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PISCINE BIODIVERSITY CHARACTERIZATION OF THE STUBBS CREEK, NIGER DELTA, NIGERIA RECEIVING OIL SPILL EFFLUENTS

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ABSTRACT

A parsimonious survey of the fish biodiversity of the Stubbs Creek, a coastal freshwater/ blackwater stream in the Niger Delta, Nigeria was conducted. The all Teleostei fishes comprised a high taxonomic heterogeneity with 32 species, 24 genera and 17 families. They were organized in three eco physiological assemblages (the primary freshwater, secondary freshwater and peripheral Assemblages) and four mesohabitat assemblages (benthic, benthopelagic, pelagic and epipelagic assemblages). Approximately 84.4% of the fish species were found to be equipped with a variety of biophysical life enhancement devices which enable them to optimally exploit the available resources of the habitat space. The Stubbs Creek has the potential of producing about 27.2 tonnes km^{-2} year^{-1} of fish flesh for human consumption, barring the impacts of oil spill effluents from a major oil producing company within the Stream basin/catchment area. Elevated levels of Hydrocarbon (PAHs) and heavy Metals, far above WHO recommended levels were observed in this study. It is figured that the results of this study qualify the Stubbs Creek to be considered as 'Stream of Special Scientific Interest' (SSSI) for management and conservation purposes.

Key words: Coastal stream, Fishes, Taxonomic heterogeneity, Ecological assemblages, Oil Spills, Hydrocarbons, Heavy Metals.

INTRODUCTION

The Stubbs Creek Forest Reserve (SCFR) is located in the Southeastern Coast of Akwa Ibom State, Nigeria. It was established in 1930 by Order 45 of the British colonial administration. This Order was subsequently amended in 1941 and replaced by Orders 16, 17 & 28. The forest reserve was officially gazette in 1955 (Gazette No. 236) and has since remained a government protected environment where illegal timber logging and wildlife hunting are prohibited.

The SCFR harbours some fauna of conservation significance e.g. the Sclater's Guenon, *Cercopithecus sclateri*, Mona monkey, *Cercopithecus mona*, red-capped Mangabey, *Cercopithecus torquatus*, *agwantibo*, *Articebus calabaricus.* The bushbuck, *Tragelus scipus*, the bush pig, *Potamochoerus procus* and forest elephant, *Loxodonta Africana* (last sited in the early 1980s). The SCFR also harbours heterogeneous assemblages of amphibians, reptiles, birds, maro-invertebrates and macrophytes.

The establishment, in the 1970s, of the EXXON Mobil oil tank farm/operational base at Ibeno encroached on the original territory of the SCFR. Moreover, the 24 hours gas flares from the area has threatened the ecological integrity of the area along with the noise generated by choppers landing and taking off from the nearby helipad.

The SCFR is drained by the Stubbs Creek or Widenham Creek, a small freshwater coastal stream that serves as the main link between the Qua Iboe River estuary on the West and the Cross River estuary on the East. Given the constant onslaught of anthropogenic perturbations of the area with oil spills almost on a monthly basis, occasioned by the establishment of the EXXON MOBIL OIL, the piscine fauna of this unique coastal stream has hitherto not been documented, hence the rational for the present parsimonious study.

Oil spills introducing Polycyclic Aromatic Hydrocarbons (PAHs), Heavy Metals and other harmful substances into the aquatic environment and the catchment soils have been reported to have profound adverse effects on Ichthyofaunal species (Ekwu, 2006), Invertebrates (Olatunji *et al.* (2023), as well as posing severe human health risks (Adeniji *et al.*, 2019; Birch *et al.*, 2024). Anyanwu *et al.* (2021) also elucidated the adverse effects of PAHs, N-PAH and Heavy Metals from oil spills in Bodo Creek and Bonny Estuary, Nigeria.

