Visual Adaptation of a Herbivore and a Carnivore Insect

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Introduction:
Insect eyes are very special and different from the camera eyes of most animals, in that they are composed of many single eyes (Fig. 1). Each of a single eye (ommatidia) produces one pixel of the whole image. Therefore, the more single eyes an insect has, the greater the resolution the whole eye provides.

We are interested in comparing the eyes of the predatory praying mantis (Tenodera sinensis) and the herbivore stick insect (Anisomorpha buprestoides) to determine their respective resolution. Our hypothesis is that the predatory insect will have a higher visual acuity because predators need more accuracy in their vision. In order to determine the resolution we have to count the number and size of the ommatidia, as well as their distribution over the entire eye. In addition, we have to determine the visual direction of each single eye which represents the visual angle.

Method:
We anesthetized female adults from Tenodera sinensis and Anisomorpha buprestoides. We determined three parameters: a) the body size, b) the interommatidial angle (ø) within 20° intervals and c) the average diameter of the ommatidial lenses (D), and d) the total number of ommatidia.

After removing the head, a fine needle was placed underneath the base of the eye and perpendicular to the vertical axis. The needle was then mounted onto a turn table (Fig 2). In the area where the microscope focuses parallel to the axis of the ommatidia, a black spot will be seen. This spot is called the pseudopupil (see title picture). With the rotation of the eye, the pseudopupil moves in the same rotational direction to a new location 20° apart (Fig 3). The interommatidial angles (ø) were determined by dividing the degree intervals (20°) by the number of ommatidia between two pseudopupils. The lens diameter (D) was measured directly on the digital microscope images on the computer screen.

The eyes of both species were dissected under a dissecting scope. We then removed the sensory structures until the separated eye cuticle could be flattened on a microscopic slide and photographed using a digital camera. The total number of lens facets were counted.

Results:
The size of the mantis had a whole body length of 10 cm and an eye surface area of 166 mm². The stick insect had a whole body length of 6.5 cm and an eye surface area of 11.5 mm².

The average interommatidial angle (ø) is much larger in the stick insect compared to the praying mantis (Fig. 4).

The average lens size is greater in the praying mantis than the stick bug (Fig. 5). The combined results form Figure 4 and 5 support the known fact that in insects the greater the lens and the smaller the interommatidial angle, the better resolution of the ommatidium (see reference).

Figure 6 shows the comparison of the distribution of the ommatidial lens sizes over the periphery of the whole eye from the posterior to anterior. In the mantis we find that the lens sizes within the focal area are larger than the ommatidia in the posterior and anterior rim. This indicates a better resolution in the focal area. In contrast, the stick insect’s ommatidial lenses do not show any distinct size differences and no focal area.

We found extreme differences between the number of ommatidia per eye (Fig 7). This is an indication for a much greater resolution of the whole eye for the mantis compared to the stick insect.

Discussion:
Since the mantis is a day active predator insect, it needs a much greater visual acuity than the stick insect which is a night feeding herbivore. We found that the resolution of the single ommatidium is greater in the mantis due to a relative large lens diameter especially in the focal area and the interommatidial angle is smaller. The stick insect, being night active, is more chemically oriented and has a smaller lens size and a larger interommatidial angle, which does not provide a good resolution for the ommatidium.

In regards to the whole eye, the mantis has a much larger eye and many more ommatidia (8000 vs. 1300) providing a much greater resolution.

This study supports our hypothesis that the mantis eye and the stick insect eye are adapted to their specific living environment and behavior.