National Journal of Advanced Research
Online ISSN: 2455-216X; Impact Factor: RJIF 5.12
www.allnationaljournal.com
Volume 3; Issue 1; January 2017; Page No. 10-16

Short communication on record of *Clarias gariepinus* (Burchell, 1822) and its impact on biodiversity of seasonal swamp at Thoothukudi, Tamil Nadu

[*1] Sudhan C, [2] Moulitharan N

[1] PG Research Scholar, Department of Fisheries Biology and Resource Management, School of Fisheries Resources and Environment Management, Fisheries College and Research Institute, Tamil Nadu Fisheries University, Thoothukudi, Tamil Nadu, India

[2] Third Year UG Scholar, Fisheries College and Research Institute, Tamil Nadu Fisheries University, Thoothukudi, Tamil Nadu, India

Abstract
This paper contributes and provides additional information pertaining to the morphometrics, morphology, meristics characteristics, systematic classification, biology, distribution, country wise occurrence, ecological role, fishery status, life cycle, mating behavior, habits, habitats, human uses and their impacts on production systems and natural habitats in relation with biodiversity has been discussed with the clinical signs observed in the collected samples of *Clarias gariepinus* (Burchell, 1822) in seasonal swamp of Thoothukudi district, Tamil Nadu, India. Based on the opinion analysis from the fishers of swamps and calculated biodiversity indices shows the relative abundance of the fish species caught was relatively reduced with negative impact pertaining to biodiversity on the ecosystem.

Keywords: morphometrics, morphology, clinical signs, biodiversity and swamp

1. Introduction
Swamps were low-lying, water logged, shallow areas with loose peaty bottom, rich in decaying organic matters retaining with water either perennially shrinking during the summer or seasonally drying up during the summer months. Swamps were also known as forested wetlands. Like marshes, they were often found near rivers or lakes and have mineral soil that drains very slowly. Unlike marshes, they have trees and bushes. They may have water in them for the whole year or for only part of the year. Swamps vary in size and type. Some swamps have soil that is nutrient rich; other swamps have nutrient poor soil. Swamps were often classified by the types of trees that grow in them. Based on the observation, the study area was considered to be seasonal freshwater swamps. These freshwater swamps were formed around lakes or streams. Rain and seasonal flooding cause water levels to fluctuate. In the wet soil, water-tolerant vegetation grows and helps maintain a moist, swampy condition. Alligators, frogs, fishes like tilapia, climbing perch, catfishes and weed fishes and many other animals live in these swamps. These animals are adapted to fluctuating water levels. The shadowy tree root system and root nodes provide a rich, sheltered habitat for nesting birds, as well as fish, amphibians and reptiles. In these swamps, the African catfishes were found while fishing and all characteristics has been noted to study the impacts on the ecosystem. Generally, African catfish were mentioned for traditional capture and culture-based aquaculture for centuries ago. Yet, their culture in modern times follows a similar trend to that of tilapias.

2. Review of Literature
2.1 Etymology
Clarias derived from Greek word "chlaros" which means "lively", in reference to the ability of the fish to live for a long time out of water; *C. gariepinus* named after River Gariep, South Africa.

2.2 Systematic position of African Catfish
Kingdom: Animalia
Phylum: Chordata
Sub-phylum: Vertebrata
Class: Actinopterygii
Order: Siluriformes
Family: Clariidae
Genus: *Clarias*
Species: *C. gariepinus*
Binomial name: *Clarias gariepinus* (Burchell, 1822)
Common Name: African Catfish (Belongs to Air-breathing catfishes)

2.3 Environmental Range
It belongs to freshwater and habitat benthopelagic; potamodromous in nature i.e. Migration of species within freshwater regions (Riede, 2004) [13]; depth range falls within 0 - 80 m (Witte and de Winter, 1995); Subtropical (de Moor and Bruton, 1988) [5]; 8°C - 35°C; 42°N - 28°S, 17°W - 51°E with respective to latitude and longitude directions.

