' (log10): 1.87 against 1.51). The diversity indices were generally lower in the covered end than in the cod end (Figure 6).

Weight and length relationships

Weekly weight and length relationships were computed for the dominant species. Some of them are the following (Figure 7). In general, the four species were found to have an allometric growth (82% of the equation) over the period of the study. This was found to be same for the two bags.

Species and length selectivity for abundant species

From the covered cod end experiment using criteria outlined in King (1995), the following selectivity plots (Figure 8) were observed for the four dominant species measured.

The Lc, shown in Figure 8, stands for the mean at first capture. The higher the selection factor is for a species, the higher the gear's ability to capture the particular species. This implies that that the 25 mm mesh size selects *C. Chrysurus* and *P. notialis* the most and *S. dorsalis* the least. All the selection factors (Figure 8) were high.

For *S. dorsalis*: Lc = 7.377 cm while SF = 0.295
For *C. chrysurus*: Lc = 9.626cm while SF = 0.385
For *B. auritus*: Lc = 7.592 while SF = 0.304
For *P. notialis*: Lc = 9.590 cm while SF = 0.384

Comparison of catch per unit effort

It was observed that the CPUE whether in kg/min or kg/man, did not correlate well with the time (in weeks) in the covered cod end than in the cod end. The CPUE reduces slightly as time wore on into the lean season. Whenever the catch is related with the effort, it was higher in the covered end, R^2 = 0.1221 against 0.0047 for the cod end (Figure 9a and b) in terms of minutes but almost the same for the covered cod end and the cod

Table 3. Average species composition of catch by weight.

Taxonomic name	Taxonomic family	Cover end	%	Covered end	%
Ablennes hians	Belonidae	1,346.00	0.13	0	0
Alectis alexandrinus	Carandidae	3,110.90	0.29	306.8	0.04
Batrachoides liberiensis	Batrachoididae	0.00	0.00	12.5	0.00
Bothus podas africanus	Bothidae	57.50	0.01	0	0
Brachydeuterus auritus	Haemulidae	58,485.90	**5.43**	46218.7	**5.44**
Callinectes amnicola	Portunidae	26,205.00	2.44	2649.9	0.31
Caranx hippos	Carangidae	2,861.40	0.27	1042.6	0.12
Caranx rhonchus	Carangidae	33.00	0.00	10.4	0.00
Chaetodon robustus	Chaetodontidae	42.40	0.00	4212	0.50
Chloroscombrus chrysurus	Carangidae	74,765.00	**6.95**	81807.6	**9.62**
Cynoglossus canariensis	Cynoglossidae	6,032.60	0.56	4071.2	0.48
Cynoglossus monodi	Cynoglossidae	4,301.50	0.40	991.8	0.12
Cynoglossus senegalensis	Cynoglossidae	138.50	0.01	776.8	0.09
Daysatis margarita	Dasyatididae	5,316.00	0.49	0	0
Decapterus punctatus	Carangidae	1,591.30	0.15	1030.5	0.12
Decapterus volitans		0.00	0.00	10.2	0.00
Dentex angolensis		150.00	0.01	0	0
Dentex canariensis		58.00	0.01	0	0
Drepane africana	Drepanidae	12,804.70	1.19	763.1	0.09
Engraulis encrasicolus	Engraulididae	107.20	0.01	8.1	0.00
Ephippion guttifer	Tetradontidae	116.10	0.01	235.7	0.03
Epinephelus aeneus	Serranidae	0.00	0.00	135.5	0.02
Ethmalosa fimbriata	Clupeidae	35,827.60	3.33	19368	2.28
Eucinostomus melanopterus	Gerreidae	101.40	0.01	116.3	0.01
Exhippolysmata hastatoides	Hippolytidae	50.00	0.00	0	0
Galeiodes decadactylus	Polynemidae	42,949.00	3.99	12598.3	1.48
Gerres malanopterus	Gerreidae	694.20	0.06	0	0
Hemiramphus brasiliensis	Hemiramphidae	4,000.00	0.37	2399.5	0.28
Ilisha africana	Clupeidae	53,166.70	4.94	26989.8	3.17
Lagocephalus laevigatus	Tetraodontidae	2,285.20	0.21	10260.9	1.21
Lagocaphalus lagocephalus		0.00	0.00	1632	0.19
Lobotes surinamensis		6,000.00	0.56	0	0
Mugil cephalus	Mugilidae	3,281.60	0.30	405	0.05
Panulirus regius	Palinuridae	2,560.00	0.24	0	0.00
Penaeus notialis	Penaeidae	156,571.00	**14.55**	209450	**24.63**
Pentanemus quinquarius	Polynemidae	338.50	0.03	2285.4	0.27
Pomadasys jubelini	Heamulidae	2,057.50	0.19		
Polydactylus quadrifilis		884.80	0.08	1101.7	0.13
Portunidae		230.10	0.02	37.6	0.00
Priacanthus arenatus		722.80	0.07	262.4	0.03
Pseudotholithus brachygnathus	Sciaenidae	3,632.00	0.34	3939.2	0.46
Pseudotholithus senegalensis	Sciaenidae	12,842.00	1.19	9661.7	1.14
Pseudotholithus typus	Sciaenidae	33,334.70	3.10	36634.7	4.31
Pteroscion peli	Sciaenidae	40,504.50	**3.76**	62983	**7.41**
Raja miraletus	Rajidae	2,120.00	0.20	0	0
Remora nocrates	Echeneididae	0.00	0.00	43.2	0.01
Rhinobatos rhinobatos		0.00	0.00	368	0.04
Sardinella aurita	Clupeidae	350.00	0.03	1400	0.16
Sardinella maderensis	Clupeidae	47,377.30	4.40	20889.8	2.46
Scomberomorus tritor	Scombridae	22,732.30	2.11	359.2	0.04
Scorpaena scrofa	Scorpaenidae	1,140.00	0.11	0	0

