Comparative Catch Selectivity of Four Fishing Gears on the Lower Benue River, Nigeria

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Abstract
A comparative study on the selectivity of four fishing gears (cast net, dragnet, gill net and Hook and line) was carried out on the stretch of the Benue River between Makurdi and Abinsi fishing ground on the coordinates; 8° 31'N and 7° 35'E. The operation of these gears was observed for two days in a month for twelve months (one year), during which each of their catches was sampled. The 12 months comprised of two seasons (dry and wet seasons). A total number of 5,853 specimens which comprised of 82 species in 22 families were caught during the 12 months of the study (July 2014 – June, 2015). Of the four gears used for the experiment cast net had the highest catch with 2,786 specimens, dragnet ranked second with 1,972 specimens. Gill net recorded 803 specimen and hook and line recorded 292 specimens. The numbers of specimens caught by each gear, in the dry and wet seasons were also noted. A bench mark of 5% of the total catch by each gear was used to determine its species selectivity, the number/spread of each species of fish caught within the above range were regarded as being selective for that gear. The study establishes that cast net and gill set nets are all season gears in the Lower Benue River, Gill set net catches more in the wet season because the draught reduces the fishing area for the gear. Hook and line appear to be more efficient and effective during the wet season as it records higher catches in biomass and is size selective for larger fishes. Drag net is more effective in the dry season and make relatively higher catches but it appears to be environmentally unfriendly as the small mesh sizes observed are not size selective and does not allow for conservation.

KeyWords: *Gear selectivity, fish species caught, seasonality and sustainable fishing*

Introduction

The Benue River is the major tributary of the Niger River. The river is approximately 1,400 km long and is almost entirely navigable during the wet season between the months of August and February and so it serve as transportation route in the regions through which it flows (Marie *et al* 2001). It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Reservoir, into Nigeria south of the Mandara-mountains, and through Jimeta, Ibi and Makurdi before meeting the Niger at Lokoja. Apart from being an important water route, it is also one of the major fishing areas in Nigeria and several fishing gears are used along this river (Reid and Sydenham, 1979).

There is a growing interest in the measurement of technical efficiency of different fishing fleets. This interest is twofold: to establish the underlying factors, and to assess the effects of management measures on technical efficiency and potential catch. Fishery managers may reduce technical efficiency by constraining the use of certain inputs (Pascoe *et al* 2001), or alternatively, they may improve it by expanding these inputs or by taking measures that properly define the property rights of the fishery. The efficiency of fishing gears is an important tool in fisheries management (Khan et al 2005).

Generally, technical efficiency is defined as the ability of a decision-making unit (DMU) to obtain the maximum output from a set of inputs (output orientation) or to produce an output using the lowest possible amount of inputs (input orientation) (Kumbhakar and Lovell, 2000). Newman *et al.*, (2012)

stated that technical efficiency, its measurement, and the factors determining it are of crucial importance in production theory. Determining those factors affecting it allows stakeholders to take measures to limit or improve it. According to Balik *et al* (2001), gillnets are used widely in the coastal and inland fisheries of the world because of their versatility, low cost, and ease of operation. Thus, these gears are important in inland fisheries and the efficiency of these net types are influenced by mesh size, exposed net area, floatation, mesh shape and hanging ratios, visibility and type of netting material in relation to it stiffness, and breaking strength. The amount of damage a fishing gear causes can vary considerably depending on its design and operational deployment (Collie *et al*., 2000, Kaiser *et al*., 2006). Knowledge of the efficiency of gears is important for the reconstruction of the fish population (Machiels *et al*., 1994). In recent years there has been a growing focus on "ecosystem effects of fisheries", addressing the impact of fishing operations not only on the target species, but also on by-catch of or other effects on non-commercial species or habitats. Energy efficiency, reduced pollution and improved quality of the catch are also important aspects related to fishing gears and fishing operations as highlighted in the "Code of Conduct for Responsible Fisheries, Article 7.2.2" (FAO, 1992). Obande *et al* (2010), identified some of the fishing gears and their efficiency on the Benue River Understanding the selectivity of fishing gears (nets, traps, hook and line) is very important as they employ large numbers of fishers and take a significant proportion of the total catch. The gear selectivity in the Lower Benue fisheries and their impact on stocks needs to be understood for proper management measures.

