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Investigating the insect biodiversity of an agricultural area in Midnapore, West Bengal, India

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Abstract

Biodiversity, or biological diversity, refers to the variety among living things within an ecosystem. Insects, the most diverse species in the Arthropoda phylum, are crucial for ecosystem health due to their diverse body sizes, behaviours, fecundity, breathing techniques, and eating habits, impacting agriculture, pollination, human health, and natural resources. These consequently constitute the primary justification for examining the state of insect diversity. Insects are vital components of agricultural ecosystems, contributing to processes like pollination, pest control, and soil health. In regions like West Bengal, known for its diverse agriculture, understanding insect biodiversity can help enhance both ecological health and farm productivity. While insect biodiversity across the entire state is important, focusing on one specific agricultural area can provide detailed insights into how local farming practices influence insect populations. Such a study can guide sustainable farming practices, supporting long-term agricultural productivity and environmental health. This study was undertaken in the Bhadutala area of Medinipur, West Bengal. To identify and gather a variety of insect species to determine the frequency of each kind of insect habitat and to estimate the diversity of insect species in the study area, we collected insects from various habitats, including gardens, lawns, and farmlands, using multiple traps and collection gear. The study aimed to understand the insect orders and families in the research region, with the primary objective of determining its insect biodiversity.

Keywords: Biodiversity, ecosystem, fecundity, insects, arthropoda

Introduction

Biodiversity encompasses the diverse life forms, including plants, animals, microorganisms, genes, and ecosystems. It's a sustainable wealth due to evolutionary history. The diversity is dynamic, rising and falling due to new species, ecosystems, genetic variations, and species extinction. It offers cultural and social benefits. However, human efforts to increase food production have led to overriding natural selection, reducing biodiversity (Crist *et al*., 2017) [8]. Scientists believe diverse ecosystems are more resilient to human-induced shocks like drought and habitat destruction. They have diverse primary production paths and nutrient cycling processes, allowing normal operation even with lost pathways. Reducing biological diversity is crucial for ecosystem preservation (Rawat *et al*., 2015) [33]. Even though there are millions of different species of insects, the precise number is unknown. This lack of awareness about the diversity of life on Earth is astounding. They are frequently encountered in large quantities throughout freshwater and on land, and a small number in seas beyond the tidal limit (Eldredge *et al*., 2020) [9]. Insects have diverse habitats and unique adaptations, but human activity is responsible for most insect population declines and extinctions. To address this, we must recognize and measure our responses to these changes, as there is still much to learn (Samways *et al*., 2020) [37]. Protecting insect diversity ensures the continuation of vital pollination services, crucial for the reproduction of many plants and the production of food crops. This study aims to understand and conserve insect biodiversity which helps to maintain ecological balance by preserving key interactions within ecosystems.

West Bengal's agricultural landscape is diverse, ranging from rice paddies and jute fields to vegetable farms and fruit orchards. Each area is likely to harbor a distinct insect community, shaped by the types of crops grown, farming practices, and environmental conditions. By narrowing the study to a specific agricultural area, researchers can examine the unique insect populations and their interactions with the crops in that setting. Focusing on one area also makes it easier to assess the effects of local farming practices, such as pesticide use, crop rotation, and irrigation methods, on insect biodiversity. This can help provide actionable recommendations for improving farming practices in that area. Let's consider a rice farming area in West Bengal, such as the Paschim Medinipur district, known for its extensive rice cultivation. This region experiences a high level of monsoon rainfall, which affects both crop growth and insect activity. By focusing on such a site, we can closely examine the biodiversity of insect species in rice fields, where the abundance of both pests and beneficial insects is critical to crop health. In this rice farming region, the goal would be to identify and catalog the insect species present, including both pests and beneficial insects. Understanding the diversity of species is the first step in assessing the health of the ecosystem. Investigating the roles insects play in this particular agricultural area is critical. Pollinators (such as bees), natural pest controllers (like ladybugs), and decomposers (such as ants) all contribute to the overall function of the ecosystem and crop productivity. The study would also aim to assess how specific farming practices in this rice-growing region affect insect populations. Based on findings, the study would provide tailored recommendations for improving farming practices in the region. These could include suggestions for integrated pest management (IPM), reducing pesticide use, or promoting practices that support the conservation of beneficial insect species.

Ecological role of biodiversity and its influence on agriculture

Bulkeley *et al*., 2022 [5] concisely summarize the various benefits associated with the current state of our naturally diverse biological ecosystems. To fulfil human needs and preserve the biological mechanisms that keep our environment functioning, biodiversity is crucial. As a rich biological resource with special reference to food plants and domestic animals, medicine (including medications obtained from numerous plants, animals, and microbes), and energy from fuel wood and fossilized plants, biodiversity directly benefits agriculture. Biodiversity therefore forms the basis for food chains and food webs in the preservation of ecological equilibrium. To maintain soil fertility, biodiversity is necessary for recycling nutrients. It also helps to purify the air and water, detoxify waste products, reduce pollution, and moderate floods and droughts. It is especially useful for controlling pests and illnesses, stabilizing the climate, and preventing erosion in watersheds. There are also aesthetic and cultural advantages to biodiversity (Mikkonen *et al*., 2024) [27]. Biodiversity broadens our knowledge and fosters innovation in technology, comprehension of human ecology, and survival. It also changes attitudes and convictions towards the protection of species. Society benefits from non-extractive ecological services such as pest control, pollination, flood control, and water pollution, but institutional mechanisms are required to create interest and incentives for their preservation.

Insect biodiversity conservation

The management of nature and biodiversity on Earth with the goal of safeguarding species, their habitats, and ecosystems against unsustainable rates of extinction and the degradation of biotic interactions is known as conservation biology.

