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Introductory Chapter: The Complex World of Ants

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1. Introduction

1.1. Origin, classification, and distribution

Ants fall into the largest family of insects, with respect to diversity of species and total number of individuals. They belong to a single family, the Formicidae, within the order Hymenoptera, consisting of 11 subfamilies and 297 genera [1]. In 1967, Wilson et al. obtained the first ant remains of the Cretaceous period [2, 3] that were estimated to be about 80 million years. Having said this, there are well over 8800 described species, to date. Most of the genera stem are from the Neotropics and Afrotropical regions. Remarkably, individual colonies may contain 20 million members [4]. Ants dominate much of the terrestrial regions of the world, ranging from deserts to subarctic tundra. Interestingly, recent measurements indicate that approximately one-third of the entire animal biomass of the Amazonian *terra firme* rain forest is composed of ants and termites. Each hectare of soil contains in excess of 8 million ants, in contrast to only 1 million termites [1].

1.2. Morphology

Ants (Formicidae) bear a narrow “waist” between the abdomen and thorax. The “waist” is comprised of a one-segmented (petiole) or two-segmented (petiole and postpetiole) constriction located between the thorax and bulbous poster portion of the abdomen or gaster. The gaster is composed of 4–5 posterior segments. Ants have large heads and powerful jaws. The adult workers and queens bear bent (elbowed or geniculate) antennae consisting of a long basal scape and 3–11 short funicular segments. In males, the basal segments are not long, so the antennae will not appear to be bent. The last two or three segments may be enlarged, forming a club. The antennae are believed to function as a two-way communication device [5], rather than just a receptor. Wang et al. analyzed the behavior and surface chemistry of many ants, focusing on the use and function of the cuticular hydrocarbons covering the ants’ bodies.

They found that this layer not only served to protect the ants from dehydration, but also formed a critical role in their communication. Their research showed that when the layer was removed from the antennal surface, information regarding nest identification was lost, no longer allowing the ants to identify their colony.

1.3. Feeding behavior and communication

Ants play important roles in natural ecosystems. They are omnivorous feeders and can live in a wide range of habitats. They build nest sites, typically underground, thus contributing to nutrient cycling, seed dispersal, and the scavenging of dead organisms. They are considered major predators of other arthropods and small invertebrates, including pests, such as crop feeding caterpillars and ticks. Secretions stemming from their metapleural gland, rich in antibiotics, allow them to disinfect moist environments and allow them to live in areas that other organisms do not live in, especially in the tropics [1].

Communication is necessary in order to coordinate the activities within a colony. This is mediated via chemical signals (pheromones). Some of these pheromones include a queen pheromone, allowing workers to recognize a queen, trail following pheromones (used by workers to mark paths between the nest and food), and alarm pheromones (cause ants to disperse and/or attack). In addition, chemical cues are used to recognize colony nestmates and play additionally a role in aggression and territorial boundary markings between colonies [1].

1.4. Life/colony cycle

Ants are eusocial insects. They (1) perform cooperative brood care, where the adults care for the immatures, (2) bear overlapping generations, and (3) have a division of labor among reproductive and nonreproductive (workers) groups. The latter group is responsible for performing tasks necessary for colony survival, including foraging, care of immatures and reproductive adults, and nest building. Such a division of labor results in the formation of castes or specialized behavioral groups [1].

Ants display complete or holometabolous metamorphosis, consisting of four life stages: egg, larvae, pupae, and adult. The aforementioned first three stages are collectively called brood. The ant colony is almost exclusively female until the time of the nuptial flight. The life cycle of the ant colony can be divided into three parts [6]. The founding stage is initiated with the nuptial flight. The virgin queen (virgin reproductive) leaves the nest, leaving behind the queen and her sisters, who are sterile workers or virgin reproductives. When she meets one or more males and is inseminated, she finds a suitable nest site in the soil or plants and builds a first nest cell and rears the first brood of workers. The workers eventually take on the tasks of foraging, nest enlargement, and brood care, so that the queen can confine her duties to egg laying. The ergonomic stage is defined as increase in work devoted to colony growth. The reproductive stage is set after one or more seasons when the colony begins to produce new queens and males and these sexual forms go forth to begin new colonies [6].