Table 3. Contd.

Selene dorsalis	Carangidae	178,270.30	**16.57**	95120.9	**11.19**
Sepia officinalis hierredda	Sepiidae	41,668.00	3.87	6131	0.72
Sepiella ornata	Sepiidae	232.90	0.02	1668.8	0.20
Sphyraena sphyraena	Sphyraenidae	88,126.50	**8.19**	77885.7	**9.16**
Squatina oculata	Squatinidae	400.00	0.04	0	0
Stromateus fiatola	Stromatidae	7,079.50	0.66	864.8	0.10
Torpedo torpedo		120.00	0.01	0	0
Trachinocephalus myops		0.00	0.00	60	0.01
Trachinotus goreensis	Carangidae	326.50	0.03	0	0
Trachinotus teraia	Carangidae	1,435.50	0.13	0	0
Trachinotus ovatus	Carangidae	5,546.60	0.52	3023.2	0.36
Trichiurus lepturus	Trichiuridae	79,343.70	**7.37**	92518.7	**10.88**
Umbrina canariensis	Sciaenidae	315.50	0.03	368.8	0.04
Species X		544.70	0.05	0	0
Species Z		0.00	0.00	135.1	0.02
Gastropod		350.00	0.03	135.3	0.02
Total		1,076,113.90	100.00	850268.9	100.00

end in terms of number of men, R^2 = 0.0016 and 0.0086 (Figure 9c and d).

DISCUSSION

The number of sixty-seven species recorded for both bags throughout the study period does not differ from earlier studies such as Lasiak (1984) and Nunoo et al. (2007). There were differences in the species composition of the cod end bag and covered cod end. Even though common major taxonomic families were found (Penaeidae, Carangidae, Haemulidae and Trichiuridae); the abundance, the catch and the species were not the same. Lasiak (1984) study in South Africa revealed a complement of 59 species. In Ghana, Sakumono has the highest species richness with 63 species in number) followed by Cape St. Paul and Adina beaches which both showed a total of 39 species. Kateck near Saltpond followed with an observation of 37 species and Lolonya showed the least species richness with 35 species (Nunoo et al., 2007). As Lasiak (1984) pointed out, the contrary findings on the species complement of surf-exposed beaches reflects differences in sampling technique, length and mesh size of gears used. Another reason to explain the differences is that the shore-zone fish assemblage is a constantly changing population (Warlef and Merriman, 1944).

It was observed that few species numerically dominated the community. In the cod end as well as in the covered cod end, in terms of abundance, three species (*P. notialis, C. chrysurus*, *S. dorsalis*) in order of decreasing contribution took up 70.3 and 78.49% of the catch respectively. Warlef and Merriman (1944), Lasiak (1984), Clark et al. (1994), Nunoo (2003), Asem-Hiable (2004) also observed the same trend. In contrast to expectations, Aggey-Fynn et al. (2012) observed that *P. notialis* was in low relative abundance in the central coast of Ghana. This also confirmed his observation that most of the fish species and shrimps obtained had been reported to occur in the eastern coast of Ghana (Nunoo et al., 2007), western Gulf of Guinea (Mehl et al., 2004, 2005) and the entire Gulf of Guinea (Schneider, 1990).

However, on the basis of the catch most dominant species were not the same for both bags as in terms of abundance. In the cod end, in terms of biomass six species (*S. dorsalis, P. notialis, S. sphryraena, T. lepturus, C. chrysurus,* and *B. auritus* and *Pteroscion peli,*) made up in order of decreasing contribution 62.82% of the catch while in the covered cod end, seven species (*P. notialis, S. dorsalis T. lepturus, C. chrysurus, S. sphryraena, P. peli* and *B. auritus*) in order of decreasing contribution accounted for 59.06% of the catch. This alludes to the fact that though one species might be numerous in numbers, they were relatively small in size (Asem-Hiable, 2004). The significant difference in the catch composition of the covered cod end and cod end bags (22.39%) is most likely as a result of the differences in mesh size as expected.

