Odonates are one of the ancient orders of insects. It first appeared during the Carboniferous period of the Palaeozoic Era [3]. Odonates are primarily aquatic in their pre-adult stages and their life is closely tied with flowing and stagnant water bodies. Even though species are usually highly specific to a habitat, some have adapted to urbanization and use man-made water bodies. Being primarily aquatic, their life history is closely linked to specific aquatic habitats. Naturally, these insects become a marker, an indicator of wetland health [4].

Madhya Pradesh is a landlocked State of India, it is completely surrounded by land, hence rivers are the dominant water sources of the state. Madhya Pradesh is also known as ‘NADIYO KA MAYKA’ meaning originating point of rivers, approximate 207 small and large rivers flow in Madhya Pradesh. Betwa is the 5th largest river of MP [5]. The Betwa or Betravati is a river in Northern India and a tributary of the Yamuna. The length of the Betwa is 480 km. It rises in the Vindhya Range (Kumragaon; Raisen) just north of Hoshangabad in Madhya Pradesh and flows north-east through Madhya Pradesh and Orchha to Uttar Pradesh. In the present study the riparian ecosystem of Betwa river of Bhopur region was studied using odonates as marker of its health, their Abundance, Richness, diversity and similarity between various sites were recorded during the study.

Material and Methods

The present study was conducted in the Riparian zone of Betwa river in its Bhopur region, District Raisen, Madhya Pradesh, India from July to December 2019.

Study Area

Bhojpur is situated on the Betwa River, 28 km from Bhopal, the state capital of Madhya Pradesh. The site is located on sandstone ridges typical of central India, next to a deep gorge through which the Betwa River flows. Two large dams, constructed of massive hammer-dressed stones, were built in the eleventh century to divert and block the Betwa, so creating a large lake. Bhojpur is located between 23°6′54″N latitude and 77°35′43″E longitude in the state of Madhya Pradesh, India.
It is located at a height of 463m (1,519 fits) from the mean sea level. The average annual temperature is 26.10 °C and the average annual precipitation is 1560 mm. The different types of habitats which were surveyed are as following:

**Site A - Riparian zone adjoining with forest**
Coordinates- 23°10'56"N and 77°57'92"E
It is spread in the northern and north west region of Bhojeshwar temple. This site has zero anthropogenic activities hence it has a calm and peaceful environment that provides natural habitat to Odonates. Fishing nets were laid for fishing. Riverside fencing protects unfortunate accidents with tourists and it also provides safeguarding to the riparian zone from human interferences. Social behaviour of wandering glider or Globe skimmer (*Pantala flavescens*) was recorded on this site during the study. Their copulatory calling by tail movements and wheel position was also spotted there.

**Site B - Digamber Jain Atishay Kshetra (Jain Temple)**
Coordinates- 23°10'56"N and 77°57'92"E
Bhojpur also has an unfinished Jain temple which is the worship place of Digambar jain situated in the eastern part of Bhojeshwar temple. Restaurants and children’s park established there for entertaining tourists. Plastic bags and other pollutants (canes, wrappers, glass, etc.) were dispersed here and there.

**Site C - Bhojpur Ghat**
Coordinates- 23°09'63"N and 77°57'87"E
Bhojpur Ghat is situated in the southwest of Bhojeshwar temple both the sides of Betwa river. People were spotted performing several religious practices there. Some people were bathing and washing clothes. Boating was also performing to entertain tourists. The egg-laying position of Zygopterans was recorded there.

**Site D - Riparian zone adjoining to Agriculture field**
Coordinates- 23°09'95"N and 77°57'61"E
A small farmhouse spotted there and caretaker was gardening in the field. The Agri area has black fertile soil. Bumblebee and honeybees spotted there in huge numbers. Farmers have laid fencing for limitation of their agricultural areas.

**Survey Method**
Adult Odonates were sampled for a period of 6 months (July to December 2019) in four different types of habitats across the study area. Data collection was done twice a week starting from July 2019 to December 2019 undertaken between 7:00 to 10:00 AM morning and 4:00 to 6:00 PM evening [4]. A sampling of adult odonates was done on days with fine weather conditions. Capturing of odonates was done along transects with a width of 50m perpendicular from the water systems to maximize the area along with water systems. The line transect method has been widely used for the quantitative sampling of Odonates [6]. The species were identified using various keys [8, 9, 10, 3]. Species that could not be identified in the field were collected and stored in 70% ethyl alcohol for identification [7]. Environmental parameters were recorded for the sample points which included the colour of the stream, type of immediate vegetation, etc. The abundance is determined by the number of individuals found during visual surveys, along transects. The total number of individuals of each species encountered during the study period (July to December 2019) is used for comparing their abundance.

