The Ecological Adaptation of Honeybee Eyes: A Review

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Abstract: This paper a review about honeybee brain and eyes. In this paper we discuss about brain and vision and habitat as environmental condition honeybee with special ecology adaptation as multifunction animals in our ecosystem. Honeybee can learn, decision making, understanding colour of flowers targets as source nectar. Small insect like honeybee be able to think and food from nectar flowers. Honeybee can visually distinguish landscape scenes, many types and odors of flowers, many shapes and patterns with such a small visual brain. This capability are supported by specific work honeybee brain, eyes and environmental condition.

1 INTRODUCTION

Animals as living things interact ecologically with the environment. One group of invertebrate animals that have the ability to interact with the environment is insects. Insects already have brains and vision organs as well as animals and tall as birds and mammals. Brain and eye are inseparable mutually support is vital as a supporter of existence in our earth. Brain and eye are very important to support the life of insects. An excellent insect genus of development is honeybee (Apis spp). Honeybee is one type of insect that has a very developed eye and supports its role in the ecosystem. (Ribbands 1954; Lindauer and Kerr 1960)

The eyes of the honeybee grows supported by a reliable nervous system that forms the brain. These eyes and brains are a form of adaptation and function of the honeybee. Honeybees are able to observe, learn, remember the pattern, color, movement and direction and the target flowers as a source of nectar which is the food. Honeybees are also able to smell the flower that is the result of interaction, communication and honeybee recruitment patterns in the colonies. This ability is supported by a very effective brain and nervous system working simultaneously and precisely (Ribbands 1954; Lindauer and Kerr 1960; Johnson1967;

2 BRAIN VISUAL SPATIAL PROCESS OF HONEYBEE

In the brain of insects is commonly known as the mushroom bodies. This section is the center of the brain that plays a role in learning and recall proeses (Mizunami et al., 1993).The head houses the brain, a collection of about 950,000 neurons. These neurons are specialized, and they communicate with specific neighboring neurons. This division of tasks is part of why a bee's brain. This is a fraction of the size of the bee's head can perform complex tasks that might ordinarily require a bigger brain. A system of nerves allows the brain to communicate with the rest of the body. On its head, a bee has two sensory antennae. It also has five eyes -- three simple eyes, or ocelli, and two compound eyes. The compound eyes are made of lots of small, repeating eye parts called ommatidia. In each compound eye, about 150 ommatidia specialize in seeing patterns and polarized light (https://animals.howstuffworks.com/insects/bee1.html, 2018).

The Honeybees represent an attractive model for research the integration of different visual features in the insect brain. Visual process cues are detected by compound eyes made of ommatidiium and hosting nine cells of photoreceptor . Three types of photoreceptors were found, S, M, and L (for short-, mid-, and long-range wavelength, respectively).

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The peak of wavelength are the UV, blue, and green regions of the spectrum, respectively. They have been identified in the honeybee retina (Peitsch et al., 1992; Wakakuwa et al., 2005).

The lamina is composed of thousands of optical cartridges, each receiving an axon bundle that contains the axons of the nine photoreceptors from an overlying ommatidium, as well as the dendrites of different types of monopolar cells. Most L photoreceptors are terminated in the first neuropil of the optic lobe. The lamina have some synapse on lamina monopolar cells (Menzel, 1974). The spatial arrangement of photoreceptor axons and lamina monopolar cells within a cartridge remains constant throughout the lamina, thus providing the basis for a retinotopic organization. Axons of lamina monopolar cells and M and S receptors proceed to the second visual neuropil, the medulla, by way of the outer chiasm, which reverses retinotopic organization in an anteroposterior manner. (Mobbs, 1982, Ehmer and Gronenberg, 2002).

Major output neurons from the medulla project via the inner chiasm to the third visual neuropil, the lobula. Extrinsic lobula neurons convey information to different brain regions, including the mushroom bodies (Mobbs, 1982, Ehmer and Gronenberg, 2002). The optic lobe of the contralateral eye and different subregions of the ipsilateral lateral protocerebrum (Hertel and Maronde, 1987).

