IMPACTO CIENTÍFICO EDITORA

ENTOMOLOGY: A REVIEW ON DIRECT AND INDIRECT DAMAGE, RESPIRATORY SYSTEM, ECDYSIS, ANATOMY AND MORPHOLOGY, REPRODUCTION, AND CHEWING AND SUCKING INSECTS

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ABSTRACT

The article addresses several fundamental aspects of insect biology and ecology, with emphasis on their importance for agriculture and terrestrial ecosystems. Initially, it distinguishes the damage caused by insects to plants as direct and indirect, emphasizing their impacts on agricultural production. It then describes the tracheal respiratory system of insects, highlighting their efficiency for survival in dry environments and their role as an entry route for insecticides. The text also explores the process of ecdysis (molting), controlled by hormones such as ecdysone and juvenile hormone, essential for the growth and development of insects and are used in biological control strategies.
In addition, it discusses the anatomy and morphology of insects, fundamental for their identification and control, highlighting adaptations such as the modification of mouthparts and specialized sensory systems. The article emphasizes the ecological and economic importance of insects as pollinators, decomposers, and pests and highlights their high reproductive and adaptive capacity. Finally, he comments on the rare phenomenon of hermaphroditism and the classification of pest insects according to the oral system, focusing on Coleoptera with a chewing apparatus.

Keywords: Insect pests. Biological control. Insect morphology.

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DAMAGE

Damage can be defined as the loss of usefulness of the crop in response to injury. They cause greater or lesser damage depending on the species, population density, duration of the attack, and plant structure attacked.

According to the part of the plant that is attacked by the insects:

a) Direct damage: they attack the product to be sold.

Example: small tomato borer (*Neoleucinodes* elegantalis Guenée, 1854) that attacks tomato fruits.

b) Indirect damage: They attack plant structures that will not be commercialized (leaves and roots, for example), but that alter physiological processes, causing reflections on production. In addition, they can act indirectly, transmitting pathogens, especially viruses, facilitating the proliferation of bacteria and the development of fungi (sooty mold) and other pathogens, or injecting toxicogenic substances during the food process.

Example: soybean caterpillar (*Anticarsia gemmatalis* Hueb.) that causes defoliation in soybean plants.

INSECTS

Insects, being arthropods, have a relatively inefficient circulatory system, open with no vessels to carry oxygen to the different parts of their body.

Due to the ineffectiveness of the circulatory system, such lungs do not meet the respiratory demands of the insect's cells. Instead, the insects have evolved a very simple trachea system that relies on a network of small tubes that channel O2 directly to different parts of the body.

The tracheal system is made up of chitin-lined tubes called trachea that connect directly to the air through openings in the body wall called spiracles. The tracheae are reinforced with chitin rings, the same material that makes up the exoskeleton of arthropods.

The branching of the tracheae into smaller and smaller tubes is called tracheoles, which eventually end up in the plasma membrane of all cells in the insect's body.

The tips of the tracheolas are closed and contain fluid. Air enters the trachea through the blowholes and travels through the tracheoles to the fluid-filled tips, where oxygen diffuses from the tracheoles directly into the cells, and CO2 diffuses from the cells into the tracheoles.

Many authors consider the respiratory system of insects as a point of penetration or absorption of chemical and/or biological insecticides, being transported through the trachea to the hemolymph and other tissues, including the nervous system (CHAPMAN, 1998; EDWARDS et al., 1958).

Advantage of tracheal respiration: Insects can control their breathing by opening and closing the tracheoles with muscle contractions. This condition is important for survival in dry environments, as it prevents water loss.