**Data Analysis**
Margalef’s richness (\(D_{Mg}\)) index is used here to determine species richness. If ‘S’ is the number of species recorded and ‘N’ is the total number of individuals in the sample, the indices are calculated as follows:

\[ D_{Mg} = \frac{(S-1)}{\ln N} \]

The Shannon-Weiner index is used here to calculate the diversity of species in different habitats. The Shannon-Weiner index (\(H'\)) is given by the formula as follows:

\[ H' = -\sum_{i=1}^{S} p_i \ln p_i \]

where ‘s’ is the number of species, and ‘\(p_i\)’ is the proportion of individuals of each species belonging to the \(i^{th}\) species of the total number of individuals. The negative of this sum is taken as the index. The higher the index, the higher is the species diversity.
Jaccard’s index (Cj) was used to calculate the similarity of odonate species between two habitats among the different types of habitats studied. It is given by the following relation:

$$C_j = \frac{c}{a + b + c}$$

Where ‘c’ is the total number of species common in both sites, ‘b’ is the number of species unique to first site and ‘c’ is the number of species unique to second site.

**Results and Discussion**

**Abundance**

A total of 30 species were recorded during the study. The Infraorder Anisoptera is represented by 2 Families and 22 species and the Infraorder Zygoptera by 3 Families and 8 Species. 23 species were recorded from Site A (Riparian Adjacent To Forest) followed by 22 species were recorded from Site C (Bhojpur ghat) followed by 21 species from Site D (Riparian adjacent to Agriculture field) and 16 species from Site B (Jain Temple).

Species richness or Margalef’s richness index (D_Mg) was found to be 3.455 in Site A followed by 3.292 in Site D followed by 3.361 in Site C and it was 2.835 found to be least in Site B.

Jaccard’s similarity index (C_j) as shown in Table-2 was highest (0.692) between Site A and Site C and it was lowest (0.4) between Site B and Site D.

**Diversity and similarity index**

The Shannon – Weiner index (Site A: H' = 1.345; Site B: H' = 1.163; Site C: H' = 1.2655; Site D: H' = 1.23064) as shown in table 2 does not vary much among the different sites.

Species richness or Margalef’s richness index (D_Mg) was found to be 3.455 in Site A followed by 3.292 in Site D followed by 3.361 in Site C and it was 2.835 found to be least in Site B.

Jaccard’s similarity index (C_j) as shown in Table-2 was highest (0.692) between Site A and Site C and it was lowest (0.4) between Site B and site D.

### Table 1: Table showing Odonata species recorded, their Abundance, Margalef’s Coordinates- 23°10′56″N and 77°57′9″E richness index (D_Mg) and Shannon- Weiner index (H’) in different sites of study area

| Sub Order | S. No. | Scientific Name | Common Name | No. of individuals encountered (Abundance) |
|-----------|--------|----------------|-------------|------------------------------------------|
|           |        |                |             | Site A | Site B | Site C | Site D |
| **Anisoptera** |        |                |             |       |       |       |       |
| 1.        |       | Anax immaculifrons | Blue darter | - | 23 | - | 81 |
| 2.        |       | Anax guttatus | Lesser green emperor | 6 | 5 | 12 | - |
|           |        |                |             | Family: Aeshnidae |       |       |       |       |
| 3.        |       | Pentala flavesens | Wandering glider | 36 | 14 | 63 | 68 |
| 4.        |       | Acisoma panorpoides | Trumpet tail | 46 | - | - | - |
| 5.        |       | Orthetrum Sabina | Green marsh hawk | 43 | 15 | 91 | - |
| 6.        |       | Crocothemis erythraea | Scarlet darter | 18 | 21 | 31 | - |
| 7.        |       | Trithemis aurora | Crimson marsh glider | 47 | - | 40 | 21 |
| 8.        |       | Bradinopryga geminate | Granite ghost | 16 | 27 | 10 | - |
| 9.        |       | Potamarcha congener | Yellow tailed ash skimmer | 23 | 21 | - | 23 |
| 10.       |       | Orthetrum cancellatum | Black tailed skimmer | - | - | 38 | 20 |
| 11.       |       | Orthetrum praionsum | Crimson tailed marsh hawk | - | 14 | - | 19 |
| 12.       |       | Tramea onusta | Red saddlesbags | - | - | 3 | - |
| 13.       |       | Neurothemis tullia | Pied paddy skimmer | 33 | - | 12 | - |
| 14.       |       | Trithemis pallidinervis | Long legged marsh glider | 24 | - | - | 18 |
| 15.       |       | Lathrecista asiatica | Asiatic blood tail | 11 | - | 3 | 5 |
| 16.       |       | Diplacodes nebulosi | Black tipped ground skimmer | 17 | - | 8 | - |
| 17.       |       | Neurothemis fulvia | Fulvous forest skimmer | 21 | - | - | 15 |
| 18.       |       | Diplacodes trivialis | Chalky percher | 13 | 9 | 12 | 4 |
| 19.       |       | Libellula saturate | Flame skimmer | 5 | 12 | 1 | 6 |
| 20.       |       | Brachythemis cantaminata | Ditch jewel | 5 | 6 | 9 | 18 |
| 21.       |       | Rhvothemis variegate | Common Picture wing | 8 | 5 | 2 | 11 |
| 22.       |       | Urothemis signata | The greater crimson glider | 7 | 12 | 3 | 9 |
|           |        |                |             | Family: Libellulidae |       |       |       |       |
| 23.       |       | Ceriagrion coromandelianum | Yellow wax tail | 28 | - | 46 | 37 |
| 24.       |       | Ceriagrion aurora | Golden dartlet | 63 | 4 | - | - |
| 25.       |       | Ceriagrion olivaceum | Rusty marsh dart | - | 11 | - | 34 |
| Total     |       |                |             | 582 | 200 | 517 | 435 |
|           |        |                |             | D_Mg | 3.455 | 2.835 | 3.361 | 3.292 |
| H’        |        |                |             | 1.345 | 1.163 | 1.2655 | 1.23064 | 1.23064 |

