Lec. 2 / Insect coloration: types and functions

Pigment and structural coloration in insects

Animals use colours for diverse purposes such as body protection, signalling, and physiological adaptations (Cott 1940; Caro and Notes 2005; Cuthill et al. 2017). Colour patterns vary in shapes, luminance, tints, or polarisation and convey multiple channels of information. Melanin pigments are responsible for the black and brown colors in most arthropods except for spiders.

Most insects exhibit colors via absorption or reflection of sunlight using pigments, cuticular surface structures, or their combination. Only some springtails, flies, and beetles possess luciferases—enzymes, which catalyze light-producing biochemical reactions, being capable of bioluminescence. Several classes of pigments are involved with insect coloration.

Generally, melanins produce shades from black to reddish-brown, and pterins, (or **visual pigment**), ommochromes and carotenoids contribute to red, orange, and yellow colors. Furthermore, flavonoids, which are plant secondary metabolites, also create orange colors in insects .Bile pigments or bilins result in greenish and bluish tints, violet, and golden colors often appear because of structural interference (Chapman et al. 2013) (Fig.1).

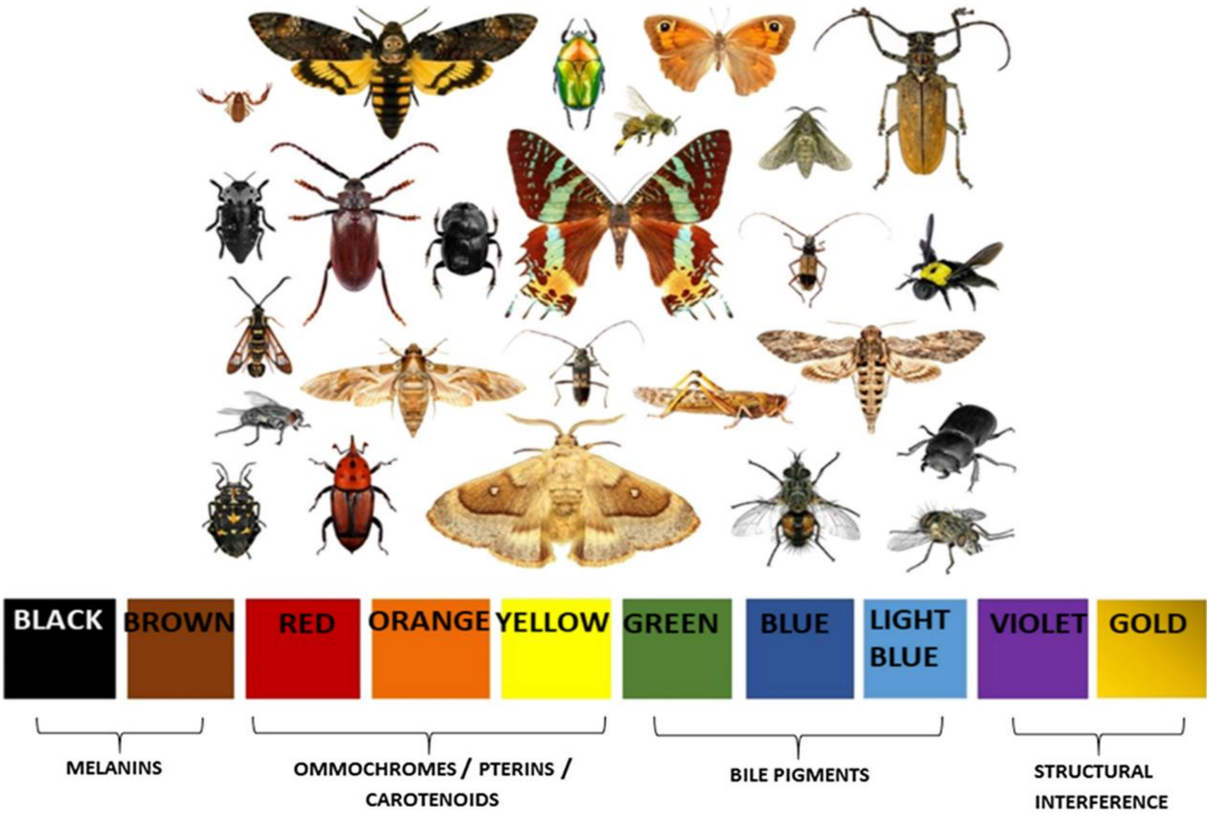

Fig.1 Main classes of pigment- and structure-based colors in insects.