MATERIALS AND METHODS

Study Area

The SCFR (Fig. 1) is a roughly rectangular forested area located at 4.5481°N, 7.9828°E in the South – East coast of Akwa Ibom State, Nigeria. The geological deposit of the 513 km^2 area is the quaternary alluvium, thus suggesting that the forest reserve is approximately 2.58 million years old. The SCFR is drained principally by the Stubbs Creek or Widenham Creek, a small freshwater/blackwater coastal stream that runs horizontally from East to West, linking the Qua Iboe estuary in the West with the Cross River estuary in the East. The southern border of the SCFR is the Gulf of Bonny of the Atlantic Ocean but there is no direct link between the stream and the sea. The Stubbs Creek is unique because it is a freshwater stream despite being enveloped by the saline mangrove swamp forest. Existing records of the Hydrographic characteristics of the area were obtained from FUGRO (2004), presented in Table 1.

The climate of the area is typical of the equatorial regime with year-round rainfall (Table 2). However, the rainfall distribution reveals the existence of six distinct eco-seasonal periods: Early Dry Season (EDS ~ November),

Mid Dry Season (MDS ~ December – February), Late Dry Season (LDS ~

March – April), Early Wet Season (EWS ~ May – July), Mid Wet Season

(MWS ~ August) and Late Wet Season (LWS ~ September – October)

Monthly mean rainfall is approximately 379.1 mm mo^{-1}) while annual total is 4548.7mm. Ibeno has the highest rainfall in Akwa Ibom State. The rainfall varies 12.8 –fold, from a minimum of 56.7 mm in February to a maximum of 722.1 mm in August. Although the SCFR is enveloped by a predominantly saline mangrove forest, the Stubbs Creek is freshwater because of the year –round heavy rainfall that it receives. It is this rainfall that also dilutes the stream water thus resulting in low conductivity.

The air temperature varies narrowly (1.2 – fold), from a minimum of 27.0 °C in August to a maximum of 31.3 °C in February (Table 1).

Table 1. Monthly mean rainfall and air temperature at Ibeno (1992 – 2002).

Months	Rainfall (mm)	Air temperature (°C)
January	67.4	30.4
February	56.3	31.3
March	261.3	30.8
April	272.8	30.5
May	442.6	30.0
June	635.1	28.6
July	678.0	27.5
August	722.1	27.0
September	581.6	27.4
October	507.2	28.2
November	255.9	30.2
December	68.4	30.2
Total	4548.8	-
Mean	379.1	29.3

Source: FUGRO (2004)

The Stubbs Creek which was hitherto regarded as being pristine is currently under severe threat of hydrocarbon and heavy metal pollution from oil exploration and exploitation activities.

Sampling and analyses

(i) Sampling for Physico-Chemical Parameters

Water Samples were collected from four locations along the Creek's course, from where fish samples were obtained. Sampling and analysis of the creek water was done according to APHA (2005). Temperature, pH, electrical conductivity and total dissolved solids were determined in-situ using Hanna Instrument (model HI 98129). Secchi Disc Transparency was measured using a Secchi Disc and the depth expressed as Zsd in meters, while water samples for Biochemical Oxygen Demand (BOD) were taken under water, in Amber glass bottles, ensuring that air bubbles were excluded (APHA, 2005). For the other parameters, One litre of water was collected from each station and transported to the laboratory for the analysis.

(ii} Collection of Fish Samples

Fish samples were obtained from four locations along the Stubbs Creek
(February – April, 2018):

1. Ine Akpautung: 4° 32′ 24″N, 8° 14′ 04″E
2. Itak Idim Ekpe: 4° 32′ 40″N, 8° 11′ 48″E
3. Atia: 4o 32′ 43″N, 8° 32′43″N, 8°08′ 24′E
4. Itak Ifa: 4° 32′ 43″N, 8° 06′ 27″E

Fishing was done with the assistance of young sport fishers who used hooks and valved basket traps. Fishing was mainly during the day. The specimens were identified, counted and measured (mm total length) prior to preservation in 10% formalin solution. Representative specimens were sent to the Ichthyologie

Laboratoire, Musee Royal de l′ Afrique Centrale, Tervuren, Belgium for the confirmation of the fish identities. The taxa used in this study were the species, genus and family. A simple fish taxonomic richness index (FTRI) was computed thus:

FTRI = [FSR x FGR x FFR$^{0.3}$ .. (1)

where FSR = fish species richness (i.e number of species present); FGR = fish

Generic richness (i.e number of genera present); FFR = fish familial richness

(i.e number of families present). A fish species diversity index (FSD) was calculated on sample size thus (Odum, 1971; King and Jonathan, 2003):

FSD = FSR$_{per}$ 1000N .. (2)

where FSR = the observed species richness; N= number of specimens collected (sample size). This index is simply interpreted as the expected number of fish species per 1000 specimens caught.