MATERIALS AND METHODS

Study Area

The lower Benue River as defined by Reid and Sydenham (1979) as the Benue River Basin downstream of the faro Benue confluence, an area, which is contained within the Federal Republic of Nigeria. The study was carried out at three stations namely; (i) Head bridge, (ii) Agbaaye and (iii) Abinsi on the stretch between Makurdi and Abinsi fishing ground on the coordinates; 8^{o} 31'N and 7^{o} 35'E (Figures 1). The lower Benue strongly flows through an extensive alluvial plain which stretch for many kilometers along the river route. The river's largest tributary is the Mayo Kébbi, which connects it with the Logone River during floods. Other tributaries are Taraba River, Donga and Katsina-Ala Rivers.

Fish Sampling

Fish specimens were collected with the assistance of the fishers operating in the study area. The setting and operation of these gears was observed for two days in a month for twelve months (one year), after which each of their catches wase sampled. The 12 months comprised of two seasons (dry and wet seasons), dry season begins from December and end in May while the wet season is from June to November. Gill net and hooks and line were usually set in the evening and retrieved the following morning for fish collection. Cast net and Drag net were actively operated any time of the day. Specimens were collected through purchase and personal donations from the fishers. A motorized wooden canoe was the main navigational craft for the field operations.

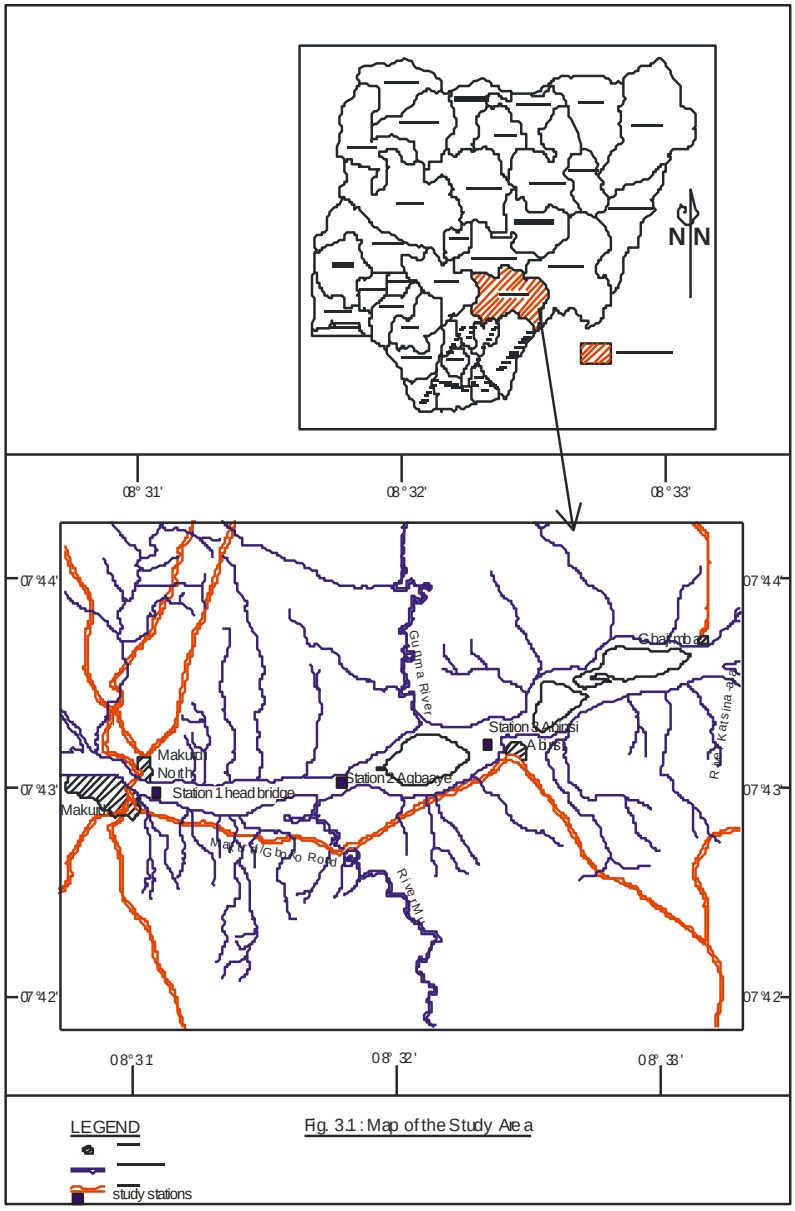

Figure 1: Map of Nigeria and the study Area

Gears Observed

The common gears in operation were observed based on the following parameters; lengths, depths (Cast, Gill net and Dragnets), and sizes for hooks and meshes of nets. Setting, retrieval and active operation of the gears were also noted. Fish caught by individual gears were recorded and fishers were identified by personal communication and in few cases catch per individual effort was noted. Materials used in constructing various gears were observed as well as the riparian vegetation of the river.