It is obvious that conservation biology has three objectives:

1. to explore and characterize the diversity of life on Earth;
2. to comprehend how human activity affects species, communities, and ecosystems; and
3. to create workable, multidisciplinary strategies for preserving and reintroducing biological variety.

The field of conservation biology is significant in two ways at least. First, by modifying their surroundings to increase their chances of survival, we try to protect endangered species. Second, we make every effort to preserve the natural ecosystems. We shall g*et al*l of the above-listed benefits if we effectively protect biodiversity.

Overview of the insect

Insects represent the most diverse species on Earth, with 1.75 million living species known as the most widely accepted 14,13,000 known living forms, despite their classification and importance (Jayakumar *et al*., 2006) [17]. Approximately 7,51,000, or 54%, of these are insects. This is even more evident when one considers that of the 10,32,000 known animal types, insects make up around 73% of the total (Jayakumar *et al*., 2006) [17]. Insects, primarily found in temperate regions, have a significant ecological impact due to their large number and role as herbivores, predators, and pollinators, crucial for terrestrial ecosystem health. Insects are categorized into 32 orders, with Coleoptera, Hymenoptera, Lepidoptera, and Diptera comprising 80% of all species, while the remaining 28 accounts for only 20% (Jayakumar *et al*., 2006) [17]. Lepidoptera is the second most varied group with over 1,12,000 species, whereas Coleoptera, which makes up 38% of all insects and 10% of all mammals, has 2,90,000 species (Jayakumar *et al*., 2006) [17]. Like the beetles, the Hymenoptera vary significantly in body form and habitat kinds. Approximately 1,03,000 species are recognised (Jayakumar *et al*., 2006) [17]. Diptera has around 98,000 species (Jayakumar *et al*., 2006) [17].

Evolution and biodiversity of insects

Biodiversity is a dynamic system evolving from species to individual organisms, with an average half-life of one to four million years. 99% of species are extinct, and fossilized evidence suggests insects lived 400 million years ago (Sankarganesh *et al*., 2017) [38]. Insects, the first animals with flight, have fused segments in their head, thorax, and abdomen. They have evolved into various habitats, including Antarctica and the Great Salt Lake. Insects are ideal models in evolutionary biology for studying speciation, biogeography, and organismic interactions. The classical theory of origin and evolution suggests that species are divided into populations, leading to polymorphism and new species (Pfenning *et al*., 2010).

The value of insect diversity's components

Generally, three categories of advantages may be distinguished from preserving biological diversity: social, biological resources, and ecological services. Here are a few instances of these advantages. Using insects as nourishment for humans Insects from around 370 genera and 90 families (Scudder *et al*., 2017) [39], including maybe 1,000 species, are or have been utilised as food in many parts of the world, particularly in Latin America, Asia, Australia, and central and southern Africa (Srivastava *et al*., 2009) [41]. In general, food insects avoid chemically protected species and feed on both dead and live plant tissue (Fürstenberg-Hägg *et al*., 2013) [11]. Insects that are commonly eaten include termites, crickets, grasshoppers, locusts, beetles, ants, bee broods, and moth larvae. While insects can make up 5–10% of the animal protein that certain indigenous peoples consume annually (Shockley *et al*., 2014) [40], they are also abundant in energy, protein, and a variety of vitamins and minerals.

Insects as feed for domesticated animals

Insect-derived diets are an affordable substitute for traditional fish meals, and they are widely acknowledged as nutrient-dense feed for fish, fowl, and pigs. For chicken feedstock, insects such as mealworm larvae, house flies, and silkworm pupae are utilised. Additionally, techniques for recycling insects are being developed to turn organic waste into feed additives. Businesses that produce bug food have many options due to the diversity of insects.

Insect as a Pollinator

Via cross-pollination, higher plants whether self-fertile or self-infertile help perpetuate species and promote sexual reproduction (Kanagarajan *et al*., 2023) [19]. Wind and insects are examples of pollinators, and they are essential in drawing pollinators to different types of crops. Chemicals found in insects can be extracted, synthesised, or gathered for use in a variety of ways (Bell *et al*., 2013) [4]. Chitin, a substance found in insect cuticles, has anticoagulant properties, improves wound healing, lowers cholesterol, and produces non-allergic medication carriers. While honey bees produce honey with a higher economic value (Khalifa *et al*., 2021) [20], silkworm moth silk is utilised to make cloth (Rouhova *et al*., 2021) [35]. Bee wax, which has mythical significance and is utilised in food and medicine, is also produced by honey bees. In addition, scale insects make varnish and red dye (Waldbauer *et al*., 2017) [44].

Insects as a model

Insects are increasingly being used as model organisms for genetics, development, behavior, and neurobiology due to their genetic similarities, ethical constraints, and ease of large-scale breeding (Baiano *et al*., 2020) [3]. Their concise life cycle and strong reproduction rate also allow trans-generational investigations and high-throughput screening (Ogidi *et al*., 2024) [28]. Given their parallels to mammals, insects may be used widely, especially in early-stage preclinical research. Approximately 80% of pathogen infection tests conducted on mammals might be substituted with insect models (Renwick and Kavanagh 2007) [34]. The most widely used insect model organisms are the fruit fly *Drosophila melanogaster.* The 1.32×10^9 bp genome of the fruit fly *D. melanogaster* (Adams *et al*. 2000) [1]. Approximately 14,000 genes on four chromosomal pairs make up the genome sequence of Drosophila melanogaster, which is about 20 times less than that of humans. In contrast, humans have approximately 22,000 genes on 23 chromosome pairs. Nevertheless, the genome of fruit flies contains homologs or even orthologs for more than 60% of human disease genes (Rubin *et al*. 2000) [36].