A similar procedure was adopted in the computations of fish generic diversity

Index (FGD) and the fish familial diversity index (FFD).

RESULTS AND DISCUSSION

Physico-Chemical Parameters

Results of Physico-Chemical parameters and Heavy metals are given in Table 2.

Table 2. Key physico-chemical parameters of the Stubbs Creek, Nigeria

Parameters	Means	Ranges
Surface Temperature (°C)	26.3	26.1 – 26.5
Total Suspended Solids (mg/l)	0.035	0.28 – 0.040
Total Dissolved Solids (mg/l)	0.020	0.12 – 0.026
Total Solids (mg/l)	0.055	0.40 – 0.064
Conductivity (µS/cm)	13.87	10.80 – 19.90
Total Alkalinity (mg/l $CaCO_3$)	2.70	0.80 – 4.60
NH_4 (mg/l)	0.29	0.23 – 0.41
NO_3–N (mg/l)	0.322	0.310 – 0.326
PO_4–P (mg/l)	0.065	0.54 – 0.072
SO_4 (mg/l)	7.4	6.2 – 8.4
Pb (mg/l)	0.028	0.02 - 0.03
Zn (mg/l)	0.017	0.09 - 0.22
Fe (mg/l)	0.054	0.32 - 0.67
Cd (mg/l)	0.02	0.01 - 0.03
Hydrocarbon (mg/l)	51.08	1.04 – 71.12

Except for Hydrocarbon Concentration and some Heavy Metals, the ranges of the Physico-chemical parameters were generally narrow probably because they do not necessarily represent annual variations. A more comprehensive study of Physico-chemical parameters of this area has been reported by Ekwu (2007).

The stream water colour is light brown and transparency was as far as the depth.

The relatively low surface temperature of the stream is due to the thick overhanging vegetation above the stream channel. Danba *et al.* (2021) reported a similar observation in River Taraba. The load of suspended solids was low probably because of the bordering freshwater swamps that absorb non-point surface runoff. The stream pH was slightly acidic as is typical of tropical blackwater riverine ecosystems (Welcomme, 1979). The low conductivity is also a typical tropical blackwater trait (Welcome, 1979). The dominant anion was SO_4 (68.6%). This was followed by CO_3 (25.0%), NO_3 (3.0%), NH_4 (2.7%) and PO_4 (0.7%).

Taxonomic inventory

The fish taxa used in this study were: the family, genus and species. These are the taxa that are most commonly used in biological, ecological and fisheries studies. The taxonomic composition of the fishes of the Stubbs Creek (Table 3) reveals a high taxonomic heterogeneity comprising minima of 67 species, 50 genera and 25 families. It is possible that more intensive/extensive sampling would have yielded more fish taxa. Only Teleostei fishes were caught from the stream, thus indicating that all the fishes in the stream can be regarded as a mega taxocene.

All the fishes were indigenous or native and no alien species was identified. This suggests that the stream is relatively free from piscine biotic intrusions.

A comparative fish taxonomic profile of some Nigerian streams (Table 4) indicates that with the exception of Ikpa and Esedeke streams, the Ikpa River has the highest fist taxonomic heterogeneity, compared to the Stubbs Creek with a rather homogeneous taxonomic composition. This may

Table 3. The taxonomic composition of the fishes of the Stubbs Creek, Nigeria.

