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Diversity of insect fauna in three selected sacred groves of Murshidabad District, West Bengal, India

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Abstract
Sacred groves are tiny islands or areas of original woodland or ecosystem that have been largely or entirely preserved by local religious or cultural authorities. They are kept up by intricate, traditional institutions that occasionally work without the help of the government. By protecting virgin forests, acting as key refuges for rare and valuable local species, and providing supplies of herbs for medicinal, social, and religious uses, sacred groves provide essential ecological and socio-cultural services. The number of sacred groves in Murshidabad, West Bengal, India is thought to be 153. A study of the insect diversity from three holy groves in the Murshidabad district has been made. The dominating order of insects which were found in three different sacred groves where Hymenoptera (69%), then Hemiptera (8%), then Lepidoptera (5%), Coleoptera (5%), Diptera (5%), then Orthoptera (3%), then collembola (2%), then Dermaptera (1%), Dictyopteran (1%), Odonatan (1%) and then Diplura (0%), Thysanoptera (0%).

Keywords: Insect diversity, 3 different sacred groves, Murshidabad district, West Bengal, India

Introduction
The most numerous, successful, and dominant taxon group on the planet is the insect family. Due of their diversity, they have a significant impact on agriculture, human health, and natural resources as well as ecology. The diversity of insects found in terrestrial, marine, and other aquatic ecosystems is referred to as insect biodiversity. They have an incredible range in size, and their ability to fly allows them to flee from danger and disperse to different locations since they have a protective exoskeleton or shell. Insects can see, hear, smell, taste, and feel because they have a nervous system that is similar to ours.

Insects are extremely diverse and important to ecosystems and they are what make the ecosystems tick [1, 2, 3]. Insects provide enormous promise for understanding ecosystems and serving as indicators of the health of such systems. One of the biggest problems in contemporary ecology is comprehending the magnitude of insect diversity. Over 75% of the known animal species are composed of them, and they permeate the various and crucial natural processes that maintain biological systems [4].

India has been a major role recently, exhibiting its broad representation of roughly 7% of the faunal diversity of the planet [5]. Insects outnumber all other living things on Earth, making up more than three-fourths of the estimated 751,000 species that have been identified [6]. Insects can survive and even thrive in a variety of ecological niches all around the world thanks to the adaptability built into their structure. Eighty percent of all currently known living forms on Earth are insects, which are represented by the astounding 1.4 million species that have been catalogued in scientific literature [3, 7].

For cultural and religious purposes, communities collectively guard and dedicate forest pieces as sacred groves (SG). Through their social taboos and customary rights, the local communities protect these tree clusters and the accompanying animals. These community-conserved locations, where there is little to no human activity, are thought to be the homes of local deities or ancestral spirits, according to local viewpoint. India's biodiversity is regarded as one of the richest in the world, and West Bengal, a state in the country's east, is no exception. There are several sacred groves in the Murshidabad district of the state's northern region that have been kept intact for generations as places of worship and spiritual

significance. These groves are renowned for their vast biodiversity and are said to be the habitat for numerous insect species as well as other flora and fauna species.

In the past, multiple studies on the insect variety of various sacred groves from West Bengal areas other than Murshidabad were recorded [8, 9]. Therefore, in order to fill this gap, the current study was created to look into the variety of entomo fauna in three specially chosen sacred woods in the Murshidabad area of West Bengal. The study will concentrate on identifying and recording the various insect species found in these groves, including their number, distribution, and variety. This study has significance because it will provide valuable information on the biodiversity of these sacred groves that can be used for management and conservation efforts. Additionally, it will add to the expanding amount of information on the entomo fauna of West Bengal and encourage additional study in this field.

Materials and Methods

Site Selection

The Indian district of Murshidabad is renowned for both its historical significance and its natural splendour. It is situated in the state of West Bengal. The district is located on the banks of the Bhagirathi River, a Ganges distributary. Murshidabad is well-known for its entomo-faunal richness, encompassing a diverse range of insects. Murshidabad is located in the centre of West Bengal, between latitudes 23°43'N and 24°52'N and longitudes 87°49'E and 88°44'Ewith an area of 5316.11 sq. km. Murshidabad is known for its greenery and atmosphere. Total 153 numbers of sacred groves are present in Murshidabad District. Three Sacred Grooves were selected from Murshidabad, West Bengal, India as sampling sites during the present study from November 2022 to April 2023, which are as follows (Fig.1a-d):

- **Sacred Grove 01:** Shree Kiriteswari Shakti Peeth Temple [KSPT].
- **Sacred Grove 02:** Residency Cemetery of Babulbona [RCB].
- **Sacred Grove 03:** Pataleswar Shiv Mondir [PSM].

Methods Adopted for the Study

The study involved field visits to the 4sacred groves from November 2022 to April 2023. The insects collections were carried out in the early hours of the day. Broadly following methods were adopted for the collection.

