Article: RT0393

Biotica Research Today

Vol 2:11 2020

1174/1178

Why Insects are Dominance in the Biosphere?

Devi, M. [1*] and K. Indirakumar[2]

[1]Dept. of Agricultural Entomology, MIT College of Agriculture and Technology, Musiri, Tamil Nadu (621 211), India
[2]Central Silk Board, Tura, West Garo Hills, Meghalaya (794 101), India

Open Access

Corresponding Author

Devi, M.
e-mail: deviagri84@gmail.com

Keywords

Adoptability, Arthropod, Defense mechanism, Dominant

Article History

Received in 29th October 2020
Received in revised form 25th November 2020
Accepted in final form 26th November 2020

E-mail: bioticapublications@gmail.com

How to cite this article?

Devi and Indirakumar, 2020. Why Insects are Dominance in the Biosphere?. Biotica Research Today 2(11): 1174-1178.

Abstract

Insects or Insecta are hexapod invertebrates and the largest group within the arthropod phylum. Circumscriptions vary; usually, insects comprise a class within the Arthropoda. Insects have a chitinous exoskeleton, a three-part body, three pairs of jointed legs, compound eyes and one pair of antennae. Insects are the most diverse group of animals; they include more than a million described species and represent more than half of all known living organisms. The total number of extant species is estimated at between six and ten million; potentially over 90% of the animal life forms on Earth are insects. Insects may be found in nearly all environments, although only a small number of species reside in the oceans, which are dominated by another arthropod group, crustaceans.

Introduction

Nearly all insects hatch from eggs. Insect growth is constrained by the inelastic exoskeleton and development involves a series of molts. The immature stages often differ from the adults in structure, habit and habitat, and can include a passive pupal stage in those groups that undergo four-stage metamorphosis. Insects that undergo three-stage metamorphosis lack a pupal stage and adults develop through a series of nymphal stages. The higher level relationship of the insects is unclear. Fossilized insects of enormous size have been found from the Paleozoic Era, including giant dragonflies with wingspans of 55 to 70 cm. The most diverse insect groups appear to have coevolved with flowering plants.

Adult insects typically move about by walking, flying, or sometimes swimming. As it allows for rapid yet stable movement, many insects adopt a tripedal gait in which they walk with their legs touching the ground in alternating triangles, composed of the front and rear on one side with the middle on the other side. Insects are the only invertebrates to have evolved flight, and all flying insects derive from one common ancestor. Many insects spend at least part of their lives under water, with larval adaptations that include gills, and some adult insects are aquatic and have adaptations for swimming. Some species, such as water striders, are capable of walking on the surface of water. Insects are mostly solitary, but some, such as certain bees, ants and termites, are social and live in large, well-organized colonies. Some insects, such as earwigs, show maternal care, guarding their eggs and young. Insects can communicate with each other in a variety of ways. Male moths can sense the pheromones of female moths over great distances. Other species communicate with sounds: crickets stridulate, or rub their wings together, to attract a mate and repel other males. Lampyrid beetles communicate with light.

There are several structural, morphological and physiological factors responsible for insect dominance. They are:

1 Capacity for flight
2. More adaptability or universality
3. Smaller size
4. Presence of exoskeleton
5. Resistance to desiccation
6. Tracheal system of respiration
7. Higher reproductive potential
8. Presence of complete metamorphosis
9. Presence of defense mechanisms
10. Hexapod locomotion

Structural Characters

1. Capacity for Flight

Insects are the only invertebrates that can fly. Flight gave these insects a highly effective mode of escape from predators that roamed the prehistoric landscape. Efficient use of energy allows some insects to travel great distances or remain airborne for long periods of time. More than 200 species, including moths, dragonflies, locusts, flies, and beetles are known to migrate over long distances byair. The migratory locust, *Schistocerca gregaria*, can fly for upto 9 hours without stopping. Monarch butterfly can fly 600 km at a time. Wings may have evolved from appendages on the sides of existing limbs, which already had nerves, joints, and muscles used for other purposes. These may initially have been used for sailing on water, or to slow the rate of descent when gliding. Two insect groups, the dragonflies and the mayflies, have flight muscles attached directly to the wings. In other winged insects, flight muscles attach to the thorax, which make it oscillate in order to induce the wings to beat. Of these insects, some (dipterans and some beetles) achieve very high wingbeat frequencies through the evolution of an "asynchronous" nervous system, in which the thorax oscillates faster than the rate of nerve impulses.