Taxa	Ecophysiological division	Meso habitat
POLYPTERIDAE		
Erpetoichthys calabaricus	Primary freshwater	Benthic
PANTODONTIDAE		
Pantodon buchholzi	Primary freshwater	Epipelagic
NOTOPTERIDAE		
Xenomystus nigri	Primary freshwater	Benthopelagic
MORMYRIDAE		
Isichthys henryi	Primary freshwater	Benthic
Brienomyrus brachyistius	Primary freshwater	Benthic
DISTICHODONTIDAE	Primary freshwater	
Neolabias ansorgii		Benthopelagic
HEPSETIDAE		
Hepsetus odoe	Primary freshwater	Epipelagic
CLAROTEIDAE		
Parauchenoglanis fasciatus	Primary freshwater	Benthic
Parauchenoglanis guttatus	Primary freshwater	Benthic
CLARIIDAE .	Primary freshwater	Benthic
Clarias macromystax		
Clarias pachynema		
Clarias agboyiensis		
MALAPTERURIDAE	Primary freshwater	Benthopelagic
Malapterurus electricus		
APLOCHEILIDAE	Secondary freshwater	Epipelagic
Epiplatys sexfasciatus		
Epiplatys graham		
Aphyosemion escherichi		
CHANNIDAE	Primary freshwater	Benthopelagic
Parachanna obscura		
Parachanna africana		
CICHLIDAE	Secondary freshwater	Benthopelagic
Chromidotilapia guntheri		
Thysochromis ansorgii		
Pelvicachromis pulcher		
Hemichromis fasciatus		
Hemichromis elongatus		
Tilapia zillii		
NANDIDAE	Primary freshwater	Pelagic
Polycentropsisabbreviate		
ELEOTRIDA	Peripheral	Benthic
Eleotris vittta		
Eleotris senegalensis		
ANABANTIDAE	Primary freshwater	Pelagic
Ctenopoma kingsleyae		
Ctenopoma muriei		
PHRACTOLAEMIDAE	Primary freshwater	Benthic
Phractolaemus ansorgii		

stem from annual contributions from both the Qua Iboe River and the Cross River. Moreover, the age of the stream basin (c. 2.58 million years BP) is sufficient for specific, generic and familial levels of evolution to take place.

Fish species spectrum

The observed fish species richness for the Stubbs Creek (FSR =32; is high when viewed *vis-a- vis* the records for other Nigerian streams (Table 4) which are 18.8 – 59.4% short of the fish species richness status of the Stubbs Creek. This is probably because the Stubbs Creek harbours a number of species that are not common in other streams e.g. *Arnoldichthys spilopterus* (Aleateidae), *Neolabias ansorgii* (Distichodontidae), *Epiplatys grahami/ Epiplays escherichi* (Aplocheilidae), *Hemichromis elongates* (Cichlidae), *Ctenopoma muriei* (Anabantidae) and *Phractolaemus ansorgii* (Practolaemidae). Of all previous Stream fish studies (Sydenham, 1975; Udoidiong, 1991; Udoidiong and King, 2000; Onuoha *et al*., 2010; Udo-Udo, 2012), *Phractolaemus ansorgii* is here reported for the first time. The comparative sample size - based fish species diversity indices of some Nigerian stream fishes (Table 5) shows that the Stubbs Creek displays the highest species diversity (FSDI = 254) which is 56.3.7 - 83.2.4% higher than other estimates. Fish species density in the SCFR was 16 km^{-2}.

The high fish species variety in the Stubbs Creek may be associated with Faunal dispersal contributions from the Qua Iboe River and Cross River Systems.

Table 5. Estimated fish species diversity indices for some Nigerian stream Ecosystems

Streams	FSR	N	FSD	Source
Odo- Ona	13	305	42.6	1
Ikpoba	58	253	111	2
Udom	17	349	48.7	3
Nung-Oku	19	270	70.4	3
Mission	22	226	97.4	3
Ikpa	26	442	58.8	4
Iba - Oku	19	321	60.9	5
Stubbs Creek	32	253	254	6

FSR = fish species richness; N= sample size (number of specimens);
FSD = fish species diversity
Source: 1 = Sydenham (1975); 2 = Victor and Tetteh (1988) 3 = Udoidiong (1991); 4= Onuoha *et al.* (2010); 5 = Udo – Udo (2012);
6 = This study.