Handpicking, This is the simplest and most direct method of collecting insects. It involves carefully catching insects by hand or using forceps and placing them into a container. Handpicking is effective for slower-moving insects or those found in easily accessible areas, such as butterflies, beetles, or grasshoppers. Sticky traps, are commonly used in insect collecting and monitoring to capture a wide range of flying and crawling insects. They are simple yet effective tools that rely on adhesive surfaces to trap insects. These traps consist of a flat or folded surface coated with a sticky substance, often a non-drying adhesive or glue.Insects that come in contact with the surface become stuck and are unable to move. Pitfall traps, are designed to capture ground-dwelling insects. A container, such as a plastic cup or jar, is buried in the ground, with its rim level with the soil surface. A quarter part of each cup is poured with soapy water so that insects that fall inside cannot escape, and the cups are placed there for a few days. All specimens are collected from the traps by pouring the soap water into different containers. After that, they are picked up from it with forceps.

Aerial net, is a commonly used tool for collecting insects in flight. It is designed to capture flying insects such as butterflies, dragonflies, bees, and other flying insects that cannot be easily caught by hand. The aerial net consists of a long handle with a fine mesh net attached to the end.The aerial net is a versatile tool that allows collectors to capture a wide variety of flying insects in various habitats, such as open fields, forests, wetlands, or gardens. After capturing an insect in the aerial net, it is essential to handle it gently to avoid harming the specimen. The collector can carefully transfer the captured insect from the net to a temporary holding container or a more suitable preservation method.

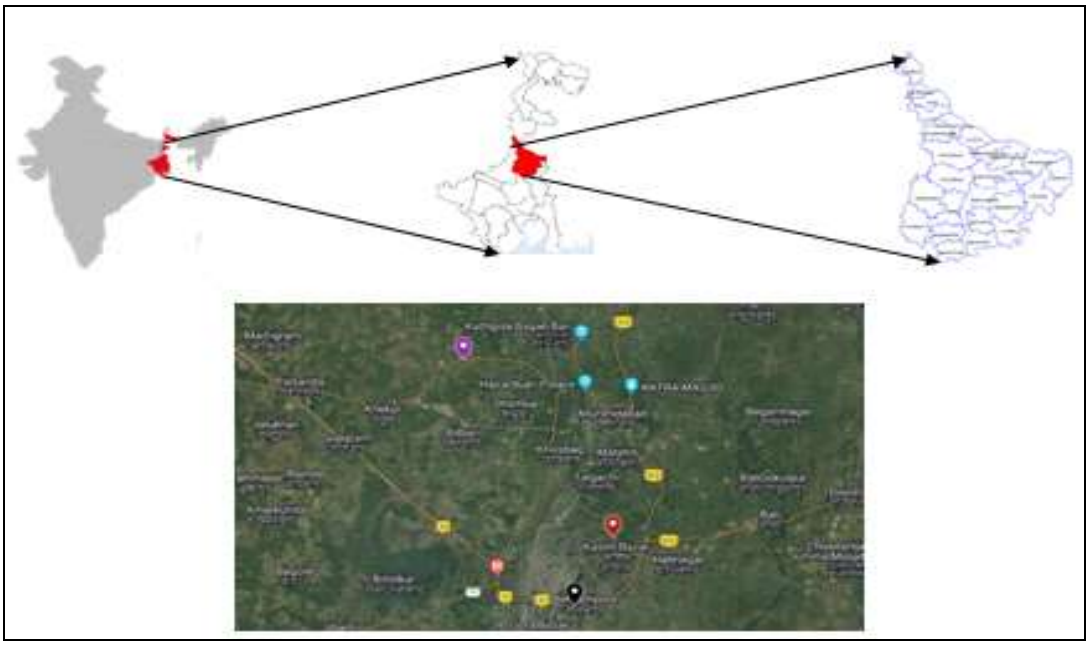

Fig 1a: Three different scared groves in Murshidabad

Fig 1b: Shree Kritesawri shakti Peeth temple (Scared Grove 1)

Fig 1c: Residency cemetery of Babulbona (Scared Grove 2)

Fig 1d: Pataleswar shiv mandir (Scared Grove 1)

Preservation of Collected Insects

Collected specimens were then rinsed & then preserved in containers containing 70% alcoholic solution & labelled.

Identification of the collected samples

In the laboratory, the collected insects underwent a meticulous sorting process, and their identification was carried out up to the order and family levels. Extensive efforts were made to study and understand these insects to the best of our abilities at this stage. However, due to the limited availability of literature resources, it was challenging to identify the insects beyond the family level.

Data Analysis

For the statistical analysis of the soil litter insect fauna recorded from the study area were analysed by using various diversity indices, which are as follows.

The following formula is used to calculate the relative abundance of species in an area.

$$\text{Relative Abundance (\%)} = \frac{\text{Total Number of Individual insect species}}{\textit{Total Number of insect Species Population}} \times 100$$

The Simpson index of diversity mathematical formula is giving as follows.

(D)= 1- [Σni(ni-1) / N(N-1)]

Where,
Σ = sum of (Total)
ni = the number of individuals of each different species
N = the total number of individuals of all the species.

The Shannon-Weiner index of diversity mathematical formula is giving as follows.

(H) = [Σ(n/N) x In(n;/N)]

Where,
Σ= Sum of (Total).
ni = The number of individuals of each different species.
N = The total number of individuals of all the species.

The Margalef diversity index expressed as 'd' can be calculated in a spreadsheet by using the formula.

(d) = (S-1)/ log N

Where,
S = The number of species.
N = The total number of individuals in the sample.