Some insect taxa have specific pigments, like aphis and butterflies producing a variety of tints resulting in yellow, orange, and red colors. Both pigments processes that can act in conjunction, the Melanins which cause Melinization (darkening) and Pterins cause (hardening) are two prevalent classes of insects' appearance of a color.

During recent years, the emerging interest in colour research has been raised in social hymenopterans such as ants, wasps, and bees. These insects provide important ecosystem services and many of those are model research organisms.

Functions of color

We consider the variety of color functions in insects can be summarized as:

(1) Body protection (physical, immunological).

(2) Signalling (camouflage, warning coloration, rival quality, mate choice).

(3 Physiology (thermoregulation, UV- resistance, drought (Fig.2).

(4) colors are also valuable for species identification, distinguishing individual quality, and revealing ecological or evolutionary aspects of insecst's life.

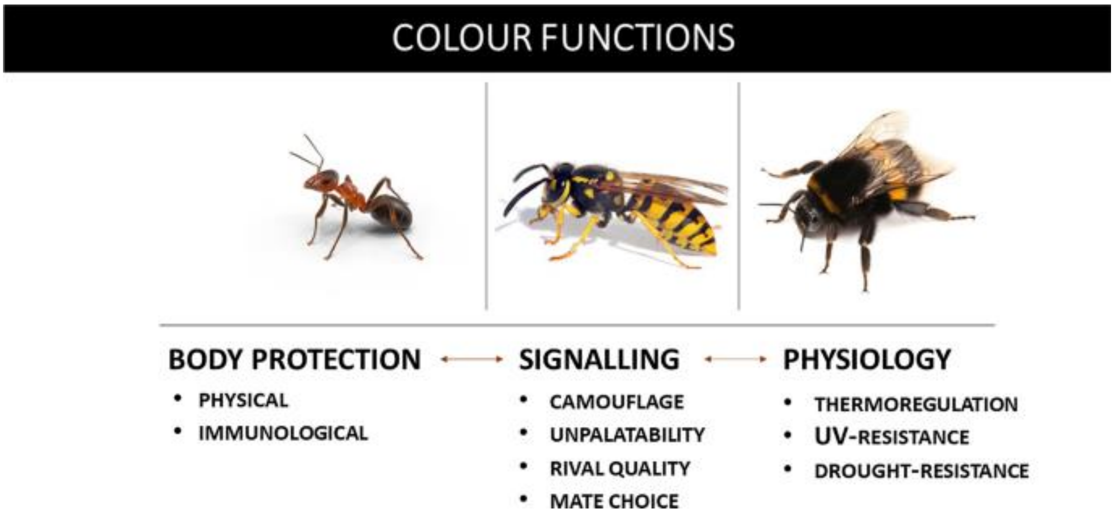

Fig. 2 Interconnections between color functions in social insects (ants, wasps, and bees).

In many cases, these functions are interacting, which highlights the multifunctional and integrative role of coloration. For example, camouflage and warning coloration can be referred to as both body protection and signaling; or the thermoregulatory function of a color can also possess a UV-radiation protective component. However, such a simplified classification clarifies the multifunctional and integrating role of colors in the insects' life (Fig.3).

