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Ichthyofaunal diversity of the Kadana reservoir in Mahisagar district, Gujarat, India

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Abstract
The present study deals with Ichthyofaunal diversity of Kadana reservoir, Gujarat. Sampling was done at every month during July 2018 to February 2019. Total 32 species from 6 orders, 13 families and 22 genera were recorded during the present study. Cypriniformes was the dominant order in term of species diversity (12 species) followed by Siluriformes (10 species), Perciformes (6 species) and Synbranchiformes (2 species) and Osteoglossiformes and Beloniformes were represented by 1 species each. Dominant families were Cyprinidae (12species) followed by Bagridae (4 species), Siluridae and Channidae (3 species), Mastacembelidae (2 species), 1 species of Claridae, Heteropneustidae, Schilbeidae, Cichlidae, Ambassidae, Gobiidae, Belonidae and Notopteridae families. Total of 32 species of fishes were recorded during study period. Out of these 1 species comes under vulnerable status, 27 fish species comes under status of least concern, 1 fish species comes under data deficient status and 4 fish species comes under near threaten. During month of February highest fish diversity was found. Average fish diversity was found during month of July and lowest diversity was found during the month of November. This is first ever study on the fish diversity of Kadana reservoir and would help in explore the fish fauna of Kadana reservoir.

Keywords: Kadana reservoir, Ichthyofaunal diversity, Seasonal variation, physico-chemical parameters

1. Introduction
According to Ayyappan and Diwan though traditionally a vegetarian state, Gujarat has shown a tremendous development in inland culture and capture fisheries over the last three decades [1]. In Gujarat, 50 Reservoirs has been listed by State Fisheries Department of Gujarat covering an area of 242205 ha along with there are 561 small irrigation tanks, which are actually reservoirs, with a water spread of 44025 ha. The total area under reservoirs in the State is 286230 ha. Most of them are mad-made belong to the small category while in respect to area they contribute only 29% of the total area [2]. The diversified flora and fauna species recorded from India qualifies it as one of the mega diversity nations of the World [3].

India has prolonged inland fisheries resources with different aquatic water bodies such as tributaries and distributaries of river system and interconnection of canals crisscrossing of the country. It also includes natural lakes, a large number of man-made reservoirs, estuaries and lagoons. India accounts 975 reservoirs spread over in India, covering an area of 3.15 million ha in India which is expected to grow further to 6 million ha in due course of time (25 years) [4].

Reservoirs can be classified as small, medium and large according to their size of less than 1000 ha, 1000-5000 ha and larger than 5000 ha respectively. In India, Indo Gangetic Basin accounts 1.16 million ha reservoirs which are 36.8% of total reservoir area of India. Small reservoirs account for the largest area (40.6 percent), followed by large (33.0 percent) and medium (26.4 percent) reservoirs [5].

Indian reservoirs are very low fish yielding at rate of 20 kg/ ha/yr. as compared to 100 kg/ha/yr. in Sri-Lanka and 88 kg/ha/yr. in Russian Federation. The reason behind this low yield may be an inadequate knowledge of biodiversity of the system, ecology and production functions which may lead to unscientific management and low priority laid on their fisheries development. However, the systematic reservoir fishery investigations were initiated by Central Inland Fisheries Research Institute (CIFRI), Barrackpore as early as in 1963 [6].

Ichthyofaunal biodiversity refers to variety of fish species depending on context and scale; it could refer to alleles or genotypes within of life forms within a fish community and to species or life forms across aqua regimes [7].

According to Jayaram all over the world, 21,723 living species of fish are listed out of 39,900 species of vertebrates [8]. They live in almost all conceivable aquatic habitats in which 8,411 are freshwater species and 11,650 are marine. In India, 2,500 species of fishes have been recorded out of these 930 live in freshwater and 1570 are marine [9].

Kadana Dam came up in 1979 with a 35-million dollar funding from the International Bank for Reconstruction and Development (World Bank) and the International Development Association (IDA) for the multipurpose such as Irrigation, Water Supply, Power Generation and Fisheries. The objective of the study is to provide the updated checklist of fish species available in Kadana reservoir, Mahisagar district of Gujarat.