The estimations of fish species diversity and equitability were relatively lower than the findings of Aggrey-Fynn et al. (2012) and Blay (1997) (H' = 2.83; J' = 0.77) during the three years study in the central coast of Ghana. This is probably due to the two different cod ends used in this study and the duration of sampling which were not the same.

The weekly length frequencies obtained showed that the 10 mm mesh size bag caught fish of smaller size than the 25 mm mesh size bag. This was also observed in several studies done in Ghana on beach seines using the

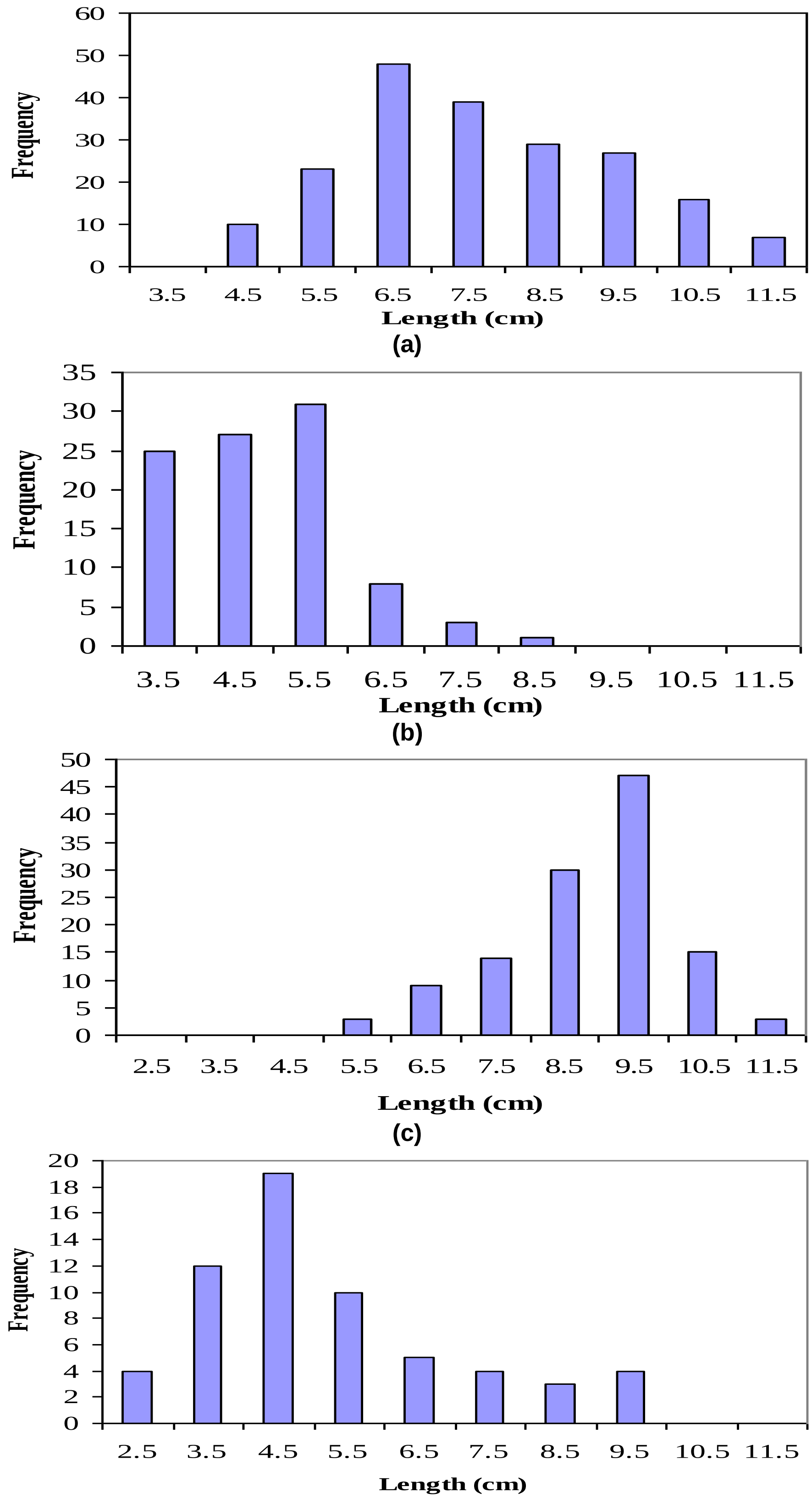

Figure 4. Length frequency of (a) *Penaeus notialis* in the cod end (Week 2) (b) *Penaeus notialis* in the cover end (Week 2) (c) *Chloroscombrus chrysurus* in the cod end (Week 2) and (d) *Chloroscombrus chrysurus* in the cover end (Week 2).

