



An Empirical Assessment of Diversity in Fish Species: Case Study of Madhubani District, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Sarisab Pahi Chaur is a wetland sites in the Madhubani district, Bihar has rich fish diversity. The present investigation was undertaken the status of fish diversity and seasonal impacts on them in Sarisab Pahi Chaur of Madhubani, Bihar. A total number of 29 species representing 17 families of 9 orders of class Actinopterygii were identified from Sarisab Pahi Chaur wetland, the various species of order Cypriniformes 49% and Clupeiformes 16% dominated in the wetland followed by order Siluriformes 15%, Perciformes 12%, Channiformes 6%, Symbrachiformes, Beloniformes, Anguilliformes and Mugiliformes respectively. In present investigation species diversity of fishes of Sarisab Pahi Chaur, ranged between the lowest 0.943 June, 2021 and the highest 1.346 May, 2022. Species evenness (J) of fishes of Sarisab Pahi Chaur, varied from the lowest 0.787 July, 2021 and the highest 0.933 March, 2022 during the investigation period. Species richness (d) of fishes of Sarisab Pahi Chaur, varied from the lowest 6.603 June, 2021 and the highest 12.411 May,

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2022. The value of Shannon-Wiener diversity, Species richness and the Evenness in different months are the different value which is depends upon the fish density and physico-chemical parameters of water of wetland. The paper takes into account to explore the importance of wild variety in fish seed production and its support in sustainable livelihood development.

Keywords: *Fish diversity; fish fauna of wetland; Sarisab Pahi Chaur; wetland of Bihar; wetland of madhubani.*

1. INTRODUCTION

North Bihar has huge network of rivers which forms numerous wetlands in their way. These wetlands are rich in flora and fauna and are sites to thousands of resident birds and are also thronged by a large number of migratory birds. These are major sources for the irrigation and aquaculture. There are some important wetlands, Kabartal (Begusarai), Kusheshwarsthan (Darbhanga), Gogabeel (Katihar), Saraiyaman (West Champaran), Baraila (Vaishali) of the North Bihar region that play vital role in ground water recharge, irrigation and aquaculture and sustain the livelihood of human beings and other organisms to a considerable extent [1].

Madhubani district, Bihar has large inland fisheries and adequate fresh water resources in the form of rivers and their tributaries, Ponds, tanks, wetlands (Chaur), and canals. Madhubani district is reach in water resources, which play significant role in livelihood resources due to highly productive flora and fauna. Thousands of ponds, tanks, *chaur*s (land depressions) and *moins* (ox-bow lakes) constitute the lifeline of the area by serving as the source of irrigation and pisciculture. Wetlands of Madhubani District such as *chaur* provide a basis to capture fishes, shell fishes, crabs etc. it supports thousands of people in securing their food supply and sustaining their livelihood [2,3].

Sarisab Pahi Chaur is an important wetland in Madhubani district. It located at latitude:26.23501 and longitude: 86.18359. It is valuable repository of both flora and faunal biodiversity. This perennial wetland lies beside the Dhar of Paith Ghat. During the rainy season, vast areas of this chaur get flooded. The floods leave behind deposits of sand, silt and clay in layers of varying thickness. Due to fresh alluvial deposits and rich manures and nutrients, the soil of this area is very fertile which supports the biodiversity of wetland. A variety of zooplankton and phytoplankton thrive in this wetland under warm and humid conditions. This water body is not used for fisheries only but makhana (*Euryale ferox*) also cultivated. The abundant water resource used for irrigation and other purpose, thus provide the basis of livelihood for human beings and other organisms to a considerable extend like it known for wintering ground for migratory birds. This ecosystem attracts a lot of birds of different species for feeding and breeding. Therefore, it has the potential of being developed as a place for eco-cum-religious tourism. It could create employment opportunities and hence support local people for their livelihood.

Hence, in this paper efforts have been made to illustrate the status of fish diversity in wetland, Sarisab Pahi Chaur and highlight the value of the wetland and its products in sustaining livelihood in Madhubani.



Fig. 1. Sarisab Pahi Chaur, Madhubani

2. MATERIALS AND METHODS

The fish samples were collected from four different stations of wetland, Sarisab Pahi Chaur, Madhubani in the morning period around 9 to 10 am., from June, 2021 to May, 2022, with the help of local skilled fishermen. Press net and cast net are used for collection of fish. Specimens were collected and kept in an open container with a battery operated aerator and transported to the laboratory. The fishes were identified by using standard literature- Jhingran, [4], Talwar and Jhingran, [5], Beavan, [6], Hamilton, [7].