Insect endangerment

A study from the World Commission on Environment and Development highlights the increasing agreement that species are vanishing from Earth at rates never seen before. However, it also said that "we have no accurate figures on current rates of extinctions, as most of the species' vanishing are the least documented, such as insects in tropical forests." Scientists and environmentalists agree that there is an increasing number of extinct insect species. How many people have died and how many are still in danger is unknown. Ancient insects Insect species that are declared extinct globally are listed by the International Union for Conservation of Nature and Natural Resources (IUCN) as 72. Numerous experts think that these figures significantly understate the true rate of insect extinction and that thousands, if not hundreds, of species have disappeared in North America and Europe during the past 200 years without anybody noticing. Given that human activity has the potential to wipe out a widespread species, many endemic tropical animals face dire consequences as their only remaining habitat is being destroyed.

Humans drove several species to extinction, including the Xerces blue butterfly, Antioch katydid, Tobias' caddisfly, Colorado burrowing mayfly, and Rocky Mountain grasshopper. Nevertheless, a great number of these species and the essential functions they provide for ecosystems are under danger due to changes in the natural environment brought about by humans. Insects that are endangered It is clear from the facts at hand that a significant number of insects are in risk of extinction. Since insects make up the majority of creatures on the earth, there must be a very high number of endangered insects if the same factors that risk other species also harm insects. The 2000 IUCN Red List of Threatened Species lists 163 insect species as either globally endangered or severely endangered (Nicholopoulos *et al*., 1999). In 1987, West Germany and Austria both designated 34 percent and 22 percent, respectively, of their respective 10,290 insect and other invertebrate species as vulnerable or endangered. 11.8 percent of the 14,634 known insect species in Great Britain are uncommon, fragile, or endangered, according to more current data from 2000. The value of threatened insect species In a broad ecological system, a rare and endangered species of insect is unlikely to decide its destiny, but collectively, it might have a significant impact. More often than not, specialists like the American burying beetle carry out ecosystem duties like recycling nutrients. Numerous specialised insects exist that consume certain types of wood, dung, or carrion. For example, the plates covering tortoises' shells are composed of keratin, a protein that is difficult for scavengers to break down. On the other hand, the larva of a moth found in Florida called *Ceratophaga vicinella* seems to have become specialised in eating the shells of dead gopher tortoises. In tiny, specialised systems, like caverns, marine islands, or some pollinator-plant connections, endangered species can also serve as a vital link. In the case of many plant species, one or a small number of pollinators are necessary. Particularly if a plant is dependent on a single, obligatory pollinator, a decrease in the number or absence of any of these pollinators might have disastrous effects. Certain species that are at risk of extinction may yield valuable goods that may be used to combat illness, investigate different ecosystems or organismal processes, or even just give direct economic advantages.

Endangering factors the same harmful causes that affect many other creatures also put insects in danger of extinction. The main factors that put animals in risk, according to the IUCN, are overharvesting, habitat degradation, chemical pollutants (such pesticides) causing habitat alterations, and species displacement by introduced species. destruction of habitats Habitat degradation impacting federally listed endangered and threatened insect species is most commonly caused by agriculture, commercial development, outdoor recreation (especially off-road vehicles), pollution, and water development. In the Kuturiya-Bhadutala region of Paschim Medinipur, we are attempting to gather, characterise, and monitor the current state of insect biodiversity.

Impact of Farming Practices on Insect Biodiversity

In many regions of West Bengal, rice farmers often rely on chemical pesticides to control pests like the rice weevil or stem borer. However, these pesticides can have unintended consequences, killing both harmful and beneficial insect species. A focused study would examine how the application of these chemicals affects the local insect community, particularly natural predators like spiders and parasitoid wasps.

Rice farming in the region is typically dominated by monoculture, which may limit the diversity of insect species. A study could compare fields with diversified cropping systems (e.g., intercropping rice with vegetables or legumes) and monoculture rice fields to see if diversity is higher in the former.

Rice fields are often irrigated, creating a wetland environment that attracts certain aquatic insects. Examining how different water management techniques, such as flooded versus intermittent irrigation, impact insect populations would be important for understanding their relationship with the crop.

If organic or low-input practices are used in some sections of the region, researchers could compare insect biodiversity in those fields with conventional ones. Organic farming may support a higher abundance of beneficial insects due to reduced pesticide use.

Methodology

The present investigation will be undertaken from agricultural farm, garden and other nearest locality of Bhadutala which is located at 29.48'N, 87-32°E respectively in Paschim Medinipur district. The entire area of more than 16 acres blessed with green vegetation, grass lands, large trees, shrubs, etc. Equipment used for collection are hair brush, forceps, Stick, Hand net, Killing bottle. After the collection insects were transferred into the killing bottle. A cylindrical glass Jar is used to make the killing bottle. The dead insects used to transfer into boxes for temporary storage. The sacrificed insects than properly pinned by steel pins and kept for proper drying. Naphthalene balls will be placed inside the insect boxes to prevent the attacks of fungus (Ghosh, A.K. 1996). Various insects' species will be collected from Bhadutala area in around overnight (18.00 to 4.00hrs) in months of December to March and April to June to know the diversity of insects in Bhatutala. Insects will be collected live from the sampling site by hand picking, shaking or beating, by trapping and collection tools. Hemiptera, Hymenoptera, Coleopteran and Lepidoptera will be collected by aerial nets, sweeping nets and beating shrubs using long stick and a cloth on the ground for collecting the falling insects. Sweeping or beating will be performed 5-6 times per plant. Collected materials will be kept in 70% alcohol for identification. Orthoptera will be collected with help of large forceps. Collected specimens will be kept in 70% alcohol in killing bottles.

Statistical analysis

Species richness, population density, frequency and abundance will be estimated using different biodiversity indices like Shannon Weiner Index, Simpson's Index, Jacard's Similarity Index etc.

