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# Diversity of ichthyofauna in Hiran-II reservoir, Gujarat (India)

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**Abstract**
The present study deals with ichthyofaunal diversity of Hiran-II reservoir, Gujarat. Sampling was carried out on monthly basis from January 2019 to February 2020. Total 23 species from 6 orders, 10 families and 19 genera were recorded during the present study. The range of water parameters such as temperature, pH, dissolved oxygen alkalinity and hardness were recorded and found suitable for fish production. Dominant family Cyprinidae with 12 species and 08 genera followed by Bagridae with 03 species 02 genera and other all families Claridea, Heteropneustidae, Cichilidae, Channidae, Gobiidae, Belonidae, Mastacembelidae, Poecilidae and Anguilidae contributed single species with single genera. Regarding conservation status out of 23 fish species 21 species least concern and 2 species near threaten. During month of December (post monsoon) highest fish diversity was found. Seasonal diversity indices such as Shannon-Wiener species diversity, Pielou's evenness, Margalef's species richness, were calculated based on the abundance of fish species to access the ecosystem health of Hiran-II reservoir. These studies will be help for the maintenance and regulation of Ichthyofauna and other aquatic ecosystem of the Hiran-II reservoir.

**Keywords:** Hiran-II reservoir, Ichthyofaunal diversity, seasonal variation, physico-chemical parameters, diversity indices

## 1. Introduction
Fishes are one of the important groups of vertebrates which influence the life of human in various ways. Fishes are an important ecological link in the food chain [1]. The nutritional and medicinal value of fishes has already been recognized [2]. India is having rich source of inland water bodies in the form of rivers, lake and reservoir. The reservoir is constructed by impounding the river system. The reservoirs are constructed for effective utilization of water for irrigation, drinking, power generation and flood control. Reservoir fishery in India is also important from socio-economic point of view.

The total area under the reservoir in India is 3.15 million hectare. This includes 19,000 small reservoirs with the total water spread area of 14,85,557 hectare and about 180 medium and 56 large reservoirs of 5,57,541 hectare and 11,40,268 hectare area respectively [3]. A number of large artificially constructed fish water impoundments have come into existence in India, especially during last four decades, adding considerably to the already existing rich water potential for the development of the country's fishery resources fish fauna of various reservoirs has been reported [4].

Reservoirs form the most important component of inland fishery resources of India with immense potential to enhance the country's inland fish production [5]. In spite of this fact, reservoir fish production has been treated as a by-product and reservoir fisheries have not made significant progress in the country [6].

Biodiversity is essential for stabilization of ecosystem protection of overall environmental quality for understanding intrinsic worth of all species on the earth [7]. A healthy and biologically diverse of aquatic bodies is important to a human who provides food, recreation, pharmaceuticals etc.

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 [8].

Fish constitutes half of the total number of vertebrates in the world. India is one of the mega biodiversity countries in the world and occupies the ninth position in terms of freshwater mega biodiversity [9].

They live in almost all conceivable aquatic habitats; 21,723 living species of fish have been recorded out of 39,900 species of vertebrates, out of these 8,411 are freshwater species and 11,650 in marine; about 2500 species (11.7%) are found in Indian waters. Out of these so far listed, 73 species (3.32%) belong to the cold freshwater regime, 544 species (24.73%) to the warm freshwater domain, 143 species (6.50%) to the brackish water and 1440 species (65.45%) to the marine ecosystem [10].

The 'index of diversity' defined by Fisher *et al*, [11] are two measures of the degree of concentration or diversity achieved when the individuals of a population are classified into groups [12]. In general, there have been two approaches to measuring species diversity, both of which incorporate information on the number of species (species richness) and the relative abundances of individuals within each species (species abundance).

The State fisheries department of Gujarat (India) has listed 711 reservoirs, covering an area of 2,86,230 ha. This is in addition to 561 small irrigation tanks, which are actually reservoirs, with a water spread of 44 025 ha. Thus, the total area under reservoirs in the state is 2,86,230 ha. More than 95% (in number) of these man-made lakes belong to the small category, although they form only 29% of the total area. The small reservoirs in the state have an average size of 349 ha. There are 7 number of large, 28 number of medium and 676 number of small reservoirs present in Gujarat [13].