Figure 1: A tau emerald (Hemicordulia tau) dragonfly has flight muscles attached directly to its wings

2. More Adoptability or Universality

A combination of large and diverse populations, high reproductive potential, and relatively short life cycles, has equipped most insects with the genetic resources to adapt quickly in the face of a changing environment. Adaptation is an ongoing process. Populations must continually change as new resources appear and old ones disappear.

3. Smaller Size

Majority of insects are small in their size conferring the following physiological and ecological advantages. Most species are between 2 and 20 mm (0.1 - 1.0 inch) in length, although they range in size from giant moths that would nearly cover your computer screen to tiny parasitic wasps. *Dichomorpha echmepterygis* is the smallest of the small. Adult males may be only 0.139 mm (0.00055 inch) in length - nearly 1/3rd smaller than some single-celled protozoa. Advantage of small size is the minimal resources needed for survival and reproduction. Small size is a big advantage to insects that must avoid predation. They can hide in the cracks of a rock, beneath the bark of a tree, behind the petal of a flower, or under a blade of grass.

Figure 2: Coleopteran pest from smaller size to larger size of the insects

4. Presence of Exoskeleton

Insect body is covered with an outer cuticle called exoskeleton which is made up of a cuticular protein called **Chitin**. This is light in weight and gives strength, rigidity and flexibility to the insect body.

5. Resistance to Desiccation

Insects minimize the water loss from their body surface through prevention of water loss (wax layer of epicuticle, closable spiracles, egg shell) conservation of water (capable

Figure 3: Presence of Exoskeleton on coleopteran pest

of utilizing metabolic water, resorption of water from fecal matter, use less quantity of water to remove the nitrogenous waste).

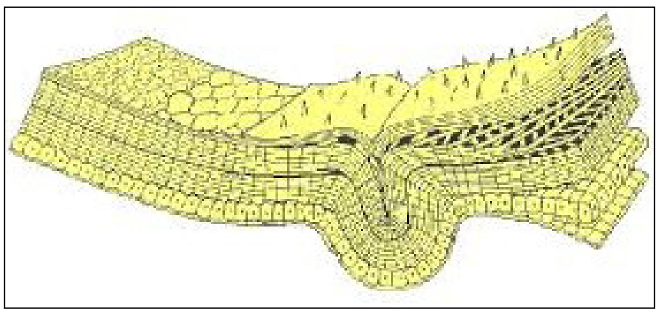

Figure 4: Epicuticle layer of the insects

6. Tracheal System of Respiration

This ensures direct transfer of adequate oxygen to actively breathing tissues. Spiracles through their closing mechanism admit air and restrict water loss.