Heat map, a common means of graphical representation of data in matrix form with colour intensity based on values, was produced to visualise the abundance of each insect families in 3 different Secret Groves using Microsoft Word version 2010. The Bray-Curtis dissimilarity indices were calculated to determine the dissimilarity/similarity of total insect abundance (on the basis of families) among 3 different Secret Groves using PAST (Version 4.13).
One-Way ANOVA was calculated using Microsoft Excel 2010 to observe the difference in insect species composition across the three localities under SBR.

Results

During the present study by means of different trapping procedure, a total of 2108 insects were collected using different trapping methods which include 54 families belonging to 12 orders were collected from all the three different sacred grooves (Table 1). Off these 12 orders the order Hemiptera, was the most diverse order with 12 families (Pyrrhocoridae, Lygaeidae, Pseudococcidae, Coreidae, Cicadellidae, Aphididae, Aleyrodidae, Berytidae, Psyllidae, Alydidae, Corixidae), & Thysanoptera, Diplura, Dictyoptera, Collembolla, Dermaptera and Odonata found to be the least divers insect orders with one families (Thripidae, Entomobryidae, Anisolabididae, Japygidae, Blattidae, Coenagrionidae) under each of them. (Table 1& 2). It was

also recorded during the present study that Sacred Groove 03 shows maximum number of insect populations (36.24%) followed by Sacred Groove 02 (35.1%) and Sacred Groove 01 (27.84%) as shown in Fig. 2. During the present study the Oder Hymenoptera shows maximum R.A. value of 69% and the Order Thysanoptera showed minimum R.A. value of 0.23% (Table 2; Figure 3). In Site Again, Sacred Groove 01 shows maximum variety of insect orders with all the 12 orders followed by Sacred Groove 02 and Sacred Groove 03 with 11 orders each (Table 1-3; Fig. 2-4). In terms of insect distribution Sacred Groove 03 proves to be the most diverse one than the other two Sacred Grooves (Table 4; Fig. 5).

Table 1: Occurrence of insects Order/Family wise from 3 Sacred Groves of Murshidabad

Order	Family	Sacred Grove 01	Sacred Grove 02	Sacred Grove 03	Total number
Hymenoptera	Trichogrammatidae	7	0	0	7
	Formicidae	390	470	510	1370
	Eulophidae	6	2	0	8
	Agaonidae	4	0	0	4
	Sphecidae	5	3	9	17
	Scelionidae	6	8	7	21
	Mymaridae	0	3	0	3
	Crabonidae	0	4	1	5
	Vespidae	3	7	5	15
Lepidoptera	Nymphalidae	9	14	16	39
	Pieridae	2	4	7	13
	Lycaenidae	5	13	9	27
	Papilionidae	0	3	5	8
	Hesperiidae	9	2	4	15
	Sphingidae	1	0	3	4
	Pyralidae	3	5	2	10
Hemiptera	Pyrrhocoridae	5	7	4	16
	Lygaeidae	3	6	7	16
	Pseudococcidae	4	0	0	4
	Coreidae	8	3	6	17
	Cicadellidae	0	7	5	12
	Aphididae	0	3	0	3
	Aleyrodidae	2	11	14	27
	Berytidae	3	5	6	14
	Psyllidae	1	6	1	8
	Alydidae	0	7	3	10
	Corixidae	0	0	2	2
	Nepidae	0	13	19	32
Coleoptera	Coccinellidae	6	7	6	19
	Staphylinidae	7	0	5	12
	Bostrychidae	10	0	0	10
	Carabidae	9	13	20	42
	Lampyridae	0	3	0	3
	Curculionidae	0	0	5	5
	Chrysomelidae	0	1	3	4
	Tenebrionidae	2	5	3	10
Thysanoptera	Thripidae	4	0	1	5
Diptera	Sphaeroceridae	7	0	0	7
	Drosophilidae	11	14	6	31
	Projapygidae	5	0	2	7
	Sciaridae	0	5	0	5
	Simuliidae	0	8	3	11
	Phoridae	0	3	1	4
	Chloropidae	0	6	1	7
	Chironomidae	0	4	8	12
	Ephydridae	0	7	0	7
	Psychodidae	3	5	7	15
Collembola	Entomobryidae	14	21	17	52
Orthoptera	Gryllidae	16	13	9	38
	Acrididae	3	8	5	16
Dermaptera	Anisolabididae	5	9	6	20
Diplura	Japygidae	4	1	0	5
Dictyoptera	Blattidae	3	11	7	21
Odonata	Coenagrionidae	2	7	4	13
Total insects found					2108

Table 2: Relative Abundance of Orders of all insects found

Sl. No.		Order	Relative Abundance (%)
1.	Hymenoptera	1450	68.78557875
2.	Lepidoptera	116	5.5028463
3.	Hemiptera	161	7.637571157
4.	Coleoptera	105	4.981024668
5.	Thysanoptera	5	0.237191651
6.	Diptera	106	5.028462998
7.	Collembola	52	2.466793169
8.	Orthoptera	54	2.561669829
9.	Dermaptera	20	0.948766603
10.	Diplura	5	0.237191651
11.	Dictyoptera	21	0.996204934
12.	Odonata	13	0.616698292
Total		2108	100

Table 3: Comparing Relative Abundance of Orders of all Insects Found in 3 Different Sacred Groves of Murshidabad