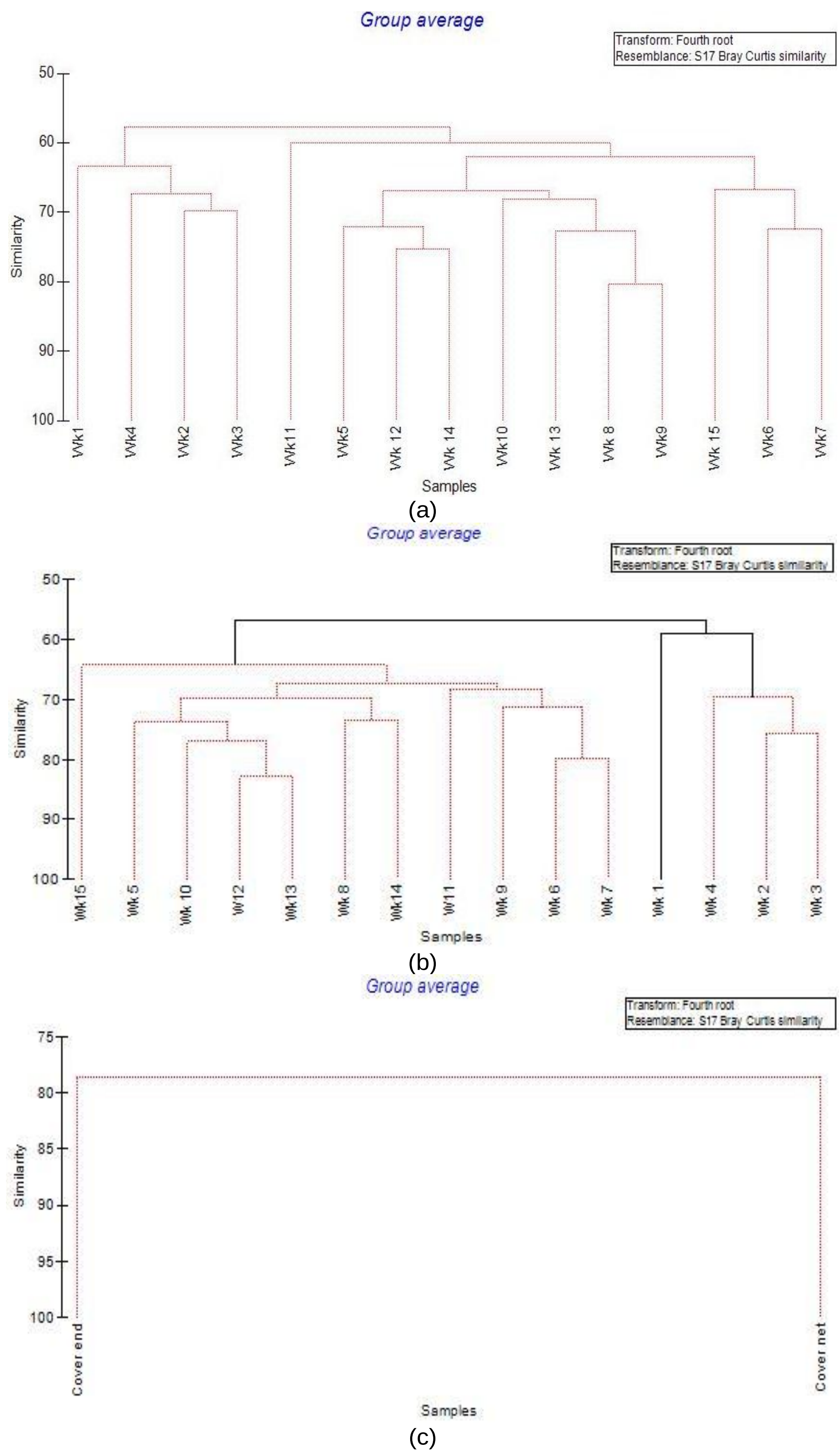

Figure 5. Dendrogram resulting from group-average clustering of species caught in the (a) cod end (b) cover end (c) cover end and the cod end.