ECDISIS

a) Ecdysis: The growth of an animal's body is more or less cyclical, with periods of rest alternating with periods of activity. However, in no group is this as evident as in insects, in which development is discontinuous and characterized by a series of integument changes (ecdysis).

b) Ecdysis is the main mechanism of growth, being conditioned by the properties of the cuticle. During ecdysis, the production of the new cuticle and the loss of the old cuticle occur. In addition to growth, shape-shifting is another purpose of ecdysis.

c) The control of ecdysis is governed by endocrine hormones (a type of hormone) produced by glands without a proper duct (endocrine glands), which release their secretions into the hemolymph (the circulating body fluid of the body of invertebrate animals). Ecdysis can occur several times in an animal's lifetime, an unlimited number that varies from species to species. The mechanism is dictated by the action of two hormones: ecdysone, which performs the function of stimulating epithelial cells to start the ecdysis process; and juvenile hormone (JH). The entire cycle takes place in 4 stages:

- First. Pro-ecdysis – the stage that precedes molting, in which the animal prepares to release an exoskeleton, replacing it with another. In this phase, the animal's body retains water and air, which facilitates its support during the exchange and exerts pressure that helps to break the old carapace.
- 2nd. Ecdysis – effective exchange of exoskeletons, that is, the stage in which the old skeleton is discarded, giving way to a new one.
- Third. Post-ecdysis – a stage after molting, in which the animal increases in size and has its new exoskeleton gradually hardened.

- 4th. Intermolt – comprises the period between one molt and another, in which the animal stores nutrients to prepare for the restart of the entire cycle. The effective growth of the animal occurs at this stage.

d) The old cuticle that is discarded with each ecdysis is called exuvia. This is made up of epicuticle and exocuticle.
e) In addition to being a significant aspect of arthropod evolution, ecdysis also represents an important adaptive value, since it enables the adaptation of these animals to several different types of environments. On the other hand, this property can bring some damage to the living being, since, after molting, the animal is vulnerable for a certain period (due to the high energy expenditure), which facilitates the attack of natural predators.

Insects perform essential tasks for the survival of various living beings, such as pollination – transmission of pollen from one flower to another – without them, most angiosperms (plants that produce flowers and fruit) would not exist. They have great ecological importance, as they occupy several niches.

When it comes to the interest in controlling an insect that may be causing damage to production, ecdysis can be used as follows:

Insecticides called ecdysone agonists (cause agony) act by mimicking the natural ecdysone hormone.

They trigger the ecdysis process prematurely by binding to the ecdysone receptor protein, which is activated, initiating the molting process.

The larva stops feeding after ingesting the insecticide. A new (deformed) cuticle is produced underneath the old one, however, the old one does not fall apart, and the larva dies of starvation and dehydration.

The insecticides of this group act more quickly and have a more specific action on caterpillars than the physiological chitin inhibitors.

ANATOMY AND MORPHOLOGY

Anatomy describes the shape of organs, systems, and apparatus. It comprises the study of the integument, digestive system, and excretion system, circulatory, respiratory, and reproductive systems, nervous system and sense organs, muscular and glandular systems.

Morphology describes the external body parts of insects. The morphological characteristics will be presented for the three regions of an insect's body: head, thorax, and abdomen.

Importance of the study of morphology for agriculture: knowledge of orders, families, and genera for the correct identification of insects and the characterization of habits and behavior.

Importance of the study of anatomy for agriculture: Knowledge of the structures of the internal organs of insects is the basis for understanding their functioning.

We can talk about some changes that facilitate the survival of insects.

For adequate nutrition, alterations in the mouthparts aiming to provide all types of diet, by the way food is captured, occurred among the insects on their evolutionary scale.

The exchange of gases is carried out through a system of trachea that contains a pair of blowholes, The blowhole has a closing mechanism that reduces water loss, a structure that makes it possible to succeed in the terrestrial environment. Also, terrestrial insects have filtering devices in the atrium that prevent the entry of parasites.

Communication between individuals of the same species, as well as interspecific communication, is done through the use of chemical (pheromones), tactile, visual (bioluminescence), and auditory signals.

The auditory organs are mainly located in the wall of the body, each type has a specific stimulus, such as chemical, mechanical, visual, auditory, and other stimuli.

