**On the presence or absence of air in the bones of birds / by Edwards Crisp.**

## On the presence or absence of Air in the Bones of Birds. By Edwards Crisp, M.D.

As one of the objects of the founders of this Society, as expressed by the Charter, was the cultivation of Physiology, and as our communications of late, upon this subject, have been rather scanty, I am induced to submit this paper to the notice of the members, and I do so with a hope that it may serve to dispel one of the many errors that unfortunately encumber the science of Zoology.

My attention was first especially directed to the investigation of this matter in consequence of hearing the following statement by Professor Owen, in one of his Lectures at the College of Surgeons, on the *Vertebrata*, of which I took notes at the time. The lecturer, to show the permeability of the bones of birds to air, said, "that a friend of his saw a man driving sea-gulls near Boulogne, and being surprised that the birds did not fly, he inquired the reason, and was told by the man that their thigh-bones had been perforated to let out the air;" and in further corroboration of this, Professor Owen said, "every sportsman knows that when the legs of a partridge are broken, it falls from the same cause."

I knew that this latter statement was an error, for two reasons—first, because a partridge does not fall when its legs are broken; and, secondly, and especially, because the thigh-bones of this bird do not contain air. In my dissections of the gulls I had not examined the thigh-bones; but to my surprise on investigating this matter, I found in all specimens afterwards dissected, that neither the *humeri* nor the *femora* contained air, but were filled with marrow. I next began to ask myself whether the presence of air in the femora of most birds would not act as an impediment to their flight, by diminishing the strength of the bone, and more particularly by depriving them of that weight and ballast which might be essential to their aërial progress? I knew, moreover, that most of our bats (the bones of which are free from air) could keep on the wing for many hours, some of them carrying their young, whilst probably the sparrow, robin, wren, partridge, and many other birds, could not sustain a continuous flight for five minutes. I next discovered that in many specimens of the common fowl, a bird that had scarcely ever topped a brick wall, the humerus was hollow; but in other birds of long flight that I examined at the same time, including the snipe, curlew, and many birds of passage, that none of the bones of the extremities contained air. Before proceeding further with the investigation, I consulted several modern writers upon the subject, and I subjoin extracts from their works for the purpose of showing the prevailing opinion upon the matter. It was not till this morning, after the above was written, that I consulted the essays of Camper and Hunter, and it will perhaps be more methodical to quote these anatomists before the others.

The first writer I find upon the subject is Camper, 'Œuvres d'Anatomie Comparée,' Paris, 1803, vol. iii. p. 460. The paper was presented to the Haarlem Academy, and he calls the discovery one entirely new, "that nearly all the bones of birds are filled with air by respiration;" he entitled it a discovery, because he knew of no author who had indicated the same thing. Marsighni had spoken of the wing-bones of the pelican as very light and hollow, but he did not allude to air, nor the manner in which it entered the cavity. The first observations (February 1771) were made on the sea-eagle, owl,

maccaw, turkey, black-cock, and common fowl. The *humeri* and *femora* were perforated, and the air-sacs and lungs inflated through the apertures. He came to the conclusion (verified by finding that the thigh- and wing-bones of a sparrow contained marrow) that all high-flying birds had the bones of the extremities filled with air; and he thought it probable that the wing-bones only of the swans, geese and ducks would be found to be hollow.

After John Hunter's paper in the sixty-fourth volume of the London Philosophical Transactions, 1774, being "An Account of certain receptacles of air in birds, which communicate with the lungs and are lodged among the fleshy parts and in the hollow bones of these animals," Camper published a letter (vol. iii. p. 474) claiming the discovery three years before Hunter had spoken of it.