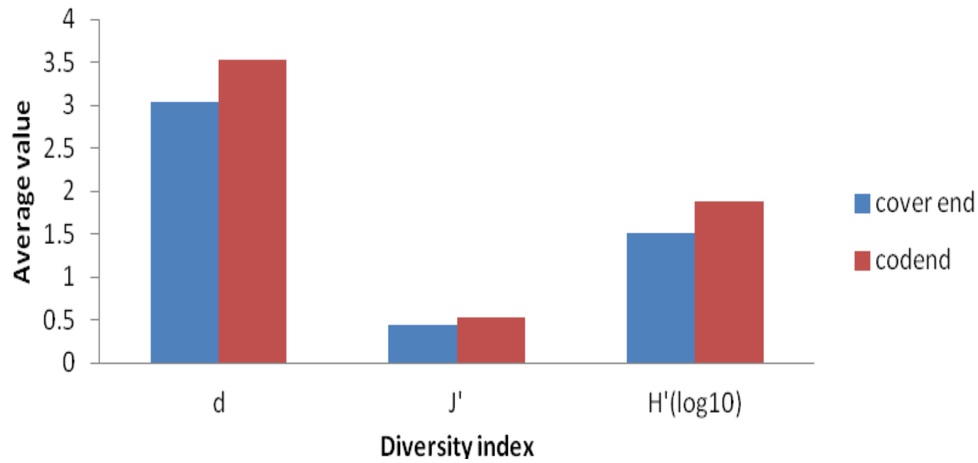

Figure 6. Comparing diversity indices of species caught in cover end and cod end.

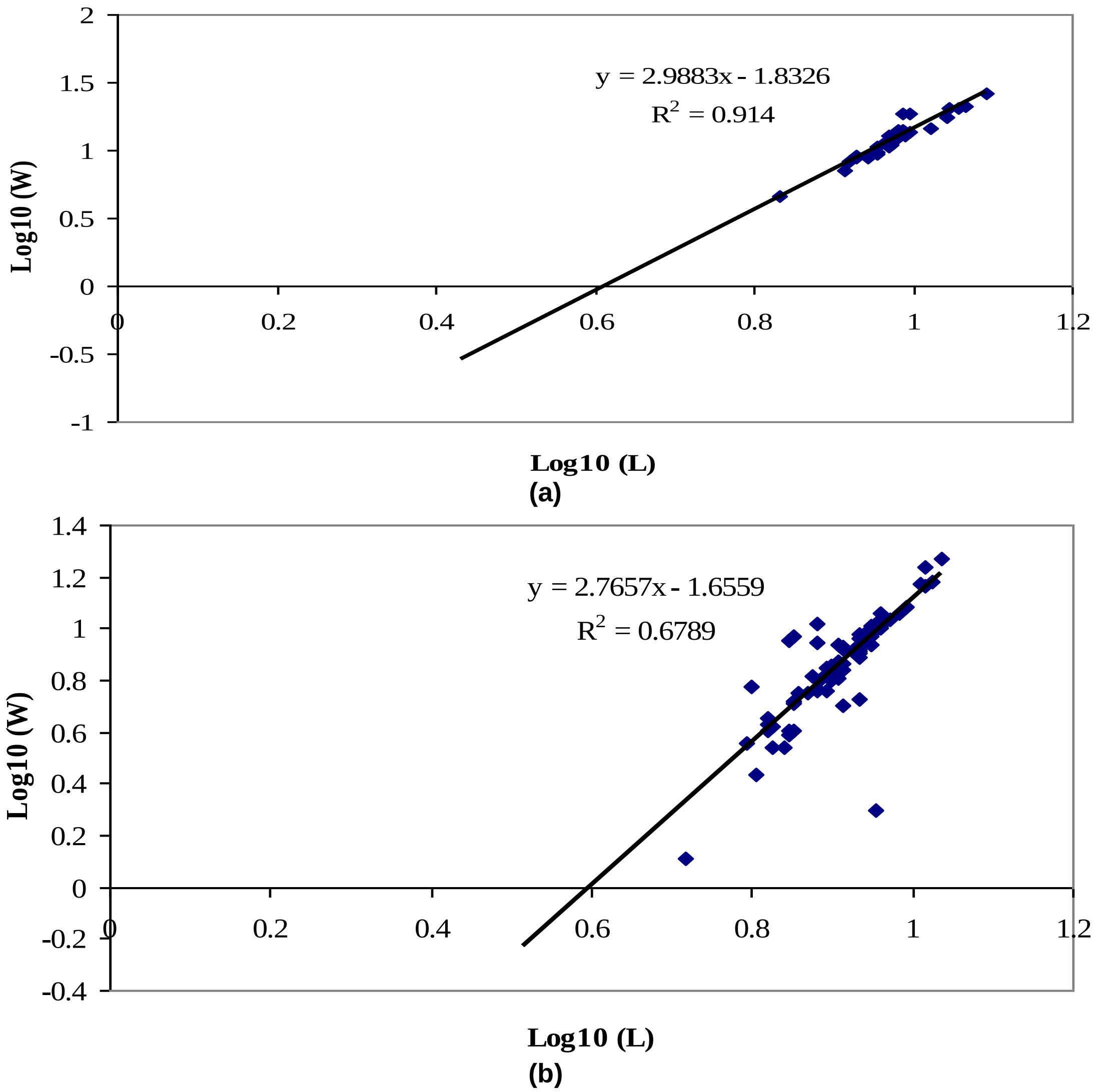

Figure 7. Weight and length relationship of *Brachydeuterus auritus* in a) codend (Week 3) and b) cover end (Week 3).

