Vision

Shortcomings of an eagle's eye

from Graham R. Martin

EXCEPTIONAL sensory capacity has often been invoked as an explanation of apparently unusual behavioural performance. For example, superiority of visual resolution over that of other animals is often cited to explain the hunting prowess of diurnal birds of prey: modern ornithology texts quote estimates of maximum visual resolution in the larger eagles of up to ten times that of man. However, as knowledge has increased of the physical and physiological factors that ultimately limit the visual resolution of vertebrate eyes[1], visual scientists have come to question the possibility that visual performance in these birds can attain the high levels claimed. The first evidence that visual performance in a raptorial bird does not outstrip that of man came three years ago when maximum spatial visual acuity in a small falcon, the American kestrel, *Falco sparverius,* was shown just to equal that of man[2]. Now, the first measurement of the spatial visual acuity of an eagle's eye shows that its resolution out-performs that of man by a factor of two at best[3].

Working with a wedge-tailed eagle, *Aquila audax,* Liz Reymond of the Australian National University trained the bird to learn a two-choice simultaneous discrimination task. The bird viewed the stimulus panels from six metres and expressed its choice by flying to one of two perches placed in front of the stimuli. With this arrangement it was possible to measure how the bird's visual resolution varied with both the contrast and luminance of the stimuli; Reymond was also able to test human subjects in the same apparatus to provide direct comparisons.

Reymond's findings are important since they show that the maximum performance of this eagle's eye can be predicted in a straightforward manner from knowledge of the focal length of the eye and the dimensions of the cone photoreceptors in the central fovea of the retina. Thus they provide a confident base for the prediction of visual resolution in other raptors and also demonstrate that there is no need to invoke a special role for the fovea in providing some sort of local magnification of the retinal image to enhance acuity, an idea which has been presented a number of times[4]. It may simply be that the eagle's fovea is no more than an area where the neural layers have been radially displaced so that light scattering is reduced before it reaches the cone photoreceptors.

The dimensions and packing density of the retinal cone cells in the eagle's fovea were found to be very close to the ultimate limit predicted by the waveguide properties of photoreceptors[5]. It should be a simple matter to predict the maximum spatial resolution to be found in the eye of other eagles as long as the size of the eye, or preferably the focal length of the eye, is known. (The focal length of the wedge-tailed eagle's eye is about 22 mm; that of the human is about 17 mm.) In absolute terms the eye of the wedge-tailed eagle is among the largest known and so it is unlikely that maximum spatial resolution in any other bird eye will be greater.

Reymond's study also shows that the eagle's eye is specialized for vision at the highest light levels that occur naturally. This has definite penalties once light levels start to fall and, in the eagle, spatial resolution deteriorates more rapidly with reducing light levels than in the case of man. Again this is in line with predictions based on the physical factors that limit the ways in which information can be extracted from an image by an array of receptors[6]. It also explains why raptors rarely hunt at or after twilight.

Ornithologists, falconers and the casual bird watcher may have difficulty in reconciling these findings with their field observations of the hunting performance of the eagle. They might, however, find comfort in the fact that the eagle's eye seems to obey in a straightforward manner the predictions of optical physics. ☐

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Meteorites

Unexpected Antarctic chemistry

from George W. Wetherill

THE meteorites found in Antarctica during the past 16 years are clearly different from those found elsewhere in several well-understood ways. Approximately 7,000 have been collected — they are on average much smaller than other meteorites, because it is easier to identify a small black fragment on a glacier; and they have been on Earth much longer, because they have been relatively protected against weathering by being encased in glacial ice. On page 390 of this issue, J.E. Dennison and colleagues report another difference that is both surprising and less easy to explain[1]. They find that the concentrations of a number of trace elements in a sample of Antarctic meteorites is different from the concentrations in a similar-sized sample of non-Antarctic meteorites. Several explanations can be suggested but various reasons make all of them difficult to believe.

The great importance of Antarctica for the recovery of meteorites was accidentally discovered by Japanese glaciologists in 1969. Since then, frequent expeditions from several nations have collected thousands of meteorites, probably representing more than 1,000 separate events. Dennison *et al.*[1] report neutron activation measurements on 23 stony meteorites from Victoria Land, near the Ross Sea and McMurdo Sound, all of the same chemical class and metamorphic grade (H5 ordinary chondrites). The analyses were compared with a sample of 20 non-Antarctic meteorites of the same type.

For 8 of the 13 elements studied, the differences in mean concentrations of the two samples were judged to be statistically significant. Plausible reasons are presented for believing that these differences are not laboratory artefacts or sampling bias and the authors conclude that two distinguishable populations are being sampled. They also give reasons for rejecting the hypothesis that the differences are attributable to weathering of the Antarctic samples during the approximately 3×10^5 years since they fell to Earth, so they propose that the differences must be extraterrestrial in origin. They suggest that the differences result from variation with time of the asteroidal source regions from which meteorites of this kind are derived and present a scenario in which such a change in population would result from a single burst in ejection occurring after the fall of the Antarctic meteorites. They also propose that such differences may be caused by decay of meteorite fluxes with time, caused by discrete bursts at different times before the fall of the Antarctic meteorites.

No timescale is given for this scenario — the authors note that serious difficulties arise with attempts to be more quantitative. For example, an event occurring since the fall of the Antarctic samples would result in an abundance of cosmic-ray exposure ages of less than 3×10^5 years in non-Antarctic samples, but such young