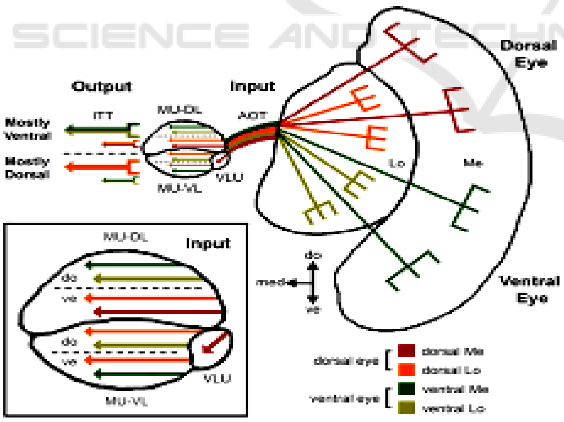

Figure 1. Anterior Optic Tubercle (AOTu) which contribute to spatial vision by processing dorsoventrally segregated information (Mota et al., 2011).

Our analyses showed that the honeybee AOTu is composed of four compartments. The MU-VL and the MU-DL (figure 2)that together constitute a major unit, and two smaller units placed posterior to the MU, the VLU and the LU. We found retinotopic small-field input to the MU, with dorsal and ventral parts of the medulla and lobula differentially supplying MU-VL and MU-DL. In contrary, the VLU only receives input from the dorsal medulla. Input from the mushroom body supplies the MU exclusively. The LU, conversely, does not seem to receive input from the optic lobe or mushroom body but is connected to the contralateral AOTu and to the LAL. We cannot exclude, however, the possibility of having missed in our mass fillings some specific optic lobe input to the LU. Inter-tubercle neurons innervate all AOTu compartments in both brain hemispheres.

Each AOTu receives from and provides to the contralateral AOTu dorsoventral segregated information. Distinct types of output neurons connecting the AOTu with the LAL appear to originate from different AOTu compartments, but the organization of dorsoventral information in these neurons remains to be clarified by additional studies. Our results show that some level of segregation between dorsal and ventral eye information occurs in the AOTu and point toward a specialization of certain AOTu compartments for this segregated spatial processing. Input– output circuits in the AOTu Input from the optic lobe runs via the AOT, which contains two main neural types: (1) transmedullary neurons and (2) lobula columnar neurons. Dual supply from the medulla and lobula to the AOTu was also described in butterflies (Strausfeld and Blest, 1970), flies (Strausfeld and Na¨ssel, 1981), and locusts (Homberg et al., 2003).

3 HONEYBEE BRAIN VISUAL FLOWERS IMAGE

In a new study, researchers report that a regulatory gene known to be involved in learning and the detection of novelty in vertebrates also kicks into high gear in the brains of honey bees. When honeybees are learning how to find food and bring it home. Activity of this gene, called *Egr*, quickly increases in a region of the brain known as the mushroom bodies whenever bees try to find their way around an unfamiliar environment.

The researchers observed this gene is the insect equivalent of a transcription factor found in mammals. Transcription factors regulate the activity of other genes.The researchers found that the increased *Egr* activity did not occur as a result of exercise, the physical demands of learning to fly or the task of memorizing visual cues; it increased only in response to the bees' exposure to an unfamiliar environment. Even seasoned foragers had an uptick in *Egr* activity when they had to learn how to navigate in a new environment.This discovery gives us an important lead in figuring out how honey bees are able to navigate so well, with such a tiny brain. The *Egr*, with all that this gene is known to do in vertebrates, provides another demonstration that some of the molecular mechanisms underlying behavioral plasticity are deeply conserved (https://news.illinois.edu/view/6367/204800, 2018)

Honeybees must gather widely dispersed nectar and pollen and then return to their nests to feed their brood. For honeybees that exploited hundreds of flowers spread over several kilometers at each foraging trip, this involves learning a large number of places. This foraging lifestyle is cognitively demanding. Foraging involves learning to recognize flowers, discriminating the most profitable flower patches, and learning how to handle flowers of different species. Because flower meadows are extremely dynamic environments. Where resources appear and disappear within hours or days, flower foraging also requires flexible learning processes for being able to keep track of environmental variability. This in a miniature brain of about one million neurons. To accomplish these feats, honeybees have been included excellent memory and navigation skills. In the bee brain, visual and olfactory stimuli are first processed in specialized sensory lobes. After that tranfer information to multisensory integration centers dedicated to learning, memory, and spatial navigation tasks. While the results of some human activities, like habitat loss, directly compromise bee survival, others. Pesticides, parasites, and malnutrition, threaten colony survival by compromising bees' cognitive capacities.