	Sacred Grove 01		Sacred Grove 02		Sacred Grove 03	
	Number of Insects	Rlative Abundance	Number of Insects	Rlative Abundance	Number of Insects	Rlative Abundance
Order						
Hymenoptera	421	71.72061	497	65.6539	532	69.63351
Lepidoptera	29	4.940375	41	5.416116	46	6.020942
Hemiptera	26	4.429302	68	8.982827	67	8.769634
Coleoptera	34	5.792164	29	3.830911	42	5.497382
Thysanoptera	4	0.681431	0	0	1	0.13089
Diptera	26	4.429302	52	6.869221	28	3.664921
Collembola	14	2.385009	21	2.774108	17	2.225131
Orthoptera	19	3.236797	21	2.774108	14	1.832461
Dermaptera	5	0.851789	9	1.188904	6	0.78534
Diplura	4	0.681431	1	0.1321	0	0
Dictyopera	3	0.511073	11	1.453104	7	0.91623
Odonata	2	0.340716	7	0.924703	4	0.52356
Total	587	100	757	100	764	100

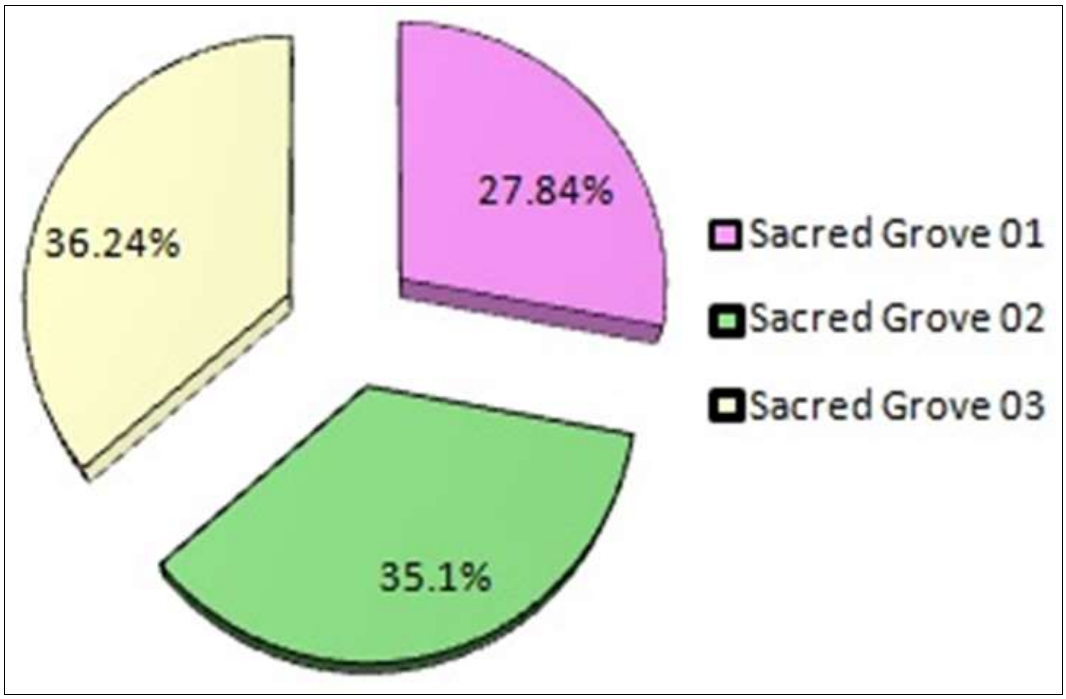

Fig 2: Representing total insect population (%) collected from 3 Sacred Groves of Murshidabad during the present study