Chemical smell sensations are felt by organs located primarily in the antennae. Many insects can smell at very great distances, on the order of kilometers. The taste organs are located mainly in the mouthparts, other possible places are the antennae and tarsi. Contact is necessary to taste it.

In the case of insects, the key role they play in terrestrial ecosystems is undeniable and generally consensual. This group of fauna is involved in several ecological processes and interactions, highlighting pollination, seed dispersal and predation, nutrient cycling, and regulation of populations of both plants and other animals (biological control). In addition, they can be of extreme economic importance, acting, for example, in the production of honey or the form of agricultural pests.

The correct identification of agricultural pests is essential for efficient control. However, in Brazil, there are few taxonomists, who are the specialists who make the identifications. In most cases, it is not possible to determine the species of pest in the crop, requiring both a specialist and a reference collection, which works as a library for the taxonomist.

In addition, the loss of Biodiversity is today a central issue in the main discussion forums on ecology, and the case of the Brazilian Cerrados, this biological diversity is still in the characterization phase for most groups, especially insects. The region, however, is already almost completely incorporated into the agricultural production process, leaving only a small percentage of remaining natural areas. Thus, it becomes urgent to concentrate efforts, both for the systematization of existing data in regional biological collections, and for the collection of new information, thus making it possible to establish priorities for conservation, enable the correct identification of biological control agents, pollinators, dispersers and agricultural pests, in addition to the identification of entomological risk material whose interception and quarantine is necessary.

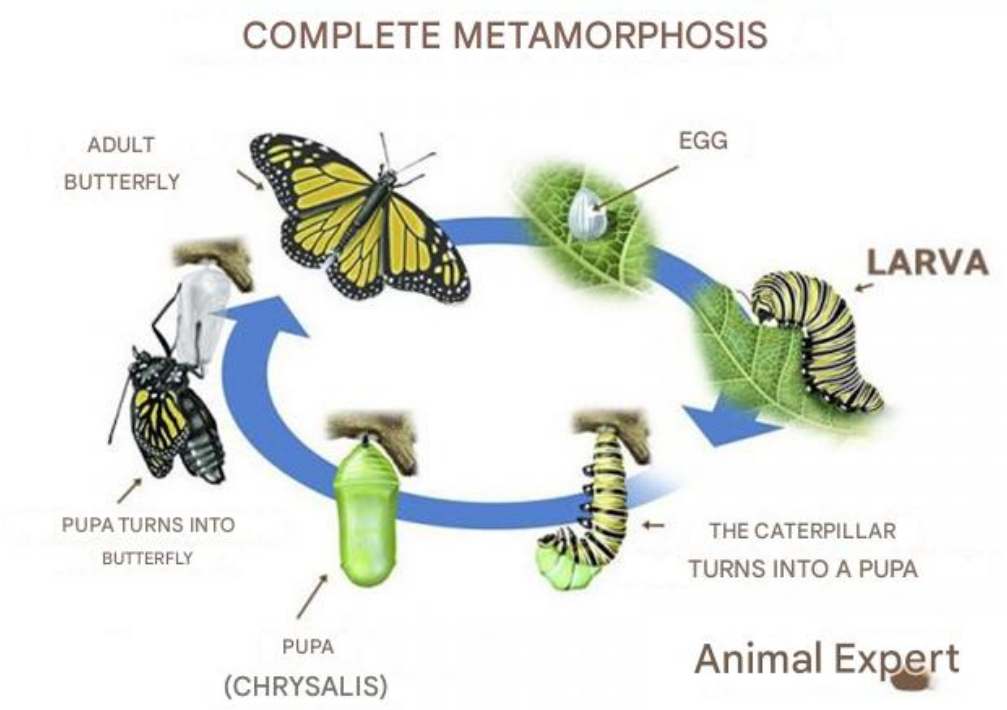
DIRECT AND INDIRECT DEVELOPMENT

Ametabolous insects are those that have direct development, such as moths, which only increase in size. It is a simple growth process, since the being that is born or hatches is morphologically very similar to the adult and has poorly developed reproductive organs.