2. Materials and methods

2.1 Study site description

Kadana reservoir is one of the largest reservoirs of Gujarat. This dam is an earthen and masonry type dam is being constructed 3 km upstream of the Kadana village situated on the banks of river Mahi located in Mahisagar district of Gujarat. The basin lies between geographical co-ordinates of 23°34' N latitudes and 730 85' E longitudes.

The total catchment area of 25,520 km² and 760 millimeters of annual rainfall. The maximum height is about 66m (217 ft.) and the length of the dam is 575m (1886 ft.). The total exist area of reservoir is 166 km². The Gross Storage capacity of water is 1542Mm³. and the effective storage capacity is 1203 mm³.

The maximum discharge of water is 49497 m3/s. there are 21 main gates and 6 additional gates with Radial type and size of gates are (15.5m x 14m). The canal of Kadana reservoir has length of 42km which has water capacity of 11m³/s. the gross command area of canal is 12795 hectare and cultivable command area is 11059 hectare [10].

2.2 Fish sampling method

Fish samples were collected monthly from the selected site of reservoir with the help of local fishermen by various craft and gear. The fishermen were mainly using local fishing gear and nets for fishing and captured fishes were recorded. After collection, fishes were examined, photographed and identified. A few specimens of unidentified species were preserved in buffered formaldehyde 39 solutions (5%) and transported to the laboratory of college of fisheries, Veraval Gujarat for species confirmation. The collected fish samples were sorted and identified up to species level. A few specimens of unidentified species were washed in clean portable water and preserved in formaldehyde solution for further studies. The preserved fishes were sorted into taxonomic groups and Identification was done on the basis of Morphometric characters, Descriptive characters and Fin formula. For the identification of fishes different morphometric characters were noted which includes, total length, standard length, head length, depth of head, eye diameter, snout length, length of pre dorsal fin, pre pectoral fin, pre anal fin, pre caudal fin. rays and spine count of different fins, maximum girth and minimum girth. Along with this morphometric characteristics shape of body, skin colour, texture and position and shape of the mouth, lateral line system were also noticed at fish biology laboratory of Fisheries College, Veraval. The specimens were identified and confirmed with available literature. Specimens with doubtful identifying characters were confirmed from M. S. University, department of zoology, Baroda (Gujarat) [11-13].

3. Results

Kadana reservoir is one of the largest researvoir of Gujarat in terms of Area and water holding capacity but compare to another reservoirs such as Narmada and Ukai poor attention has been paid towards development of Fisheries and systematic investigation on diversity of fish fauna. Earlier studies on this reservoir was focused on the downstream fauna of the Mahisagar researvoir while in present study we focused on the fish fauna of the reservoir and its upstream so it is felt that there is a need to generate information of diversity. Tthe present investigation was undertaken to prepare a checklist of fishes from Kadana reservoir and it is the first effort in this direction. In the present Ichthyofaunal study, a total of 32 fish species belonging to 6 orders, 13 families, and 21 genera were recorded from the Kadana Reservoir. Details of these fishes along with their local name and IUCN status are listed in table-1 and figure 1.

Table 1: List of fishes and their order, family, species, common name, Fin formula, level of abundance and IUCN status of Kadana reservoir.