2.4 Length – Weight Relation
Lm stands for length at first maturity was reported to be 30.8 cm and falls within the range 34 – 70 cm, the maximum recorded length was 170 cm (i.e. Total Length – unsexed); (IGFA, 2001) [10]; the recorded standard length was 90.0 cm (Van Oijen, 1995) [19]; the maximum published weight was reported to be 60.0 kg (Robins *et al*., 1991) [14]; and the maximum reported age was 15 years (Weyl and Booth, 2008) [20].

2.5 Meristics Characters

Dorsal spines (in total number): 0; Dorsal soft rays (in total number): 61-80; Anal spines (in total number): 0; Anal soft rays (in total number): 45 - 65; Vertebrae (in total number): 56 - 63.

2.6 Morphological and Morphometrics Characters

Body depth 6-8 times in standard length, head 3-3,5 times. Head somewhat between rectangular and pointed in dorsal outline; snout broadly rounded; eyes supero-lateral and relatively small (Teugels, 1986) [17]. Teeth on premaxilla and lower jaw small, fine and arranged in several rows; nasal barbels 1/5-1/2 times as long as head in fishes longer than 12 cm, and 1/2-4/5 of head length in smaller individuals; maxillary barbels rarely shorter than head, usually somewhat longer and reaching to a point midway between origin of dorsal fin and insertion of pelvic fins; outer mandibular barbel longer than inner pair. Contrary to other Clarias species, *Clarias gariepinus* has a high number of gill rakers varying from 24-110 (Hanssens, 2009) [9], the number increasing with size of the fish; gill rakers long, slender and closely set. Distance between occipital process and base of dorsal fin is short; dorsal fin almost reaches caudal fin; anal fin origin closer to caudal fin base than to snout, nearly reaching caudal fin; pelvic fin closer to snout than to caudal fin base; pectoral fin extends from operculum to below 1st dorsal fin rays; pectoral spine robust, serrated only on its outer face, the number of serrations increasing with age; lateral line appears as a small, white line from posterior end of head to middle of caudal fin base; openings to secondary sensory canals clearly marked. 2 colour patterns can be discerned like uniform and marbled pattern; in uniform pattern, dorsal surface and flanks of body and dorsal parts of pectoral and pelvic fins are generally dark greyish-greenish black, while belly and ventral parts of paired fins are lightly coloured; in marbled pattern, specimens show irregular dark blotches on light coloured background above and laterally, belly and ventral parts of the paired fins are whitish. Most specimens show pigmentation bands on both sides of lower surface of head (Teugels *et al*., 2007) [18], but these might be absent. A series of light and dark bands may occur on caudal fin; proximal third of caudal fin lightly coloured while other part is dark; occasionally, irregular black spots may occur on caudal fin.

2.7 Distribution

i) **Africa** almost Pan-Africa, absent from Maghreb, the upper and lower Guinea and the Cape Province.

ii) **Asia:** Jordan, Israel, Lebanon, Syria and southern Turkey. It was widely introduced to other parts of Africa, Europe and Asia.

iii) Several countries report adverse ecological impact after introduction.

2.8 Countries and their occurrence

i) Native

Algeria; Angola (Angola); Benin; Botswana; Burkina Faso; Burundi; Cameroon; Central African Republic; Chad; Congo; Congo, The Democratic Republic of the; Egypt; Eritrea; Ethiopia; Ghana; Guinea; Israel; Jordan; Kenya; Libya; Malawi; Mozambique; Namibia; Niger; Nigeria; Rwanda; Senegal; Somalia; South Africa; Sudan; Swaziland; Syrian Arab Republic; Tanzania, United Republic of; Togo; Turkey; Uganda; Zambia; Zimbabwe.