2.1 Statistical Analysis

To understand fish biodiversity analysis of fish species was carried out. This statistical methods are using by the Shannon-Weiner index, Evenness index and species richness.

Shannon-Weiner index: Shannon-Weiner diversity index: $H' = -\sum P_i \log P_i$

Where:

- H = the Shannon diversity index
- P_i = fraction of the entire population made up of species i
- S = numbers of species encountered
- Σ = sum from species 1 to species S

Evenness index:

Evenness index was determined by the following equation (Pieleu, 1966).
Evenness (J) = $H'/\ln S$

Where,

- J = Evenness index,
- H' is the *Shannon – Weiner index*,
- H_{max} = $\log S$, 'S' is the number of species.

Species richness index:

The species richness is calculated the species richness by Margalef (1968)

$$\text{Species richness (S)} = s-1/\log N$$

Where,

- S = index of species richness
- N = total number of species
- s = Individual number of species.

3. RESULTS

The present investigation was undertaken and carried out during the years June, 2021 to May, 2022.

3.1 Quantitative Fluctuation of Fishes of Sarisab Pahi Chaur

Distribution of fish's population has been shown in Tables 1 and 2., whereas Table 3 show the quantitative fluctuation of their population on monthly basis and represent their seasonal variations in Sarisab Pahi Chaur, Madhubani wetland. Table 1, Fig. 2, show the numerical composition of different order of fishes and Table 2, Fig. 3, show the numerical composition of different family of fishes in Sarisab Pahi Chaur, wetland. A systematic survey of this wetland resulted in the identification of many fish species.

Sarisab Pahi Chaur, Madhubani showed occurrence of 29 species belong to 17 families and 9 orders. Minimum population of total fishes were recorded during winter season in Sarisab Pahi Chaur. Maximum population of total fishes were recorded during monsoon season in the wetland.

Quantative as well as qualitative fluctuation of fishes population and their seasonal variation in Sarisab Pahi Chaur, Madhubani were as follows:-

Anguilliformes: In present study only one species of anguilliformes was found. It was *Pisodonophis boro*.

Beloniformes: Only one species of beloniformes was found during present study. It was *Xentodon concilla*. Total beloniformes population was minimum in winter and summer but maximum in monsoon. The annual average was 0.33 in Sarisab Pahi Chaur, Madhubani.

Channiformes: Three species of channiformes were observed from Sarisab Pahi Chaur in present investigation. These were *Channa maurilius*, *Channa punctatus* and *Channa gachua*. Total channiformes annual average was 6.42 in Sarisab Pahi Chaur, Madhubani which cover about 6% of total fish production of this wetland.

Clupeiformes: Three species of clupeiformes were observed during the investigation period in Sarisab Pahi Chaur, Madhubani. These were *Noropterus notopterus*, *Notopterus chitala* and *Gudusia chapra* (Suiha). Annual average of *Noropterus notopterus*, *Notopterus chitala* and *Gudusia chapra* were 3.75, 1.16 and 17 respectively. Total population of clupeiformes were minimum during winter and summer and

maximum during monsoon in the wetland. Total clupeiformes annual average was 16% in Sarisab Pahi Chaur, Madhubani.

Cypriniformes: Ten species of cypriniformes were reported from Sarisab Pahi Chaur, Madhubani. These were *Catla catla*, *Labeo rohita*, *Labeo calbasu*, *Puntius chola*, *Puntius sarana*, *Cirrihinus mirigala*, *Cirrihinus reba*, *Oxygester bacaila* (Chelba), *Lepidocephalus thermalis* and *Oxygester gora* (Chelba). Total cypriniformes annual average was 69 in Sarisab Pahi Chaur, Madhubani which cover about 49% of total fish production of this wetland.

Mugiliformes: Only one specie of mugiliformes was found during investigation. It was *Rhinomugil corsula* (Ankghurwa). Only observed in monsoon.

Perciformes: Four species of perciformes were reported from Sarisab Pahi Chaur. There were *Anabas testudineus* (Kawai), *Colisa fasciatus* (Khesra), *Glossogobius giuris* (Bulla) and *Nandus nandus* (Dhalwa). Total perciformes annual average was 20.41 in Sarisab Pahi Chaur, Madhubani which cover about 12% of total fish production of this wetland. The annual average of total perciformes was maximum in

monsoon in Sarisab Pahi Chaur, where it was minimum in winter and summer.