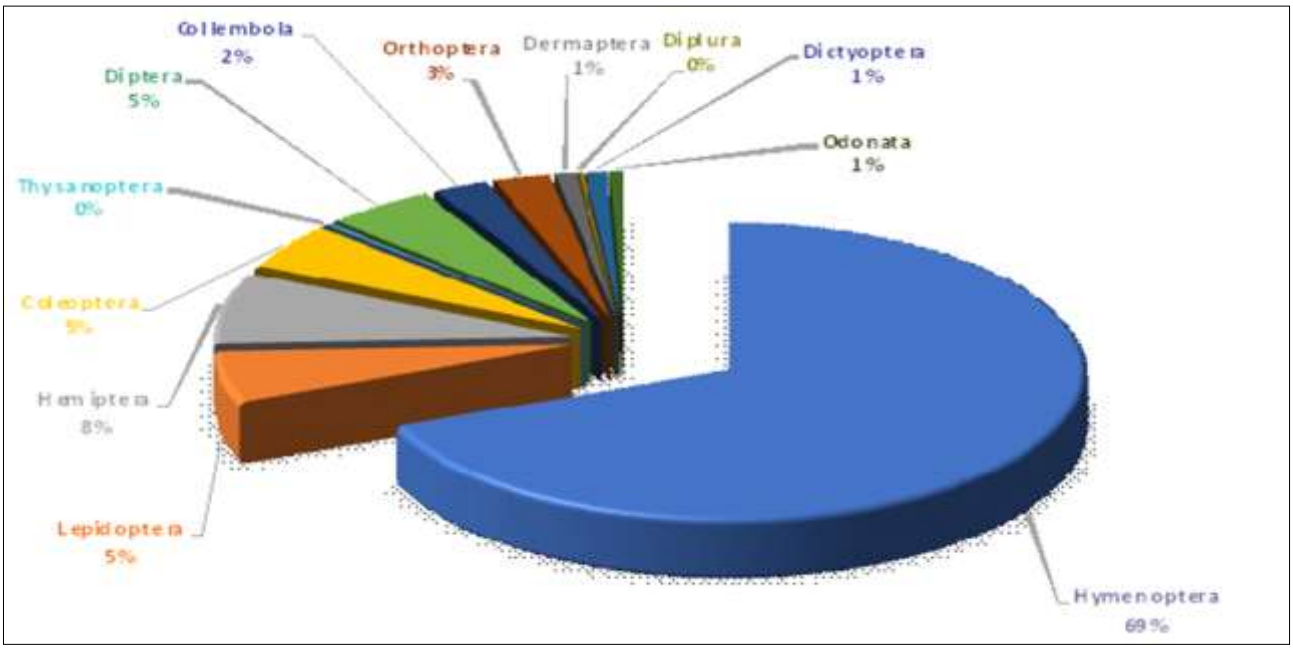

Fig 3: Pie Chart Showing the Relative Abundance of Orders of All Insects Found

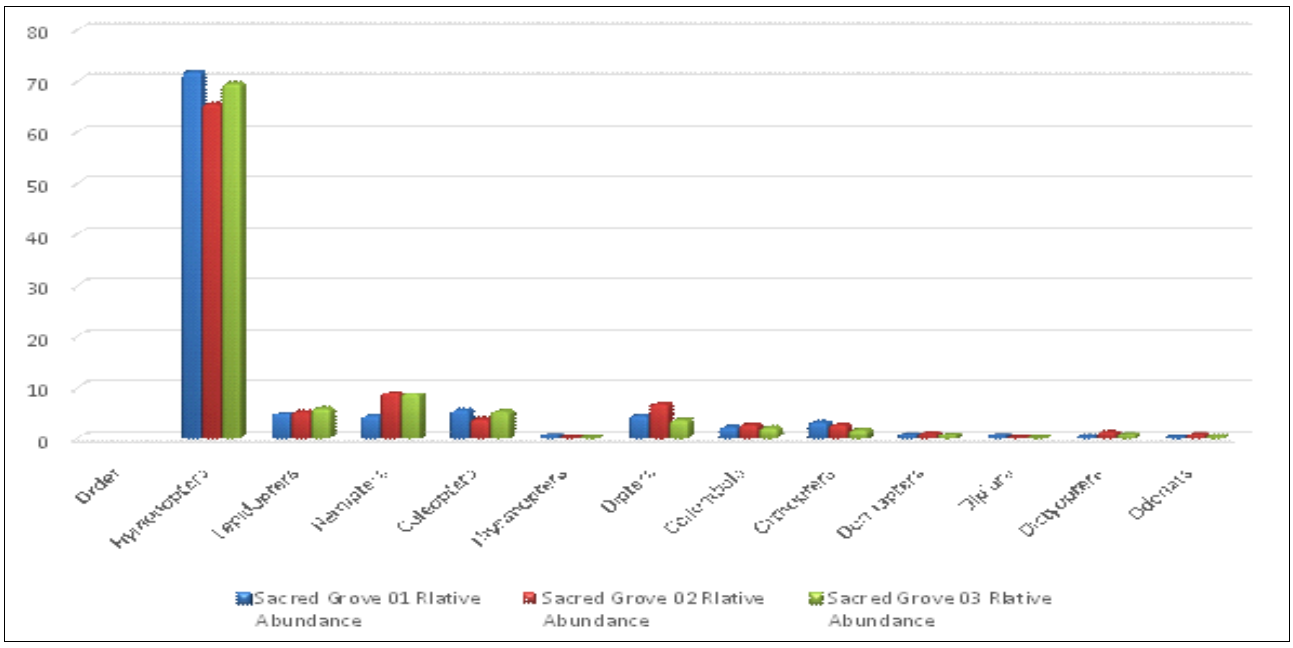

Fig 4: Order-wise Relative Abundance in 3 different Sacred Groves of Murshidabad

Table 4: Distribution of Insect Fauna in 3 different Sacred Groves of Murshidabad

Insect Order	Sacred Grove 01	Sacred Grove 02	Sacred Grove 03
Hymenoptera	421	497	532
Lepidoptera	29	41	46
Hemiptera	26	68	67
Coleoptera	34	29	42
Thysanoptera	4	0	1
Diptera	26	52	28
Collembola	14	21	17
Orthoptera	19	21	14
Dermaptera	5	9	6
Diplura	4	1	0
Dictyoptera	3	11	7
Odonata	2	7	4
Total	587	757	764
Mean	48.91666667	63.08333333	63.66666667
S.E.	33.9901	39.9089	43.0048
Mean ± S.E.	48.9167±33.9901	63.0833±39.9089	63.6667±43.0048