Sr.no	Scientific name	Common Name	Local name	Fin formula	Conservation status		Level of abundance
					IUCN	CITES	
Order: Cypriniformes Family: Cyprinidae							
1.	*Catla catla* (Hamilton, 1822)	Catla	Katla	D.18(3/15);P.19;V.9;A.8(3/5);C.19;L.I.38; L.tr.71/2/6	LC	NE	+++
2.	*Labeo rohita* (Hamilton, 1822)	Rohu	Rohu	D.16(3/13);P.17;V.9;A.7(2/5);C.19;L.I.42; L.tr.7	LC	NE	+++
3.	*Labeo calbasu* (Hamilton, 1822)	Black rohu	Kalvat	D.17;P.18;V.9;A.7(2/5);C.19;L.I.40;L.tr.6/7;	LC	NE	+
4.	*Cirrhinus mrigala* (Hamilton, 1822)	Mrigal	Mrigal	D.15(3/12);P.18;V.9;A.8(2/6);C.19;L.I.42; L.tr.7	LC	NE	+++
5.	*Cirrhinus reba* (Hamilton,1822)	Reba carp	Reba	D.11(3/8); P.15;V.9;A.8(2/6);C.19;L.I.23;L.tr.4 1/2/4 1/2	LC	NE	++
6.	*Hypophthalmichthys nobilis* (Richardson, 1845)	Big head Carp	Silver	D.8(1/7);V.8(1/7);A.14(2/12);L.I.110; L.tr.28-33/16-28	DD	NE	-
7.	*Puntius sarana* (Hamilton, 1822)	Olive barb	Dhodhra	D.11(3/8);P.15;V.9;A.8(3/5);C.19;L.I.32; L.tr.61/6/5	LC	NE	+++
8.	*Puntius sophore* (Hamilton, 1822)	Stigma barb	Dhodhra	D.11(3/8);P.15;V.9;A.8(2/6);C.19;L.I.23; L.tr.41/2/4/1/2	LC	NE	++
9.	*Puntius chola* (Hamilton, 1822)	Swamp barb	Dhodhra	D.11(3/8);P.14;V.9;A.8(3/5);C.19;L.I.27; L.tr.31/2/5	LC	NE	-
10	*Salmostoma bacaila* (Hamilton, 1822)	Razor belly Minnow	Chal	D.9(2/7);P.12;V.9;A.15;C.19;L.I.43;L.tr.12/10	LC	NE	+++
11	*Chela laubuca* (Hamilton, 1822)	Indian glass barb	Chal	D.10(2/8); P.13; P2.7; A.21-22(3/18-19)	LC	NE	++
12	*Garra gotyla* (Gray, 1830)	Sucker head	Patharchatta	D.10(2/8);P.15;V.9;A.7(2/5)	LC	NE	++