Siluriformes: Seven species of siluriformes were reported from Sarisab Pahi Chaur, Madhubani. There were *Ompok bimaculatus*, *Wallago attu*, *Mystus vittatus*, *Mystus seenghala*, *Clarias batrachus*, *Ailia coilia* (Patasi) and *Heteropneustus fossilis*. Total siluriformes annual average was 15.83 in Sarisab Pahi Chaur, which cover about 15% of total fish production of this wetland. The annual average of total perciformes was maximum in monsoon in Sarisab Pahi Chaur, Madhubani where it was minimum in winter and summer.

Symbranchiformes: Three species of symbranchiformes were reported from Sarisab Pahi Chaur. There were *Amphipnous cuchia* (Bami), *Macrogathus aculeatus* and *Macrogathus armatus*. Total symbranchiformes annual average was 2.5 in Sarisab Pahi Chaur, which cover about 2% of total fish production of this wetland. The annual average of total perciformes was maximum in monsoon in Sarisab Pahi Chaur, Madhubani where it was minimum in winter and summer.

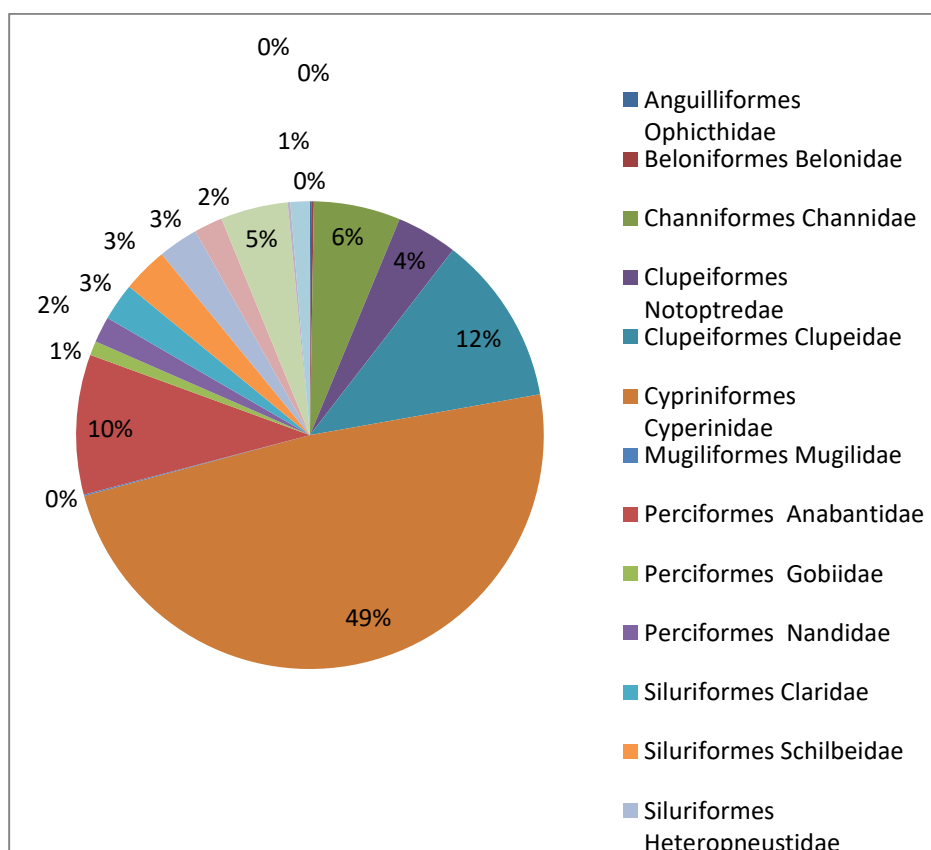


Fig. 2. Annual fish collected

Table 1. Fishes collected from Sarisab Pahi Chaur, Madhubani in period 2021-2022

| Order | Family | Species | Jun | Jul | Aug. | Sep. | Oct. | Nov. | Dec. | Jan | Feb | Mar | Apr | May | Annual | |
|------------|------------------|------------------|---------------------------------------|-----|------|------|------|------|------|-----|-----|-----|-----|-----|--------|-----|
| 1 | Anguilliformes | Ophichthidae | <i>Pisodonophis boro</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 2 | Beloniformes | Belonidae | <i>Xentodon concilla</i> | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| 3 | Channiformes | Channidae | <i>Channa maurilius</i> | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 4 | 11 | |
| | | | <i>Channa punctatus</i> | 2 | 4 | 8 | 7 | 6 | 4 | 2 | 0 | 0 | 2 | 3 | 3 | 41 |
| | | | <i>Channa gachua</i> | 2 | 3 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 15 |
| 4 | Clupeiformes | Notopteridae | <i>Notopterus notopterus</i> | 2 | 3 | 6 | 8 | 5 | 4 | 3 | 2 | 0 | 0 | 0 | 33 | |
| | | | <i>Notopterus chitala</i> | 0 | 2 | 2 | 5 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 14 | |
| | | Clupeidae | <i>Gudusia chapra</i> (Suiha) | 8 | 14 | 18 | 25 | 26 | 16 | 5 | 4 | 2 | 5 | 6 | 2 | 131 |
