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Role of Insects in the Environment and their Adaptations in Special Reference to Terrestrial Environment

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Abstract

Insects are the most abundant creatures on the earth and found to reside in all kinds of environment from extreme hot springs to freezing snow caps which makes them the most wondrous organisms due to their impeccable body size, ability to fly, hexapod locomotion, decentralized nervous system, malphigian tubules as excretory organs and etc. Insects are known to play a very important role in various ecological processes such as pollination, predation/parasitism, ecosystem cycling, insects as food and decomposition. Insects have the capability to adapt to different environmental stresses like low temperatures, high temperatures and adopt morphological, behavioural and physiological adaptation strategies for their survival. This article gives insights regarding the important role of insects in ecological processes and their adaptations in terrestrial environment.

1. Introduction

Insects are the most diverse and abundant group of animals on earth, with over one million species described and many more undiscovered. Insects have evolved over millions of years, adapting to various environments and ecological niches. Insects have a common body plan that consists of three main segments: the head, the thorax and the abdomen. They also have an exoskeleton, a pair of antennae, compound eyes and three pairs of legs. Some insects have wings, which enable them to fly and disperse. Insects play important roles in ecosystems, such as pollinating plants, decomposing organic matter, controlling pests and providing food for other animals.

2. Role of Insects in Environment

2.1. Pollination

About 75% of crop species gets benefitted from insect pollinators (Bartomeus et al., 2014). The pollination effects the quality and yield. Hence good pollination is a sign of greater yield. Major insect pollinators include honey bees, bumble bees, butterflies, moths and

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flies. Therefore, insects are crucial in maintaining plant diversity, there is a famous quote by Albert Einstein- "If the bee disappeared off the surface of the globe, then man would have only four years of life left".

2.2. Predation/Parasitism

Predation in insects is a common phenomenon. The adults and youngs of mantids, odonates, lacewings, scorpion flies, tiger beetles, ground beetles show predatory behaviour. Majority of the hymenopterans like braconids, ichneumonids, trichogrammatids, scelionids, act like parasitoids in different stages of their life cycle namely egg, larval, pupal and adult parasitoids.

2.3. Ecosystem cycling

Insect herbivores change the quality and quantity of detrimental organic matter into useful substrates inturn enhancing the soil quality by maintaining the balanced soil nutrition by proper ion fluxes. Example: Grasshoppers influence nitrogen cycling by their excrement (Belovsky and Slade, 2000).

2.4. Insects as food

Insects are rich source of essential minerals, dietary fibres, vitamins, proteins etc. Insects serves as food for humans as well as in industrial feed production for poultry, fishes etc namely yellow meal worms (Tenebrionidae), black soldier flies (Stratiomyidae) are extensively used (Dobermann et al., 2017). Edible insects like grasshoppers, crickets, locusts are particularly protein rich (Rumpold and Schulter, 2013). Recently in Odisha, *kai chutney* which is prepared from weaver ant species (*Oecophylla smaragdina*) treated as a delicacy in the tribal areas of Mayurbhanj district and simlipal forest areas bagged geographical indication tag due to its authentic dish flavour and nutritional value. In the near future, insects might take a upper hand in replacing plant based food products (Specht et al., 2019).

2.5. Decomposition

Insects play a key role in decomposition process of organic wastes such as cow dung and carrion. Insects like dung beetles, termites, bot flies, sarcophagids help in conversion of dumps of wastes into nutrient cycling thus helping in ecosystem stability. Insects due to the habit of decomposition they are used in crime investigations (Anderson and Cervenka, 2001).

3. Adaptations of Insects in Terrestrial Environment

Adaptation in simpler term refers to an organism's ability to cope with the changing environmental circumstances. Mainly in terrestrial environment, three categories of adaptations are seen in insects viz.,

- ❖ Behavioural adaptations
- ❖ Morphological adaptations
- ❖ Physiological adaptations

3.1. Behavioural adaptations

It refers to internally directed system of adaptive activities that facilitate survival and reproduction. Adaptations include migration, diapause, sounding scary, shooting spray, thanatosis and web spinning.

3.1.1. Migration

It refers to the movement of an individual from one location to another for the purpose of feeding and breeding. It involves two kinds of migration like long term migration and short term migration. In long term migration it involves only alate forms i.e winged insects. The best known example is Monarch butterfly (USA). In Indian context, approximately 250 species of butterflies are migratory which includes pieridae and nymphalidae families (Wikipedia, 2024).

3.1.2. Diapause

It is a state of seasonal dormancy adapted to recurring periods of adverse environmental conditions (Tougeron, 2019). It is of two types

- ✓ Obligatory diapause- Diapause occurs at a fixed time interval, mostly in univoltine insects (one generation/year).
- ✓ Facultative diapause- Diapause occurs at varied time interval, seen in bi/multivoltine insects.

Examples: May or June beetles undergo diapause in soil and emerges when they receive the first spell of monsoon rains.

3.1.3. Sounding scary

Insects produce high pitched squeaky sounds in order to scare away their natural enemies. Cockroaches produces hissing sounds, deaths head moth produce scary noise when disturbed. Due to these sounds, predators get startled or confused.

3.1.4. Shooting spray

Some of the insects produce defensive and foul smelling hydro compounds from the specialized body parts for protection against the predators. One of the classical examples is Bombardier beetle which emits defensive hot liquid from its abdomen when it gets disturbed.

Rove beetles curl their abdomen back while releasing defensive liquids.

3.1.5. Thanatosis

It refers to death feigning mechanism where insects behave as if they are dead. It is widespread in many insects like mustard saw fly larva, red flour beetle etc.

3.1.6. Web spinning

It refers to the production of fine thread like network for the entanglement of the predator species. It is mostly seen in insect orders like lepidoptera, embioptera, psocoptera.

3.2. Morphological adaptations

It refers to the physical features of an insect which helps to thrive it in harsh environmental conditions.

The adaptations include

1. Mimicry

2. Camouflage

3.2.1. Mimicry

It refers to the adaptive resemblance in signal between several species in a locality. Classical examples: Batesian mimicry and mullerian mimicry.

1. Batesian mimicry: palatable species mimics the unpalatable species

Ex: viceroy butterfly mimics monarch butterfly

2. Mullerian mimicry: Two aposematic noxious forms mimics for their mutual benefit.

3.2.2. Camouflage

Insects survive by blending with their surrounding environment so that they won't be visible for predators and gets protected. Example: Stick insects, Leaf insects.

3.3. Physiological adaptations

It refers to the cellular features, internal organs and mechanisms help an organism to survive in its environment. Adjustments in the internal functions or processes of insects that help them to maintain homeostasis or cope with stress. For example, some insects can regulate their body temperature by basking in the sun or seeking shade (thermoregulation), adjust their water balance by absorbing or excreting fluids (osmoregulation), or modulate their energy metabolism by using different reserves such as sugars or lipids (metabolic regulation).

3.3.1. Adaptations to low temperature

Temperature is one of the important abiotic factors important abiotic factor which determines the activity of an organism. Insects are divided into two groups such as freeze tolerant and freeze avoiding insects to counteract the effects of low temperatures. Tolerance is due to the presence of cryoprotectants like glycerol, ribitol, glycols, trehalose.

3.3.2. Adaptations to high temperature

High temperatures kill insects by denaturing protein structure, alteration of cell walls and loss of water. Acclimation is a phenomenon which helps insects to survive in high temperature conditions.

4. Conclusion

There are diverse adaptations that insects have evolved to interact with their environment and overcome various challenges. Insects are remarkable organisms that demonstrate high levels of plasticity and resilience in the face of environmental changes.

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