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ON THE

SCLEROTIC RING

OF

THE EYES

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OF

BIRDS AND REPTILES.

BY

THOMAS ALLIS, ESQ.

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[*Extract from the "Proceedings" of the Yorkshire Philosophical Society.*]

On the Sclerotic Ring of the Eyes of Birds and Reptiles.—

By THOMAS ALLIS, ESQ. *Read April, 1849.**

When I began the preparation of Bird's Skeletons, I was not aware that their eyes were furnished with this bony apparatus, and when first informed of the fact, it was mentioned only with reference to rapacious birds.

By accident the sclerotic bones of an Eagle Owl became detached from each other in consequence of over boiling ; I was induced to articulate them together and to count them ; and on finding it stated in Cuvier's *Comp. Anatom.* that the usual number of these bones was twenty, whereas in the bird in question they only amounted to fifteen, I was led to proceed further, and after dissecting minutely the sclerotic ring of upwards of seventy birds, taken from every great division, the greatest number I have found in any instance is seventeen ; and the smallest number eleven ; except in a single instance, in which the ring is composed of but one single bone. I have sixty-seven species on these tablets : of these, the ring consists in one instance of only a single bone ; three have eleven bones ; eight have twelve ; twelve have thirteen ; twenty have fourteen ; nineteen have fifteen ; two have sixteen ; and two have seventeen. I have consulted several authors, but have met with little respecting either the bones themselves or their functions ; the little I have found is contained in the following extracts ; after giving which, I shall mention concisely those particulars in which the results of my own researches differ from the statements made by these authors.

Blumenbach *Comp. Anat.*, 296, says, "the eyes of birds of

* This paper was composed in 1837, and in that year was read to the British Association assembled in Liverpool. At the request of the Yorkshire Philosophical Society, in whose Museum the Allisian Collection of Comparative Osteology is preserved, it was read to that Society in 1849. In the interval between these dates, Mr. Allis had the satisfaction of shewing to the authors of that splendid publication, 'The Dodo and its Kindred,' that their inference of the place of Dodo among the Columbidae was entirely confirmed by the independent evidence of its Sclerotic Bones.—(*Note by Editors.*)

prey have a peculiar form ; which is similar to that of the chalice or cup used in the communion service ; the cornea which is very convex forms the bottom of the cup, and the posterior segment of the sclerotica resembles the cover ; this peculiar form arises from the curvature and length of the bony plates, which, as in all other birds, occupy the front of the sclerotica, lying close together and overlapping each other ; these bony plates form in general a slighty convex ring ; being long and curved in the Accipitres, they form a concave ring, which gives the whole eye-ball the above-mentioned form."

Dr. Albers observes, " that the orbit is very imperfect in birds, and that this bony ring may supply the deficiency."

Carus says, " the firm and elastic sclerotica of birds, the structure of which has been very accurately examined by Albers, consists of three laminæ, between the outer and middle ones of which the osseous circle is inserted anteriorly. This structure, which already exists in some fishes and amphibia, is common to all the species of birds ; it is composed of from fifteen to seventeen oblong quadrangular laminæ of bone, with the corners rounded off ; forming in some cases simply a smooth circle, in others a more or less prominent cylinder ; in Owls this cylinder is particularly long."

Cuvier says, " the sclerotic of birds is divided into laminæ, the interval of which receives a circle of small, thin, hard, oblong bones, which lie over each other like tiles, and which give to the anterior part of the eye a great degree of firmness and a fixed form. These ossicula are almost flat in the greater number of birds ; in which they form only an annular disk of little convexity ; they are slightly arched and concave externally in the Horned Owl, in which they form a short tube in the form of a truncated cone ; they are usually twenty in number." Cuvier further states, that " the sclerotica determines the shape of the eye ; it can therefore be really soft and flexible only in animals that have the eye nearly globular ; that is to say in man and quadrupeds ; because their sclerotic assumes of itself that shape, in consequence of the nearly uniform resistance made by the fluids contained in the eye to the pressure of its

coats ; but in all animals that have the eye more removed from a spherical form, as the Cetacea, Fishes and Birds, that membrane is supported by hard accessory parts ; or by a greater solidity of texture and a more considerable thickness."