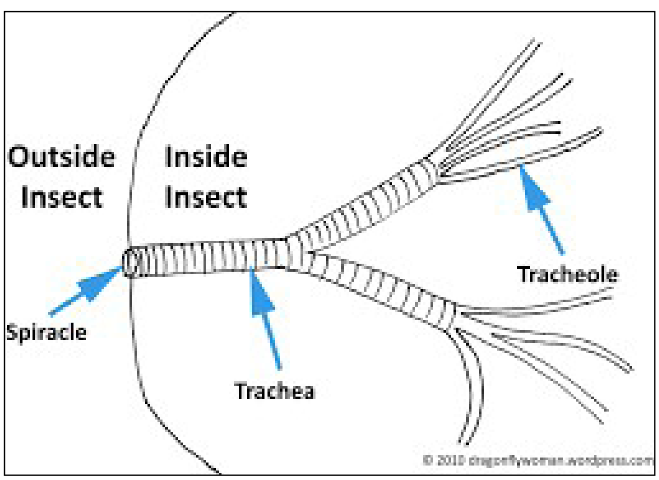

Figure 5: Insect tracheal system

Developmental Characters

1. Higher Reproductive Potential

Reproductive potential of insect is high e.g., Egg laying capacity (fecundity) of queen termite is 6000 – 7000 eggs per day for 15 long years. Short development period e.g., Corn aphid produces 16 nymphs per female which reaches the adulthood within 16 days. Presence of special types of reproduction other than oviparity and viviparity like Polyembryony, Parthenogenesis and Paedogenesis.

2. Presence of Complete Metamorphosis

More than 82 percent of insects undergo complete metamorphosis (holometabolous insects) with four stages. As the larval and adult food sources are different, competition for food is less.

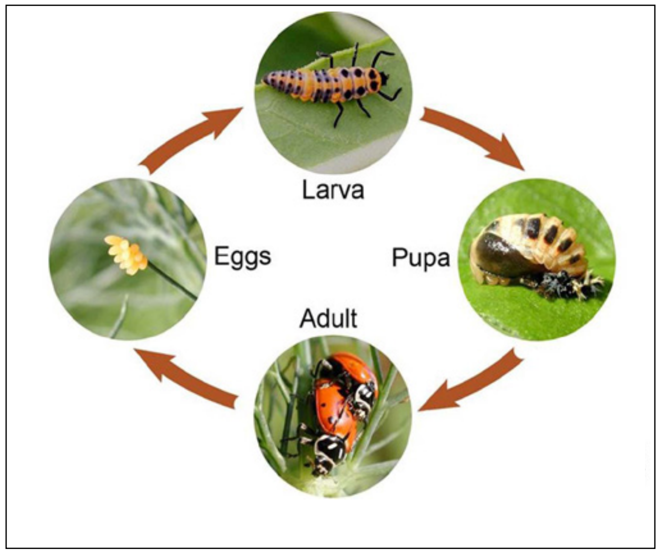

Figure 6: Complete life cycle of insect

Protective Adaptations and Devices

1. Presence of Defense Mechanisms

By different defense mechanisms, insects escape from the enemies to increase their survival rate. The exoskeleton serves also as a water-impermeable barrier, protecting the insect against desiccation. The main part of the barrier is located in the wax-covered epicuticle. An important function for the exoskeleton is to act as a barrier preventing microorganisms from access to interior of the animal. Insects have had millions of years to evolve mechanical defenses. Perhaps the most obvious is the cuticle. Although it's main role lies in support and muscle attachment, when extensively hardened by the cross-linking of proteins and chitin, or sclerotized, the cuticle acts as a first line of defense. Additional physical defenses include modified mandibles, horns, and spines on the tibia and femur. When these spines take on a main predatory role, they are termed raptorial. Some insects uniquely create retreats that appear uninteresting or inedible to predators. This is the case in caddis fly larvae which encase their abdomen with a mixture of materials like leaves, twigs, and stones.

Morphological Defense: Leaf insects use camouflage to take on the appearance of a leaf. They do this so accurately that predators often aren't able to distinguish them from real leaves. In some species the edge of the leaf insect's body even has the appearance of bite marks. To further confuse predators, when the leaf insect walks, it rocks back and forth, to mimic a real leaf being blown by the wind. They and stick insects go together in the Order Phasmatodea.

Figure 7: Leaf insects on leaf

Physiological Defense: The shedding of appendages is also used to distract predators, giving the prey a chance to escape. This highly costly mechanism is regularly practiced within stick insects (order Phasmatodea) where the cost is accentuated by the possibility that legs can be lost 20% of the time during molting. Harvestmen also use autotomy as a first line of defense against predators.