Development is said to be indirect when the living being has phases with different aspects between birth and adulthood, that is, when the living being undergoes metamorphosis.

> **Holometabolia**. Metamorfose completa, que compreende as fases de ovo, larva, pupa e adulto. Portanto, há uma transformação drástica nas formas imaturas até atingir o estádio adulto. Essa transformação passa pela fase de pupa antes da emergência do adulto. É a metamorfose apresentada pelos besouros, borboletas, mariposas, moscas, pernilongos, abelhas, vespas, formigas, pulgas etc. Nor-

From the hatching of the egg arises a larva that transforms into a pupa (chrysalis), then an imago, reaching the adult stage after successive molts (gradual growth with exoskeleton change).



REPRODUCTION

One of the reasons to explain the great adaptive capacity of insects on earth is their high reproductive capacity. Reproduction in insects generally depends on the meeting of the two sexes and the fertilization of the egg by the spermatozoon. The development of an insect, on the other hand, involves both growth in size and change in shape. It can be divided into embryonic (egg stage) and post-embryonic.

Being adapted, insects have reproductive capacity and thus are expected to be able to develop.

Without reproduction and development, there would be no insects on Earth. From these processes, insects have different functions in agriculture, they can be beneficial or harmful. Even if malefic, they are part of the life cycle of these insects.

Benefits:

- Silk production: the silkworm is a moth larva that has modified salivary glands and produces the silk cocoon in which they lay their eggs. This silk is used in the manufacture of fabrics.
- Honey production: Bees are the insects responsible for producing this delicious and nutritious food. In addition to honey, these insects also produce propolis, which is considered a powerful antibiotic.
- Decomposition of organic matter: Some insect larvae feed on decomposing organic matter, that is, the corpses of animals and plants. This contributes a lot to the

environment, as it recycles nutrients necessary for the metabolism of every living being, whether animal or vegetable.

- Plant pollination: most plants on the earth's surface depend on insects, such as bees, wasps, beetles, among many others, to be pollinated.
- Fundamental elements of the food chain: Many birds, mammals, fish, amphibians, and reptiles feed on the insects. Given this, we can conclude that if it weren't for insects, many animals would be extinct due to a lack of food.

Losses:

- Pests in agriculture: Many farmers have already lost their crops because of insect infestation. They are attracted to easy food, and as they have it in abundance, they can reproduce more quickly, becoming real pests in the crops. For this reason, many farmers use insecticides to get rid of insects. This is very bad, as these products cause pollution of the environment, soil, and water, putting the lives of other animals and even humans themselves at risk. Because of this, some farmers are opting for biological control, that is, they use animals that prey on these pests, as is the case with the ladybug, which ends up with the aphids that parasitize the plants.
- Pests in livestock: the botfly is an insect that lays its eggs on the surface layer of the skin of mammals and birds, causing wounds that leave them weak, and can even cause death.
- Disease transmitters: Many diseases, such as dengue, malaria, yellow fever, and elephantiasis, are transmitted by mosquitoes. In addition to mosquitoes, we can also mention lice, fleas, and kissing bugs that also transmit diseases to humans and domestic animals. Flies transmit viruses and bacteria that cause dysentery.
- Food loss: fruit flies lay their eggs on various types of fruit, so that their larvae feed on the pulp of that fruit. As a result, they end up rendering them useless and preventing their consumption by other animals and humans.

HERMAPHRODITE INSECTS

Hermaphrodites happen when there is the presence of both sexes in the same individual. It is extremely rare in insects.

This phenomenon occurs in the cochineal (Icerya purchasi), males are rare, and adult females are hermaphrodites that self-fertilize.

INSECT MOUTHPARTS

For the oral system, most of the most important pest insects can be divided into two groups: masticating apparatus (or crusher) and lip sucker (or sucker-sucker).