Fish species richness – stream morphology relationships

A number of statistical models have been developed for predicting the FSR of African riverine ecosystems based on riverine morphology parameters. The models of Daget and Iltis (1965) and Welcomme (1979) are expressed respectively as:

$$FSR = 5A^{0.25} \quad .. (3)$$

$$FSR = 0.449A^{0.434} \quad .. (4)$$

where A = basin area (km^2) (here 513 km2 for the SCFR). The model of King (2013) is given as:

$$FSR = 24.731N^{0.3918} \quad .. (5)$$

Table 4. The fish taxonomic richness indices for some Nigerian streams

Streams	FSR	FGR	FFR	FTRI	Source
Odo-Ona	13	12	9	8.8	1
Ikpa	40	35	24	20.8	2
IKpa	26	14	7	10.5	5
Esedke	25	23	24	17.5	2
Iba -Oku	18	17	13	12.0	2
Iba -Oku	19	16	13	12.0	4
Ntak Inyang	26	14	7	10.5	5
Udom	17	15	10	10.5	3
Nung -Oku	19	16	11	11.4	3
Mission	22	17	12	12.5	2
Stubbs Creek	32	24	17	17.2	6

FSR = fish species richness; FGR = fish generic richness; FFR = fish familial richness; FTRI = fish taxonomic richness index.
Source: 1 = Sydenham (1975); 2 = Udoidiong and King (2000);
3 = Udoidiong (1991); 4= Udo –Udo (2012);
5 = Onuoha *et al* (2010); 6 =This study

where N = hydrographic nodality or the number of tributary junctions or (nodes) (here N= 30 for the Stubbs Creek). Equations 3 and 4 predictions for the Stubbs Creek are respectively FSR = 23 and FSR = 7 which are 28.1% and 78.1% short of the observed FSR. Equation 5 predicts FSR = 94 which is 193.8% over the observed FSR. The poor performance of the above predictive models is probably because they were not originally configured for small riverine ecosystems like the Stubbs Creek. However, the FSR = 94 prediction of equation 5 may be taken as the fish species richness carrying capacity of the Stubbs Creek. This suggests that further sampling may yield additional 62 species.

Fish generic spectrum and representation

The Stubbs Creek harbours a minimum of 24 fish genera (i.e FGR = 24). There is approximately 1 species per genus (i.e. 1.33 spp genus^{-1}). The Stubb Creek generic richness (FGR =24) is higher than the records for some Nigerian streams, including Odo-Ona stream (FGR = 12; Sydenham, 1975), Udom stream (FGR = 14; Udoidiong, 1991), Nung – Oku stream (FGR = 16; Udoidiong, 1991), Mission stream (FGR = 17; Udoidiong, 1991), Ikpa srteam (FGR = 14; Onuoha *et al.,* 2010) and Iba –Oku stream (FGR = 16; Udo –Udo, 2012) but is slightly (39.5%) less than the FGR = 38 for the Ikpoba stream (Table 6).

Estimates of the fish generic diversity indices for the above streams (Table 6) reveal that the Stubbs Creek tops other streams which are 26.1 – 47.8% short of the estimate for the Stubbs Creek. The fish generic density is FGD = 22 genera km^{-2}. A total of 16 genera (69.6%) are monospecific while 7 genera (30.4%) are polyspecific with 2 or more species in each. *Clarias* (3 species or 13.0%) is the most diverse genus. This is closely followed by *Parauchenoglanis*, *Epiplatys*, *Parachanna*, *Hemichromis*, *Eleotis* and *Ctenopoma* (each with 2 species of 8.7% contribution).

Table 6. The fish generic richness and fish generic diversity indices for some Nigerian streams.