Table 1: List of insects collected from this study area

Sl no	Species name	Common name	Order	Family	No. of individuals
1	*Pheropsophus jessoensis*	Asian bombardier beetle	Coleoptera	Carabidae	250
2	*Hermetia illucens*	Black soldier fly	Diptera	Stratiomyidae	255
3	Delphacidae nymph	Plant hopper	Hemiptera	Delphacidae	240
4	*Rhyparochromus vulgaris*	Bright spotted ground bug	Hemiptera	Rhyparochromidae	380
5	*Aleyrodidae* sp.	White fly	Hemiptera	Aleyrodidae	400
6	*Psylliodes chrysocephala*	Cabbage stem flea beetle	Coleoptera	Chrysomelidae	235
7	Black Giant Ant	Black carpenter ant	Hymenoptera	Formicidae	390
8	House Fly	House fly	Diptera	Muscidae	240
9	*Triatoma infestans*	Barber bug	Hemiptera	Reduviidae	260
10	*Tenebrio obscurus*	Dark meal worm	Coleptera	Tenebrionidae	260
11	*Tettigonia viridissima*	Great green bush cricket	Orthoptera	Tettigonidae	250
12	*Cimex lectularius*	Bed bug	Hemiptera	Cimicidae	225
13	*Harmonia axyridis*	Simply Asian lady beetle	Coleoptera	Coccimellidae	240
14	Collembola	Spring tails	Agnatha		245
15	*Brachinus* sp.	Bombardier beetle	Coleoptera	Carabidae	210
16	*Anopheles sp.*	*Anopheles sp.*	Diptera	Culicidae	350
17	*Culex sp.*	*Culex sp.*	Diptera	Culicidae	328
18	*Periplaneta sp.*	Cockroach	Blattodea	Blattidae	235
19	Nairobi fly	Acid fly	Coleoptera	Staphylinidae	225
20	*Drosophila sp.*	Fruit fly	Diptera	Drosophilidae	320

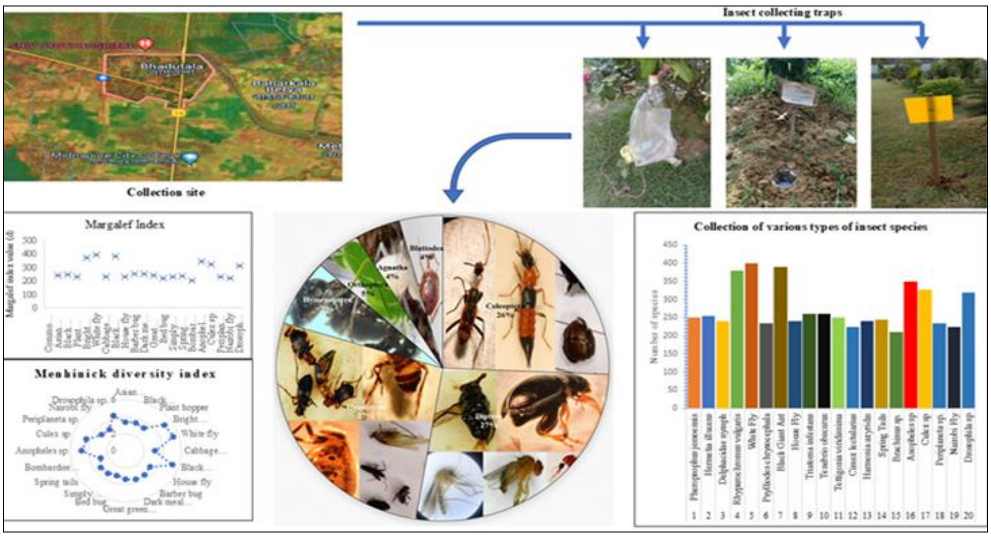

Fig 1: Graphical abstract

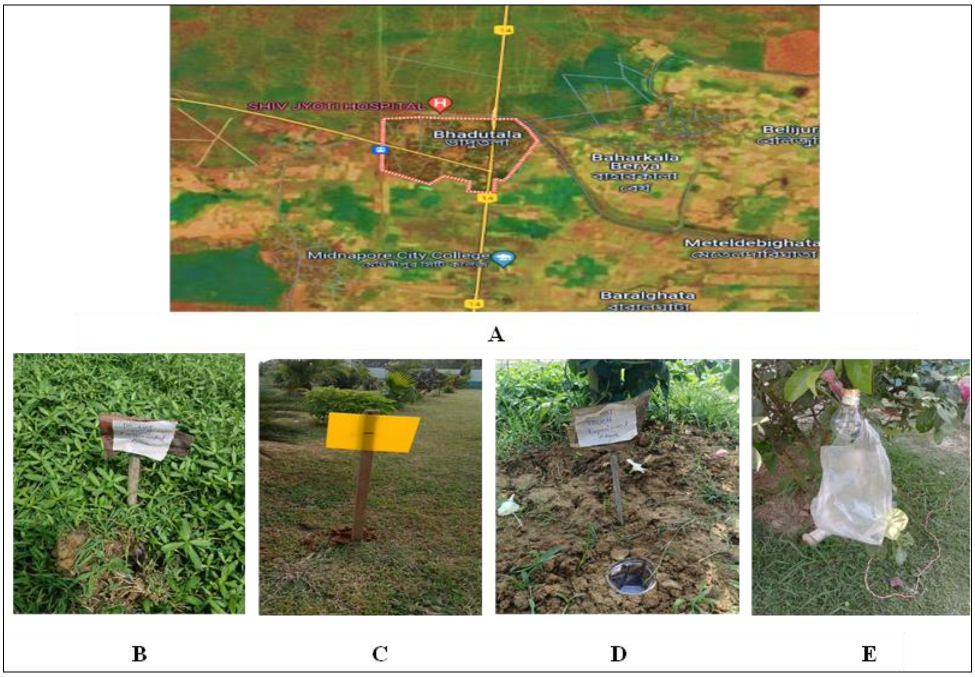

Fig 2: A- Geographical location of Study area; B, D- Pitfall trap, C- Sticky trap, and E- Light trap

Results

The various insects' species were collected from this study are to identify the insect species and their diversity. Among them various insect species belonging to order Coleoptera, Hemiptera, Orthoptera, Diptera and Hymenoptera were collected. Insects are unique creatures and they are adapted to all environment.