Present investigations were under taken to study ichthyofaunal diversity of Hiran-II reservoir. Hiran-II reservoir is located near Umrethi village of Talala taluka of Gir-Somnth district, Gujarat (India). The total catchment area of reservoir is 349 $Km^2$. The annual rainfall is about 915 mm. The maximum height is about 15.70 m above the lowest point of foundation. The length of the top of the dam is 3050 m. Total area at full reservoir level is 8 $km^2$. The gross storage capacity of water is 38.58 $mm^3$ [14].

## 2. Materials and Methods

**2.1 Location:** The present study was conducted at Hiran-II reservoir located (Fig.1) near Umrethi village of Talala taluka of Gir-Somnth district, Gujarat (India). The basin lies between geographical co-ordinates of 21°02′47"N latitudes and 70°47′25" E longitudes. The study was carried out on a seasonal basis summer (March to June), Monsoon (July to October) and winter (November to February) periods during January 2019 to February 2020.

**2.2 Analysis of water:** Water samples were collected monthly basis at sampling station during the morning hours. The water temperature was recorded at the site using a digital thermometer and pH was measured in field using a digital pH meter and samples were brought to the laboratory. For DO the samples were collected in glass stopper bottle very carefully in order to avoid contact of the sample with air. The analysis of water samples was carried out for the parameters total hardness (TH), total alkalinity (TA), dissolved oxygen (DO) were determined according to the standard methods in the laboratory [15].

**Fig 1:** Satellite images of study site and inner view of Hiran-II reservoir.

**2.3 Fish sampling process:** Fin fishes were collected from site by random sampling method and data were taken at every one month interval. At the sampling stations fishes were collected from reservoir water by using different types of craft and gears with the help of local fishermen. The fishermen were mainly using local fishing gears and nets for fishing and captured fishes were recorded. Immediately photograph of fish samples were captured with the help of digital camera. Sample fishes were taken at college of fisheries, Veraval after preserving in 10% formalin (commercial i.e. at 40% conc.) solution in separate specimen jar (1000 ml/2000 ml) according to their size. Small fishes were directly placed in the 10% formalin solution while large fishes were dissected and preserved. Collected fish sample were measure and identify up to the species level, with the help of standard keys, book and standard taxonomic references like Day [16], Talwar

and Jhingran [17], Jayaram [18], FAO identification sheets [19] and Fish Base [20]. Specimens with doubtful identifying characters were identified from ICAR-CIFRI (Central Inland Fisheries research institute, Vadodara (Gujarat).

**2.4 Calculation of fish diversity indices:** Using the average species occurrence data as input data, the following biodiversity indices were calculated. The diversity indices were calculated by Shannon s index (H), Species evenness (J') and Species richness (d).

**2.4.1 Measurement of diversity (H)**
The type of diversity were used here is α- diversity which is the diversity of species within a community or habitat. The diversity index was calculated by using the Shannon – Wiener diversity index, [21].

Diversity index = H = – ∑ Pi In Pi

Where Pi = S / N S = number of individuals of one species, N = total number of all individuals in the sample, In = logarithm to base e

**2.4.2 Species evenness (J')**
This was a measure of equitability and a measure of how evenly the individuals are distributed among the species. Evenness was calculated for each station following Pielou's evenness (*J'*) using the formula,

$J'=H'/log2S \text{ or } H'/\ln 2S$

Where, *H'* is the diversity in bits of information per individual and S is the total number of species [22].

**2.4.3 Species richness (d)**
Species was a measure of the total number of species present, making some allowances for the number of individuals. Species richness for each station was calculated following Margalef's index (d) using the formula,

$d=(S-1)/\log e\ N$

Where, S is the total number of species in each sample i.e. samples with non-zero counts and N is the total number of individuals in each sample [22].