Order: Siluriformes Family: Bagridae							
13.	*Mystus cavasius* (Hamilton, 1822)	Gangetic mystus	Desi katiyu	D.8(1/7);P.9(1/8);V.6;A.10(2/8);C.16; Barbles four pairs	LC	NE	-
14.	*Mystus bleekeri* (Day, 1877)	Day's mystus	Katiyu	D.8(1/7);P.9(1/8);V.6;A.10(2/8);C.17; Barbles four pairs	LC	NE	++
15.	*Mystus vittatus* (Bloch, 1794)	Striped dwarf catfish	Katiya	D.8(1/7);P.8(1/7);V.6;A.9(3/6);C.17; Barbles four pairs	LC	NE	-
16.	*Sperata aor* **(**Hamilton, 1822)	Aor catfish	Katiyu	D.8(1/7);P.10(1/9);V.6;A.11(3/8);C.17; Barbles four pairs	LC	NE	+
Family: Siluridae							
17.	*Ompok pabda* (Hamilton, 1822)	Pabdah catfish	Pabda /Gangol	D.5; P.1/14; V.9-10; A.3/66-71; Barbles two pairs	NT	NE	+++
18.	*Ompok bimaculatus* (Bloch, 1794)	Butter catfish	Gangol	D.4;P.15(1/14);V.8;A.70;C.17; Barbles two pairs	NT	NE	+
19.	*Wallago attu* (Bloch & Schneider,1801)	Freshwater shark	Padhin	D.5;P.15(11/4);V.10;A.91(4/87);C.17; Barbles two pairs	NT	NE	+
Family: Claridae							
20.	*Clarias batrachus* (Linnaeu, 1758)	Philippine catfish	Magur	D.65;P.9(1/8);V.6;A.47;C.17; Barbles four pairs	LC	NE	+
Family: Heteropneustidae							
21.	*Heteropneustes fossilis* (Bloch, 1794)	Stinging catfish	Singhi	D.6;P.8(1/7);V.6;A.74;C.19;Barbles four pairs	LC	NE	++
Family: Schilbeidae							
22.	*Clupisoma garua* (Hamilton, 1822)	Garua bachcha	Bekdi	D.8(1/7); P.12(1/11); V.6; A.32(3/29); C.17; Barbles four pairs	LC	NE	-
Order: Perciformes Family: Cichlidae							
23.	*Oreochromis mossambicus* (Peters, 1852)	Mozambique Tilapia	Tilapia	D.28(16/12);P.14;V.6(1/5);A.14(3/11);C.16; L.I.33;L.tr.31/2/31/2	NT	NE	+++
Family: Ambassidae							
24.	*Chanda nama* (Hamilton, 1822)	Elongate glass perchlet	Buchi	D.22(1+6/1+14);P.12;V.6(1/5);A.19(3/16); C.17;L.tr.Scales deciduous	LC	NE	++
Family: Channidae							
25.	*Channa striata* (Bloch, 1793)	Striped snakehead	Doke	D.43;P.16;V.6;A.24;C.13;L.I.40;L.tr.15(5/10)	LC	NE	++
26.	*Channa punctata* (Bloch, 1793)	Spotted snakehead	Doke	D.32;P.16;V.6;A.22;C.12;L.I.35;L.tr.4/7	LC	NE	+
27.	*Channa marulius* (Hamilton, 1822)	Great snakehead	Doke	D.51;P.18;V.5;A.32;C.15;L.I.65;L.tr.51/2/12	LC	NE	++
Family: Gobiidae							
28.	*Glossogobius giuris* (Hamilton, 1822)	Tank goby	Upridola	D.6/1+9;P.20;V.6(1/5);A.10(1/9);C.17;L.I.32;L.tr.12	LC	NE	+
Order: Beloniformes Family: Belonidae							
29.	*Xenentodon cancila* (Hamilton, 1822)	Freshwater garfish	Suva	D.16;P.11;V.6;A.17;C.15	LC	NE	+++
Order: Osteoglossiformes Family: Notopteridae							
30.	*Notopterus notopterus*(Pallas, 1769)	Bronze feather back	Patola	D.8(1/7);P.17;V.6;A.100;C.19;L.I.200; L.rt.25/50	LC	NE	++
Order: Synbranchiformes Family: Mastacembelidae							
31.	*Mastacembelus armatus* (Lacepede, 1800)	Zig zag spiny eel	Bam	D.34/74;P.23;V.abst.; A.3/75;C.20(Confluence with dorsal and anal)	LC	NE	+++
32.	*Macrognathus pancalus* (Hamilton, 1822)	Barred spiny eel	Bam	D.25/32;P.19;A.3/40;C.12	LC	NE	++

+ = Present ++ = Common +++ = Abundant – = Rare

IUCN red list status. (2015-4): EN- Endangered; VU- Vulnerable: LRnt- Lower risk near threatened; LRlc- Lower risk least concern; LC- Least concern; DD-Data Deficient; NE- Not evaluated, NT-Near threaten.

D- Dorsal fin; P- Pectoral fin; V- Ventral/ Anal fin; C- Caudal fin; L.I.- Lateral line of perforated scale; L.tr. - Lateral transverse row of scale

On the basis of percentage composition and species richness, order Cypriniformes was dominant (12 species) followed by Siluriformes (10 species), Perciformes (6 species), Synbranchiformes (2 species) and Beloniformes, Osteoglossiformes (1 species each). During the present investigation the order of dominance is as follows:

Cypriniformes > Siluriformes > Perciformes > Synbranchiformes > Beloniformes = Osteoglossiformes.

The family Cyprinidae under order Cypriniformes was represented by 12 species, *Catla catla, Labeo rohita, Labeo calbasu, Cirrhinus mrigala, Cirrhinus reba, Hypophthalmichthys nobilis, Puntius sarana, Puntius ticto, Puntius sophore, Salmostoma baicala, Chela laubuca, and Garra gotyla,* Under order Siluriformes family Bagridae was represented by 4 species, *Mystus cavasius, Mystus bleekeri*, *Mystus vittatus* and *Sperata aor;* family Siluridae was represented by 3 species *Ompok bimaculatus, Ompok pabda* and *Wallago attu;* family Claridae was represented by 1 species *Clarias batrachus;* family Heteropneustidae was represented by 1 species *Heteropneustes fossilis.* family Schilbeidae represented by 1 species *Clupisoma garua*, under order Perciformes family Cichlidae was represented by 1 species *Oreochromis mossambicus;* family Ambassidae was represented by 1 species *Chanda nama;* family Channidae was represented by 3 species *Channa striata*, *Channa punctatus* and *Channa marulius* family Gobiidae represented by 1 species *Glossogobius giuris*, under order Beloniformes family Belonidae was represented by 1 species *Xenthodon cancila*, under order Osteoglossiformes family Notopteridae was represented by 1 species, *Notopterus notopterus* and under order Synbranchiformes family Mastacembelidae was represented by 2 species *Mastacembelus armatus* and