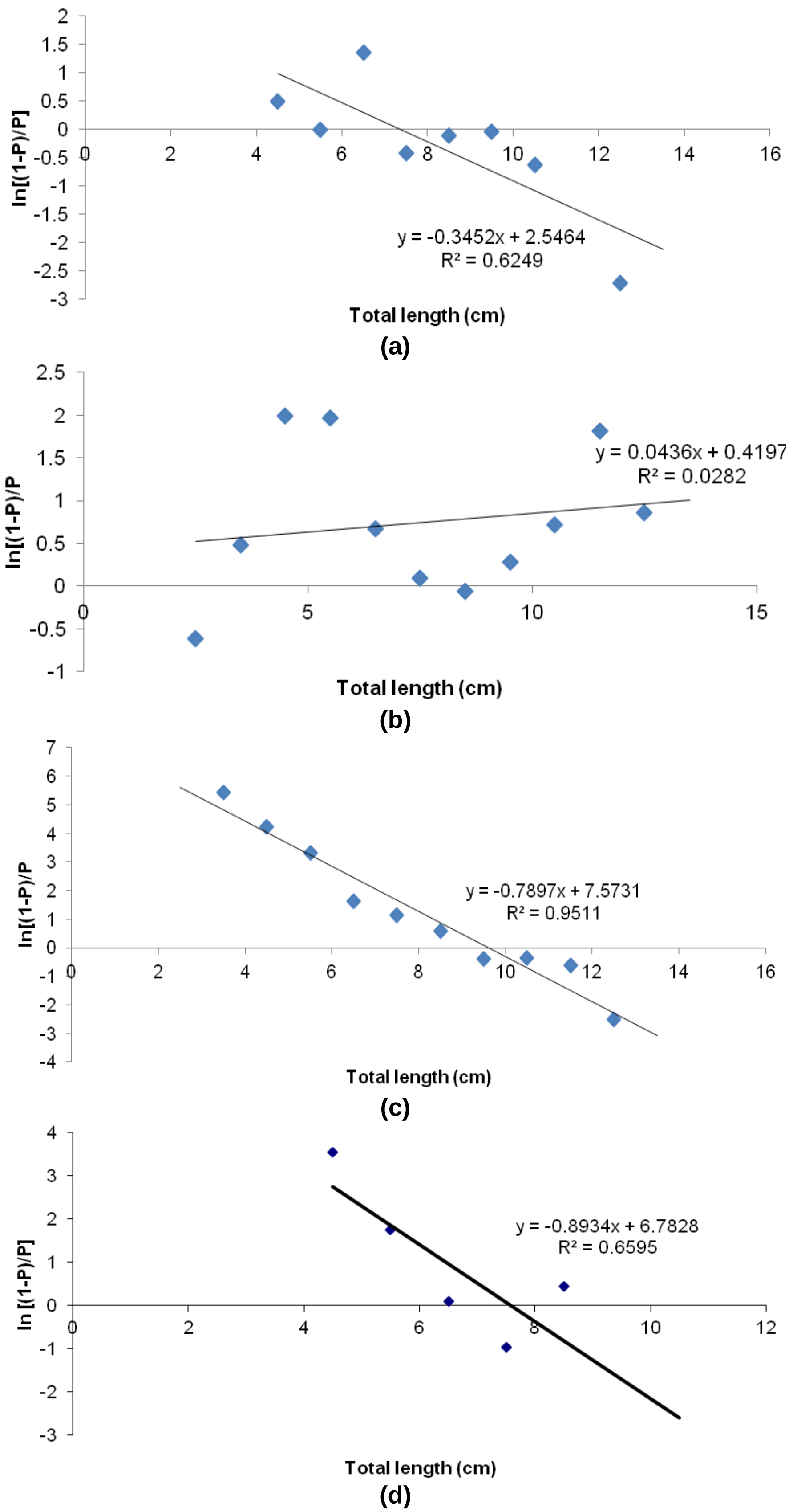

Figure 8. Selectivity plot (ln [(1-P)/P] against total length) for (a) *Selene dorsalis* (b) *Chloroscombrus chrysurus* (c) *Penaeus notialis (d) Brachydeuterus auritus.*