## 3. Results and Discussions

### 3.1 Water quality parameters of Hiran-II reservoir

Temperature is an important factor affecting the aquatic chemistry and biological processes of the organisms dwelling therein. Temperature fluctuation in water was influenced considerably by air temperature, humidity and solar radiation [23]. Temperature is one of the most significant water quality parameter that affect aquatic animals [24]. The average temperature during the study period was 24.9±0.71°C. The highest temperature (30.6°C) was observed during the June 2019 (summer) and the lowest temperature (21.4°C) during the December 2019 (winter) at study site. Water temperature in summer, was high due to clear atmosphere, low water level and high solar radiation. Similar observations were reported in Wanparakalpa reservoir Nagpur [25], in Anjanapura reservoir Karnataka [26]. According to Harikrishnan and Azis [27] the water temperature from 28.0°C to 32.0°C was ideal for fisheries in the Neyyar reservoir.

Water of Hiran-II Reservoir was found alkaline in nature throughout the study period. The average pH during the study period was 7.7±0.06. The high pH (8.2) was recorded in the month of June, 2019 (summer season) and the minimum (7.4) was recorded in the month January, 2020 (winter season). The higher concentration of pH during summer season, in Hiran-II reservoir could be attributed to decreased water level, high temperature, enhanced rate of evaporation and increased photosynthesis. Similar observations were reported by Singh and Mahajan [28], Tamot and Bhatnagar [29]. pH range from 6.4 to 8.3 is favourable for fish growth. According to Jhingran and Sugunan [30] the pH range between 6 and 8.5 was medium productive reservoirs, more than 8.5 were highly productive and less than 6 were less productive reservoirs. Input of sewage and agricultural waste are also responsible for higher values of pH in water. Based on these criteria, Hiran-II is a medium productive type. Similar observations were reported by Singh and Mahajan [28], Tamot and Bhatnagar [29].
The average dissolved oxygen during the study period was 8.07±0.35 mg/l. The maximum (9.9 mg/l) was recorded in the month of December, 2019 (winter season) and the minimum (6.0 mg/l) was recorded in the month May, 2019 (summer season). Minimum values of DO were recorded during summer season and maximum during winter months. Minimum DO in months may be due to high metabolic rate of organisms. Maximum DO may be due to low atmospheric temperature. Similar trends were observed by Adebisi [31] and Deshmukh and Ambore [32]. The DO level (7.5 mg/l) of reservoir water may be favorable for aquatic organisms [33].
Hiran-II reservoir average total hardness during the study period was 106.35±4.63 mg/l. the maximum value of Total Hardness was recorded in the summer season month of May 2019 (133 mg/l) and lower in the winter season in the month of December 2019 (86 mg/l) at Hiran-II reservoir. According to Bhatnagar and Devi [34] hardness range 75-150 mg/l is optimum for fish culture. Similar observations were reported by Hujare [35].
The average total alkalinity during the study period was 142.71±1.97 mg/l. the maximum value of total alkalinity was recorded in the month of April 2019 (156 mg/l) and lower in the winter season in the month of December 2019 (130 mg/l) at Hiran-II reservoir. The alkalinity value was maximum in April (summer) due to increase in bicarbonates in the water. High values of total alkalinity during summer may be due to the high water temperature, low water level and increased rate of decomposition and minimum in winter due to high photosynthetic rate. Similar observations were reported by Hujare [35]. Sakhare and Joshi [36] also studied the water quality of Migni (Pangaon) reservoir, Maharashtra.

### 3.2 Total ichthyofaunal diversity recorded in Hiran-II reservoir

In present periodical survey of ichthyofaunal diversity revealed the occurrence of 23 species from 6 orders, 10 families and 19 genera were recorded from Hiran-II reservoir. Cypriniformes was the dominant order in termers of species diversity (12 species) followed by Siluriformes (5 species), Perciformes (3 species), Beloniformes, Cyprinodontiformes and Anguilliformes were represented by one species each (Fig. 2). In Hiran-II reservoir, family with maximum number of taxa was Cyprinidae with 12 species and 08 genera followed by Bagridae with 03 species 02 genera and all other families Claridea, Heteropneustidae, Cichilidae, Channidae, Gobiidae, Belonidae, Mastacembelidae, Poecilidae and

Anguilidae contributed single species with single genera (Fig. 3). They were *Catla catla, Labeo rohita, L. fimbriatus, Cirrihinus mrigala, Puntius sarana, P. Sophore, P. Chola, Salmostoma bacaila, Chela laubuca, Garra mullya, Garra gotyla, Rasbora daniconius* under Cypriniformes, *M. cavasius, M. bleekeri, M. gulio, Clarius batrachus, Heteropneustes fossilis* under Siluriformes, *Oreochromis mossambica, Channa striatus, Glassogobius giuris,* Synbranchiformes under *Xenentodon cancila* under Beloniformes and *Gambusia affinis* under Cyprinodontiformes order. A systematic list of fishes observed from the reservoir has been provided in Table 1.