| 5 | Cypriniformes | Cyprinidae | <i>Catla catla</i> | 0 | 1 | 3 | 5 | 6 | 2 | 2 | 0 | 0 | 1 | 2 | 0 | 22 |
| | | | <i>Labeo rohita</i> | 5 | 4 | 11 | 14 | 17 | 5 | 3 | 5 | 7 | 3 | 3 | 4 | 81 |
| | | | <i>Labeo calbasu</i> | 0 | 0 | 3 | 4 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 14 |
| | | | <i>Puntius chola</i> | 11 | 14 | 20 | 24 | 32 | 20 | 8 | 6 | 2 | 3 | 5 | 7 | 152 |
| | | | <i>Puntius sarana</i> | 1 | 3 | 11 | 12 | 15 | 12 | 4 | 3 | 2 | 0 | 0 | 0 | 63 |
| | | | <i>Cirrihinus mirigala</i> | 5 | 3 | 10 | 9 | 12 | 3 | 5 | 2 | 0 | 0 | 2 | 3 | 54 |
| | | | <i>Cirrihinus reba</i> | 2 | 1 | 2 | 4 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 14 |
| 6 | Mugiliformes | Mugilidae | <i>Oxygester bacaila</i> (Chelba) | 8 | 12 | 20 | 26 | 32 | 12 | 8 | 5 | 2 | 5 | 7 | 6 | 143 |
| | | | <i>Rhinomugil corsula</i> (Ankhgurwa) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | | <i>Anabas testudineus</i> (Kawai) | 4 | 5 | 5 | 11 | 12 | 6 | 3 | 0 | 0 | 0 | 1 | 2 | 49 |
| 7 | Perciformes | Anabantidae | <i>Colisa fasciatus</i> (Khesra) | 6 | 7 | 9 | 8 | 11 | 6 | 3 | 2 | 2 | 0 | 2 | 3 | 59 |
| | | Gobiidae | <i>Glossogobius giuris</i> (Bulla) | 0 | 2 | 2 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| | | Nandidae | <i>Nandus nandus</i> (Dhalwa) | 1 | 2 | 4 | 5 | 4 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 20 |
| 8 | Siluriformes | Siluridae | <i>Ompok bimaculatus</i> | 0 | 1 | 3 | 4 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 17 | |
| | | | <i>Wallago attu</i> | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| | | Bagridae | <i>Mystus vittatus</i> , | 6 | 9 | 12 | 8 | 9 | 3 | 0 | 0 | 0 | 2 | 2 | 1 | 52 |
| | | Claridae | <i>Clarias batrachus</i> | 1 | 4 | 2 | 3 | 5 | 8 | 2 | 2 | 1 | 1 | 0 | 0 | 29 |
| | | Schilbeidae | <i>Ailia coilia</i> (Patasi) | 0 | 6 | 8 | 7 | 10 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 35 |
| 9 | Symbranchiformes | Heteropneustidae | <i>Heteropneustus fossilis</i> | 1 | 3 | 5 | 7 | 7 | 2 | 2 | 1 | 1 | 2 | 0 | 31 | |
| | | Amphinidae | <i>Amphipnous cuchia</i> (Bami) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| | | Mastacembelidae | <i>Macrognathus aculeatus</i> | 0 | 4 | 5 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| Family= 17 | | | <i>Spcies=29</i> | 67 | 108 | 176 | 210 | 229 | 113 | 56 | 34 | 19 | 29 | 37 | 39 | |

