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Insects as Environmental Bioindicators

Moirangthem Monalisa Devi
PhD Scholar, Department of Entomology, College of Agriculture, CAU, Imphal, Manipur-795004

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Introduction

Research on bioindicators and environmental pollution has recently piqued researcher's attention. Identification of species capable of reliably detecting environmental disturbances and illustrating the effects of such disturbances on other species or biodiversity as a whole constitute the fundamental goal of bioindicator research. Insects are very useful in assessing the effects of human activity on the terrestrial ecosystem, the aquatic system, and the atmosphere because they frequently come into touch with the toxic compounds present in soil, water, and the atmosphere. A limited number of terrestrial insect taxonomic orders are employed as bioindicators. Even though these indicator taxa aren't widely accepted as comprehensive markers of biodiversity, they could be useful in identifying the effects of habitat management. The most common group of organisms utilized as bioindicators for metal and soil contamination is the coleopteran family

Bioindicator Selection Criteria

The selection criteria of the indicator are subject to change and are mostly determined by the goals of the investigation. Examples of these goals include the indicator's need to be used in biological diversity studies, habitat loss, climate change, and contaminated areas. It must meet a number of criteria in order to be considered a respectable indicator. One popular and affordable way to recognize and track environmental changes is through the use of bioindicators.

A good bioindicator should be broadly distributed over a large geographic area, have well-established taxonomy and ecology, be specialized to meet specific habitat requirements, provide early warning of change, be easy and inexpensive to survey, be largely independent of sample size, and be able to distinguish between trends or cycles that are triggered by natural cycles.

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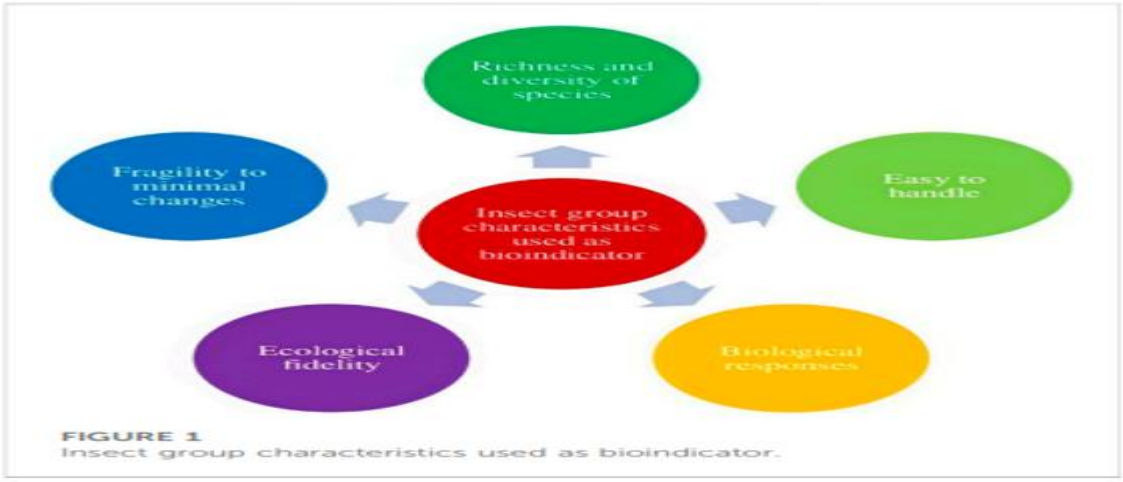

Fig.1 Insect group characteristics used as bioindicator

Classification of Bioindicator

A bioindicator tracks the evolution of biological or non-biological elements in an environment; in certain cases, it centers on a living being. It acts as a metaphor for comprehending and evaluating the condition of the ecosystem. It also can, however, be used more widely or precisely to describe the effects of environmental change on a species or group of species that are representative of the state of inanimate things or living forms in the environment. Similarly, it can be applied to characterize organisms or collections of organisms that show the diversity within or across a taxonomic group. Environmental, ecological, and biodiversity indicators are the three categories into which bioindicators can be divided based on their different backgrounds and applications.

Major Bioindicator Insect Groups

There are 6 major insect orders that can be used as bioindicators viz: Coleoptera, lepidoptera, Diptera, Hymenoptera, Orthoptera and isoptera.

- **Coleoptera**: The most common insect used in environmental biomonitoring, particularly for assessing environmental pollutants and forest management, is the beetle. Coleopterans are thought to be potential bioindicators and primarily belong to the group Carabidae, Staphylinidae, and Curculionidae. Certain species have varying degrees of indication; for example, the tenebrionidae family is utilized as a fire recovery indicator. As a bioindicator of heavy metal accumulation, ground beetles are employed. An investigation into the absorption of heavy metals in soil, litter, and *Oulema gallaeciana* leaf beetles was conducted. Morphology of beetle is also modified due to

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heavy metal accumulation. *Blaps polycresta* is the species of beetle that demonstrates ultrastructure modification in ovarian tissues. The most often identified metals in these ovarian tissues are lead, copper, zinc, and cadmium. The *Parallelomorphus laevigatus* carabid beetle is employed to identify environmental contamination caused by soil metals.