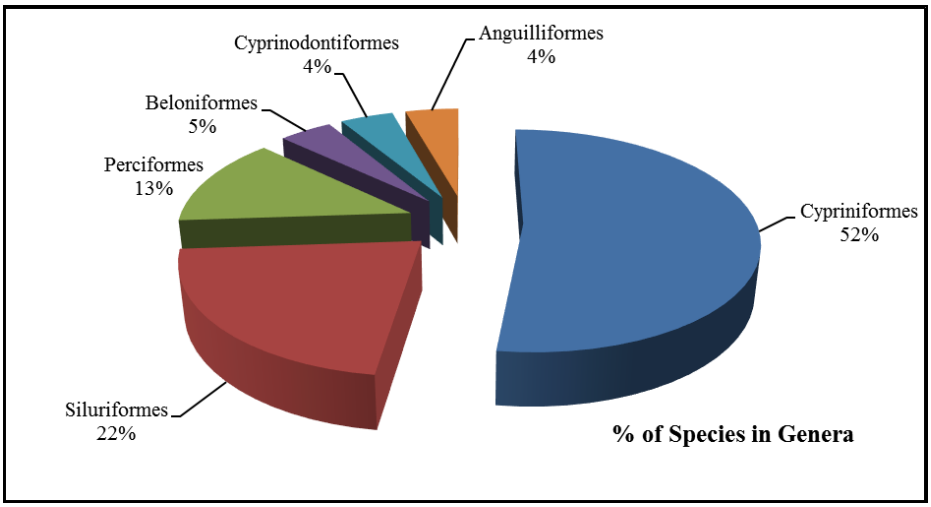


**Fig 2:** Graphical representation of percentage contribution of species in an order of Hiran-II reservoir.

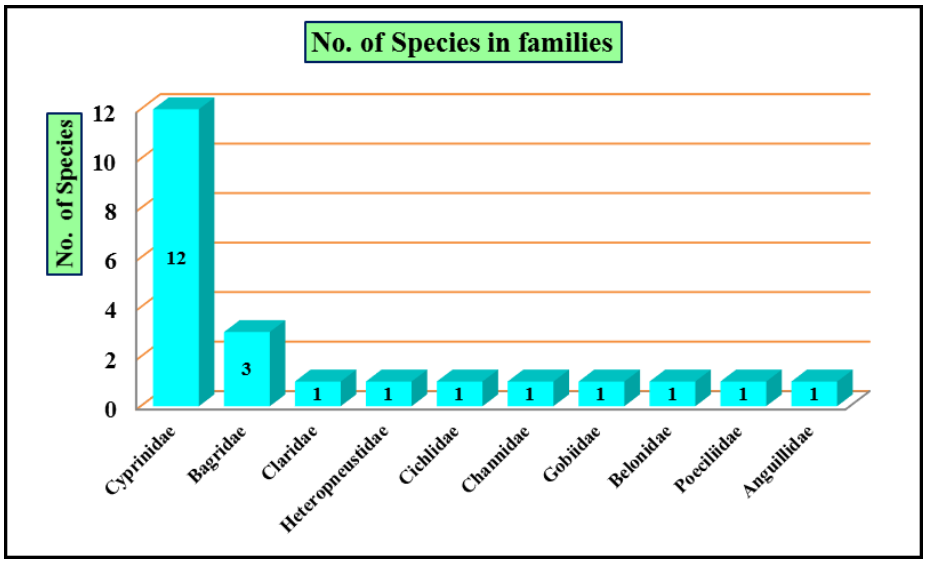


**Fig 3:** Graphical representation of total number of species in families of Hiran-II reservoir.

Similar type of explorations were carried out by Pawar *et al.* [37] on Shirur dam (Maharashtra) and confirm the occurrence of 11 fish species belong to 5 orders. Mahapatra [38] recorded a total of 43 fish species in Hirakud reservoir of Orissa. Another study was conducted by Nagma and Khan [39] where they recorded 36 fish species belonging to 6 orders, 11 families and 23 genera from Bijnor district of Uttar Pradesh. The order Cypriniformes was dominant with 18 species, followed by Siluriformes 10 species, Perciformes 4 species, Osteoglossiformes 2 species, Synbranchiformes and Clupeiformes 1 species each.

The IUCN [40] status of fishes in the Hiran-II reservoir of Gujarat is represented by total of 23 species of fishes, out of these 21 (91.30%) fish species comes under status of least concern and 2 (8.69%) fish species comes under near threaten (Table: 1). Similar result is obtained by other researcher. Katwate *et al.* [41] who had studied the fish fauna of Raigad District for two years. Sixty six freshwater and secondary freshwater fish species belonging to 31 families and 53 genera were collected from various sampling sites. Cyprinids were the most dominant group represented by 22 fish species belonging to 13 genera. Out of the 66 fish species, five belong to the Vulnerable (VU), four to Near Threatened (NT), 37 to the Least Concern (LC) category and 20 were found to be not evaluated for IUCN Red List criteria (Table: 2).

**Table 1:** List of fishes and their order, family, species, common name, local name, level of abundance, IUCN status and economics value of Hiran-II reservoir.

| S. No | Scientific name | Family | Common Name | Local Name | IUCN status 2015-4 | Level of abundance | Economics Value |
|---|---|---|---|---|---|---|---|
| ORDER : Cypriniformes | | | | | | | |
| 1. | *Catla catla* (Hamilton, 1822) | Cyprinidae | Catla | Katla | LC | +++ | Food fish |
| 2. | *Labeo rohita* (Hamilton, 1822) | Cyprinidae | Rohu | Rohu | LC | +++ | Food fish |
| 3. | *Labeo fimbriatus* (Bloch, 1795) | Cyprinidae | Fringed-lipped peninsula carp | Belji | LC | + | Food fish |