The mesh sizes for both, cast net, gill net and dragnets fall within the ranges of 4cm-32cm stretched meshes. Stretched cast nets mesh sizes were common in the ranges of 4cm – 8cm. Dragnets were mostly in the ranges of 4cm-18cm. Small mesh size below 2cm where observed and were mostly operated by children below 12year and older fishers above 65 years. The largest mesh sizes (Stretched) ranged between 20-32cm were recorded in the gill nets. Hooks were made of metal steel (mainly circle- shaped) with size range between No. 17 to 5 (small sizes – big sizes) were recorded.

RESULTS AND DISCUSSIONS

Individual fish species as caught by each gear during sampling are shown Table 1. Selectivity of the gear was determined by considering any fish species that constituted up to 5% of the total sampled catch. 23 species of the total fishes caught made up to the 5% and also showed significant differences in the percentage composition among the gears, and were regarded as being selective both in numbers and biomass, they include; *Alestes baremose, Auchenoglanis biscutatus, A. occidentalis, A.occidentalis, Bagrus bayad, Bagrus filamentosus, Brycinus nurse, Citharinus citharus, Clarias anguillaris, C. gariepinus, Clarotes laticeps, Hemichromis bimaculatus, Hepsetus odoe, Heterobranchus bidorsalis, Hydrocynus brevis, Labeo coubie, Lates niloticus, Mormyrops anguilloides, M. macrophthalmus, M. rume rume, Synodontis batensoda, S. clarias, S. courteti* and *Tilapia zillii.*

The number/spread of each species of fish caught within the above range were regarded as being selective for the gear. Species selectivity of each gear for the two seasons (Dry and Wet) are shown in Table 2 and Figures 2 to 5. Cast net caught more fish in the dry season than in the wet season. *Synodontis clarias* was caught only in the wet season (Figure 2). It however caught different species in both seasons. Dragnet caught more fish in the dry season than the wet season. Among the fishes caught only *Tilapia zillii* was caught in both seasons and *Hepsotus odoe* was caught only in the dry season (Figure 3). Gill net caught more fish in the wet season and less in the dry season. Two species (*Hydrocynus brevis* and C*itharinus citharus*) were caught only in the wet season (figure 4). Hook and line hook was also more efficient in the wet season. It caught eight (8) species in the wet season and only six (6) in the dry season and none of the species were caught in both seasons (Figure 5).

A total number of 5,853 specimens which comprised of 82 species in 22 families were caught during the 12 months of the study (July 2014 – June, 2015). Of the four gears used for the experiment (cast net, dragnet, gill net and Hook and line), cast net had the highest catch with 2,786 specimens, dragnet ranked second with 1,972 specimens. Gill net recorded 803 specimen and hook and line recorded 292 specimens. The numbers of specimens caught by each gear, in the dry and wet seasons are shown in Table 2.

The lengths of fishes observed using Powell Wetherall plot among the four gears and the species selected for gear efficiency shows that Drag net recorded the highest length with *Labeo coubie* (71cm) and *Bagrus filamentosus* (61cm). Their predicted extreme lengths were lower than the observed lengths. Gill net and Hook and line had higher observed lengths than the predicted (61cm against 52 and 53 respectively). It was only Castnet that recorded fish lengths lower than the predicted length (31cm against 34cm) Table 3.

This study establishes that cast net and gill set nets are all season gears in the Lower Benue River. However catch by cast net is negatively affected by high volumes of water associated with higher velocities during the wet season. Gill net is affected by dry season as the draught reduces the fishing area for the gear. Hook and line appear to be more efficient and effective during the wet season as it records higher catches in biomass and is size selective for larger fishes. Drag net is more effective in the dry season and make relatively higher catches but it appears to be environmentally unfriendly as the small mesh sizes observed are not size selective and does not allow for conservation. Gill net and Drag net only differ in operational methods (passive and active operations) but exhibit same catching principles. Drag net records higher catches and is most preferred by fish anglers. It is important to construct specific gears for research in Nigeria as adoption of those used by commercial fishers may not give good scientific results.