- **Hymenoptera**: Ants, bees, and wasps are examples of hymenopterans. Ants are typically utilized to examine biological activity, habitat diversity, and disturbances to the landscape. Thus, it arranges a crucial portion of the biomass of living things in terrestrial settings and responds to weight far better than vertebrates. Heavy metals like aluminum (Al), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), nickel (Ni), lead (Pb), and zinc (Zn) are accumulated by red wood ants *Formica lugubris* in both worker ant bodies and nest material. Ants are being employed more and more as bioindicators to track the health of ecosystems. The other invertebrate taxa present in an area are also somewhat reflected in the ant fauna. Honey bees are employed in the detection of radionuclides, heavy metals, and insecticides.
- **Lepidoptera:** Given that they become affected by even the smallest change in environmental conditions, butterflies are important bioindicators. In industrial states and even within metropolitan areas, they have been widely utilized as bioindicators of environmental contamination and heavy metals. Climate variables have a great effect on butterflies. The range shifts, oviposition sites, egg-laying rates, larval development, and survival rates of butterflies are all strongly influenced by temperature. This species, *Zizeeria maha* (Lepidoptera, Lycaenidae), has been identified as a useful biological indicator to identify changes in the human environment following the Fukushima nuclear accident, according to a recent study done in Japan. According to the findings, this nuclear accident has decreased the species richness and biodiversity of this butterfly.
- **Diptera:** Diptera's ecological diversity makes them useful as bioindicators. One such bioindicator in open situations is *Drosophila melanogestar*, a model insect utilized in genetics and forensic studies. Forest disturbance and habitat degradation are two applications for dipterans. Larvae of the Chironomidae family can serve as useful bioindicators in urban environments with varying trophic levels. When the environment changed, these larvae's mouthparts became malformed.

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- **Orthoptera:** Grasshoppers and crickets are examples of orthopterans, which are also employed as ecological indicators to identify environmental changes. Orthopterans are also employed as a heavy metal build up indication. *Tetrix tenuicornis* (Tetrigidae, Orthoptera) was gathered from both polluted and unpolluted places for a scientific study. The species' cytogenic alterations and the stress on heat shock proteins were examined, and it was discovered that these species were similarly vulnerable to grassland conditions and climate change.
- **Isoptera**: By comparing the physical and chemical characteristics of soil from termite mounds to soil that has been chemically fertilized, termites, who are known as "ecosystem engineers," serve as bioindicators of soil fertility. In 2019 study, Alajmi *et al*. found that there was a significant indirect association for Ba, Cr, Ni, Co, and Fe, but a significant direct link for the concentrations of Al, Cu, Zn, Be, Cd, Mn, Ca, Mg, Pb, V, and Mo when termites were present.

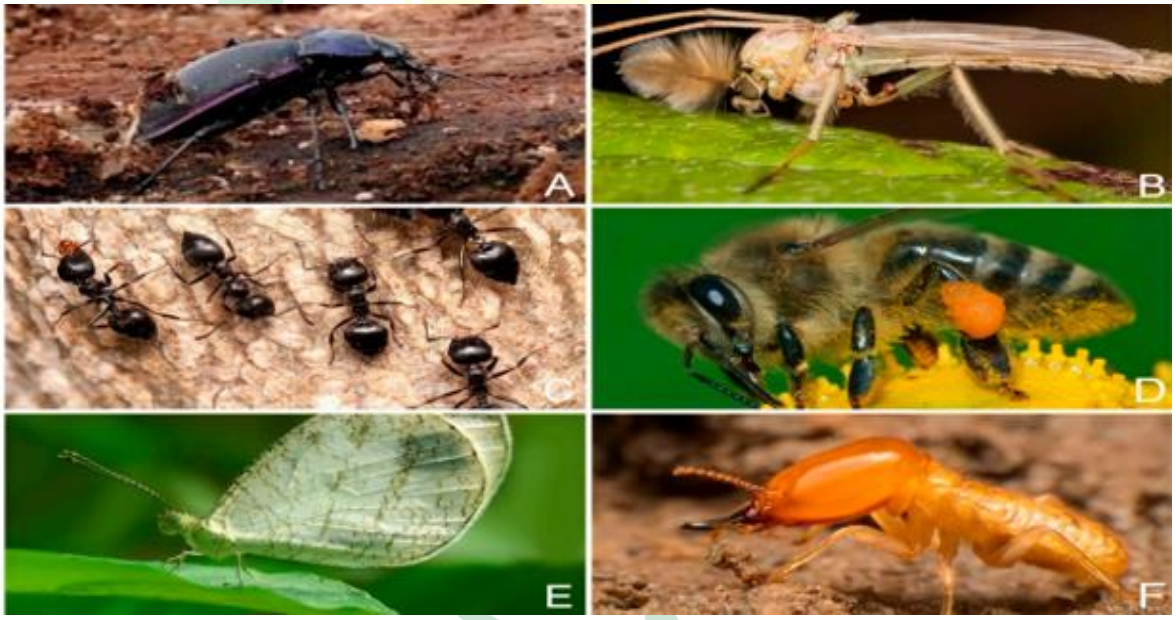

Fig. 2 Major bioindicator insects. (A) Beetle, (B) Chironomid, (C) Ant, (D) Bee, (E) Butterfly, (F) Termite

Conclusion

Indicator species are important ecological markers for environmental monitoring. The main characteristics and features of a bioindicator include species richness and variety, simplicity of handling, cost-effectiveness, ecological faithfulness and fragility to minute environmental changes, and ease of assessing environmental changes. All of them belong to

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the class Insecta. Insects are an important indicator of changes in the water, air, and soil quality. These changes affect many species' physiological traits and abundance, even if it can be challenging to identify a specific indicator and understand the connection between them and their specific applications. Because we can utilize it to identify pollution in the soil, water, and air, this insect will be extremely valuable as an indicator species in the future. Future habitat loss and pollution reduction will be possible as a result of our actions.

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