Figure 8: Adrobunus grandis showing its body structure and long legs

Behavioral Defense: Behavioral responses to escape predation include burrowing into substrate and being active only through part of the day. Furthermore, insects may feign death, a response termed thanatosis. Beetles, particularly weevils, do this frequently. Bright colors may also be flashed underneath cryptic ones. A startle display occurs when prey takes advantage of these markings after being discovered by a predator. The striking color pattern, which often includes eyespots, is intended to evoke prompt enemy retreat. Better formed eyespots seem to result in better deterrence.

Figure 9: Many butterflies, such as this gladeye bushbrown (Mycalesis patnia), have eyespots on their wings

2. Hexapod Locomotion

Insects uses 3 legs at a time during locomotion, while the remaining 3 legs are static, which gives greater stability. Grasshopper can high-jump vertically upwards 45 cm (10 times its body length) and long-jump 90 cm horizontally (20 times its body length). This is equivalent to a human high-jumping 60 feet (20 m) and long-jumping 120 feet (40 m) Insects are also strong for their size, being capable of carrying 2-3 times their body weight, and up to 7-10 times their body weight in the case of ants. More specifically the force to weight ratio, of a grasshopper's jumping leg is about four times that generated by a human leg. (In comparison, measurements indicate that the jumping power of a chimpanzee leg is equal to that of a human leg, even though the muscle volume of the chimpanzee leg is about half and chimpanzees typically lighter - chimpanzees are very good jumpers). This can be partly explained by the greater relative strength of insects, due to their small size, but this results in an acceleration rate that muscles cannot achieve unaided. It is the fact that the insect cuticle contains a very elastic material called resilin, which is abundant in the cuticle of the legs of jumping insects that enables the insect leg to store energy. When preparing to jump the leg is locked in place as the powerful tibia flexors (situated in the femur) contract, straining the cuticle of the locked leg which builds up elastic energy. Suddenly, the cuticular lock is released and the leg springs straight, releasing the stored elastic energy as the insect jumps. Resilin is almost perfectly elastic: 97% of the stored energy is released as mechanical

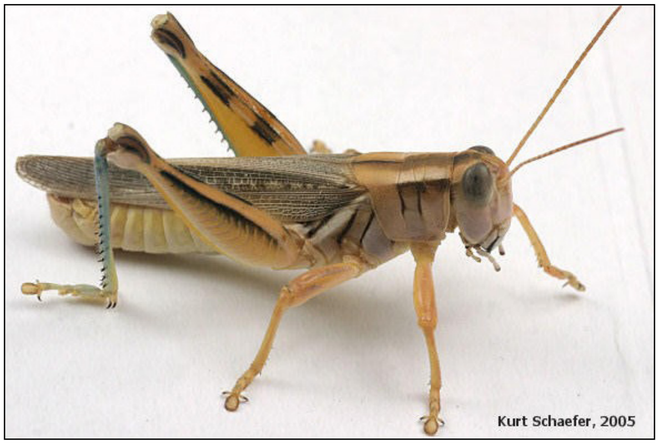

Figure 10: Grasshopper locomotion

energy; only 3% is lost as unusable energy (heat and sound).

Conclusion

Insects that feed on other insects are beneficial to humans if they eat insects that could cause damage to agriculture and human structures. Aphids feed on crops and cause problems for farmers, but ladybugs feed on aphids, and can be used as a means to significantly reduce pest aphid populations. While birds are perhaps more visible predators of insects, insects themselves account for the vast majority of insect consumption. Ants also help control animal populations by consuming small vertebrates. Without predators to keep them in check, insects can undergo almost unstoppable population explosions.

References

Chapman, A.D., 2006. Numbers of living species in Australia and the World. Canberra: Australian Biological Resources Study. ISBN 978-0-642-56850-2.

Dossey, Aaron T., 2010. "Insects and their chemical weaponry: New potential for drug discovery". Natural Product Reports. 27 (12): 1737–1757. doi:10.1039/c005319h. PMID 20957283.

Wilson, E.O. "Threats to Global Diversity". Archived from the original on 20 February 2015.