Table: 1 Fish Species composition and Selectivity of the Four Gears

Family	Fish species	C n	Dn	Gn	HL
ARIIDAE	*Arius gigas*	x	X	-	X
BAGRIDAE	*Auchenoglanis biscutatus*	x	X	x	X
	A. occidentalis	x	X	x	X
	Bagrus bayad	x	X	x	X
	B. docmak	x	-	-	X

	B. filamentosus	x	X	x	X
	Chrysichthys auratus	x	X	x	X
	C. nigrodigitatus	x	X	x	X
	Clarotes laticeps	x	X	x	X
CENTROPOMIDAE	*Lates niloticus*	x	X	x	X
CHARACIDAE	*A. baremose*	x	X	x	X
	A. dantex	-	-	x	-
	A. macralepideth	-	-	x	-
	Brycinus brevis	x	-	x	-
	B. leuciscus	x	-	-	-
	B. macrolepidotus	x	-	-	-
	B. nurse	x	-	x	-
	Hydrocynus brevis	x	X	x	X
	H. forskalii	x	X	x	-
	H. vittatus	x	-	x	-
	Micralestes humilis	x	-	-	-
CICHILIDAE	*Chromidotilapia guentheri*	-	-	x	-
	Haplochromis bloyeti	x	-	-	-
	Hemichromis bimaculatus	x	-	-	-
	Oreochromis aureus	x	X	x	-
	O. niloticus	x	-	x	-
	Tilapia dageti	-	-	x	-
	T. melaneupleura	-	-	x	-
	T. zillii	x	X	x	x
CITHARINIDAE	*Citharidium ansorgii*	-	X	-	-
	Citharinus citharus	x	X	x	x
	Citharinus latus	-	X	x	-
	Distichodus brevipinnis	x	X	x	x
	D. engycephalus	x	X	x	x
	D. rostratus	-	X	x	x
	Nannocharax fasciatus	x	-	-	-
CLARIIDAE	*Clarias anguillaris*	x	X	x	X
	C. gariepinus	x	X	x	X
	C. macromystax	-	X	-	-
	C. lazera	-	-	x	-
	Heterobranchus bidorsalis	x	X	x	X
	H. longifilis	-	X	x	-
CYPRINIDAE	*Barbus ablabes*	x	-	-	-
	Labeo coubie	x	X	x	X
	L. parvus	x	X	x	-
	L.senegalensis	x	-	-	-
	Leptocypris niloticus	x	-	-	-
CYPRINODONTIDAE	*Epiplatys bifasciatus*	-	-	-	X
GYMNARCHIDAE	*Gymnarchus niloticus*				
HEPSETIDAE	*Hepsetus odoe*	x	X	x	X
ICTHYBORIDAE	*Phago loricatus*	x	-	-	-
LOPIDOSIRENIDAE	*Protopterus annectens*	-	X	-	X
MALAPTERURIDAE	*Malapterurus electricus*	-	-	x	-
MASTERCAMBALIDAE	*Mastercembelus loennbergi*	x	-	-	-
MOCHOKIDAE	*Synodontis batensoda*	x	X	x	X
	S. budgetti	x	-	x	-
	S. clarias	x	X	x	X

	S. courteti	-	-	x	X
	S. eupterus	x	-	-	-
	S. filamentosus	-	-	x	-
	S. membranaceus	-	X	-	-
	S.nigrita	x	X	x	-
	S. sorex	x	-	x	-
MORMYRIDAE	*Gnathonemus tamandua*	-	X	-	-
	G. petersii	-	X	-	-
	G. abadii	x	-	-	-
	Hyperopisus bebe bebe o.	-	X	-	-
	Marcusenius mento	x	-	-	-
	M. senegalensis	X	-	-	-
	Mormyrops anguilloides	X	X	x	x
	M. caballus	X	X	x	-
	M. hasselquistii	X	-	x	-
	M. macrophthalmus	X	X	-	-
	M. rume rume	X	X	x	-
OPHIOCEPHALIDAE	*Paranchanna obscura*	X	-	-	-
OSTEOGLOSIDAE	*Heterotis niloticus*	X	X	X	-
PANTODONTIDAE	*Cynothrissa mento*	X	-	-	-
	Pantodon buchholzi	X	-	-	-
SCHILBEDAE	*Schilbe intermedius*	X	-	-	-
	Schilbe mystus	X	X	X	-
TETRAODONTIDAE	*Tetraodon fahaka*	-	X	-	-

