THE CHELONIAN EYE IN HEALTH AND DISEASE

David Williams MA VetMB PhD CertVOphthal CertWEL FRCVS

Department of Veterinary Medicine, University of Cambridge, CB3 0ES.

Email: doctordlwilliams@aol.com

www.davidlwilliams.org.uk

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Introduction

Tortoises need to see. We know that much since blind tortoises, be they visually impaired from birth through a congenital abnormality such as microphthalmos or later in life through freeze damage during hibernation, need to be hand fed, a taxing task. But how well do turtles and tortoises actually see? And what conditions can affect their eyes, with what treatments possible? Many papers have been written on the chelonian eye and researchers spend their whole careers studying the subject, so this can be only a very superficial look at the subject, but one which will hopefully be of interest to those caring for tortoises or treating them as veterinary surgeons.

What do chelonia see?

It is notoriously difficult to assess what any animal actually sees. Indeed how can I tell that what I perceive as a red tomato is just the same as what you see, let alone what a tortoise or a turtle recognises as a visual stimulus! What we can do is to evaluate what colours are absorbed by the photopigments in the rods and cones of the chelonian retina. While we as humans see in three colours, red, blue and green, many birds, reptiles and invertebrates have a wider range of wavelengths including ultraviolet.

The tortoises that have been investigated appear to have three photopigments that see in purple, verging on the ultraviolet, the green and the orange, as can be seen from the graph in figure 1. Notice though that apart from primates, all mammals see with just two photopigments, one in around the yellow and one in the violet. Why have primates and tortoises, among others, evolved to see colour so particularly well? Our diets, back when we were in the trees (if you will excuse me!) were predominantly fruit-based. So identifying red and orange coloured items from a green background was very important, hence our trichromatic (three coloured) vision. Tortoises too eat fallen fruit amongst green vegetables, so identifying colours is important to them. Far more important than to a cow which doesn't mind quite how green the grass is, or a cheetah which is far more interested in how a gazelle moves, compared with what colour it is!

Now the interesting thing about the reptile retina, rather than being the same as the birds, is that as well as having different cones which absorb

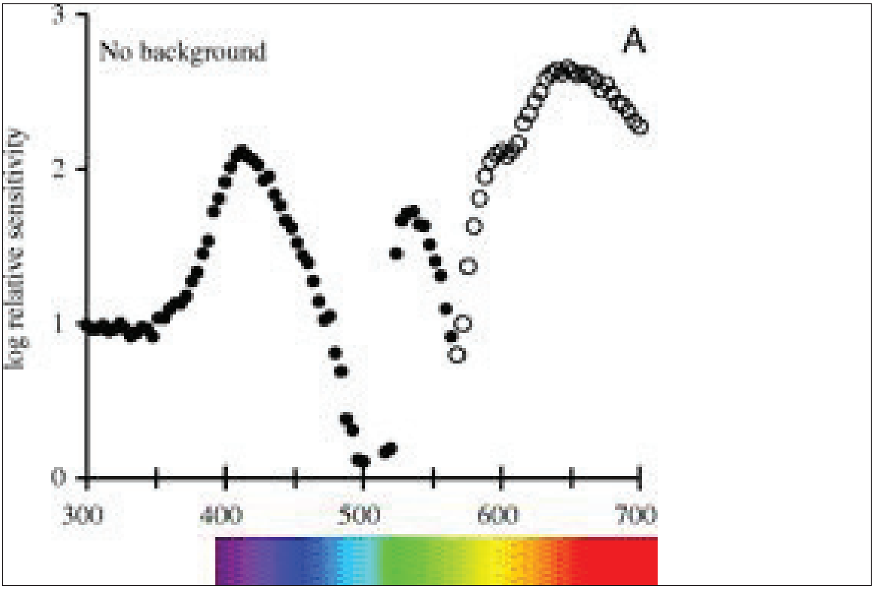

Fig. 1. Different photoreceptors in the tortoise retina.

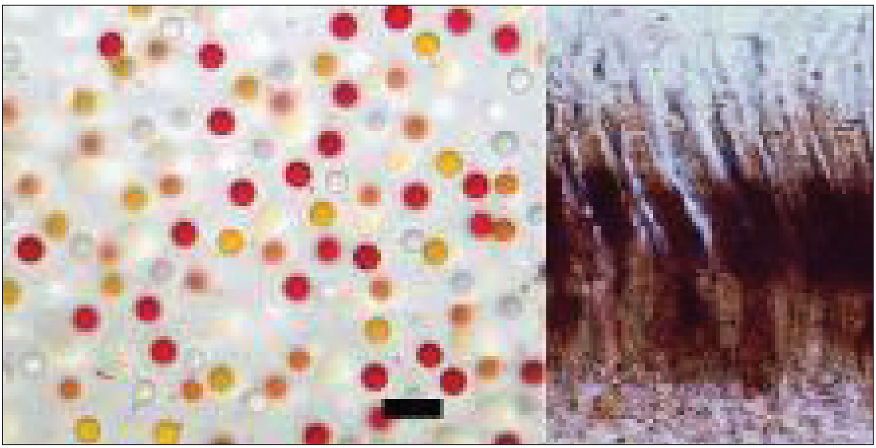

Fig. 2a. Colour oil droplets in the chelonian retina.

Fig. 2b. Photoreceptors in the chelonian retina.

different wavelengths of light, the retinal photoreceptor cells have oil droplets which absorb certain wavelengths, giving a different colour sensation. Figure 2a shows the colour oil droplets in a flat mount of a chelonian retina where each circle is a droplet overlying a particular photosensitive cell. Figure 2b shows the photoreceptor at the bottom of the picture with the brown pigment of the oil droplet absorbing much of the light before it reaches the light sensing cell.