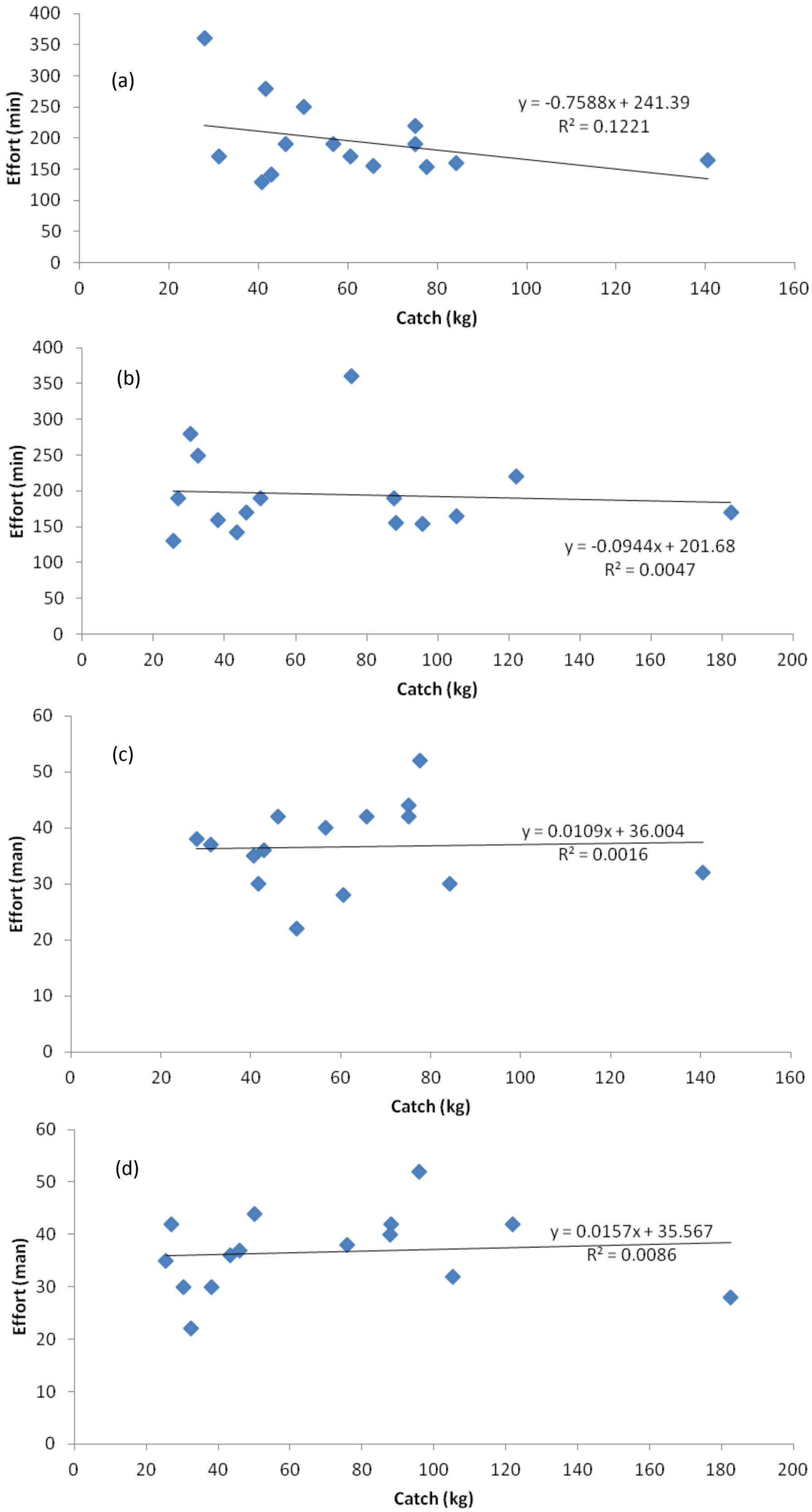

Figure 9. Catch per unit (a) effort (min) in the covered cod end (b) effort (min) in the cod end (c) effort (man) in the covered end (d) effort (man) in the cod end.

10 mm as mesh. (Nunoo et al., 2007) observed a case of recruitment overfishing as high percentages of juvenile fish (ranging between 70 and 90%) recorded in catches from all sites. The significant difference between the species lengths observed through the ANOVA test means that the size of the mesh size affects the size and range of species caught. The allometric growth observed in both bags could be one of the consequences of the negative effect of beach seine gear on the nearshore fishes.