Key: Cn= Cast net, DN= Drag net, Gn= Gill net, HL= hook and line X= indicates presence

Table 2: Seasonal Variation in Fish Caught by the Gears

Gear	dry season	wet season
Castnet	1465(25%)	1321(22.57%)
Drag net	1336(22.8%)	636(10.87%)
Gil net	395(6.75%)	408(3.20%)
Hook and Line	104(1.78%)	188(3.20%)
	3,300	2,553

Table 3 Max and Min Length (cm) Using Wetherall Plot for Fishes recorded in the Lower Benue River

Gear and Species	Loo*	Z/K	OEL	PEL
Cast net				
Lates niloticus	31.90	0.499	31.00	34.454
Tilapia zillii	19.44	0.539	-	-
Clarotis laticeps	47.50	2.488		
Dragnet				
Labeo cubie	71.00	0.000	71.00	63.38
Bagrus filamentosus	61.00	0.000	61.00	34.21

Synodontis clarias	32.23	1.536	31.00	27.66
Gill net				
Hydrocynus brevis	58.94	0.337	61.00	53.10
Auchinoglanis occidentalis	33.32	0.404	31.00	32.88
Alestes baremose	31.16	0.439	31.00	38.13
Hook and line				
Hydrocynus brevis	59.95	0.316	61.00	52.96
Alestes baremoze	40.31	0.887	41.00	43.49
Synodontis courteti	-	-	31.00	25.07

*Loo=Observed max length,
Z/K= Estimated max length,
OEL=Observed extreme length,
PEL=Predicted extreme length