ii) Introduced

Argentina; Bangladesh; Brazil; Cambodia; China; Côte d'Ivoire; Czech Republic; Gabon; Greece; India; Indonesia; Iraq; Lao People's Democratic Republic; Lesotho; Mali; Myanmar; Netherlands; Philippines; Singapore; Thailand; Viet Nam

iii) Present - origin uncertain

Cyprus; France; Hungary; Mauritania; Poland; Russian Federation

2.9 Biology

Adults occur mainly in quiet waters, lakes and pools and prefer rather shallow and swampy areas with a soft muddy substrate and calmer water (Seegers, 2008) [15]. They may also occur in fast flowing rivers and in rapids. It has wide tolerant of extreme environmental conditions. Water parameters appear to play only a very minor role. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions. They remain in the muddy substrates of ponds and occasionally gulp air through the mouth. Can leave the water at night using its strong pectoral fins and spines in search of land-based food or can move into the breeding areas through very shallow pathways (Burgess, 1989) [2]. Feed at night on a wide variety of prey like insects, plankton, invertebrates and fish but also take in young birds, rotting flesh and plants. Migrate to rivers and temporary streams to spawn. It is also known as sharp tooth catfish in aquaculture, a highly recommended food fish in Africa (Frimodt, 1995 and Okeyo, 2003) [7, 13].

2.10 Life cycle and mating behavior

It belongs to oviparous mode of reproduction. Spawning takes place during the rainy season in flooded deltas. The fishes make a lateral migration towards the inundated plains to breed and return to the river or lake soon afterwards while the juveniles remain in the inundated area. Juveniles return to the lake or river when they were between 1.5 and 2.5 cm long. First sexual maturity occurs when females were between 40-45 cm and males between 35-40 cm. Eggs were greenish. Incubation lasts about 33 hours at 25°C.

2.11 Habits

It was considered to be a nocturnal fish like many catfish. It feeds on living, as well as dead, animal matter. Because of its wide mouth, it has the ability to swallow relatively large prey as whole. It has been known to take large water birds such as the common moorhen. It was able to crawl on dry ground to escape drying pools and to survive in shallow mud for long periods of time, between rainy seasons. But, sometimes produce loud croaking sounds, not unlike the voice of the crow.

2.12 Fishery Status

It was placed under International Union for Conservation of Nature and Natural resources in red list as Least Concern (IUCN, 2014) [11] and under Convention on International Trade in Endangered Species as Not Evaluated (CITES, 2013) [4]. It was considered to be threat to humans as (Robins *et al*., 1991) [14] Potential pest even though used as minor

commercial fisheries directly supports aquaculture and commercially considered as game fish.

2.13 Predator

Humans, Aves, Crocodiles and Eagles.

2.14 Estimates of some properties based on models

The calculated Phylogenetic diversity index (Faith *et al*., 2004) [6] was found to be PD50 = 0.5000 [Uniqueness, the value ranges from 0.5 as low to 2.0 as high]. The Bayesian length-weight relationship says a=0.00708 (the value ranges from 0.00593 to 0.00845), b=3.00 (the value ranges from 2.95 - 3.05), based on Length Weight Relationship estimates for this species from the available literature (Froese *et al*., 2013). The estimated trophic level of this species was found to be 3.8 ±0.4 and the resilience was found to be medium (Cheung *et al*., 2005 and Sumaila *et al*., 2007). The minimum population doubling time 1.4 - 4.4 years (K=0.06-0.19; tm=2; Fecundity > 10,000).

2.15 Natural spawning

Spawning mostly takes place at night in the shallow, inundated areas of the rivers lakes and streams. Courtship was preceded by highly aggressive encounters between males. Courtship and mating takes place in shallow waters between isolated pairs of males and females. The male lies in a U-shape curved around the head of the female, held for several seconds. A batch of milt and eggs was released followed by a vigorous swish of the female's tail to distribute the eggs over a wide area. The pair usually rests after mating (from seconds up to several minutes) and then resume mating. Parental care for ensuring the survival of the catfish offspring is absent except by the careful choice of a suitable site. Development of eggs and larvae was rapid and the larvae are capable of swimming within 48–72 hours after fertilization.

