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THE SIZE OF OMMATIDIA IN APPOSITION EYES

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(With Three Text-figures)

INTRODUCTION

The vertebrate eye appears to have an acuity that closely approaches a theoretical limit set by the size of the pupil. The optimum resolving power obtainable with a lens of diameter δ is given by the formula

$$\theta = 1{\cdot}22\ \lambda/\delta,$$

where λ is the wave-length of light and θ is the angle (radians) subtended by two point sources which can just be detected as double. In the case of the human eye, for example, the diameter of the pupil in bright daylight is about 0·3 cm., and the light to which it is most sensitive has a wave-length $5{\cdot}6 \times 10^{-5}$ cm. This gives an optimum resolving power of 47 sec., whereas the best observed two-point acuity in the human eye is just under 1 min. The figure was known empirically before it was realized that it approached a theoretical limit set by the physical properties of light, but it is interesting to realize in retrospect that the limit deduced from the pupil diameter would have been a good guide to the actual performance.

It is usually supposed that the resolving power of a compound eye is limited simply by the angle between neighbouring ommatidia, but it is possible that the small diameter of each ommatidium compared with the wave-length of light is really the limiting factor. If it were, then it would be most inefficient simply to scale up a small compound eye to suit a large insect; in this paper the optimum relation between the size of the eye and the size of the ommatidium is deduced and eyes of varying size have been measured to see if the relationship holds.

Johannes Müller (1826—quoted by Exner, 1891) suggested that each ommatidium of a compound eye of the apposition type was only sensitive to light coming from a point lying on, or close to, the axis of the ommatidium. This was not accepted immediately, because it was thought that each single ommatidium might have some ability to discriminate the direction of the light falling on it. Exner's examination of the anatomy and optics of compound eyes made the alternatives to Müller's suggestion unlikely, and Hecht & Wolf (1929) have shown that the optimum resolving power of the bee's eye corresponds to the smallest inter-ommatidial angle. Hassenstein has recently provided convincing evidence that the ommatidia behave as functionally independent units in an eye of the apposition type.

Model compound apposition eye

Müller's suggestion seems to be well established, and the potentialities of this type of eye are most easily discussed in terms of a model. The model is not supposed