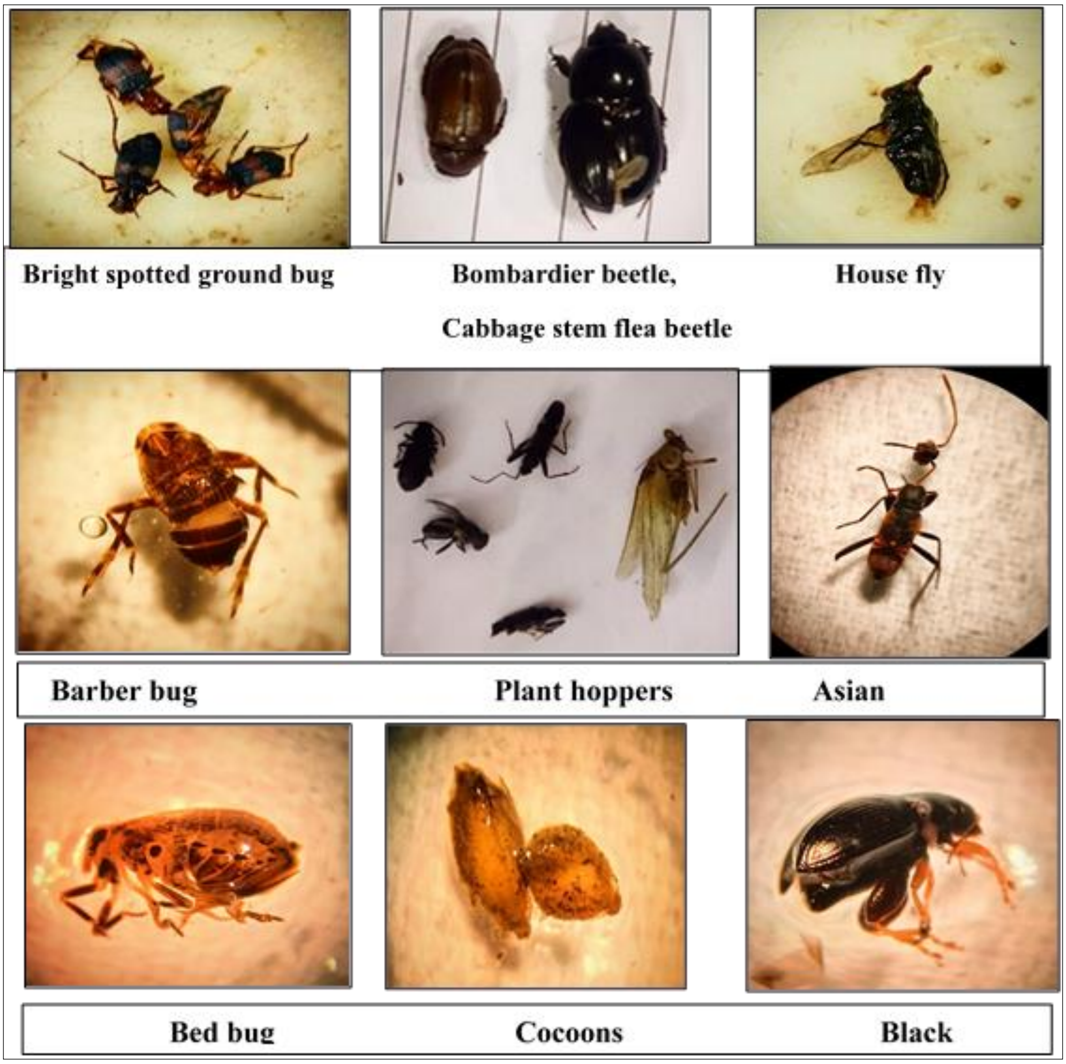

Fig 3: Different types of collecting insects

Table 2: Shanon index

Sl no	Common name (s)	No. of indi (n)	p=n/N	P^2	ln(p)	(p)x|ln(p)|
1	Asian bombardier beetle	250	0.045143	0.002038	-3.09793	0.139849
2	Black soldier fly	255	0.046046	0.00212	-3.07813	0.141734
3	Plant hopper	240	0.043337	0.001878	-3.13875	0.136024
4	Bright spotted ground bug	380	0.068617	0.004708	-2.67922	0.183839
5	White fly	400	0.072228	0.005217	-2.62792	0.18981
6	Cabbage stem flea beetle	235	0.042434	0.001801	-3.1598	0.134083
7	Black carpenter ant	390	0.070423	0.004959	-2.65324	0.186848
8	House fly	240	0.043337	0.001878	-3.13875	0.136024
9	Barber bug	260	0.046948	0.002204	-3.05871	0.143601
10	Dark meal worm	260	0.046948	0.002204	-3.05871	0.143601
11	Great green bush cricket	250	0.045143	0.002038	-3.09793	0.139849
12	Bed bug	225	0.040628	0.001651	-3.20329	0.130144
13	Simply Asian lady beetle	240	0.043337	0.001878	-3.13875	0.136024
14	Spring tails	245	0.04424	0.001957	-3.11813	0.137945
15	Bombardier beetle	210	0.03792	0.001438	-3.27228	0.124084
16	*Anopheles* sp	350	0.0632	0.003994	-2.76146	0.174523
17	*Culex* sp	328	0.059227	0.003508	-2.82638	0.167398
18	*Periplaneta* sp.	235	0.042434	0.001801	-3.1598	0.134083
19	Nairobi fly	225	0.040628	0.001651	-3.20329	0.130144
20	*Drosophila* sp.	320	0.057783	0.003339	-2.85107	0.164742
	Total (s)= 20	N=5538		$\sum p^2$= 0.052262		∑(p)x|ln(p)|=2.974352