| 4. | *Cirrhinus mrigala* (Hamilton, 1822) | Cyprinidae | Mrigal | Morakhi | LC | +++ | Food fish |
| 5. | *Puntius sarana (Hamilton, 1822)* | Cyprinidae | Olive barb | Kotra | LC | ++ | Food fish/ Aquarium fish |
| 6. | *Puntius sophore* (Hamilton, 1822) | Cyprinidae | Olive barb | Dhodhra | LC | +++ | Aquarium fish |
| 7. | *Puntius chola* (Hamilton, 1822) | Cyprinidae | Swamp barb | Dhodhra | LC | ++ | Aquarium fish |
| 8. | *Salmostoma bacaila* (Hamilton, 1822) | Cyprinidae | Razor belly Minnow | Chal | LC | - | Aquarium fish |
| 9. | *Chela laubuca* (Hamilton, 1822) | Cyprinidae | Indian glass barb | Chal | LC | ++ | Aquarium fish |
| 10. | *Garra mullya* (Sykes, 1839) | Cyprinidae | Sucker fish | Malga | LC | + | Aquarium fish |
| 11. | *Garra gotyla* (Gray, 1830) | Cyprinidae | Sucker head | Patharchatta | LC | - | Aquarium fish |
| 12. | *Rasbora daniconius* (Hamilton, 1822) | Cyprinidae | Slender rasbora | Darai | LC | - | Aquarium fish |
| ORDER: Siluriformes | | | | | | | |
| 13. | *Mystus cavasius* (Hamilton, 1822) | Bagridae | Gangetic mystus | Katiyo | LC | ++ | Food fish |
| 14. | *Mystus bleekeri* (Day, 1877) | Bagridae | Day's mystus | Katiyo | LC | + | Food fish |
| 15. | *Mystus gulio* (Hamilton, 1822) | Bagridae | Long whiskers catfish | Khaga | LC | | Food fish |
| 16. | *Clarius batrachus* (Linnaeu, 1758) | Claridae | Philippine catfish | Magur | LC | + | Food fish |
| 17. | *Heteropneustes fossilis* (Bloch, 1794) | Heteropneustidae | Stinging catfish | Singhi | LC | ++ | Food fish |
| ORDER: Perciformes | | | | | | | |
| 18. | *Oreochromis mossambica* (Peters, 1852) | Cichlidae | Mozambique Tilapia | Tilapia | NT | +++ | Food fish |
| 19. | *Channa striatus* (Bloch, 1793) | Channidae | Striped snakehead | Kadvi dor | LC | + | Food fish |
| 20. | *Glassogobius giuris* (Hamilton, 1822) | Gobiidae | Tank goby | Upridola | LC | ++ | Food fish |
| ORDER : Beloniformes | | | | | | | |
| 21. | *Xenentodon cancila* (Hamilton, 1822) | Belonidae | Freshwater garfish | Suva | LC | - | Food fish/ Aquarium fish |
| ORDER: Cyprinodontiformes | | | | | | | |
| 22. | *Gambusia affinis* (Baird & Girard, 1853) | Poeciliidae | Mosquito fish | Guppy | LC | ++ | Aquarium fish |
| ORDER : Anguilliformes | | | | | | | |
| 23. | *Anguilla bicolor* (McClelland, 1844) | Anguillidae | Indonesian Short fin eel | Vam | NT | + | Food fish/Game fish |