In a Paper in the third vol. of the Zoological Journal, Wm. Yarrell says, "the eyes of birds are much larger in proportion than those of quadrupeds, and exhibit also two other peculiarities." One of these peculiarities is "a ring of thin bony plates enveloped in the sclerotic coat. Comparative Anatomists do not seem to be agreed as to the means by which birds obtain their powers of vision ; whether by alteration in the *form* or *situation* of the crystalline lens, or by both ; either or both of which, the greater quantity of aqueous humour which birds are known to possess, would seem to facilitate, and the existence of a muscle attached to the inner surface of the bony hoop of the sclerotica and inserted by a tendinous ring into the internal surface of the Cornea, as shewn by Mr. Crampton in the Annals of Philosophy for 1813, by which the convexity of the Cornea may be altered, gives a still greater scope of action." He afterwards says, "the external convex form of the Golden Eagle will be found to extend through all the species of every genus of British birds, except the Owls, in all of which it is concave."

In speaking of the sclerotic bones generally, Dr. Buckland, page 174, of his Bridgewater Treatise, says, "In living animals these bony plates are fixed in the exterior or sclerotic coat of the eye, and vary its scope of action by altering the convexity of the cornea ; by their retraction they press forward the front of the eye and convert it into a microscope ; in resuming their position when the eye is at rest, they convert it into a telescope."

As regards the form of the bony ring, Blumenbach certainly is not correct when he says, that "in the accipitres it is concave externally ;" that is only true of the nocturnal accipitres, as stated by my friend Wm. Yarrell ; nor is the latter correct in saying that every species of British birds has it convex like the Golden Eagle. The Woodcock, Spoonbill, Caprimulgus, and some others have merely a flat and narrow ring towards the

external edge of the eye, and certainly no degree of convexity at all approaching to that of the Golden Eagle. The shape of the individual bones is so various that it cannot be given in any general term; the external edge of the bones is in most instances beautifully serrated; but the serration is not visible in the bony ring; but in the separate bones which were boiled until the extraneous matter would wipe off easily with a cloth, it is very perceptible; the rings would separate if boiled to the same extent, and in cleaning them with a knife I have not been able to preserve the serrations.

As regards the structure of the rings, the bones generally overlap each other, there being a depression on the under side of one bone, and a precisely corresponding one on the upper side of its neighbour, so that when overlapping each other, they present nearly an even surface, both exteriorly and interiorly; having one bone with both depressions on its inner surface, and forming an exterior key to the arch, and one having both depressions on its outer surface, and forming an internal key; in some instances there are two external keys; and in several instances, instead of one bone overlapping the other, they interlock into each other in a curious and beautiful manner.

I take it for granted that the principal function of these sclerotic rings is, as stated by Cuvier, to preserve that peculiar form of the eye which is adapted to the nature and wants of the animals. But in nature's laboratory there is no prodigality or waste of power; and these rings having, in the first place, fulfilled the duties for which they were primarily created, still subserve the wants of the animal in other ways, and under circumstances and in situations to which those classes of animals which have not such rings are not exposed.

I allude to their use as a defence and protection to the eye. On examining these specimens it will be found that those birds which are peculiarly pugnacious; those which have a peculiarly rapid flight; and those which, from the extended variation of altitude at which they fly, are exposed to great or very unequal degrees of atmospheric pressure, have the sclerotic rings of larger size, of more convex form, and the individual bones of

greater strength than the weak-billed or low-flying birds ; and the same remark holds good with the water birds, on comparing those that take their food on or near the surface of the water, with those that dive ; among which class are to be found the strongest bones.

Another subsidiary use, is that of altering the convexity of the Cornea as mentioned by Dr. Buckland.

I have eight specimens of diurnal Rapacidæ ; the Golden Eagle affords an example of a bony ring of greatly increased strength in a bird that takes a lofty flight and follows its prey with great velocity : it is a smaller bird than the white tailed Eagle, yet the bony ring is larger, more convex, and the individual bones much stronger. The King Vulture and Lammergeyer have the rings stronger than their congeners ; and the Secretary also has it very strong, but with its habits of flight I am unacquainted ; of this series, three have fourteen bones, four has fifteen, and one has sixteen.

Here are five specimens of Owls ; two belong to the great Horned Owl : one set of the detached bones shews the upper, the other set the under surface of these bones ; the principal use of the elongated tube appears to be, to bring the eye beyond the loose feathers of the head ; if the bones were no longer than in the generality of birds, the eyes would be so buried in the feathers that the bird would only be able to see objects straight before it. The bones of the Barn Owl are not larger than those of the little Scops, though the bird itself is nearly three times as large ; they are not required to be so long in the Barn Owl on account of the large circular disk of close and short feathers that surrounds each eye. The bones of the Owls, instead of being, as stated in general terms by Cuvier, hard, flat and thin, are very soft and porous ; as is also the case in those of the Caprimulgidæ, and those of the great Horned Owl are also of considerable thickness.