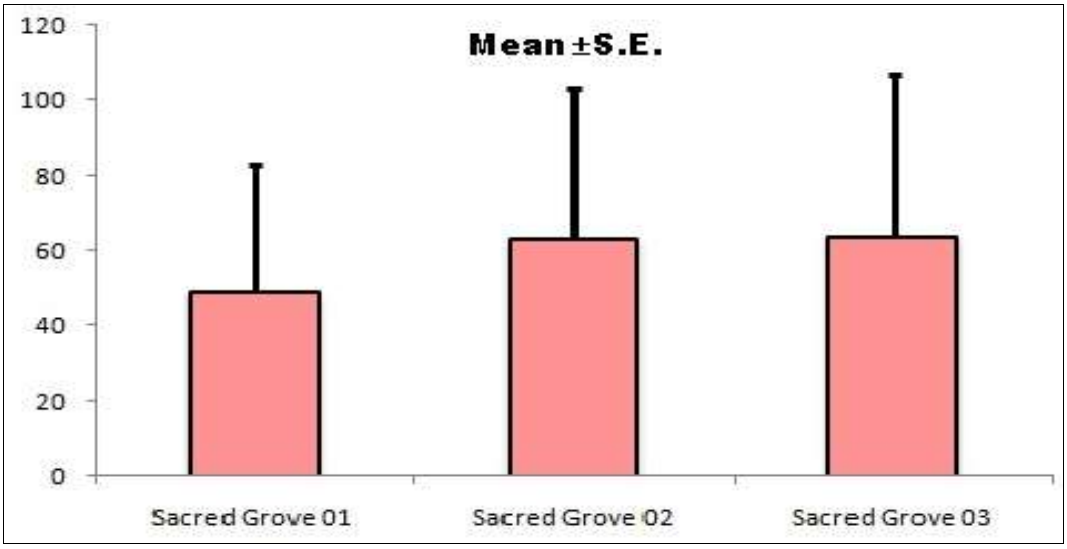

Fig 5: Representing the distribution of insect fauna in different Sacred Groves

Table 5: Comparative Biodiversity indices of 3 different Sacred Groves in Murshidabad (on the basis of Order)

Biodiversity Indices	Sacred Grove 01	Sacred Grove 02	Sacred Grove 03
Simpson's Index (D)	0.4749	0.5505	0.4991
Shannon Wiener Index (H)	1.183	1.325	1.186
Margalef Richness Index (R)	1.7255	1.508	1.506
Evenness Index (E)	0.4761	0.5525	0.4946
FISHER-ALPHA	2.13	1.82	1.82

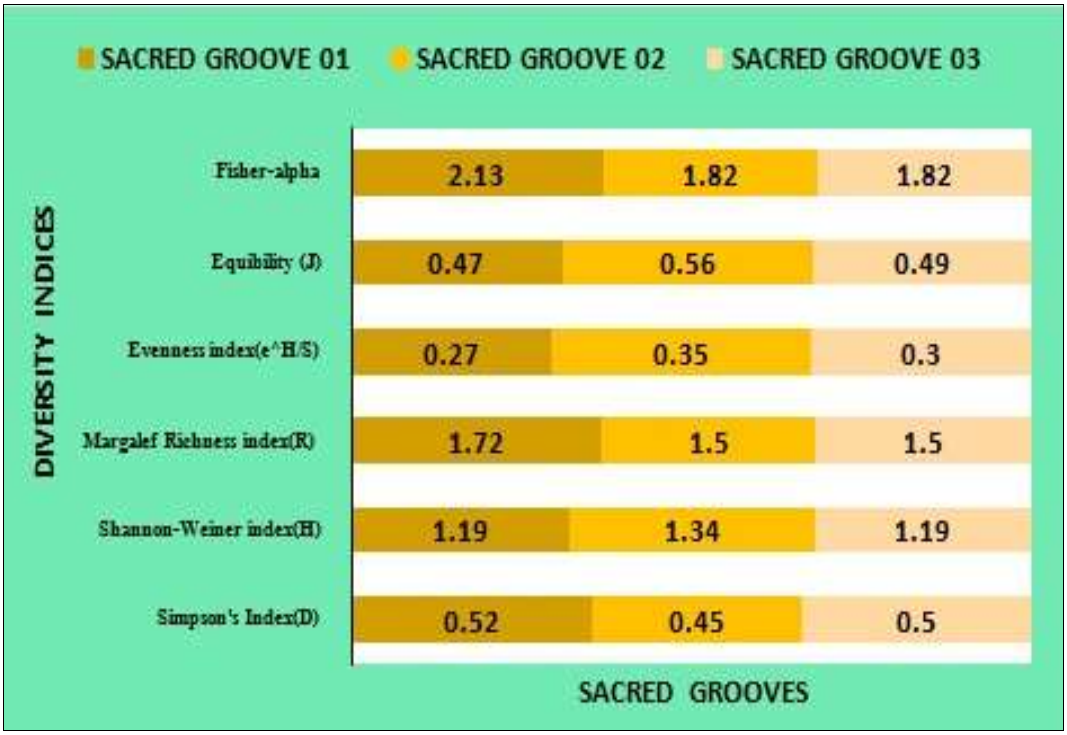

Fig 6: Biodiversity Indices of the different Sacred Groves (On the basis of ORDER)

In view of the diversity indices analysis during the present study, the Sacred groove 1, 2, and 3 had a Simpson's dominance index of 0.4749, 0.5505 and 0.1083 respectively. Sacred groove 1 had the highest Margalef index (1.7255) and Fisher -Alpha index (2.13) followed by Sacred groove 2 (1.82) and Sacred groove 3 (1.82) respectively. Sacred groove 2 shows maximum Shannon Wiener Index (H) with a values of (1.325) followed by Sacred groove 3(1.186) and Sacred groove 1 (1.183) respectively. The value of Evenness Index (E) with was observed to be the highest (0.5525) in Sacred groove 2, Station 3 with a value of 0.4946 and Sacred groove 1 had the least value of 0.4761 (Table 5; Figure. 6).