Streams	FGR	N	FGD	Source
Odo-Ona	12	305	39	1
Udom	14	342	41	2
Nung –Oku	16	270	59	2
Mission	17	229	74	2
Ikpa	14	442	32	3
Iba –Oku	L 16	312	51	4
Ikpoba	38	524	73	5
Stubbs	23	253	91	6

FGR = fish generic richness (i.e number of genera present);
N = total number of fish specimens or sample size; FGD = fish generic diversity;
Source: 1 = Sydenham (1975); 2 = Udoidiong (1991); 3 = Onuoha *et al* (2010); 4 = Udo-Udo (2012); 5 = Victor and Tetteh (1988); 6 = this study.

The high fish generic richness and diversity in the Stubbs Creek may be associated with prehistoric dispersal / faunal enrichment from the Qua Iboe and Cross River systems. It is also possible that the age of the stream basin (c. 2.58 million years BP) has encouraged considerable generic – level evolution to occur. For instance the genus *Phractolaemus* is probably a product of allopatric evolution since it is not found in the Cross River (see Teugels *et al*., 1992), the Imo River (see Orji and Akobuche, 1989; Orji and Onyejiaka, 1990) or any other proximate aquatic system.

Fish familial variety and representation

Seventeen (17) fish families are presently known from the Stubbs Creek (Tables 3 & 4). There is approximately 2 species per family (i.e 1.9 spp family^{-1}) and familial density is 30 families km^{-2}.

A comparative fish familial richness (FFR) profile of some Nigerian streams (Table 7) shows that with the exception of the Ikpoba stream (FFR =20), the Stubbs C Creek has the highest FFR of the streams compared.

Eco Ecophysiological Fish Faunal Assemblages

Fish ecologists often analyze biodiversity by classifying fishes into three Divisions or assemblages according to their physiological salinity tolerance

Table 7. The fish familial richness and fish familial diversity indices for some Nigerian streams

Streams	FFR	N	FFD	Source
Odo-Ona	9	305	30	1
Udom	10	342	29	2
Nung Oku	11	270	41	2
Mission	12	229	53	2
Ikpa	7	442	16	3
Iba Oku	11	312	35	4
Ikpoba	20	524	38	5
Stubbs	17	253	67	6

FFR = fish familial richness; FFD = fish familial diversity; N = sample size
Source: 1 = Sydenham (1975); 2 = Udoidiong (1991); 3 = Onuoha *et al* (2010); 4 = Udo-Udo (2012); 5 = Victor and Tetteh (1988); 6 = This study.

Viz: primary freshwater fishes, secondary freshwater fishes and peripheral fishes (Leveque, 1997) (Table 3). The primary freshwater assemblage comprises fishes that evolved in freshwater environments and have no extant or historical evidence of any m of Salinity tolerance. These fishes are therefore considered as freshwater stenohaline forms. Their spatial distributions are limited by the presence of Saline water habitats. The secondary freshwater assemblage consist of fishes That are usually restricted to life in fresh waters but have sufficient tolerance for Saline water such that members can freely invade coastal saline water environments. Together, the primary and secondary fresh water fishes constitute the group traditionally referred to as freshwater fishes. The peripheral assemblage comprises coastal marine fishes with members that are sporadic or permanent freshwater residents. They are mostly euryhaline, a trait that enables them to freely traverse marine, brackish water and freshwater environments. They are also known as 'marine intrusive fishes'. The fishes of the Stubbs Creek are dominated by the primary freshwater elements (21 species or 65.6% of total species number). This is followed by the secondary freshwater elements with 9 species (28.1%) while the peripheral assemblage was the least diverse with 2 species (6.3%) (Table 3). The most diverse primary freshwater fish family is Clariidae (1 genus/3 species). It is followed by Mormyridae (2genera/ 2species), Alesteidae (2genera/2 species. Each of 4 families has 1 genus and 2 species. Seven (7) families are monogeneric /monospecific, Zaret and Rand, 1971;