2.16 Advantages in rearing

1. In most countries, it fetches a higher price than tilapia, as it can be sold live at the market
2. It can be raised in high densities, resulting in high net yields (6–16 t/ha/year).
3. It grows fast and feeds on a large variety of agriculture byproducts
4. It is hardy and tolerates adverse water quality conditions
5. It matures and relatively easily reproduces in captivity
6. It tolerates difficult conditions in aquaculture

2.17 Parasites and diseases

Clarias gariepinus may host several species of digeneans, in addition to other endo- and ectoparasites like *Costia* sp., *Chilodonella* sp., *Trichodina maritinkae*, *Henneguya* sp. (Protozoans); *Cysticerca* sp. (Nematodes); *Gactylogyrus* sp. and *Gyrodactilus* sp. (Trematodes); *Saprolegnia* sp. (Fungi); *Myxobacteria* sp. and *Aeromonas hydrophila* (Bacteria) and followed by unknown disease symptoms like Broken head, Ruptured intestine syndrome, Ulcerative disease, Bloody streaks, Damaged barbells and damaged skins.

3. Materials and Methods

The study area is located in Chidambaranagar (Latitude: 8°46’48.51”N; Longitude: 78°6’36.10”E), Thoothukudi, Tamil Nadu. The structured survey schedule was prepared and results brought by SPSS (Statistical Package for the Social Sciences) software package (Version 16.0). The survey include different parameters like respondent code, age, sex, religion, literacy level, marital status, family structure, family composition, residential status, reason for fishing, nature of occupation, average days of fishing, experience in fishing, average no of fish variety caught, average annual income, account of new fish, items of consumption, health status and social affiliation were collected by this method to test correlation between the variables and their significant contribution and to know the basic details about the fishing techniques practiced, number and size of fishes caught; followed by collection of fishes and water sample for the duration of six months from February 2016 to July 2016 from study area to identify and classify the fishes according to the taxonomic classification and analyze the water quality parameters. The distribution of fish species were studied and based on the occurrence data biodiversity indices were calculated by using dominance plot in PRIMER-6, i.e. Plymouth Routine in Multivariate Ecological Research software (Version 6.1.9).

4. Results

The SPSS results found that there was a positive correlation at 0.05 significant difference (2-tailed) between average days of fishing and average number of fish varieties caught; experience in fishing and average annual income; average annual income and item of consumption; social affiliation and item of consumption respectively. The survey denies the fishing was found to be seasonal and gill net, cast net and hand lines were used to catch fishes by the fishers and other local peoples in and around the swamp. The swamp would be completely filled by occasional rain or unusual flood and partly filled by the connection with Lake korrampallam. The different biodiversity indices like Margalef index, Shannon index and Hill number index were calculated to show the richness, evenness and the impact on diversity. Therefore, average of 2.8667; 3.1425 and 9.0617 were found to be the calculated values for various indices mentioned above respectively (Table – 01). The observations were made from 150 fishes representing 3 order, 7 family, 13 genus and 15 species (Fig – 12: Dominance plot). The fishes identified were Catla, Rohu, Mrigal, African catfish, Indian walking catfish, Climbing perch, Tilapia, Fresh water shark, Murrel, Common carp, Silver carp, Barbs and other minor catfishes (Table – 03). The water quality parameters shows significant variation from Temperature shows minimum 29 to maximum 30.5°C; Dissolved Oxygen from 2.5 (min) to 3.7 (max) mg/l; pH from 7.9 (min) to 8.8 (max); Total Alkalinity ranges from 34 (min) to 67 (max) mg/l and Total Hardness ranges from 110 (min) to 250 (max) mg/l. The Morphometric analysis shows different measurements in average (centimeters) of 3 samples collected in centimeter includes Total Length 29.1; Standard Length 24.5667; Pre-Dorsal Length 8.6667; Post Dorsal Length 2.7667; Dorsal Fin Base 18.2; Body Depth 2.8; Pre-Orbital Length 2.4333; Eye Diameter 0.6; Post Orbital Length 4.2333; Head Length 5.9; Pre Anal Length 17.6667; Post Anal Length 4.9 and Length of Pectoral Fin 3.2 (Table – 02). During research period, three samples of African catfishes (Fig: 01 to 06) were collected by hand line fishing method. Among three fishes one fishes found with mechanical injuries. The identified fishes were brought to laboratory at moribund

condition (Fig: 07 to 11) and kept in cemented round tanks for physical observation of behavior and identification of other pathological symptoms.