The heat map (Fig.7) shows that have the darkest colours to determine which families have the highest number of species and also have the lowest colours to determine which families have the lowest. Thus heatmap shows the family Formicidae to be the most dominant insects in all the three Sacred Groves (Fig. 7).

The Cluster analysis of three different Sacred groves based on the abundance of insect families sampled during the present

study revealed that Pataleswar Shiv Mondir (PSM)and Residency Cemetery of Babulbona (RCB)are more similar as they are grouped together, whereas the Shree Kiriteswari Shakti Peeth Temple (KSPT) formed a separate branch (Fig. 8). The Analysis of Variant (ANOVA) study during the present study showed that there was no significant variation among the insect orders at $p< 0.05$ in case of three sacred grooves, under SBR (Table 6).

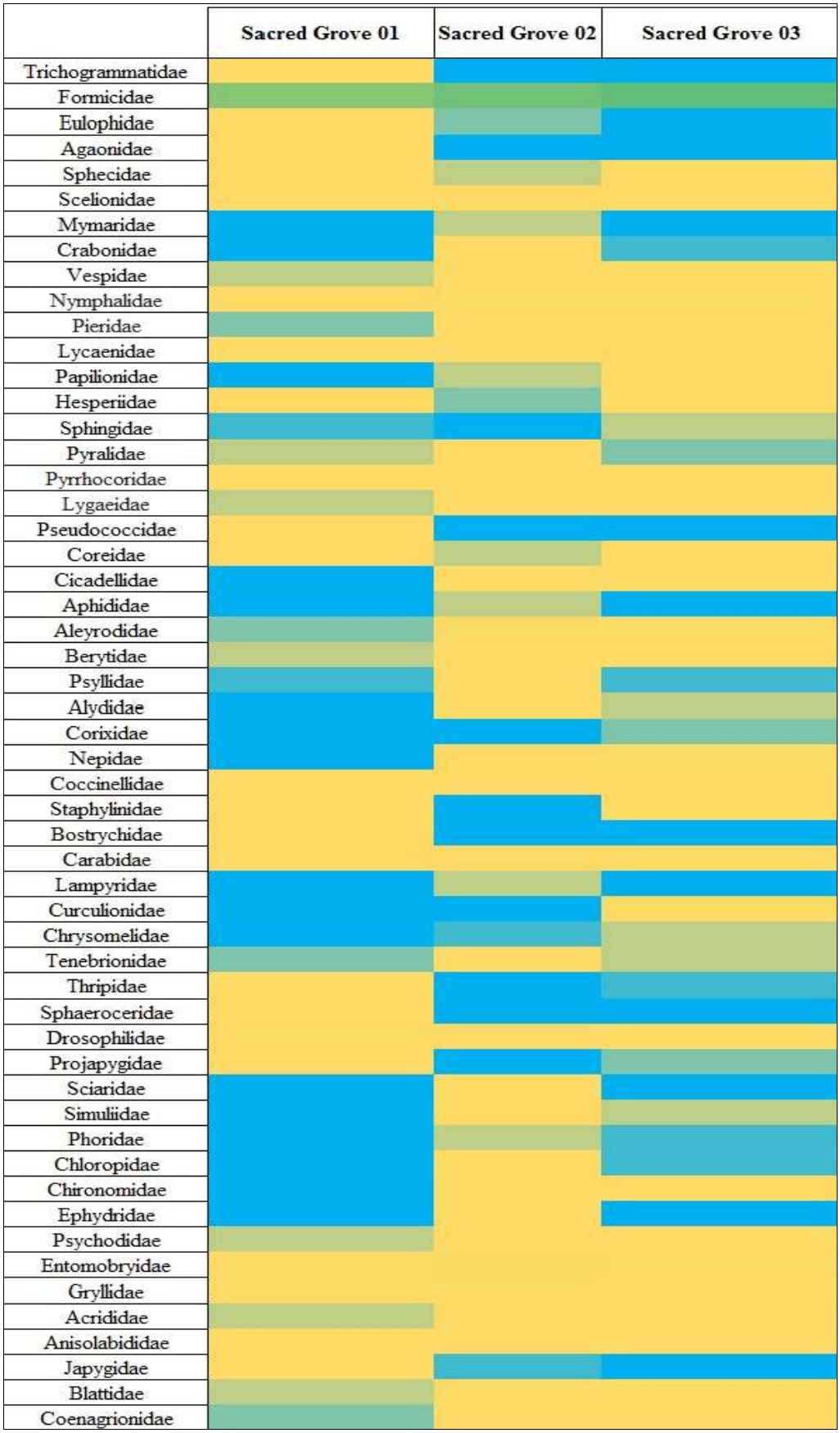

Fig 7: Heat map showing the abundance of different families of insect species in different three sacred groves of Murshidabad during entire survey period (from Nov, 2022 - Apr, 2023)