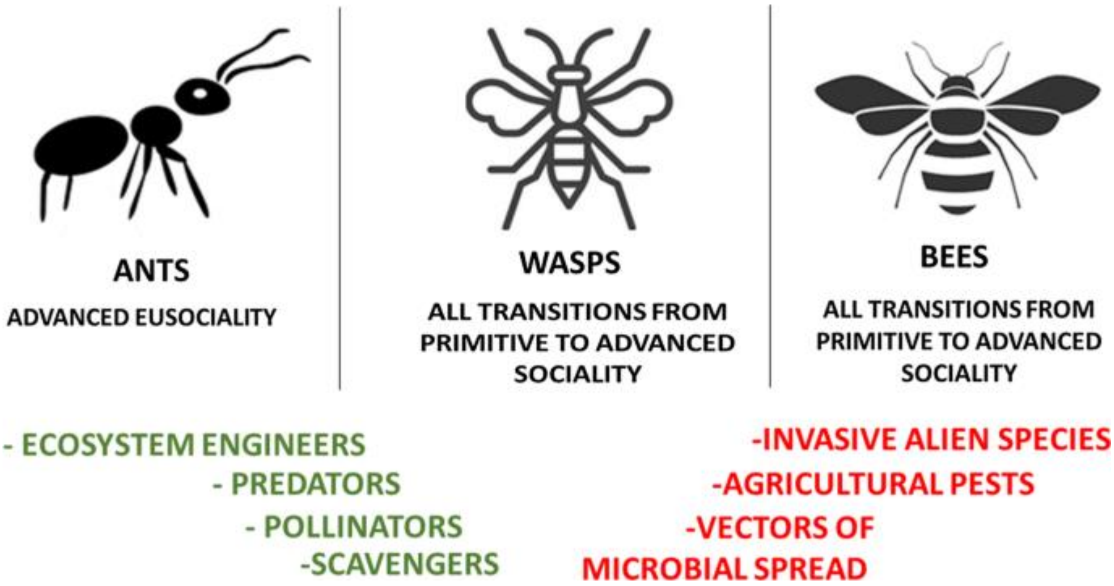

Fig. 3 Main groups of hymenopteran social insects (ants, bees, wasps), demonstrating different levels of sociality, and diverse aspects: (1) positive marked with green) and (2) negative (marked with red) of their ecological role.

Melanin pigments are responsible for the black and brown colors in most arthropods except for spiders.

As, reviewed by Roulin (2016), melanization in invertebrates is generally less affected by genetic factors than in vertebrates, therefore melanin ornaments in insects may be more dependent on the environment than genetically determined. For many insects, melanin colouration is a significant indicator of an individual's quality: Nymphalidae, Noctuidae, Coccinellidae.

Pigments are deposited in distinct places of the cuticle, which can be venation structures on the butterflies' wings or beetle elytra. Often these places are related to inner structures, such as of the cuticle or places of the muscle attachments.

For the insect species such as Colorado potato beetle*Leptinotarsa decemlineata*), firebug (*Pyrrhocoris apterus)*, and several wasp species (*Vespula* sp.) it has been shown that pigmented cuticle patterns are related to muscle bundle topography (they are places, where muscles are attached to cuticle, and the cuticle surface possess melanin spots in those places where they are attached).

Colours are related to physical and immunological body protection, darker cuticles are generally thicker, which prevent an insect body from the penetration of pathogens and parasites, Melanin pigments contribute both to insects' cuticle colouration and immunity (encapsulation response).

Colours help insects to hide from predators or scare away.

The main mechanisms for color-concealment are crypsis, disruptive patterning, mimesis, countershading, and counter illumination.

Countershading: is protective coloration used by some insects in which parts normally in shadow are light and those exposed to the sky are dark.

Counter-illumination: is a method of active camouflage seen in marine animals such as firefly, also known as lightning bugs, they're actually beetles, not flies! While these beautiful bugs are a summer night staple.

How Do Lightning Bugs Light Up?

Fireflies have a light organ located in their lower abdomen. In this part of their body, a biochemical reaction called "bioluminescence"takes place that allows them to convert chemical energy into the glowing light that we see. A chemical called luciferin can be found in the cells that make up the firefly's light producing organs. When this chemical is combined with oxygen, it forms a new chemical called oxyluciferin which causes the firefly to produce light. The light they produce can be green, yellow, or orange in color.

Fig.4 Adults of firefly at night