CHEWER: They have a mouthpiece that cuts the different parts of the plant. When they cut leaves, for example, they slow growth by reducing the area of light capture. They open galleries in the stem, interrupting the circulation of the sap and affecting development. They destroy flower buds, feed on the flowers, and reduce seed production. They destroy the seeds or reduce the germination power and attack the roots.

Coleoptera - Beetles
Name: Coleo (case) + Ptera (wings)
Situation: 40% of the class, with more than 300 thousand species described.
Characteristics*:* chewing mouthparts; anterior wings of the ELYTRA type and absence of pincer-shaped enclosures.
Feeding Habit*:* Most are phytophagous, and many are predatory and beneficial.
Assembly*:* Hard-bodied insects, mounted on an entomological pin or, when very small, in double assembly (triangle). Pinpoint on the elytra, on the inner front of the mesothorax.
Development*:* Holometabolous: egg, larva, pupa, and adult.

Lepidoptera - Butterflies and Moths
Name*:* Lepidon (scales) + ptera (wings)
Status: 20% of the class, with more than 150 thousand species described
Characteristics**:** Maxillary sucking mouthparts (adult insect), coiled in the shape of a spiral, when at rest (spirothrocbus); wings covered by scales.
Feeding Habit: Caterpillars have chewing mouthparts, are phytophagous, and many are pests. The adult only sucks floral nectar.
Mounting: Hard-bodied insects, mounted on entomological pins, and when very small, in double mounting. Pinpoint on the right, inner side of the mesothorax. The wings should be mounted in such a way that the aft margin of the forewing is at a right angle to the body and the hindwing is slightly over the forewing.
Development: Holometabolous: egg, larva (caterpillar), pupal (chrysalis), and adult.

SUCKER: through suction, they can cause loss of plant vigor, reduction of the assimilating area due to the necrosis they cause, damage to the floral organs and reduced seed production. They facilitate the entry of pathogenic agents, transmitting viruses. They introduce toxins into the plants, causing deformations.

Homoptera - cicadas, leafhoppers, aphids, and mealybugs

Name: Homo (equal) + ptera (uniformly textured wing).

Status: More than 32 thousand species described.

Characteristics: Sucking mouthparts that come out of the back of the head (retroverted). Wings, when present, have a tile shape and the same texture (membranous, slightly thickened).

Feeding Habit: Sucking insect, phytophagous (feeding on plant sap), many members being agricultural pests.

Assembly: Cicadas and leafhoppers are hard-bodied insects, mounted on entomological pins or, when small, in double assembly. Pinning should be done on the inner, right side of the mesothorax. Aphids and mealybugs are soft-bodied insects, mounted in a conservative solution.

Development: Paurometábolo: egg, nymph, and adult.

SEXUAL DIMORPHISM

Sexual **dimorphism** can be defined as the marked differences between males and females of a given species. It is worth noting that these differences do not concern the sexual organs, but are only related to other physical and behavioral characteristics that differ one sex from the sexes, such as body size, feather and hair coloration, and the emission of sounds.

Several species in the animal kingdom exhibit sexual dimorphism, and this trait is usually related to reproduction.

a) **Peacocks** have a sexual dimorphism characterized by the presence of long, colorful feathers on the male's tail and the female's discrete coloration. The main function of this gaudy tail is to draw the female's attention and ensure reproduction.

b) **Rhinoceros beetle** - *Oryctes nasicornis:* Male rhinoceros beetles are easily recognized by their horns, which can vary from individual to individual within the same species. The male also has a rear-facing horn, which in females is just a tubercle.

c) **Deer beetle** – *Lucanus cervus: Lucanus cervus* is an insect of the Order Coleoptera (family Lucanidae) and is the largest beetle in Portugal. It has a marked sexual dimorphism, with males having a much larger head and jaws than females, serving as a means of fighting with rival males.

d) **Butterfly** - *Morpho amathonte:* This species of butterfly has a wingspan of about 10 to 15 cm and has evident sexual dimorphism. The basic color in males is bright metallic blue, while in females, the wings are partially blue with a large dark brown area, decorated with small white spots along the outer edge of both wings.