Shannon Index= H= 2.974352 S=20

H_{max} = ln(S)= ln(20)= 2.99573227

E= Evenness= H/ H_{max} = 2.974352/2.99573227= 0.992863

Percentage frequency (%)= (No of individual species/Total no of species) *100

Species Density (D)= no of species/ Area of study site (2150.3 sq. ft)

Table 3: Percentage frequency and Density calculation

Sl no	Common name	No. of individuals	Percentage frequency (%)	Density (D)
1	Asian bombardier beetle	250	4.514265	0.116263
2	Black soldier fly	255	4.60455	0.118588
3	Plant hopper	240	4.333694	0.111612
4	Bright spotted ground bug	380	6.861683	0.17672
5	White fly	400	7.222824	0.186021
6	Cabbage stem flea beetle	235	4.243409	0.109287
7	Black carpenter ant	390	7.042254	0.18137
8	House fly	240	4.333694	0.111612
9	Barber bug	260	4.694836	0.120913
10	Dark meal worm	260	4.694836	0.120913
11	Great green bush cricket	250	4.514265	0.116263
12	Bed bug	225	4.062839	0.104637
13	Simply Asian lady beetle	240	4.333694	0.111612
14	Spring tails	245	4.42398	0.113938
15	Bombardier beetle	210	3.791983	0.097661
16	*Anopheles* sp	350	6.319971	0.162768
17	*Culex* sp	328	5.922716	0.152537
18	*Periplaneta* sp.	235	4.243409	0.109287
19	Nairobi fly	225	4.062839	0.104637
20	*Drosophila* sp.	320	5.778259	0.148816
	Total (s)= 20	N=5538		

Table 4: Simpson's index

Common name	No. of individuals	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$	$1-\sum\left(\frac{n}{N}\right)^2$
Asian bombardier beetle	250	0.045142651	0.0020379	0.94773841
Black soldier fly	255	0.046045504	0.0021202	
Plant hopper	240	0.043336945	0.0018781	
Bright spotted ground bug	380	0.068616829	0.0047083	
White fly	400	0.072228241	0.0052169	
Cabbage stem flea beetle	235	0.042434092	0.0018007	
Black carpenter ant	390	0.070422535	0.0049593	
House fly	240	0.043336945	0.0018781	

Barber bug	260	0.046948357	0.0022041	
Dark meal worm	260	0.046948357	0.0022041	
Great green bush cricket	250	0.045142651	0.0020379	
Bed bug	225	0.040628386	0.0016507	
Simply Asian lady beetle	240	0.043336945	0.0018781	
Spring tails	245	0.044239798	0.0019572	
Bombardier beetle	210	0.037919827	0.0014379	
Anopheles sp	350	0.063199711	0.0039942	
Culex sp	328	0.059227158	0.0035079	
Periplaneta sp.	235	0.042434092	0.0018007	
Nairobi fly	225	0.040628386	0.0016507	
Drosophila sp.	320	0.057782593	0.0033388	
Total (s)= 20	5538		0.0522616	