Diversity of habitat assemblages

Stream fishes often partition the habitat space by occupying different strata of the water column (Zaret and Rand, 1971; Watson and Balon, 1984). Hence the benthic assemblage is made up of fishes that live at the bottom and often make contact with the substrate. Most of them have flattened ventral surfaces and ventral or subventral mouths. They forage primarily on bottom food resources. The benthopelagic assemblage comprises fishes that inhabit the water column close to the bottom but not necessarily making contact with the substrate. The pelagic assemblage consists of mid water dwelling fishes. They forage primarily from mid water. Their diets hardly contain bottom food resources except foraging takes place in very shallow areas. The epipelagic fishes occupy the upper surface layer or the air – water interface. They typically have flattened dorsal surfaces with terminal or upturned mouth positions. The habitat niches of the fishes of the Stubbs Creek (Table 3) reveals the dominance of benthopelagic fishes (12 species or 37.5% of total species number). This is followed by the benthic assemblage (10 species or 31.3%), epipelagic / pelagic fishes (5 species each or 15. 6%).

Mesohabitat partitioning in the Stubbs Creek shows that the fishes do not exist in a random assemblage. Habitat partitioning promotes coexistence of high taxa packing (i.e taxonomic variety).

Diversity of life enhancement devices

Life enhancement devices are adaptive biophysical body structures and processes (Table 8) that optimize life history performance, maximize body relative wellbeing (i.e. health quality status) and promote the survival efficiency of the species population. For instance, the chemosensory/tactile barbels of fishes allow the specific taxocenes to forage efficiently at night and during periods of low transparency. The weak electric organ discharges of the Mormyriformes enable the fishes to have good orientation, detect prey/ predators as well as identify breeding partners and conspecifics. A given species can have two or more life enhancement devices.

Table 8 shows that a minimum of 27 species (84.4%) have developed one or more life enhancement device or the other. These account, in part, for the diversity and success of the fish faunal assemblage of the Stubbs creek.

Fishery potential yield

The Stubbs Creek supports modest subsistence/ sport fisheries but there are no catch records. However, an insight into potential yield (C, tonnes yr^{-1}) can be obtained from the catch –basin area relationship of Welcomme (1975):

$$C = 0.1326A^{0.8533} \quad .. (6)$$

where A = drainage basin area for a river with limited floodplain. This relationship for the Stubbs Creek with A = 513 km^2 gives a potential yield of C = 27.2 tonnes yr^{-1}. A parsimonious assessment of the catches revealed the common occurrence of the Notopteridae,Cichlidae, Channidae and Anabantidae. The numbers exploited do not appear to constitute any serious problems to the exploited fish taxa. Fishes not exploited for human

Table 8. Summary of the life enhancement devices of the fishes of the Stubbs Creek, Nigeria.

Structures / processes	Taxocene examples
Tough scales	Polypteridae (1 sp),
Phractolaemidae (1 sp)	
Chemosensory/tactile barbels	Clariidae (3 spp); Claroteidae (2spp);
Malapteruridae (1 sp)	
sensory rostral/ nasal appendages	Notopteridae (1 sp); Channidae (2 spp)
Weak electric organ discharges	Eleotridae
Strong electric organ discharges	Malapteruridae (1 sp)
Tactile filaments	Pantodontidae (1 sp)
Special respiratory organs	Polypteridae (1 sp); Phractolaemidal (1 sp); Clariidae (3 spp);
Anabantidae (2 spp).	
Bucchopharyngeal respiration	Eleotridae (2 spp)
Formidable teeth	Hepsetidae (1 sp)

consumption include Aplocheilidae, Pantodontidae, Nandidae, Polypteridae, Eleotridae and Phractolaemidae. It is either these fishes are too small in size or there are certain ancient taboos associated with them. They are thus naturally protected from over exploitation. With rational management, the estimated potential yield can sustainably supply a few families with animal protein source on a yearly time frame.

. CONCLUSION

It is figured here that the fish faunal taxonomic heterogeneity and the diversity of functional ecological assemblages are considerable reference points that qualify the Stubbs Creek to be classified as a Stream of Special Scientific Interest' (SSSI) for management and conservation purposes. It is of utmost importance for deliberate policies and actions to be put in place in order to save this valuable ecosystem from further degradation from oil pollution.

Conflict of Interest - None

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