I have seven specimens of Gallinidæ ; one of these has thirteen bones ; four have fourteen ; one has fifteen ; and one has seventeen ; the ring in most of these is strong.

Of Columbidae, I have three specimens, each of which has

eleven bones : the bones are strongest in the rapid flying Carrier Pigeon, though the Crowned Pigeon is three times its size. The ring of the Dove is small and the bones feeble.

I have a specimen of each of the Struthious birds ; the Ostriches have each fifteen bones ; the Cassowary and Emew thirteen each ; the latter affords a beautiful example of the interlocking of the bones into each other.

I have nine specimens of Grallæ : of these, one is imperfect ; one has thirteen bones ; five have fourteen ; and two have fifteen. In the soft-billed birds of this class the rings are small and feeble, and larger in the sharp-billed specimens, though not so strong in these as in some other classes.

Of Scansorial birds, I have seven specimens : of these, five have twelve bones, and two have thirteen. The Parrot, Macaw and Cockatoo have the rings particularly small and feeble ; owing, I presume, to the skulls of the Psittacidæ being provided with perfect bony orbits, which, I believe, no other class of birds possess. The Woodpecker has the ring as strikingly large ; indeed it has, with only one exception, a larger portion of the eye protected by the sclerotic ring than any other bird I have met with in proportion to its size, and as I find nothing in its mode of flight, or in the altitude at which it flies to make it require this extra protection, I am induced to think that it is intended to protect the eye from injury from the small chips of wood which it scatters in all directions when searching for its insect prey, or boring the tree for the construction of its nest.

Here are seven specimens of swimming birds : one has twelve bones ; one fourteen ; four have fifteen ; and one has sixteen. The Ducks, Geese and Swans which seek their food at or near the surface of the water, have the rings remarkably weak and small ; while the Gulls, which descend into the water with some degree of force, have them considerably stronger.

I have ten specimens of diving birds, including the Pelican, which though not strictly a diving bird, I have included in this group on account of its affinity with the Gannet ; of these, two have twelve bones ; three have thirteen ; three have fourteen ; and two have fifteen. In the Pelican, which takes its food

near the surface, we find merely a feeble annular disk ; while the other birds of the group have the ring very strong and convex : the Gannet, which takes its prey by descending perpendicularly from a considerable height, with great force into the sea, has the individual bones stronger than any other bird I have met with :—the true divers, (which dive from the surface to a considerable depth after their prey) have their ring very strong and convex, though the individual bones are much weaker than in the Gannet. The Guillemot, Razor-bill and Sea Parrot, also have the ring very convex, especially the latter.

Here are ten specimens of Passerine birds : two have thirteen bones ; five have fourteen ; one fifteen ; one uncertain ; and one (the *Podargus Humeralis*) differs from all other instances I have met with ; the bony ring being composed of one single bone, instead of a series of plates. The European Night Jar has a very weak ring without any convexity ; while its Australian congener has the ring of considerable size ; though the bone itself is of a soft and porous texture like the Owls. The Swift has the ring larger, stronger and much more convex than any other bird at all approaching its own size. The Kingfisher's is also large for the size of the bird ; and the bones of the Humming-bird are also strong.

Of Reptiles, Cuvier says, (Comp. Anatom. translation, page 396,) “ There are similar laminæ in the sclerotic of the Chameleon and several other Lizards ; but they do not form the anterior disk of the eye ; but merely surround the lateral part.” Here are bones of two species of Turtle and three species of Lizards ; Serpents and Frogs appear destitute of them. The bones of the Turtle are less symmetrical than those of birds or Lizards, and form a nearly flat disk, having but little convexity.

Out of three species of Lizard, which are all I have examined, and of which the Chameleon is one, in two cases the ring, in opposition to the statement of Cuvier, does form the anterior disk of the eye, and that as completely as in any class of birds :

in the Iguana, these bones (from which the figure in Dr. Buckland's Bridgewater treatise was taken) are remarkably broad at their inner edge, and overlap each other to a greater extent than I have observed in any birds, thereby greatly increasing the strength of the convex ring; the external edge forms a kind of pedestal or foot; in birds the external edge is generally the broadest. The Chameleon has the bones of the same form as the Iguana, but the pedestal is less produced; the ring is very strong; and to increase still further the strength of the eye's defence, the bones are covered with the external skin of the animal, leaving only the pupil exposed. The Gecko has the ring of very slight texture, and it merely surrounds the lateral part of the eye, as described by Cuvier; the single bones (of which I have only preserved one specimen) are very slight, and from back to front exhibit a considerable curve. In fossil Saurians, these bones are of a very different and less complex form than those of the Iguana or Chameleon; they appear to be merely oblong bones of uniform shape, forming a protection to the front of the eye; they are beautifully figured as placed in the head of the Ichthyosaurus in Dr. Buckland's treatise; and I have here, from our Geological collection, as beautiful an example of these bones in situ.