Table 1: Biodiversity Indices

Sample	S	N	d	H'(log2)	N1
Feb-16	10	17	3.177	3.102	8.585
Mar-16	10	21	2.956	3.178	9.048
Apr-16	12	36	3.07	3.451	10.94
May-16	13	29	3.564	3.512	11.41
Jun-16	9	27	2.427	2.946	7.708
Jul-16	7	20	2.003	2.666	6.346

S: Total species observed
N: Total number of specie observed
d: Species richness
H'(log2): Shannon index
N1: Hill number index

Table 2: Morphometric Measurements

S. No.	Morphometric Characters	Measurements (cm)		
		Sample I	Sample II	Sample III
1.	Total Length	48.90	25.6	12.8
2.	Standard Length	43.5	20.8	9.4
3.	Pre-Dorsal Length	15	7.2	3.8
4.	Post Dorsal Length	4	2.8	1.5
5.	Dorsal Fin Base	27	17.9	9.7
6.	Body Depth	5	1.9	1.5
7.	Pre-Orbital Length	3.5	2.4	1.4
8.	Eye Diameter	0.8	0.6	0.4
9.	Post Orbital Length	7	3.8	1.9
10.	Head Length	10	4.8	2.9
11.	Pre Anal Length	23.5	19	10.5
12.	Post Anal Length	7.5	4.6	2.6
13.	Length of Pectoral Fin	5	2.7	1.9

Table 3: Ichthyofaunal diversity of the swamp

Kingdom/ Phylum/ Class	Order	Family	Scientific Name	Common Name
Animalia/ Chordata/ Actinopterygii	Cypriniformes	Cyprinidae	*Catla catla* (F. Hamilton, 1822)	Catla
			Labeo rohita (F. Hamilton, 1822)	Rohu (Tastiest Fish among Indian major carps)
			Cirrhinus cirrhosis (Bloch, 1795)	Mrigal
			Hypophthalmichthys molitrix (Valenciennes, 1844)	Silver carp
			Cyprinus carpio (Linnaeus, 1758)	Common carp
			Puntius amphibius (Valenciennes, 1842)	Scarlet banded barb
	Perciformes	Cichlidae	*Oreochromis mossambicus* (W. K. H. Peters, 1852)	Mozambique tilapia
			Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia
		Channidae	*Channa striatus* (Bloch, 1793)	Striped murrel
		Anabantidae	*Anabas testudineus* (Bloch, 1792)	Climbing perch
	Siluriformes	Bagridae	*Mystus armatus* (F. Day, 1865)	Catfish
		Clariidae	*Clarias batrachus* (Linnaeus, 1758)	Walking catfish
			Clarias gariepinus (Burchell, 1822)	African sharp tooth catfish
		Siluridae	*Wallago attu* (Bloch & Schneider, 1801)	Helicopter catfish or wallago catfish
			Ompok bimaculatus (Bloch, 1794)	Butter catfish

Fig 1: Dorsal View

Fig 2: Ventral View

Fig 3: Marbled color pattern of fish

Fig 4: Mouth and barbel patterm

Fig 5: Sample fish – African Catfish (Length Measurement)

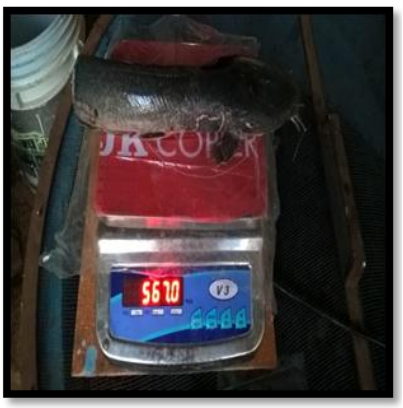

Fig 6: Weighing in Electronic Balance

Fig 7: Fin rot

Fig 8: Skin lesions

Fig 9: Broken Barbels

Fig 10: Ventral side of Fish (Observation of Bloody lesions caused by mechanical injuries)