Table 2. Family wise fishes collected from Sarisab Pahi Chaur, Madhubani during June, 2021 to May, 2022

| Order | Family | Annual Fish Collected |
|------------------|------------------|-----------------------|
| Anguilliformes | Ophichthidae | 1 |
| Beloniformes | Belonidae | 2 |
| Channiformes | Channidae | 67 |
| | Notopteridae | 47 |
| Clupeiformes | Clupeidae | 131 |
| Cypriniformes | Cyprinidae | 543 |
| Mugiliformes | Mugilidae | 1 |
| | Anabantidae | 108 |
| | Gobiidae | 11 |
| Perciformes | Nandidae | 20 |
| | Claridae | 29 |
| | Schilbeidae | 35 |
| | Heteropneustidae | 31 |
| | Siluridae | 22 |
| Siluriformes | Bagridae | 52 |
| | Amphinidae | 2 |
| Symbranchiformes | Mastacembelidae | 15 |
| | Total | 1117 |

Table 3. Seasonal variations of diversity indices of sarisab pahi chaur

| No. | Order | SUMMER | | MONSOON | | WINTER | | ANNUAL | |
|-----|------------------|--------|--------|---------|---------|--------|--------|--------|---------|
| | | AVG. | RANGE | AVG. | RANGE | AVG. | RANGE | AVG. | RANGE |
| 1 | Anguilliformes | 0--0 | 0--0 | 0.083 | 0-1 | 0--0 | 0--0 | 0.083 | 0--1 |
| 2 | Beloniformes | 0--0 | 0--1 | 1.6 | 1--1 | 0--0 | 0--0 | 0.16 | 1--1 |
| 3 | Channiformes | 6.75 | 4--11 | 11 | 7--14 | 1.5 | 2--4 | 6.41 | 2--14 |
| 4 | Clupeiformes | 14.5 | 6--20 | 39.5 | 22--52 | 12 | 2--23 | 22 | 2--52 |
| 5 | Cypriniformes | 33 | 21--49 | 122.75 | 60--162 | 46.5 | 11--87 | 67.41 | 11--162 |
| 6 | Mugiliformes | 0 | 0 | 0.25 | 0--1 | 0 | 0 | 0.083 | 0--1 |
| 7 | Perciformes | 12.75 | 5--20 | 35.75 | 19--49 | 11.5 | 6--21 | 20 | 5--49 |
| 8 | Siluriformes | 4.75 | 2--9 | 34.25 | 17--44 | 5.5 | 5--17 | 14.83 | 2--44 |
| 9 | Symbranchiformes | 0.25 | 0--1 | 5.5 | 1--11 | 0 | 0 | 1.91 | 1--11 |

(JUNE, 2021 TO MAY, 2022)

Table 4. Assessment of Species diversity, richness and evenness

| Species Diversity (H') | Total No. of Fishes (N) | No. of Species (S) | Species Evenness (J) | Species Richness (d) |
|------------------------|-------------------------|--------------------|----------------------|----------------------|
| 1.087 | 67 | 16 | 0.868 | 8.809 |
| 1.093 | 108 | 23 | 0.787 | 11.407 |
| 1.346 | 176 | 27 | 0.892 | 12.411 |
| 1.292 | 210 | 28 | 0.909 | 10.612 |
| 1.084 | 229 | 27 | 0.793 | 10.108 |
| 1.212 | 113 | 20 | 0.912 | 9.312 |
| 1.172 | 56 | 18 | 0.908 | 9.285 |
| 1.021 | 34 | 12 | 0.889 | 7.679 |
| 0.943 | 19 | 9 | 0.901 | 6.962 |
| 1.093 | 29 | 13 | 0.933 | 8.805 |
| 0.971 | 37 | 12 | 0.856 | 7.561 |
| 0.985 | 39 | 12 | 0.882 | 6.603 |
| 1.1082 | 93.08 | 18.08 | 0.877 | 9.1295 |

3.2 Species Diversity of Fishes in the sarisab Pahi Chaur

Monthwise variations in various diversity indices viz species diversity (H') species evenness (J) and species richness (d) of fishes calculated for Sarisab Pahi Chaur, are shown in Table 4. The table includes the variations in the total number of species too. Seasonal variation in above mentioned indices are presented in Table 3.

In present investigation species diversity of fishes of Sarisab Pahi Chaur, ranged between

0.943 February, 2021 to 1.346 August, 2020. Species evenness (J) of fishes of Sarisab Pahi Chaur, varied from 0.787 July, 2021 to 0.933 March, 2021 during the investigation period. Species richness (d) of fishes of Sarisab Pahi Chaur, varied from 6.603 June, 2022 to 12.411 May, 2021. Total number of individual 'N' and the number of species (s) were maximum in monsoon and minimum in summer. Annual average of species diversity (H'), species evenness (J) and species richness (d) were investigated.