4 HONEYBEE EYES

The eyes of the honeybees are used to see flowers for nectar as food. The honeybee's eye consists of many simple eyes (omatidium). Honeybee shape is hexagonal. The eyes of the honeybees are used to see flowers for nectar as food. The honeybee's eye consists of many simple eyes (omatidium). Honeybee shape is hexagonal. The amazing honeybee eyes, honeybee eyes see objects using ultraviolet light. It is also used by fish to see which planton is the food. Bee eyes are able to see objects that he saw in more detail. This is what is interesting to discuss further. Understanding of the eye will reveal how the behavior and interactions of bees to the environment ecologically in a broad sense. Eyes are a highly functional ecological and physiological interaction tool and support the life of organisms in many habitats that require light. Honeybee eyes are also like that, honeybee eyes need light in order to successfully run life activities as possible.

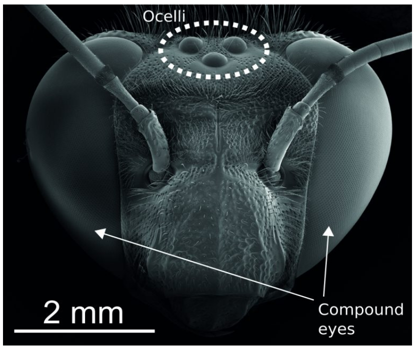

Figure 2. Compound eyes honeybee https://www.labnews.co.uk/features/x-ray-vision-09-08-2016)

In response to the pressures of parasitism, predation, and competition for limited resources, several groups of tropical honeybees and wasps have independently evolved a nocturnal lifestyle. Like their diurnal relatives, these insects like honeybee possess apposition compound eyes, a relatively light-insensitive eye design that is best suited to vision in bright light (Warrant, 2018).

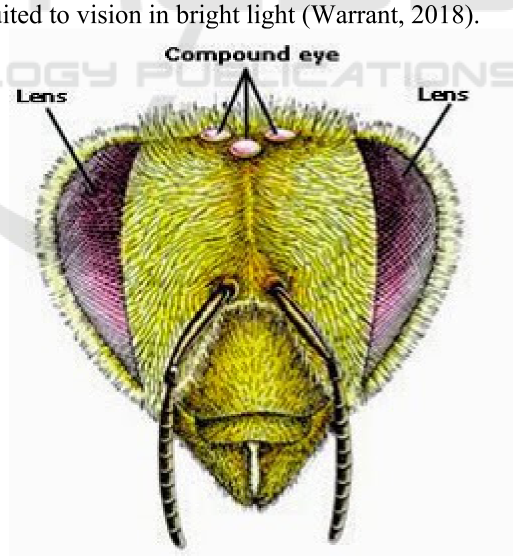

Figure 3. Five eyes honeybee (http://www.buzzingacrossamerica.com/2015)

Honey BEES have two large compound eyes on either side of their head. Three tiny eyes on the top of their head. The honey bee's two compound eyes are special because they allow her to see different colors and markings on flowers that we cannot see.

They can also see ultra violet light. A flower that looks white to us may actually look blue-green to a bee. The three eyes on top of the bees head are used to help her see in the dark, because it's dark inside the bee hive (http://www.buzzingacrossamerica.com/2015).

Honeybees have a visual system composed of three ocelli (simple eyes) LOCATED on the top of the head, in addition to two large compound eyes. Although experiments have been conducted to investigate the role of the ocelli within the visual system. Their optical characteristics, and function remain controversial. In this research, we created three-dimensional (3-D) reconstructions of the honeybee ocelli, conducted optical measurements and filled ocellar descending neurons to assist in determining the role of ocelli in honeybees. In both the median and lateral ocelli, the ocellar retinas can be divided into dorsal and ventral parts. Using the 3-D model we were able to assess the viewing angles of the retinas. The dorsal retinas view the horizon while the ventral retinas view the sky, suggesting quite different roles in attitude control. The lateral ocelli very important to higher spatial resolution compared to the median ocellus. In addition, we established which ocellar retinas provide the input to five pairs of large ocellar descending neurons.We found that four of the neuron pairs have their dendritic fields in the dorsal retinas ofthe lateral ocelli, while the fifth has fine dendrites in the ventral retina. One of the neuron pairs also sends very fine dendrites into the border region between the dorsal and ventral retinas of the median ocellus (Hung et al, 2014).

5 THE ECOLOGICAL ADAPTATION OF HONEYBEE EYES

Flowering plants are associated with a broad spectrum of animal pollinators. Honeybees constitute an important but not exclusive subset and whose sensory and learning capabilities have been explored (Weiss 2001; Dobson 2006).

The total economic value of pollination worldwide for the 100 crops used directly for human food (as listed by the Food and Agriculture Organization of the United Nations)(Gallai et al.2009). Hence, the decline of honeybees would not only cause dramatic changes in habitat diversity but also could jeopardize the considerable share of human food supply derived from insect-pollinated crops.