Hunter, in the paper above mentioned, appears to have confined his observations to a few birds, and his three quoted experiments for the purpose of showing that a bird may breathe through apertures made in the *humerus* or air-sacs, are very inconclusive. The birds he speaks of are the ostrich, the common fowl, the woodcock, pelican and canary. The chief object of the paper was to show that the air-sacs and bones are appendages to the lungs. The essays of these great anatomists, of which I have given a brief outline, will well repay perusal; and if many subsequent writers upon the subject had depended upon their own observations, the prevailing error "*that the bones of a bird are filled with air,*" would not have occurred.

In Cuvier's 'Animal Kingdom' is the following:—"The air-cavities which occupy the interior of their body, and even (usually) supersede the marrow in their bones, increase their specific lightness."

Milne-Edwards, in his 'Elémens de Zoologie,' p. 504, says, "In general, air is found in great abundance in the bones of the members most employed in locomotion. In the ostrich, for example, the air-cells in the femur have a remarkable development."

The late Mr. Yarrell, whose recent death we all so much deplore, does not in his work on British Birds speak of the bones; but in his 'British Fishes' (Introduction, p. 21), he says, in alluding to the air-bladder, "The analogy to the air-cells in birds, and the passage of air from thence into the bones of the limbs, is too obvious to be unobserved, and will give interest to further investigation." So that Mr. Yarrell's impression evidently was, that the limb-bones of birds were supplied with air.

Mr. Rymer Jones, in his 'Organization of the Animal Kingdom,' 1855, p. 75, says, "Birds, in fact, breathe not only with their lungs, but the vital element penetrates almost every part of the interior of their bodies, bathing the surfaces of their viscera, and entering the very cavities of their bones; so that the blood is most extensively subjected to its influence."

In Carpenter's 'Comparative Physiology,' 1854, it is said, that "Even the bones are made subservient to this function (respiration); for though at an early period they possess a spongy structure, like those of reptiles, and are filled with thin marrow, they subsequently become hollow, and their cavities communicate with the lungs. In the aquatic species, however, the original condition is retained through life." And in his 'Manual for the Use of Students,' p. 386, it is stated, that in most birds the bones are hollow.

Professor Owen, in his article "Aves" in the 'Cyclopædia of Anatomy and Physiology' (vol. i. p. 343), remarks, "The singular extension of the respiratory into the osseous system was discovered simultaneously by Hunter and Camper, and ably investigated by them through the whole class of birds. It is stated that if the femur into which the air is admitted be broken, the bird shall not be able to raise itself in flight." He then quotes from Hunter's experiments before alluded to.

Professor Owen goes on to say, that "the proportion in which the skeleton is permeated by air varies in different birds. In the penguins he found no air in the bones. The struthious birds have all air admitted into the cavities, except the *humeri*, *tibiæ* and distal bones of the legs, which retain their marrow. With the exception of the woodcock, all birds of flight have air admitted into the *humerus*. The pigeons, with the exception of the crown pigeon, have no air in the femur, which retains its marrow. In the owls also the femur is filled with marrow, but in the diurnal birds of prey, as in almost all other birds of flight, the femur is filled with air. In the pelican and gannet the air enters all the bones with the exception of the phalanges of the toes. In the hornbill even these are permeated by air."

In his 'Lectures on Comparative Anatomy,' vol. ii. p. 34, nearly the same opinion is expressed, and the swifts and humming-birds are said "to have air in every bone of the skeleton down to the phalanges of the claws."

I make no apology for these quotations, because they are essential for the proper understanding of the matter.

I have placed on the table a French and English partridge, a lark, a snipe, a sparrow, a starling, and the skeleton (in maceration) of a swift (*Cypselus apus*), and it will be seen that in the three first-named birds only do the *humeri* contain air; the other bones are filled with marrow; in the remaining four birds the bones contain no air: but I should observe that in two swifts before examined I found the *humeri* hollow, the other bones full of marrow. I also exhibit the bones of many birds that I have dissected; among these are the ostrich, jabiru, eagle, sparrow-hawk, Weka-rail, green woodpecker, and many of the *femora* and *humeri* of the smaller British birds, nearly all of which are filled with marrow; indeed there are no apertures in the bones for the admission of air.