Fig. 3. Morphology of fishes



Fig. 4. *Puntius sarana*



Fig. 5. *Channa marulius*



Fig. 6. *Mystus vittatus*



Fig. 7. *Botia Dario*



Fig. 8. *Mastacembelus pancalus*



Fig. 9. *Xenentodon cancila*



Fig.10. *Notopterus notopterus*



Fig.11. *Ompak maculatus*



Fig. 12. *Nandus nandus*



Fig. 13. *Heteropneustes fossilis*

4. DISCUSSIONS

4.1 Fish and Fisheries

A total number of 29 species representing 17 families of class Actinopterygii were identified from Sarisab Pahi, Madhubani, the various species of order Cypriniformes dominated in the wetland followed by order Perciformes, Clupeiformes, Channiformes, Siluriformes, Symbranchiformes, Beloniformes, Mugiliformes and Anguilliformes respectively. The maximum numbers were recorded during pre-monsoon and post-monsoon period of the wetland, Sarisab Pahi Chaur, Madhubani. Similar result also observed in Kusheshwar Sthan wetland by Das and Koley [8,9].

The present study includes the observation of fish fauna and yearly fish production of Sarisab Pahi Chaur. The obtained data analysis has shown group of species in commercial fishery as follow- Major carp: *Labeo rohifa*, *Catla catla*, *Cirrhinus mrigala*= 20.0 - 25.0%, Minor carp: *Cirrhinus reba*, *Labeo calbasu*, *Puntius sarana* = 15.0 -25%, Cat fish: *Wallago attu*, *Mystus vittatus*, *Ompak bimaculatus* = 20-25%, Airbreathing fish: *Heteropneustus. fossilis*, *Clarias batrachus*, *Anabas testudineus*= 5 – 8%, Minnows: *Nandus nandus*, *Puntius spp.*, *Chela spp.* =10 – 30 %, Murrels: *Channa spp.* =10-15%. With the current level of fish production of Sarisab Pahi Chaur is about 45-55 kg/ha/yr. The similar result also observed in Kusheshwar Sthan wetland by Das and Koley [8,9], Cyprinidae is

the most dominant family recorded from the present study as also reported by Bordoloi and Hazarika, [10], Rahman et al., [11], Sheikh and Goswami, [12] and Thapa and Saikia [13].

Diversity tended to be more in communities in stable than disturbed condition [14]. Bazmi et al. (1989) have suggested that low value of species diversity may be attributed to the fact that there is disturbance in the pond ecosystem due to heavy rains during August to October. This attribution goes against in the present finding which shows high value of species diversity in the period of July-August a period of disturbance for ecosystem. This high value of fish diversity may be attributed to the fact that period of high diversity are time of rapid change, and flood during which fish community is composed of some species that are increasing due to breeding season and other are decreasing. This finding is inconformity with the finding of Nair et al. [15] in the Neyyar River on the Western Ghats where they got similar result while working on seasonal variation and species diversity of fishes [16-18].

The value of Shannon-Wiener diversity, Species richness and the Evenness in Sarisab Pahi Chaur, Madhubani is shown in Table 4 [19]. The value of Shannon Wiener diversity index, Species richness and Evenness were calculated. Negi and Mangain, [20] were also found the species richness, showed variation and ranged from 0.036- 0.173. The value of Shannon-Wiener diversity, Species richness and the Evenness in different months are the different value which

depends upon the fish density and water quality of wetland. Aggrey and Mensah, [21], were also recorded the ranged from 2.54 to 2.83 in Shannon winner diversity index [22,23].

5. CONCLUSION

Sarisab Pahi Chaur is a perennial wetland of Madhubani district has annual fish production about 140-150 kg/ha/yr. The present study on fish diversity of this wetland concluded that all fish belong to class Actinopterygii comprise of 29 species belongs to 17 families of 9 orders. The orders Cypriniformes and Perciformes were found dominated in the wetland followed by order Clupeiformes, Siluriformes, Channiformes, Beloniformes, Symbranchiformes, Anguilliformes and Mugiliformes respectively. The paper takes into account to explore the wild variety of fish available for seed production and ornamental fish supply as a livelihood option for local fishermen of Madhubani.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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