~ 1341 ~
Table 2: Table showing Jaccard’s similarity index ($C_j$)

|          | Site A | Site B | Site C | Site D |
|----------|--------|--------|--------|--------|
| Site A   | 1      | 0.5    | 0.692  | 0.517  |
| Site B   | 0.5    | 1      | 0.407  | 0.4    |
| Site C   | 0.692  | 0.407  | 1      | 0.518  |
| Site D   | 0.517  | 0.4    | 0.518  | 1      |

*Orkhærum puiunosum (Crimson-tailed Marsh Hawk)*  
*Irihæmis/aurora (Crimson marsh glider)*  
*Orthærum Sabius (Green marsh hawk)*  
*Pantała flavesens (Globe skimmer)*  
*Mating of Dragonfly on Study Site*  
*Mating of Damselfly on study site*
Odonates are carnivore insects hence they also act as biological controllers of epidemics (Dengue, yellow fever, malaria etc.) by eating their vectors. Odonates are major components of the food chain of the riparian ecosystem and their role is important not only as predators of other insects but as prey of birds, frogs etc. many species of Odonates inhibit pest population in agricultural ecosystem. Odonates are astonishing creature of nature that not only attracts humans by its large eyes and beautiful wings, but also helps humans in form of bio-indicators (indicates the health of riparian ecotone), biological controllers (by eating vectors of epidemics), and friends of farmers (controls pests’ population in agricultural ecosystem).

**Conclusion**

In the study presented, the observers found that the diversity of Odonates in the Bhojpur region of Raisen district, India is adequate, but it has many anthropogenic activities that affect their habitat and threaten their diversity. In these activities, water pollution caused by dhobis, plastic spreaded by tourists, bathing of cattle by well-meaning villagers are prominent. Therefore, effective conservation efforts have to be made to eliminate this danger hovering over the diversity of Odonates in the region. These strategies include long-term and appropriate national level planning, fresh water conservation programs, public awareness to do so (for which nukkad plays can be resorted to) as well as it should also follow the sustainable development model to make development without any depletion of environment.

**References**

1. Dawn P, Chandra K. Dragonflies and Damselflies (Insecta: Odonton) of Chhattisgarh, India. Check List Journal of Species Lists and Distribution 2014;10(5):1104-1109.
2. Nair MV. Dragonflies and Damselflies of Orissa and Eastern India. Wildlife Organisation, Forest and Environment Department, Orissa 2011, 13.
3. Subramanian KA. Dragonflies and Damselflies of Peninsular India- A Field Guide; edition 1.0, Project Life scape, Indian academy of Sciences, Bangalore 2005, 12-25.
4. Andrew R, Subramanian KA, Tiple AD. Common Odonates of Central India, Edition 1, the 18th International Symposium of Odonatology, Nagpur 2008, 65.
5. Pandey AK, Pandey A. Madhya Pradesh Samanya Gyan Sandarbh Edition 3, Madhya Pradesh Hindi Granth Academy, Bhopal 2016, 103-115.
6. Lamptey DA, Kyerematen Rosina, Using Odonates As Markers of the Environment Health of Water and Its
Land Related Ecotone. International Journal of Biodiversity and Conservation. 2013;5(11):761-769.

7. Subramanian KA, Ali S, Ramchandra TV. Odonata As Indicators Of Riparian Ecosystem Health A Case Study From South West Karnataka, India. Fraseri. Proceedings 18th International Symposium of Odonatology 2008;7:83-95.

8. Fraser FC. The Fauna of British India, Including Ceylon And Burma, Odonata, Taylor & Francis Ltd., London 1933;1:346-366.

9. Fraser FC. The Fauna Of British India, Including Ceylon And Burma, Odonata, Taylor & Francis Ltd., London 1934;2:151-152.

10. Subramanian KA. Dragonflies of India – A Field Guide. Vigyan Prasar. India Offset Press, New Delhi 2009, 1-168