To bring the question to a more practical bearing, I subjoin a list of birds recently dissected (most of them shot by myself), in which I have examined the bones of the extremities to ascertain the presence or absence of air, and in this communication I think it better to include only British birds.

Sparrow Hawk. *F. nisus.*
Magpie. *C. pica.*
Jackdaw. *C. monedula.*
Woodpigeon. *C. palumbus.*
Turtle Dove. *C. turtur.*
Sky Lark. *A. arvensis.*
Green Woodpecker. *P. viridis.*
Common Duck.
Velvet Scouter. *O. fusca.*
Common Fowl.
Turkey.
Partridge (English). *P. cinerea.*
Partridge (French). *P. rufa.*
Bittern. *B. stellaris.*

Common Gull. *L. canus.*
Black-headed Gull. *L. ridibundus.*
Herring Gull. *L. argentatus.*
Great Black-backed Gull. *L. marinus.*
Razor Bill. *A. Torda.*
Puffin. *F. arctica.*
Red-throated Diver. *C. septentrionalis.*
Moor Hen. *G. chloropus.*
Coot. *F. atra.*
Curlew. *N. arquata.*
Godwit. *L. melanura.*
Dotterel. *C. morinellus.*
Common Snipe. *S. gallinago.*
Jack Snipe. *S. gallinula.*
Sanderling. *A. vulgaris.*
Water Ousel. *C. aquaticus.*
Swift, Common. *H. apus.*
House Martin. *H. urbica.*
Swallow. *H. rustica.*
Sand Martin. *H. riparia.*
Goat-sucker. *C. Europæus.*
Chaffinch. *F. cœlebs.*
Yellow-hammer. *E. citrinella.*
Sparrow. *F. domestica.*
Wheat-ear. *S. œnanthe.*
Wren, Common. *T. Europæus.*
Wren, Crested. *R. auricapillus.*
Robin. *S. rubicula.*
Blackbird. *T. merula.*
Thrush. *T. musicus.*
Fieldfare. *T. pilaris.*
Red-wing. *T. iliacus.*
Missel Thrush. *E. viscivorus.*
Starling. *S. vulgaris.*
Hedge Sparrow. *A. modularis.*
Little Creeper. *C. familiaris.*
Wood Lark. *A. arborea.*
Oyster-catcher. *H. ostralegus.*

I have mislaid the notes of my dissections of many other British birds, and as I do not like to trust to memory, I will reserve these for the concluding part of my paper.

Of the above fifty-two birds, the first only had many of the bones permeated with air; the next thirteen on the list had the *humeri* only hollow, and among these it will be observed that there are many of short flight. Of the remaining thirty-eight none of them had marrow in the *femora* or *humeri*, and judging from a few that were examined (the snipe, *e. g.*), none of the bones contained air. The last list includes some birds, as the swift, martin and swallow, that are longer on the wing and probably of swifter flight than any of the feathered creation.

By way of testing more accurately the correctness of my conclusions, I performed the following experiments:—I introduced a blow-pipe into the trachea of a common duck, a cock, a French partridge, an English partridge, and a snipe; I opened the *humeri* and *femora* of all, and placed the dead birds under water; I then inflated the lungs and air-cells in the chest and abdomen, the size of the birds being greatly increased by the inflation. In the cock the air escaped freely from the aperture in the *humerus*; but in the other birds no air was present. I then removed the *humerus* and *femur* at the upper joint, but still no air escaped on inflation. As I have stated before, all these birds, with the exception of the snipe, had hollow *humeri*, but none of them had air in the thigh-bones; these experiments, however, require repetition on a larger scale.

In my next paper I purpose describing the air-sacs in the thoracic and abdominal cavities of birds; the method by which air is admitted to the hollow bones; and the flight of birds in relation to these matters.

---

[*From the* Proceedings of the Zoological Society of London, January 13, 1857.]