Macrognathus pancalus. The global conservation status was assessed by IUCN and CITES evaluation criteria. As IUCN stated and on comparing the results found were 84.34% of Least Concern (LC); 12.05% of Near threatened (NT) and 3.12% of Data Deficient (DD).

The species of *Catla catla, Cirrhinus mrigala, Labeo rohita, Labeo calbasu, Cirrhinus reba, Ompok pabda, Ompok bimaculatus* and *Heteropneustes fossilis*,etc, have food fish value. *Puntius sarana, Puntius sophore Puntiuschola,* and *Salmostoma bacaila*, species have ornamental value due to small size and bright colors used as aquarium fishes. The species of *Mystus cavasius, Mystus bleekeri*, *Mystus vittatus, Mystus aor*, *Wallago attu, Channa striata, Channa punctatus, Channa marulius, Mastacembelus armatus, Macrognathus pancalus, Xenthodon cancila Hypophthalmichthys nobilis, Oreochromis mossambicus, Glossogobius giuris* are predatory, food fish. *Notopterus notopterus* have medicinal value.

Catla catla, Labeo rohita, Cirrhinus mrigala, Hypophthalmichthys nobilis, Heteropneustes fossilis, Oreochromis mossambicus, Channa striata have high commercial value. *Puntius sarana, Garra gotyla, Mystus bleekeri*, *Mystus vittatus, Chanda nama, Glossogobius giuris, Xenentodon cancila,* and *Macrognathus pancalus have* minor commercial value. *Labeo calbasu, Cirrhinus reba, Puntius chola, Puntius sophore, Salmostoma bacaila, Chela laubuca, Mystus cavasius, Mystus aor*, *Ompok pabda, Ompok bimaculatus, Wallago attu, Clarias batrachus, Clupisoma garua, Channa punctatus, Channa marulius, Notopterus notopterus* and *Mastacembelus armatus* have commercial value.