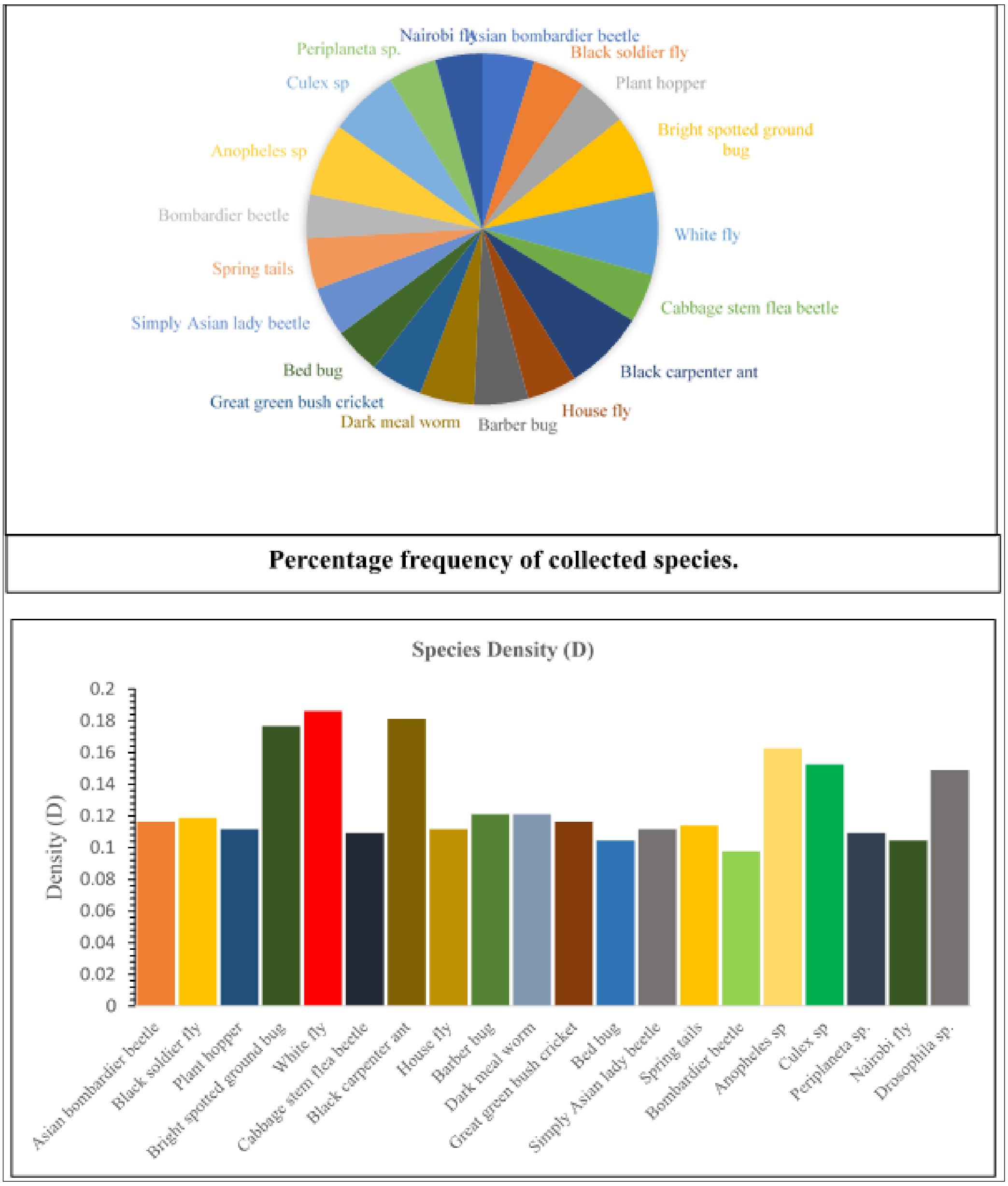

Fig 4: Percentage frequency and species Density calculation

Table 5: Menhinick index and Margalef index

		Menhinick index	**Margalef index**
Common name	**No. of individuals**	$D = \frac{n}{\sqrt{N}}$	$d = s - 1 \ln N$
Asian bombardier beetle	250	3.359416	3.359416
Black soldier fly	255	3.426604	3.426604
Plant hopper	240	3.225039	3.225039
Bright spotted ground bug	380	5.106312	5.106312

White fly	400	5.375065	5.375065
Cabbage stem flea beetle	235	3.157851	3.157851
Black carpenter ant	390	5.240689	5.240689
House fly	240	3.225039	3.225039
Barber bug	260	3.493792	3.493792
Dark meal worm	260	3.493792	3.493792
Great green bush cricket	250	3.359416	3.359416
Bed bug	225	3.023474	3.023474
Simply Asian lady beetle	240	3.225039	3.225039
Spring tails	245	3.292228	3.292228
Bombardier beetle	210	2.821909	2.821909
Anopheles sp	350	4.703182	4.703182
Culex sp	328	4.407554	4.407554
Periplaneta sp.	235	3.157851	3.157851
Nairobi fly	225	3.023474	3.023474
Drosophila sp.	320	4.300052	4.300052
Total (s)= 20	N=5538		

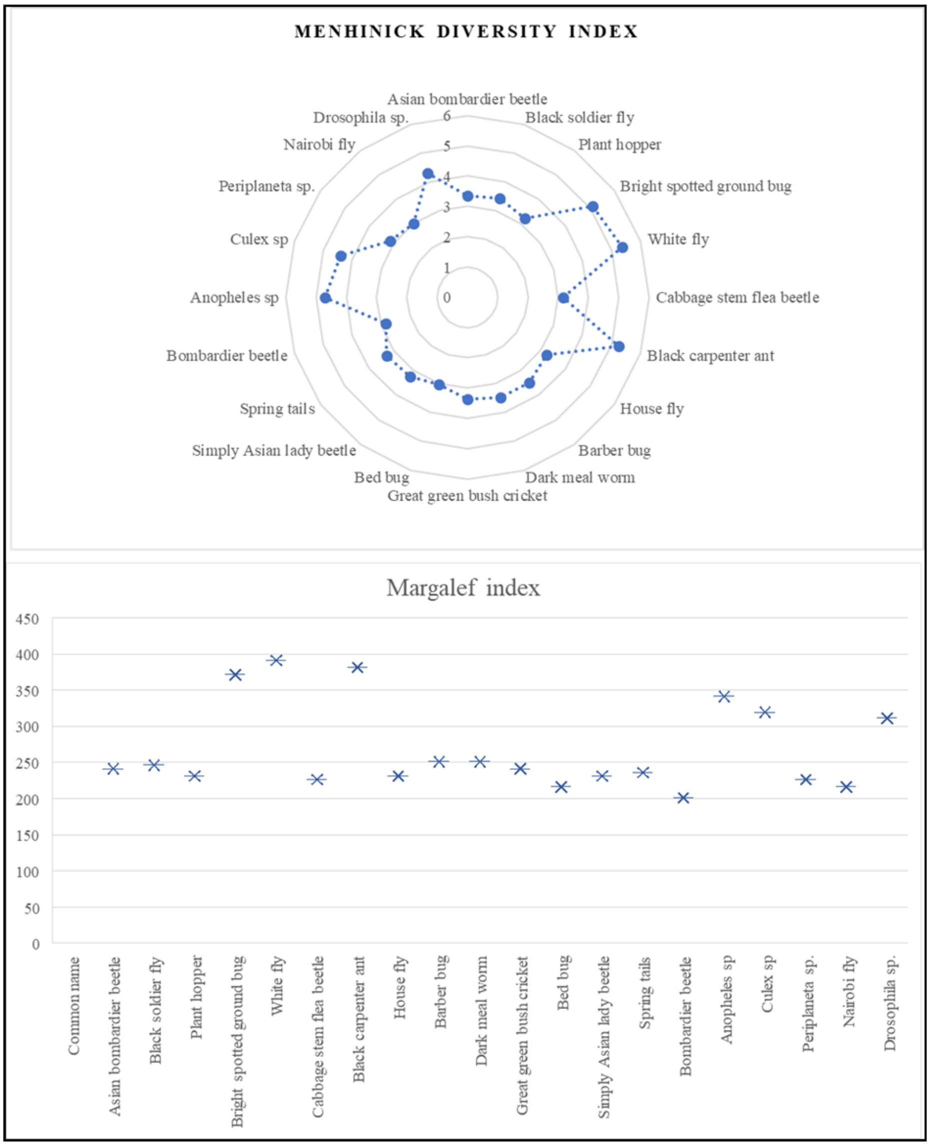

Fig 5: Menhinick diversity index and Margalef index.