Note.—The Paper was illustrated by anatomical preparations of the sclerotic rings. Figures of many examples may be seen in the plates which accompany this volume.

EXPLANATION OF THE PLATES.

PLATE 4.

Figure 1. A sclerotic ring of the Cassowary.

- 1a. The detached bony plate forming the ring ; being one of the best examples of the manner in which these bones interlock into each other.
2. Ring of the African Ostrich.
3. Ring of the Golden Eagle, which is proportionally larger and the bones thicker and stronger than the author has found in any other bird of this family.
- 3a. Detached bones of the same.
4. Ring of the White Tailed Eagle.
5. A front view of the ring of the Great Horned Owl ; in which the bones are of considerable thickness, but light and porous.
- 5a. A side view of the same, shewing a more perfect tube than is found in any other bird.
- 5b. Three detached bones of the same.

PLATE 5.

Figure 1. Sclerotic ring of the Norfolk Plover ; which is proportionally larger than in any other known instance.

2. Ring of the Spoonbill ; very small and feeble.
3. Ring of the Crane.
4. Ring of the Wild Goose ; which is proportionally one of the smallest.

Figure 5. Ring of the Herring Gull, considerably larger than in the Wild Goose, though the bird is but little more than a third its size and weight.

6. Ring of the Gannet.

6*a.* Two detached bones of the same.

6*b.* A section of one of the bones to shew its thickness; in this bird the bones are thicker, more compact, and stronger than in any other known instance.

7. Ring of the Pelican, a much larger bird than the preceding.

8. Ring of the Black-throated Diver, which is large and strong.

8*a.* Detached bones of the same.

9. Ring of the Red-throated Diver, which though a larger bird than the preceding, has the ring more feeble and smaller; indicating that it takes its food nearer the surface of the water.

9*a.* Detached bones of the same.

10. Ring of the Sea Parrot; which covers a larger portion of the eye than in any other aquatic bird; and acquires greatly increased strength from the extent to which the bones overlap each other.

10*a.* Detached bones of the same.

11. Ring of the Domestic Fowl.

12. Ring of the Collared Dove, which like all the other Columbidae which have come under the author's notice, consists of 11 bony plates; the smallest number met with in any class of birds; the extinct Dodo being the only bird with the like number.

13. Ring of the Wood Grouse.

14. Ring of the Green Woodpecker, which is larger and covers a much greater portion of the eye, than in any other scansorial bird.

15. Ring of the Blue Macaw, a bird more than twelve times the size of the Woodpecker, though with a much smaller ring.

- Figure 16.* Ring of the Lemon-crested Cockatoo, which is like the Macaws, very small.
17. Ring of the Toucan, a bird not a third part the size of the preceding, but which has a much larger ring.
 18. Ring of the Touraco or Plaintain Eater.
 19. Ring of the European Night Jar ; the bones are soft and the ring is very feeble.
 20. Ring of the Swift, proportionally one of the largest and strongest.

PLATE 4.

REPTILES.

Figure 6. Sclerotic ring of the Iguana.

- 6a. Two detached bones ; the outer edge of which forms a kind of pedestal, contrary to what is found in birds, where the outer edge is generally the broadest ; in the present case the ring is much strengthened from the extent to which the bones overlap each other in consequence of this peculiarity in their form.
7. A front view of the ring of the Gecko, which in this surrounds the eye, as described by Cuvier, and covers scarcely any part of the anterior portion of the eye.
- 7a. A side view of the same ring.
8. Ring of the Chameleon ; which covers the whole surface of the front of the eye except the pupil, and shews the smallest aperture of any known sclerotic ring.

16. Ring of the lamp, which is like the black, very small.
17. Ring of the lamp, which is like the black, very small.
18. Ring of the lamp, which is like the black, very small.
19. Ring of the lamp, which is like the black, very small.
20. Ring of the lamp, which is like the black, very small.

DEFINITIONS

1. A front view of the ring of the eye, which is this surrounds the eye, as described in the text, and covers nearly any part of the anterior part of the eye.
2. A view of the same ring.
3. Ring of the lamellae, which covers the whole surface of the front of the eye, and the pupil, and shows the small, at a distance of any known distance.
4. A view of the ring of the eye, which is this surrounds the eye, as described in the text, and covers nearly any part of the anterior part of the eye.
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