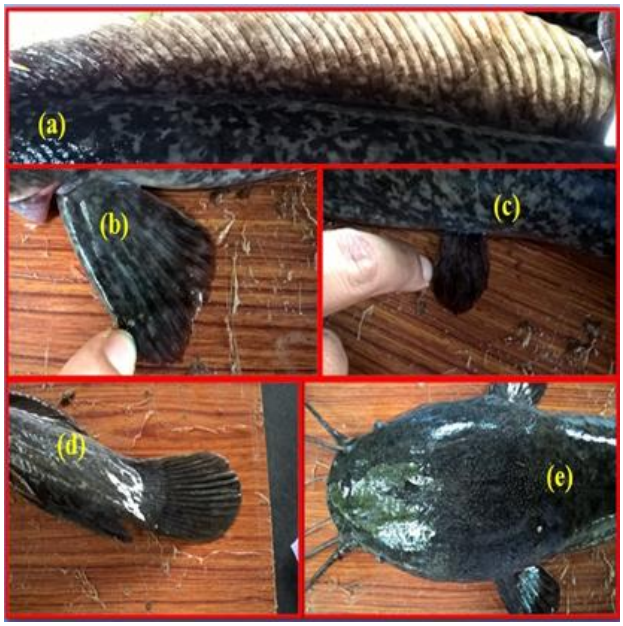

Fig 11: (a) Dorsal Fin, (b) Pectoral Fin, (c) Pelvic Fin, (d) Caudal fin and (e) Dorsal view of head along with barbels

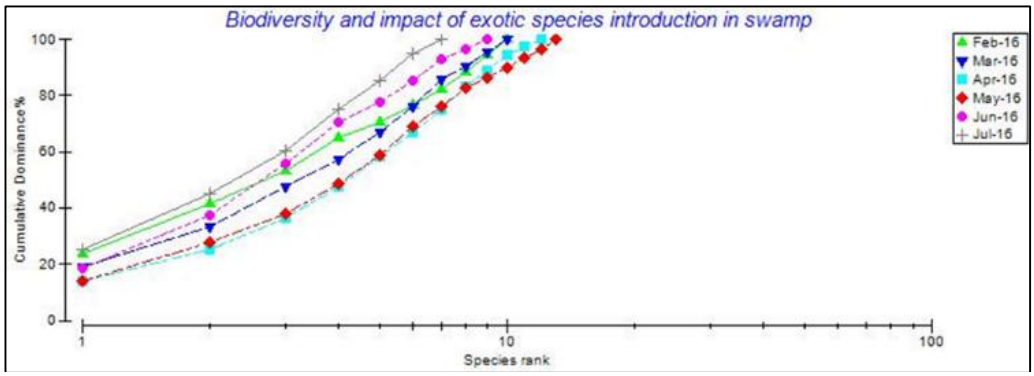

Fig 12: Dominance plot

5. Discussion

On general analysis based on the survey schedule, 0.365 significant correlation between average days of fishing and average number of fish varieties caught; 0.446 significant correlation between experience in fishing and average annual income; 0.447 significant correlation between average annual income and item of consumption; 0.446 significant correlation between item of consumption and social affiliation was found respectively. The negative impact of introduction of exotic species into the swamps or any water bodies were proved statistically by analyzing biodiversity indices. The total number of species was gradually reduced from May 2016 to July 2016. Margalef index, Shannon index and Hill number index shows fluctuation from 3.564 to 2.003; 3.512 to 2.666 and 11.41 to 6.346 from May 2016 to July, 2016. From this, we could understand that, the African sharp tooth catfish *Clarias gariepinus* Burchell, 1822 occurrence and loss of biodiversity has significant correlation in the natural system for space, food and richness in diversity. The loss of biodiversity may be due to high evaporation, temperature fluctuation and other water quality parameters, but even under these unfavorable conditions, African catfish could thrive and compete for habitat and feeding materials. As the research output, the growth rate and species diversity was significantly affected by the introduction of exotic species like *Clarias gariepinus* Burchell, 1822 in wild waters or streams could be controlled and endemic species should be protected to conserve natural and national wealth of India for future generations.