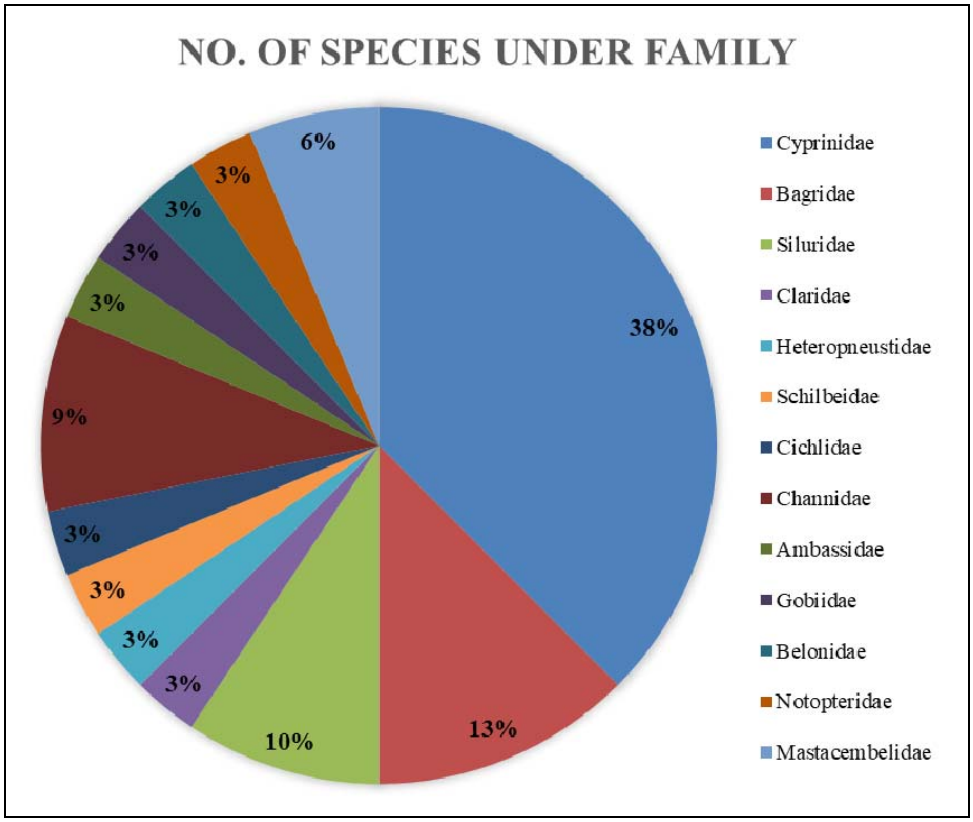

Fig 1: Family Wise Fish Species Composition

4. Discussion

Now a day due to various anthropogenic activities and various environmental influences the documentation of biodiversity has become very important aspect of science. The assessment of fisheries diversity is one of the main parameter which can useful in study of fisheries in any regime in reference to environment and pollution.

Gohil and Mankodi reported fish fauna from Downstream Zone of River Mahisagar, Gujarat includes 26 species belonging to 3 orders and 12 families [14]. Similarly Vyas, reported 27 species from 5 orders and 11 families from Bhadar-1 reservoir, Gujarat [15]. The present ichthyofaunal study was found in the line as same from M.P [16-19], Maharashtra [20-22], Bihar [23, 24], Assam [25, 26], Chhattisgarh [27, 28], Karnataka [29, 30] and Tamil Nadu [31, 32]. Yousuf *et al* reported 29 fish species from Vidisha, Madhya Pradesh. [16]. Wani and Gupta recorded 21 fish species from Sagar lake, Madhya Pradesh [17]. Sixteen fish species were been recorded from Sanjay Sagar lake, Madhya Pradesh by Solanki *et al* [18]. Shinde *et al* reported 15 species of fishes from Harsool Savangi dam, Aurangabad [21]. Ubharhande and Sonawane recorded 21 fish species from Paintakli dam from Buldhana, Maharashtra [22]. Kumar and Singh reported 33 fish species from Kararia lake, Motihari, Bihar [23]. Kumar reported 33 fish species from Sahni Tola Talab of Sundarpur Bela, Darbhanga District, Bihar [24]. Baro *et al* reported 49 species of ornamental fishes from Assam [25]. Choubey and Qureshi reported 45 species from Rajnandgaon, Chhattisgarh [27]. Naik *et al* reported 43 species from Tunga reservoir, Karnataka [29]. Thirumala *et al* reported 33 fish species from Bhadra reservoir, Karnataka [30].

In this present study, total 32 fish species were recorded from which the family Cyprinidae dominate with 12 species followed by Bagridae (4 species), Siluridae and Channidae (3

species). Compared to another studies on the same reservoir the diversity of fish fauna recorded during present study is more. The larger area in size and depth make the reservoir suitable for variety of fish species which might be the result of the higher diversity. The interior area and less accessible ways to transport fishes can render the development of fisheries. There is great scope of development of cage fisheries in the reservoir due to its large size and depth. It is also recommended to create awareness among local stock holders on the importance of the reservoir habitat and its fish fauna and the need to conserve them for future generations.

5. Conclusion

Present study deal with the ichthyofaunal diversity of Kadana reservoir. Kadana reservoir inhibits a variety of fresh water fishes of diverse type which indicates the reservoir having a healthy water body. However, there is constant threat to fish population due to eutrophication and illegal fishing activities. It is recommended that for sustainable fish production in the reservoir, there should be less interference from different anthropogenic activities and steps should be taken to maintain the ecology of the reservoir. There is an urgent need to create awareness among local peoples and illegal fishing activities should be banned. It is also recommended to form cooperative societies for the fisheries development of the reservoir, conservation of fish fauna, sustainable utilization of aquatic resources and to improve socio economic upliftment of local tribal people.

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