Innate immune system in the honey bee

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Introduction

Insects represent one of the most successful organisms on the earth and make up more than half of all living things on the planet. They colonize almost every niche from the Sahara desert to the peaks of the Himalayas. During evolutionary history, insects developed a powerful and effective immune system, which differs from the immune system of vertebrates such as humans. It is considered that insects' unique immune system, which combats a wide variety of pathogens, has led them to become the most diverse and successful animals on the earth. Vertebrates, including the human, have both innate and adaptive immunity with ‘immunological memory’, whereas insects do not possess the ability to produce antibodies. Although antigenic memory appears to be lacking, insects possess innate immunity which is characterized by non-specific immune reactions against invading pathogens. The defense mechanism in insects consists of cellular and humoral immunity.

Cellular immunity

In the cellular defense mechanism, insects have free blood cells called haemocytes within their open body cavity. Different types of blood cells have important roles in the protection of insects against foreign materials. Plasmocytes and granulocytes are the major haemocytes. They react to foreign invaders either by phagocytosis and encapsulation.

Humoral immunity

A hallmark of the humoral reactions is the synthesis and secretion of anti-microbial peptides (AMPs) that accumulate in the hemolymph against invading pathogenic bacteria. There are several families of AMPs such as cecropins, attacins, diptericins and defensins. This activity may last for a couple of days. AMPs are produced in the fat body which is a major immune-responsive tissue. It is a large biosynthetic organ located inside the open circulatory system of the insect cavity, the functional analogue of the mammalian liver. In *Drosophila*, over 20 immune-inducible AMPs have been identified, and they are classified into seven groups. They are small (<10 kDa) and show a broad range of anti-bacterial spectra.

Innate immunity in the honey bee

Honey bees are essential pollinators of over 90 economically important crops, including apples, watermelon, coffee, and sunflowers. According to a USDA report, honey bees pollinate about one-third of the human diet, and pollination is responsible for $15 billion in added crop value. Honey bees are also important as social insects. The impacts of sociality on disease are especially important, because thousands of honey bees live in narrow and crowded colonies. This high density, together with a relatively homeostatic colony environment and the presence of stored honey, makes honey bees attractive targets for pathogens. Honey bees have evolved both group- and individual-level defenses against pathogens. Grooming and other behavioural defenses can reduce the impacts of pathogenic bacteria, fungi and parasites. There are a total 6 AMPs that are found in the honey bee. Defensin1 and Defensin2 have been identified from a variety of insect species, whereas Apisimin and Hymenoptaecin have been reported only in the honey bee.

A genome-wide analysis of immune components in the honey bee has been studied with the aid of the recent completion of sequencing of the honey bee genome. Putative orthologues for almost all predicted signaling pathways associated with immunity in insects (IMD pathway, Toll pathway, etc.) were conserved. When compared to the sequenced Drosophila genomes, honey bees possess only one-third as many components in immune related gene families. It is suggested that the reduced number of immune related genes in honey bees reflects either powerful social barriers to pathogens, or that a limited set of bee pathogens have coevolved.