Fager (1963) pointed out that, the number of species, number of individuals and biomass, considered as separate entities, do not account for the structure of communities. Diversity is an integrated parameter which has been used widely to assist in the interpretation of temporal patterns in fish assemblages (Hillman et al., 1977). Using diversity indices to compare catches of both bags, it was observed that they were higher in the cod end than in the covered end (d: 3.53 against 3.03, J':0.53 against 0.44, and H' (log_{10}): 1.87 against 1.51). Since the beach seine was only one, the difference in mesh size of the two bags might be the explanation. The 25 mm can then be said to be ecologically safer for exploitation of nearshore organisms than the 10 mm. Recording species such as *L. surinamensis* and other offshore and estuarine species, the richness and importance of the nearshore environment was noticed. The CPUE getting lower as one gets deeper in the lean season was a surprise. It might due to physical and oceanographic factors in the environment or a result of depletion. Since the area of study is closer to an estuarine environment, water quality factors might offer more explanation to the observed decreasing trend in catch rates. Pierce et al. (1990) stated that capture efficiency of a beach seine gears vary greatly depending on aspects of the littoral zone habitat and fish community.

The total catch (in weight) which did not correlate with effort recorded in minutes as well as in men was contrary to expectations as observed by Asem-Hiablie (2004). In her study on beach seine gear at Woe on the eastern coast of Ghana, the total catch correlated highly with fishing effort recorded in both minutes spent and number of men pulling the net.

The high gear selectivity record shows that the gear might contribute to the depletion of *P. notialis*, *C. chrysurus* and *B. auritus* (75% of the measured species) in the nearshore waters. The L_c indicated that the sizes of the species are reducing due to the use of the 10 mm. For instance the theoretical length at maturity is about 19 cm, far below 23 to 30 cm length at maturity stated in Edwards et al. (2001), however, only 12.4 cm was recorded as the highest length at maturity. Sunoglu (2001) concluded that selection is nearly non-existent for trawls or beach seine and this is because the gear catches almost everything on its path. Not only commercial-sized fish but also all the young fish will be retained in such cod-ends. Consequently, these results support the prohibition of beach seine nets as a management measure. However cod-end diameter, twine material and mesh shape, as well as mesh size, have highly significant effects on the proportion of fish retained, demonstrating their importance in determining the selectivity of a cod-end (Sunoglu, 2001). The similarity among the weeks was contrary to the fact that there is a lean or peak fishing season. These two seasons did not show much difference, suggesting that environmental factors at the location might have affected the catches or a suggestion of impact of observed global climate change in causing shifts in fishing seasons.

Even though to fishermen, using 25 mm mesh provided 16% more revenue, they were not ready to lose about 42% (that is retained by the 10 mm mesh) of their revenue for ecological and sustainability reasons. The thinking of fishermen in this exercise will negate any attempts to even try using a compromise of either 18 or 20 mm as a beach seine bag. Such a mentality may arise from observed chronic poverty in fishing communites in Ghana (Asiedu et al., 2013).

Conclusions

The covered cod end and cod end bags of different mesh size had high diversity with the highest in the cod end. Sixty-seven species belonging to 35 families were recorded. The major families, in no particular order, were the Penaeidae, the Carangidae, the Clupeidae, the Haemulidae and the Trichiuridae. Trichiuridae and Penaeidae were not recorded as dominant families in the previous beach seine studies done along the coast; Tsokome is then unique for dominance in Ghana. The dominant species varied in terms of abundance and biomass and according to the mesh size of the bag. In common three major dominant species were recorded in the two bags: *P. notialis, B. auritus* and *C. chrysurus*. These differences can be explained by differences in sampling technique, length and mesh size of nets used, and the constantly changing population of the shore-zone fish assemblage. There was a significant difference between the catch of the two bags. In general, the covered cod end (10 mm mesh) caught species of smaller size while the cod end (25 mm mesh) caught the bigger ones. The difference in beach seine bag mesh size is obviously the reason.

The CPUE reduced as one gets deeper in the lean season and can be caused by environmental factors. Meanwhile the catch does not correlate with effort in time (minutes) and in number of men. The growth of the dominant species was allometric in both catches implying the negative impact of the gear on the nearshore species.

Clearly, the beach seine gear selectivity had shown a high contribution to the selection of the *P. notialis*, *C. chrysurus* and *B. auritus* in the nearshore waters and its effect is emphasized by the use of the 10 mm mesh bags. It reduces diversity, fish sizes and catches all species encountered on its way. The 10 mm is hence more harmful to the resources than the 25 mm. Furthermore the use of the 25 mm was seen to be 16% more financially rewarding than 10 mm bag.

Consequently, these results also support the prohibition of beach seine gears, at least for a reasonable period in the year, as a management measure or at least the enforcement of the use of the 25 mm mesh bags as stated in the Fisheries Laws of Ghana. Since total ban of the gear will be vehemently opposed by fishers closed period regulation with provision of alternative livelihood support will be the most suitable option.

Recommendations

From the above observations it would be recommended that fishermen should be educated on the need to use the 25 mm mesh. Provision of alternative gears and jobs, subsidies and incentives to those who comply will help in managing this problem.

Conflict of Interest

The authors have not declared any conflict of interests.

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