When they don't see

A key problem, at least in terrapins, is when substantial swelling occurs overtaking the eye and leading to complete blindness. Such a case is seen in figure 3, a picture from Dr Edward Elkan (Fig. 4). This is hypovitaminosis A, first reported by Edward Elkan and Peer Zwart, publishing their report in 1966. In fact both researchers independently reported their findings at the same meeting a couple of years earlier, but joined to combine their results. Both had noted that histology showed the classic signs of epithelial dysmorphology characteristic of hypovitaminosis A. This finding allowed treatment with intramuscular vitamin A, although the dosage, even after all these years, is still somewhat empirical, around 1000-3000 international units every week.

What else can cause visual disturbance? After hibernation chelonia can present with a dense white deposit on the cornea, as seen in figure 5. This proteinaceous covering can be difficult to remove – Frye suggests using a proteolytic enzyme preparation Kymar, which contains alpha chymotrypsin, but unfortunately this is not available in the UK currently. Surgical removal

Fig. 3. Hypovitaminosis A in a terrapin.

may be possible but the underlying cornea is very thin so irreparable damage may occur unless the surgery is performed using microsurgery under an operating microscope.

Such a deposit on the cornea must be differentiated from lipid deposition within the cornea as seen in figure 6. All too often this can occur when owners feed fat-rich diets such as giving biscuits as treats to their charges.

Cataracts

Given that chelonia live significantly longer than dogs or cats, when age related cataract is seen by 10 to 12 years, we do not see lens opacities in tortoises until they are around 40 years of age. A variation in this general rule is when animals have been subject to freeze damage during hibernation when cataracts can occur, although the incidence and prevalence of such changes are currently unknown. Our studies, examining 250 tortoises, have shown that, in Testudo species kept in the UK, by the age of 35 years half of the population have some degree of frank lens opacity of what we term

Fig. 4. Dr Edward Elkan.

Fig. 5. Dense white proteinaceous corneal deposit (courtesy Dr F.L. Frye).

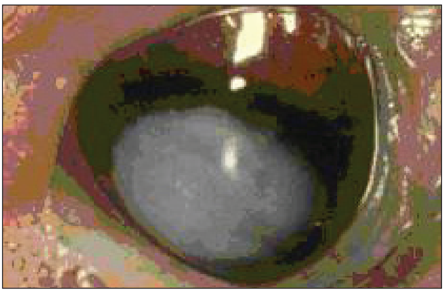

Fig. 6. Corneal lipidosis in a red footed tortoise (courtesy Dr S. Barten).

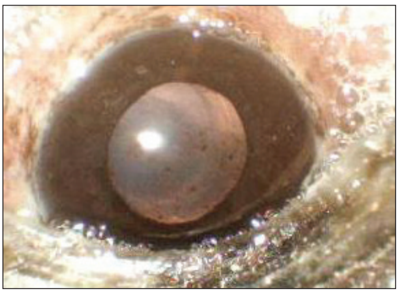

Fig. 7. Nuclear sclerosis and early cataract in *Testudo graeca*.

nuclear sclerosis, which is an ageing change in the lens which does not impair sight, as seen in figure 7. While this is interesting from an academic standpoint, lens opacities are not a significant cause of blindness in tortoises, except perhaps for animals near the end of life. We know that the ageing changes in the lens of many species, including man, are caused by oxidation of lens proteins. Perhaps the frugivorous and foliaceous diets of chelonia, rich in anti-oxidants, may account for the low incidence of lens opacities in these animals. Much work is still needed on this and I would particularly be interested in hearing from owners with a number of older animals, for the purpose of a simple eye examination to define the status of their lenses.

Ocular inflammation

A number of tortoises can be affected by conjunctivitis after hibernation, when ocular surface bacteria have a chance to multiply without the immune system being able adequately to protect the eye during periods of low body temperature. Other cases can be associated with herpes viral upper respiratory tract infection and inflammation or a dacryocystitis. This inflammation of the nasolacrimal duct is often associated with infectious stomatitis, given that the nasolacrimal duct opens into the buccal cavity at the position of Jacobson's organ. There are those who argue that the tortoise does not have a patent nasolacrimal duct, but this condition, which may present with bubbles emanating from the nasolacrimal punctum, shows this suggestion to be fallacious.

Inflammation of the iris is rare in reptiles but has been reported and may be associated with septicaemia in chelonia as has certainly been seen in squamate reptiles.

Retinal lesions

The lack of reports of retinal lesions in chelonia may indicate only that insufficient investigation has been undertaken, rather than paucity of disease. We know that some tortoises appearing blind after hibernational freeze damage have neither corneal nor lens damage, as noted above, but rather retinal degeneration, presumably after freeze-related retinal necrosis. The fact that this is the work on retinal disease in these species where so much work has been undertaken on normal retinal biology, as noted at the beginning of this paper, should just be an encouragement and challenge to we ophthalmologists to perform a greater number of retinal examinations in these species. This is not made easy by the small size of the chelonian eye, but given the number of studies of the laboratory mouse eye, of similar size, all that is required is greater enthusiasm in veterinarians to perform such examinations and owners to present animals for such investigation. It is hoped that this paper might stimulate such collaboration.

Conclusions

This contribution can only hope to skate on the very surface of chelonian vision and not plumb the depths of an area that clearly needs much more investigation. Indeed, I have not, in this short article, included all the published work on visual capabilities of tortoises and turtles, far less given as full an account as I would have liked of the diseases which prevent full visual capability in these species in the wild or in captivity. Yet I hope that this article will at least have shown some of the intricacies of chelonian vision and illustrated areas where further research is needed.