6. Reference

1. Anoop KR, Sundar KSG, Khan BA, Lal S. Common Moorhen *Gallinula chloropus* in the diet of the African catfish *Clarias gariepinus* in Keoladeo Ghana National Park, India. Indian Birds. 2009; 5(2):22-23.
2. Burgess WE. An atlas of freshwater and marine catfishes. A preliminary survey of the Siluriformes. T.F.H. Publications, Inc., Neptune City, New Jersey (USA). 1989, 784.
3. Cheung WWL, Pitcher TJ, Pauly D. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. Biol. Conserv. 2005; 124:97-111.
4. CITES. Appendices I, II and III valid from 12 June 2013. UNEP. 2013.
5. de Moor IJ, Bruton MN. Atlas of alien and translocated indigenous aquatic animals in southern Africa. A report of the Committee for Nature Conservation Research National Programme for Ecosystem Research. South African Scientific Programmes Report Port Elizabeth, South Africa. 1988; 144:310.

6. Faith DP, Reid CAM, Hunter J. Integrating phylogenetic diversity, complementarity, and endemism for conservation assessment,. Conser. Biol. 2004; 18(1):255-261.
7. Frimodt C. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, England. 1995, 215.
8. Froese R, Thorson J, Reyes Jr RB. A Bayesian approach for estimating length-weight relationships in fishes. J Appl Ichthyol. 2013, 1-7.
9. Hanssens M. A review of the Clarias species (Pisces; Siluriformes) from the Lower Congo and the Pool Malebo. J Afrotrop Zool. 2009; 5:27-40.
10. IGFA. Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA. 2001.
11. IUCN. IUCN Red List of Threatened Species. Version 2014.1. IUCN 2014. IUCN Red List of Threatened Species. 2014.
12. Okeyo DO. On the biodiversity and the distribution of freshwater fish of Namibia: an annotated updateIn M.L.D. Palomares, B. Samb, T. Diouf, J.M. Vakily and D. Pauly (eds.) Fish biodiversity: local studies as basis for global inferences. ACP-EU Fish. Res. Rep. 2003; 14:156-194, 281.
13. Riede K. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany. 2004, 329.
14. Robins CR, Bailey RM, Bond CE, Brooker JR, Lachner EA, Lea RN *et al*. World fishes important to North Americans. Exclusive of species from the continental waters of the United States and Canada. Am. Fish. Soc. Spec. Publ. 1991; (21):243.
15. Seegers L. The catfishes of Africa: A handbook for identification and maintenance. Aqualog Verlag A.C.S. GmbH, Germany. 2008, 604.
16. Sumaila UR, Marsden AD, Watson R, Pauly D. A global ex-vessel fish price database: construction and applications. J Bioeconomics. 2007; 9:39-51.
17. Teugels GG. A systematic revision of the African species of the genus Clarias (Pisces; Clariidae). Ann. Mus. R. Afr. Centr., Sci. Zool. 1986; 247:199.
18. Teugels GG, Adriaens D, Devaere S, Musschoot T. Clariidae. In M.L.J. Stiassny, G.G. Teugels and C.D. Hopkins (eds.) The fresh and brackish water fishes of Lower Guinea, West-Central Africa. Collection Faune et Flore tropicales 42. Institut de Recherche pour le Développement, Paris, France, Muséum National d'Histoire Naturelle, Paris, France, and Musée Royal de l'Afrique Centrale, Tervuren, Belgium. 2007; 1(800):653-691.
19. van Oijen MJP. Appendix I. Key to Lake Victoria fishes other than haplochromine cichlids. In F. Witte and W.L.T. van Densen (eds.) Fish stocks and fisheries of Lake Victoria. A handbook for field observations. Samara Publishing Limited, Dyfed, Great Britain. 1995, 209-300.
20. Weyl OLF, Booth AJ. Validation of annulus formation in otoliths of a temperate population of adult African sharptooth catfish Clarias gariepinus using fluorochrome marking of wild fish. J Fish Biol. 2008; 73:1033-1038.
21. Witte F, de Winter W. Appendix II. Biology of the major fish species of Lake Victoria. In F. Witte and W.L.T. Van Densen (eds.) Fish stocks and fisheries of Lake Victoria. A handbook for field observations. Samara Publishing Limited, Dyfed, Great Britain. 1995, 301-320.