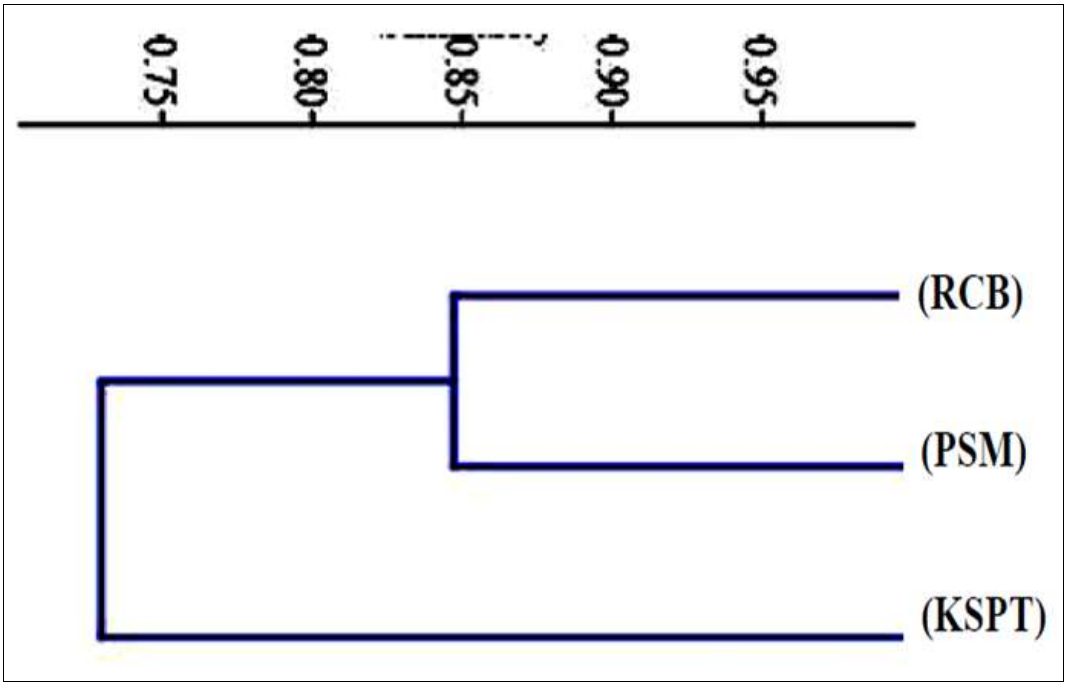

Fig 8: Dendrogram showing clustering of different Sacred groves, based on Bray-Curtis dissimilarity values for type and abundance of insect families in each of the sampled sites during the entire survey period. Height bar on the top represents dissimilarity values from 0 to 1. A value of 0 means no dissimilarity or complete similarity between two compared sites (three different Sacred groves) and 1 means complete dissimilarity or no similarity between two compared sites

Table 6: One-Way ANOVA showing difference in insect Families composition across the three different sacred groove of Murshidabad during the present study period (2022 to April 2023)

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	372.0864	2	186.0432	0.048333	0.95283	3.052891
Within Groups	612017.9	159	3849.169			
Total	612390	161				

There is no significant difference at 5% level of significance

Discussion

This study was designed to obtain information about the Entomo-fauna biodiversity in different sacred groves of Murshidabad. The results are completely dominated by the order Hymenoptera which can also be seen in the few works that's been done throughout the India. 54 families from 12 orders were collected throughout the present study. The dominating order of insects which were found in three different sacred groves where Hymenoptera (69%), then Hemiptera (8%), then Lepidoptera (5%), Coleoptera (5%), Diptera (5%), then Orthoptera (3%), then collembola (2%), then Dermaptera (1%), Dictyopteran (1%), Odonatan (1%) and then Diplura(0%), Thysanoptera (0%). Sacred Grove number 03 produce highest number of individuals whereas Secret Grove number 01 produced lowest number of individuals. All three Sacred Groves were dominated by the order Hymenoptera followed by Hemiptera, Diptera & Coleoptera. All the insects observed during the present study was also reported from different sacred grooves of India [8, 9, 10, 11]. Moreover, the family Formicidae to be the most dominant insects in all the three Sacred Groves were recorded in the present study. Similar observations were also recorded by Imtiaz *et al.* [8].

Conclusion

This report provides information on the composition, taxonomy, and structure of entomo-fauna in three separate Murshidabad Sacred Groves. The findings of this study must be considered in the perspective of conservation since the richness and composition of an insect community can be interpreted as a reflection of the biotic and structural variety of entire ecosystems.

The main order revealed in this study, Hemiptera, goes on to demonstrate its foraging behavior more than any other order. The wide range of order and family discovered is also a positive sign for the study, indicating that it was successful.

The biodiversity indices computed for these three sacred groves aid in understanding the major variance in the three communities. These indices are an excellent tool for researching the area's community structure and how this insect community affects other populations.

This subject of study is still new and little known, yet it has a lot to offer in terms of understanding ecosystems. additional research in this sector will lead to additional opportunities in the future.

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