\+ = 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

**Table 2:** Percentage occurrences of fish species under IUCN (2015-4) conservation status of Hiran-II reservoir.

| IUCN status (2015-4) | EN Endangered | VU Vulnerable | LC Least concern | LRnt Lower risk near threatened | LRlc Lower risk least concern | DD Data deficient | NE Not evaluated | NT Near threaten |
|---|---|---|---|---|---|---|---|---|
| Number of species | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 2 |
| % contribution | 9 | 0 | 91.30 | 0 | 0 | 0 | 0 | 8.69 |

During month of March 2019 (summer season) 23 (100%) highest fish diversity was found. Average fish diversity was found during month of January with 21 (91.30%) (winter season) and lowest diversity was found during the month of August with 07 (30.43%) (monsoon) at Hiran-II reservoir (Fig. 4). According to Mondal and Kaviraj [42] and Mondal *et al.* [43], number of fish species and the species density fluctuated between the seasons. The significant diversity of fish species were high in the dry season (March) may be due to the reduced water level, high rate of transparency and increased availability of food and due to loss of water evaporation as reported by Mustapha [44]. The low fish diversity recorded during monsoon (August-September) months in all three reservoirs due to human anthropogenic activities and over exploitation leads to rapid decline in the fish. With the beginning of rainy season heavy influx of freshwater and reservoir water, flood, low transparency, high water volume and inefficiency in gill net operation might have caused the decline in population during monsoon months as reported by Mustapha [44].