1.5. Mutualistic interactions

Among ant species, there is a broad range of interesting behaviors displayed. Many species have mutualisms (interactions leading to net fitness benefits for all partners involved) [7] with other insects and plants. In one example, ants will forego predation of, and offer protection to, honeydew producing aphids and mealybugs, as the ants are attracted to this sugar water sap as a food source [8]. In some ant-plant interactions, ants transport and disperse plant seeds (myrmecochory) with elaiosomes or food bodies rich in lipids, amino acids, or other nutrients that are attractive to ants, collectively known as a diaspore. Once the diaspore is carried back to the ant colony, the elaiosome is consumed and the seed is ejected from the nest [9–11]. A well-studied symbiotic relationship with plants has been reported between *Acacia* trees and the several ants in the genus *Pseudomyrmex*. The acacia tree produces thorns, which are used as nesting sites for the ants, and Beltian bodies, used by the ants as a food source. These ants offer protection to the trees from herbivorous arthropods and vertebrates and destroy competing plants trying to establish themselves, nearby [7]. Leaf cutter ants (genera, *Atta* and *Acromyrmex*) are notorious for cutting pieces of leaves or flowers and carrying them back to their nest to use as a suitable nutritional substrate for cultivating fungal growth to help degrade cellulose and other plant products inaccessible to the ants.

1.6. Parasitic relationships

In contrast to symbiotic interactions that ants have with plants and other insects, various species have parasitic relationships among each other. One such case is slavery or dulosis. In the genus *Polyergus*, workers steal larvae and pupae from the genus *Formica*. These enslaved immature insects develop into adult workers and to carry out colony maintenance tasks for their captors [12]. Other examples of parasitism occur in parasitized host colonies lacking a worker caste system in the fire ant genus, *Solenopsis*, and *Teleutomyrmex*. Here, the parasitic ant *Solenopsis daguerrei* lacks a worker caste system, so all the adults are reproductive males and females. Parasitic queens attach to the host queens and fire ant workers care for them in a similar manner to their own mother queen, whereas the parasite brood is reared by the host workers simultaneously with the host brood [13, 14]. These parasites are permanent and spend their entire life cycle in the nest of the host species. Most often, the parasite inhibits egg production of the mother queen, causing an eventual collapse of the colony [15].

1.7. Predatory behavior

Many ant species exhibit an extremely predatory behavior. In the Afrotropical region, in the genus, *Dorylus*, the African driver ants, also known as army or legionary ants, have colonies with millions of inhabitants. They have no permanent nest structure, as they move their nesting sites regularly and forage for food in large swarming columns or groups, preying mainly on insects, arachnids, and earthworms [16]. In another example, extraordinary cooperative behavior is exhibited during nest construction by the weaver arboreal ants, in the genus *Oecophylla*, living in Afrotropical regions. These ants link their bodies together to form chains

by grasping the petiole of an adjacent worker with their jaws. The living chains are used to position leaves together. Silk-producing larvae contribute their secretions to allow the leaves to be held together, eventually forming a tent and eventually a nest [17].

1.8. Pollinators

While bees, flies, and hummingbirds are thought as agents of plant pollination, some ant species have been found to serve as effective pollinators. This is despite observations, in general, that antibiotic compounds produced by the metapleural and poison glands of most ants tend to suppress pollen germination and pollen-tube growth. Worker ants, *Proformica longiseta* have been found to serve as pollinators of a mass flowering wood plant, *Hormathophylla spinosa*, in the high mountain area of the Sierra Nevada mountains. The ants were found to make contact with the plant reproductive organs when foraging for nectar and were found to transfer large numbers of pollen grains, contributing to increasing the number of viable seeds [18].

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Conflict of interest

The author declares that there is no conflict of interests regarding the publication of this chapter.

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