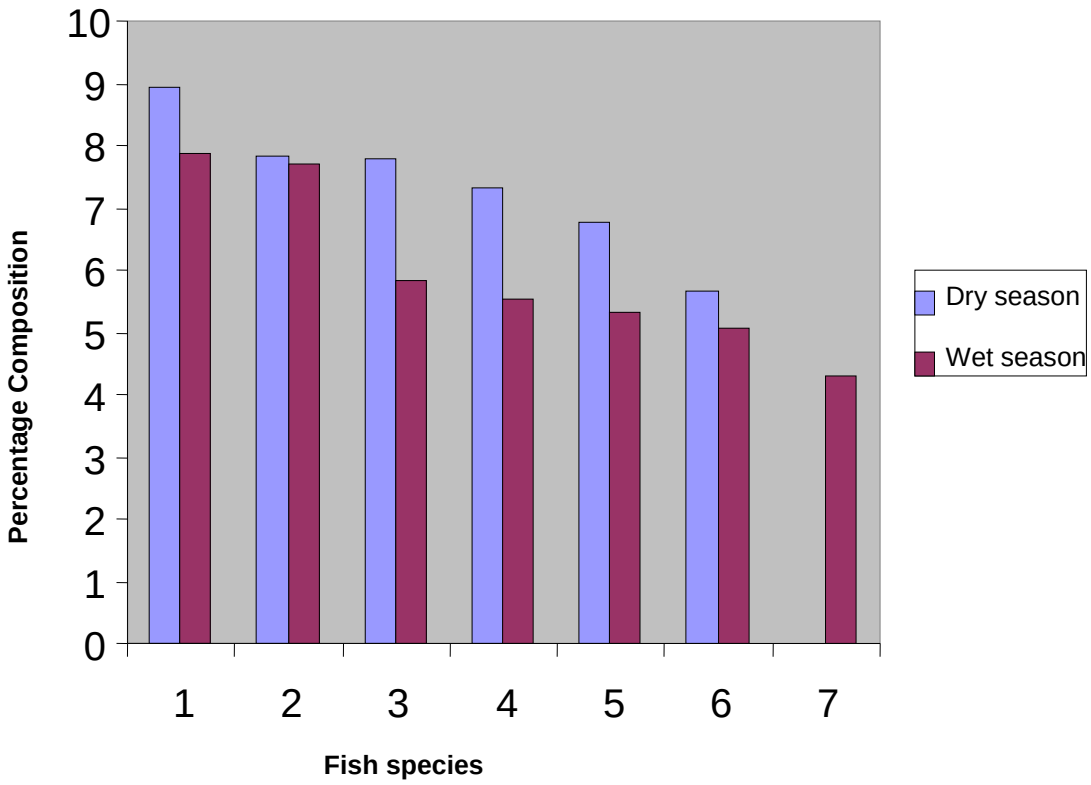

Figure 2. Castnet Selectivity for dry and wet seasons

Key (Dry): 1.*Alestes baremoze* 2.*Tilapia zillii* 3. *Brycinus nurse* 4 *Synodontis batensoda* 5. *Clarotes laticeps* 6. *Synodontis clarias* 7. *Citharinus citharus*
(Wet): 1. *Alestes baremoze* , 2. *Lates niloticus*,3.*Mormyrus rume*,4.*Hepsotus odoe* 5. *Hemichromis bimaculatus*, 6.*Tilapia zillii*, 7.*Synodontis clarias*

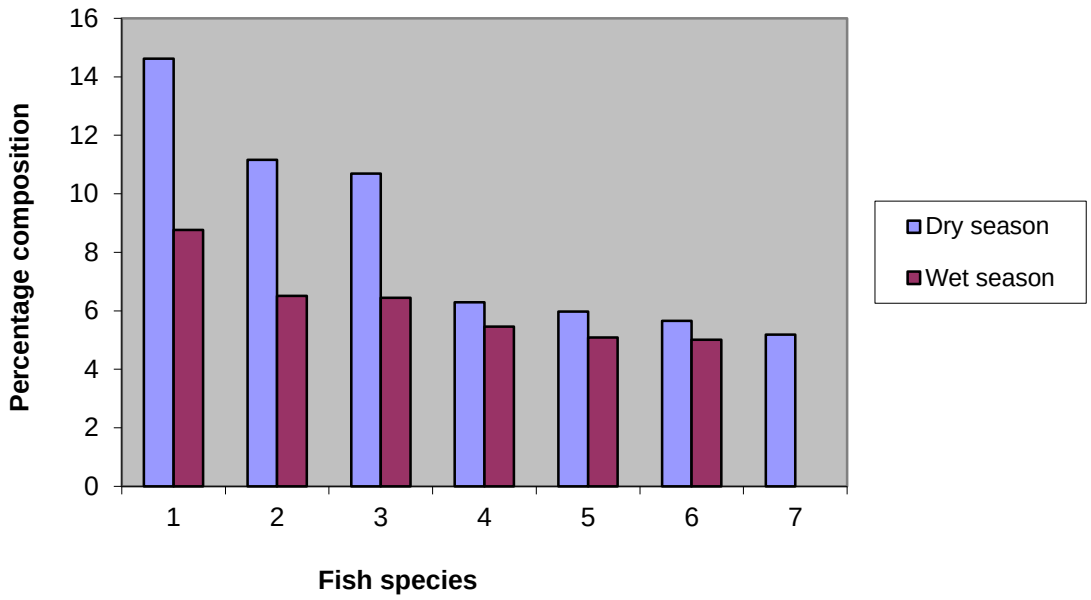

Figure 3: Dragnet Selectivity for dry and wet seasons

Key (Dry): 1. *Bagrus filamentosus, 2. Synodontis batensoda, 3. Tilapia zillii 4. Mormyrops anguilloides, 5. Bagrus bayad, 6. Mormyrus macrophthalmus 7. Hepsotus odoe*
(Wet):*1.Tilapiazillii, 2.Clariaz anguillaris, 3.Synodontis clarias, 4.Auchinoglanis biscutatus, 5.Heterobranchus bidorsalis, 6.Alestes baremoze*