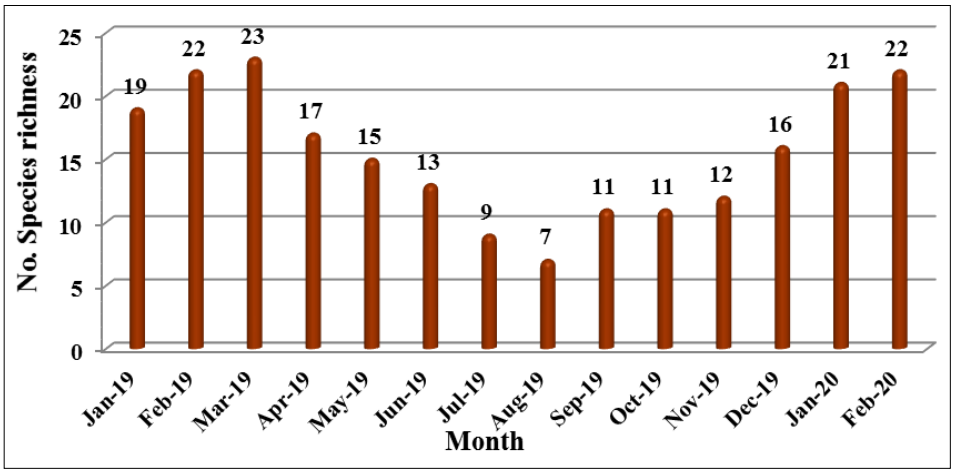


**Fig 4:** Graphical representation of fish diversity during different month of Hiran-II reservoir.

### 3.3 Diversity indices

The seasonal variation in Shannon-wiener species diversity H' (log2) varied from 1.563 to 1.981 (Table: 2 and Fig. 5). Shannon Weiner index values generally ranged between 1.5 and 3.5 in most of the ecological studies and the value above 3.0 concludes higher diversity [45]. The Pielou's evenness index values were closely related and falls between 0.2075 and 0.3153. Evenness index expresses how evenly the individuals are distributed among the different species and the value range between 0 and 1 [46]. The seasonal variation in Margalef's species richness (d') ranged from 2.373 to 2.837 at Hiran-II reservoir. The minimum values were recorded during the summer and the maximum during monsoon. Shannon-Weiner index for fish diversity in Hiran-II reservoir was at its peak in monsoon coinciding with the favorable monsoon conditions such as sufficient water and ample food resources. The diversity was low in summer probably due to the shrinkage of water spread of the reservoir. The similar investigation by Naik *et al.* [47] on ichthyofaunal diversity of Tunga Reservoir (Gajanoor Dam), Karnataka (India) and Naik *et al.* [48] on assessment of fish biodiversity in upper Mullamari reservoir, Basavakalyan, Karnataka, (India).

**Table 3:** Seasonal variations in fish diversity indices of Hiran-II reservoir.

| | Winter | Summer | Monsoon |
|---|---|---|---|
| Shannon_H | 1.609 | 1.563 | 1.981 |
| Pielou's evenness (J' | 0.2174 | 0.2075 | 0.3153 |
| Margalef's species richness (d) | 2.473 | 2.354 | 2.837 |

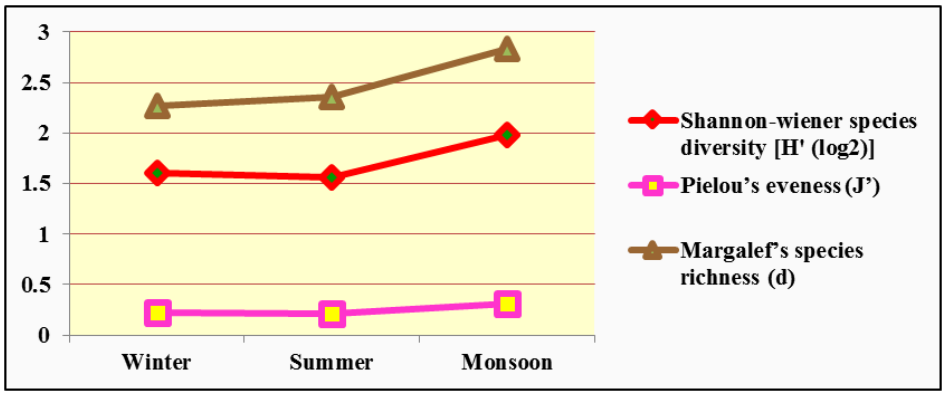


**Fig 5:** Graphical presentation of seasonal variations in fish diversity indices of Hiran-II reservoir.

## 4. Conclusion

Present study deal with ichthyofaunal diversity of Hiran-II reservoir. During the present investigation, the maximum water parameters were within the range. Hiran-II reservoir is a healthy water body providing a habitat for fresh water fishes of diverse type. However, there is constant threat to fish population due to eutrophication and illegal fishing activities. Hiran-II reservoir is a healthy water body providing a habitat for 23 fresh water fishes of diverse type. It is recommended that further the reservoir can be consider being in good condition for fish production. The fishermen should make aware about fishing of larval fish, juveniles and immature should avoided, which may help in high yield of fish production in Hiran-II reservoir. There is hence an urgent need to create awareness among local peoples and illegal fishing activities should be banned also forming a co-operative society for development of the reservoir fish fauna which leads to conserve for future generation and improving the socioeconomic condition of fishermen community.

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