To see reliably, an eye must capture sufficient light. For a diurnal activity, animals, adapted for vision in bright sunlight. This basic need is easily achieved. However, at night, or at tremendous depths in the sea, where light levels may be many orders ofmagnitude lower, reliable vision cannot be guaranteed. Indeed, many nocturnal and deep-sea animals have simply ceased to rely on vision as their primary sense, depending instead on olfaction, hearing, electroreception and mechanoreception to interpret their environments (Warrant and Locket, 2004; Warrant, 2008).

This, however, is by no means the rule: many others have INVESTED heavily in vision, evolving remarkable adaptations to see well in dim light (Laughlin, 1990; Meyer-Rochow and Nilsson, 1998; McIntyre and Caveney, 1998; Warrant, 2004; Warrant, 2006; Warrant, 2008). This review showcases one particular group of such animals then octurnal bees and wasps a group that is starting to reveal some of the basic principles used by animals to process visual information in dim light (Warrant,2008).

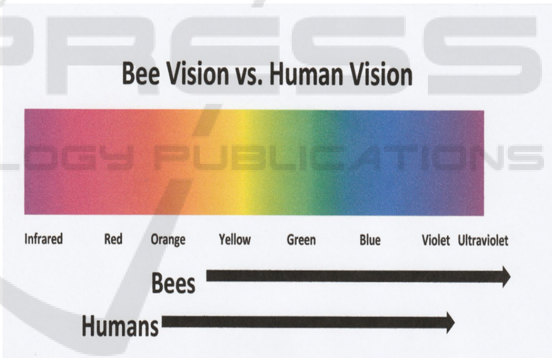

Figure 4. Honeybee vision versus human vision (https://www.google.com/search?q=vision+process+in+honeybee+brain&tbm, 2018)

To SEE well in dark, a visual system needs to extract reliable information from what may be an unreliable visual signal; that is, to extract information from a visual signal that is contaminated by visual 'noise'. Part of this noise arises from the stochastic nature of photon arrival and absorption: each sample of absorbed photons (or signal) has a certain degree of uncertainty (or noise) associated with it. The relative magnitude of this uncertainty is greater at lower rates of photon absorption, and these quantum fluctuations set anupper limit to the visual signal-to-noise ratio (Rose, 1942; de Vries,1943; Land, 1981).

Figure 5. Flowers is loved by honeybees (http://klancengsragi.blogspot.com/2018

NOT surprisingly, apposition eyes are typical of diurnal insects active in bright sunlight. This condition includes all diurnal bees and wasps. Strangely, apposition eyes are also get on several groups of bees and wasps (and also ants) that have evolved a nocturnal lifestyle. Even stranger, despite the poor sensitivity afforded by apposition eyes. Many insects invariably see quite well, with well-documented abilities learned visual landmarks and to use them during homing and foraging (Warrant et al., 2004; Greiner et al., 2007b; Somanathan et al., 2008).

6 CONCLUSION

Honeybee eyes have characteristics and good ecological adaptation especially to flowers vision**.**

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REFERENCES

Hertel H. Maronde U. 1987. The physiology and morphology, of centrally projecting visual in the honeybee brain.Journal Experiment Biology

Mizunami M, Weibrecht JM, Strausfeld NJ.1993. A new role for insects mushroom bodies: plac memory and motor control. In Beer RD, Ritzman RE, Mc Kenna T, editors. Biological neural networks in invertebrate neuroethology and robotics, New York: Academic Press, p 199-225.

Mobbs PG, 1982.The brain of honeybee Apis mellifera L.The connection and spatial organization of mushroom bodies.Pilos Trans Royal Society London B 298:309-354

Mota T, Yamagata N, Giurfa M, Gronenberg W, Sandoz JC. 2011. Neural Organization and Visual Processing in the Anterior Optic Tubercle of the Honeybee Brain. The Journal of Neuroscience, 31(32):11443–1145631(32):11443–11456

https://news.illinois.edu/view/6367/204800, 2018

https://www.labnews.co.uk/features/x-ray-vision-09-08-2016)

http://www.buzzingacrossamerica.com/2015

https://animals.howstuffworks.com/insects/bee1.html, 2018

https://www.google.com/search?q=vision+process+in+honeybee+brain&tbm=isch&source=iu&ictx=1&fir

https://animals.howstuffworks.com/insects/bee1.html, 2018)

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http://klancengsragi.blogspot.com/2018