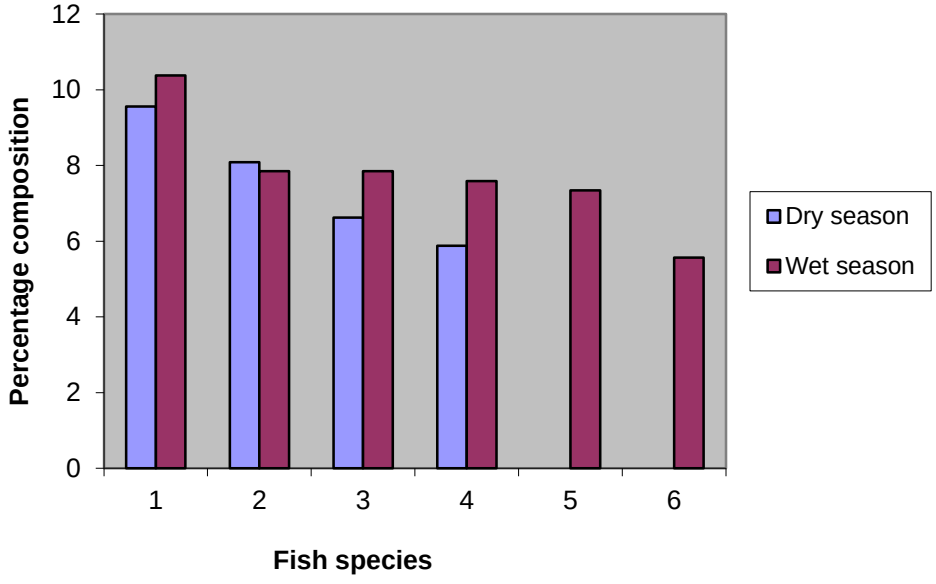

Figure 4: Gill net Selectivity for dry and wet seasons
Key (Dry): 1. *Hydrocynus brevis 2. Synodontis clarias 3. Lates niloticus. 4. Clarias anguillaris*
(Wet):*1.Alestesbaremoze, 2.Tilapia zillii, 3.Synodontis clarias, 4.Auchinoglanis occidentalis, 5.Hydrocynus brevis, 6.Citharinus citharus*

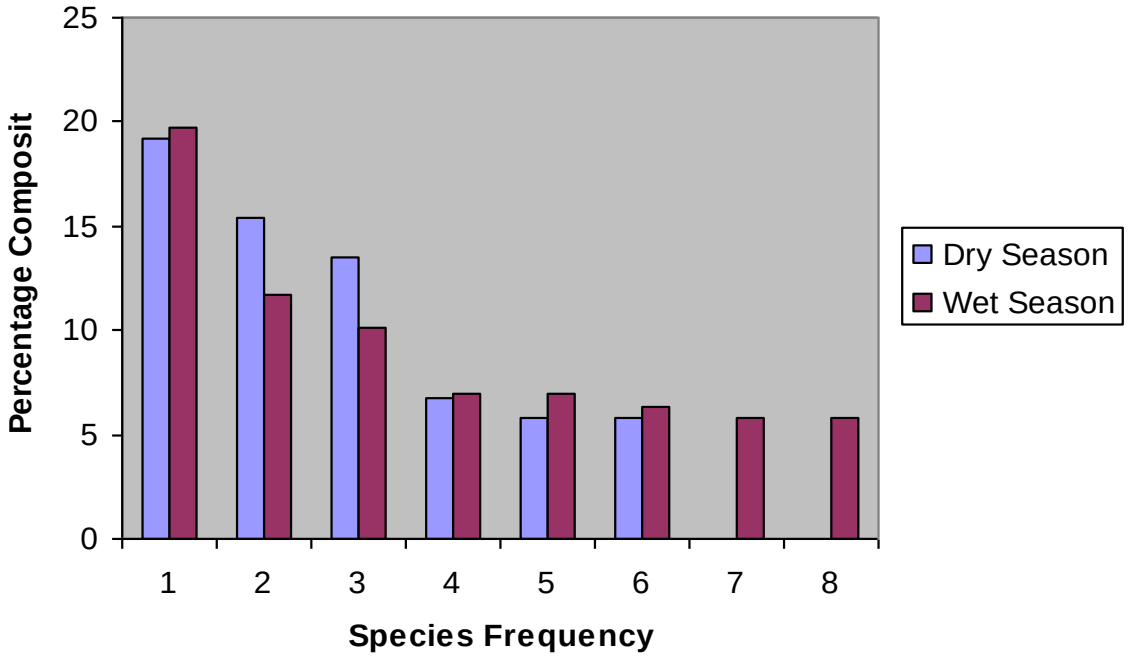

Figure 5: Hook and line Selectivity for dry and wet seasons
Key (Dry): 1. *Synodontis courteti, 2. Bagrus bayad, 3.Clarias anguillaris, 4. Hydrocynus brevis 5.Clarotes lateceps, 6.Labeo coubie*
(Wet): 1. *Alestes baremose, 2. Hydrocynus brevis,3. Synodontis clarias, 4.Tilapia zillii 5. Lates niloticus, 6. Clarias gariepinus, 7. Citharinus citharus,* 8. *Hepsetus odoe*

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