Discussion

The data we investigated indicates that in 6 insect orders (Hemiptera, Coleoptera, Hymenoptera, Diptera, Orthoptera, and Agnatha), the insect species were collected from the study site. Most of these orders are harmful to plants and crops. From the Shannon index, we observed that the value of Evenness is 0.99 or approximately 1 which means the good insect diversity shown in this study site. This study showed that white flies (7.22%) and Black carpenter ant (7.04%) are the dominant species among the rest of the collected insects. *Anopheles* sp. (6.31%) and bright spotted ground bug (6.86%) are the third and fourth species with a higher percentage frequency than the other insects. *Culex* sp. (5.92%) and *Drosophila* sp. (5.77%) hold the fifth and sixth position respectively in the percentage frequency chart. This shows that the harmful insects are more abundant than the other insects. These insect species are threatened by agricultural activity. From the result of the species density calculation, we found that the white flies (0.181) show the highest density of the rest of the insects. To control this insect population is a serious matter to think about. Whitefly damage crop fresh leaves. They cause plants to become yellow and lose leaves prematurely. Plant hoppers can also produce hopper burn, as well as plant yellowing, browning, and dryness. Plants suffer greatly from high population infestations (Prasad *et al*., 2022) [30]. House flies, on the other hand, can carry germs on their bodies and faces, contaminate food, and contribute to the spread of food-borne disease, particularly in large numbers. Because of this, they are regarded as pests (Wilson *et al*., 2021) [47]. Barber bugs are active carriers of *Trypanosoma cruzii*, a parasitic trypanosome protozoan. Trypanosoma is a severe illness that can cause irreparable damage to the brain system, muscular tissue, and heart, ultimately leading to death (Lucius *et al*., 2016) [24]. Black carpenter ants create nests in dead trees and other dead wood. This promotes decomposition, which has environmental advantages. However, the ant becomes a problem when a colony invades the wood of a home or other building, causing structural damage (Ferro *et al*., 2018) [10]. Black soldier fly larvae are used to decompose trash or turn it into animal feed. Bright spotted ground bugs are extremely valuable to ecosystems. The widespread effects they have on entire populations in both wooded and agricultural areas. Pushers are used to break up matted leaves and reduce the yearly compaction of the litter layer. Their actions, like those of deep burrowers, contribute to soil drainage, aeration, and nutrient flow (Kim *et al*., 2021) [21]. Cabbage stem flea beetle produces severe leaf damage as well as larval infestations that impair stem strength, all of which have an influence on crop growth and development, resulting in significant production losses and economic harm (Wilkinson *et al*., 2024) [46]. Mealworms are exclusively external eaters on grains and are not severe pests. Screening and fanning can readily remove them from grain shipments. However, well-grown larvae can cause substantial damage to whole grains under specific situations, such as when grain is stored for extended periods of time without being moved. The majority of the damage is due to worm infection and waste products (Mazurek *et al*., 2022) [26]. The Asian lady beetle was imported to the United States in 1916 to reduce crop-eating aphids (Korakari *et al*., 2021). Springtails influence litter decomposition, microbial activity, abundance, dispersion, and plant development. Springtails consume bacteria, fungus, lichens, algae, and rotting plants, fertilising the soil in the process (Walter *et al*., 2013) [45]. Bombardier beetles serve as both predators and scavengers, but by consuming debris, they help decompose rotting plants. Many of them enjoy wet microclimates and may frequently be found beneath logs and in leaf litter (Ahad *et al*., 2019) [2].

Challenges in Studying Insect Biodiversity

While focusing on a single agricultural area offers depth, it also presents challenges. Insect populations are highly dynamic and influenced by a variety of factors, including climate variability, seasonal changes, and human intervention. Understanding the long-term effects of specific farming practices may require years of data collection and analysis.

Additionally, accurately identifying insect species can be challenging due to the vast diversity of insects, some of which may be rare or poorly studied. Collaboration with entomologists and the use of advanced tools like DNA barcoding can help mitigate these challenges.

Conclusion

From this investigation, we can conclude that

- Good insect diversity is shown in the study area Bhadutala.
- White flies from the order Hemiptera are abundant from the other insects.
- Whiteflies are dominant among the other insects in this study area.
- White flies (0.186) show the highest species density in this study area.
- Harmful insects are dominant in this study area.

A focused study of insect biodiversity in a specific agricultural area of West Bengal, such as a rice farming region, can provide valuable insights into the role of insects in maintaining a healthy, productive farming system. By understanding how local farming practices impact insect populations, the study can help inform sustainable agricultural practices that preserve biodiversity, improve crop yields, and reduce reliance on harmful chemicals.

The findings from such a study can guide local farmers in adopting integrated pest management (IPM) strategies, promoting organic farming, and creating habitats for beneficial insects. In the long term, these efforts will contribute to the sustainability of agriculture in West Bengal, ensuring that both farmers and the environment thrive together.

It also aids taxonomists in understanding insect biodiversity. The Zoological Survey of India offers courses on identifying insects and mites of economic importance, but the CAB International Institute of Entomology offers only one (Ghosh *et al*., 1996).

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Authors contribution

Author R.S- Writing, Editing, Data calculation, preparing the manuscript. Authors M.B And S.R- collecting data, preparing traps, field works, author S.S.- visualization and Review, Author S.M.D- supervision, Conceptualization, Visualization, and Review.

Declaration of interest

The writers say they have no competing interests.

Data and Materials Availability Statement

Every dataset examined for this study is openly accessible to the public.

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