1. On the Sternum of Notornis and on Sternal Characters.
   By Professor Owen, C.B., F.R.S., F.Z.S., &c.

[Received November 10, 1882.]

In the 'Proceedings' of this Society for 1882, referring to the meeting held January 7th, it is stated that "Professor Newton exhibited the skin and bones of the trunk of a specimen of Notornis mantelli, obtained in the province of Otago eighteen months before." On these specimens the sole remark recorded is, "that the sternum figured in the Society's 'Transactions,' vol. iv. pl. 4. figs. 5–8, as of this species must belong to a totally different form" (loc. cit. p. 97).

As a means of judging of the degree and kind of difference, it may not be unacceptable to ornithologists to compare the subjoined figures (pp. 690, 691) of the sternum of Notornis mantelli, of the natural size, with those of the sternum in the plate above cited, the original of which may be seen in the Geological Department of the Museum of Natural History, Cromwell Road.

Prior to the date of Prof. Newton's communication I had received from Prof. T. Jeffery Parker, University of Otago, New Zealand, a notice of the arrival there of the skin and following parts of the skeleton of a Notornis mantelli, viz. the bones of the trunk with some lower cervical and anterior caudal vertebrae, the scapular arch with sternum, and both femora articulated with the pelvis. As it was Prof. Parker's expressed intention to submit a description of these unique specimens to the Otago Institute, and as he was so good as to send me an impression of the plate, giving reduced views, front and side, of the sternum with other bones of the trunk, I reserved any remark thereon until the reception of the Professor's full and instructive 'Memoir,' which has appeared in the 14th volume of the 'Transactions of the New-Zealand Institute,' 8vo, p. 255 (1882).

Not until the year 1870 had I the opportunity of describing the sternum of Aptornis, the extinct Ralline genus surpassing in size Notornis. I then remarked:—"The inferiority of size of the sternum figured (plate 4. figs. 5–81) to the sternum of Aptornis defossor is greater than that of the femur of Aptornis otidiformis as compared with that of Aptornis defossor." This might have favoured the conclusion arrived at, or inclined to, in 1850, and indicated in the title to my former paper, in vol. iv. p. 1, of our 'Transactions.' But further insight was to be had by comparison of the subject of plate 4. figs. 5–8 with the parts of the skeleton of Aptornis otidiformis subsequently acquired.

Such comparison suggested, in 1870, the following remarks:—
"The relative size of the smaller sternum to the femur of Aptornis otidiformis is more like the relative size of the sternum of Aptornis defossor to the femur of that species, than is the relative size of the 'smaller sternum' to the femur of Notornis. Seeing, therefore, in

the Rallines here compared, that as the wings decrease and the legs increase in size the sternum becomes shorter in proportion to the femur, I am inclined to believe that the smaller sternum (pl: 4. figs. 5–8) has belonged to *Aptornis otidiformis* rather than to *Notornis*. This view derives further support from the fact that, with the decreasing relative size to the femur, there is a progressive simplification of the sternum in the recent Rallines (*Tribonyx, Ocydromus*), by which the still more simple type of the bone in *Aptornis defossor* is approached”¹.

A ground for excuse in reproducing this passage is the notice above cited in the Society’s ‘Proceedings’ in relation to the subjects of Prof. Parker’s memoir.

In this there is no concurrence with the accomplished Cambridge Professor as to “the total difference of form of the sternum of *Notornis* from that of *Aptornis*;” and the divergence is not only “zoological” as regards the “form,” “family,” or “genus” of birds which *Notornis* most resembles, but is “critical” in relation to the earlier author and his contributions on the subject.

As to the history, Professor Parker writes: —“The genus *Notornis*

Trans. Zool. Soc. vol. viii. 1871, p. 120.
was founded by Prof. Owen in the year 1848; the skull was fully described in the 'Transactions of the Zoological Society,' and the genus referred to the family Rallidae as a close ally of Porphyrio. Shortly after he received a femur, a tibia, and a tarso-metatarse of the same bird, as well as a sternum which he, at first, erroneously referred to Notornis, but afterwards (in 1871) recognized as belonging to Aptornis otidiformis'.

Far from the genus Notornis belonging "to a totally different form," the acquisition of additional osteological data confirms its reference, together with the extinct Aptornis, to the Ralline family.

Fig. 2.

Prof. Parker selects the New-Zealand genera Tribonyx, Porphyrio, and Ocydromus for his illustrations of this affinity of Notornis; and in regard to the sternum, finds the closest resemblance to it in that of Tribonyx: in this "it is of the same proportional length to breadth;" it is shorter relatively than in Porphyrio, but is considerably longer than in Ocydromus; but its breadth, in proportion to the length of the trunk, is greater than in any of the three smaller Rallines.

As in Tribonyx and the flightless "Wood-hens," the manubrial margin of the sternum of Notornis (fig. 1, p. 690, e) does not develop

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1 'Transactions of the New-Zealand Institute,' vol. xiv. 1882, p. 245.
the process so called, but is slightly concave: its extent equals that of the coracoid margin, \( b \), the pair of which margins, with the manubrial one, divide the fore border of the sternum into three equal parts. The degree of transverse concavity is the same in each; but the coracoid ones have also a moderate excavation in the opposite direction for their articular relations with the scapular arch. The outer end of each of these joint-surfaces is slightly produced (ib. \( d \)).

Articular cavities for the sternal ends of six hemi ribs mark the costal division, \( c \), of the outer border, which is thence continued backward, with a very slight sigmoid curve, to the hind end of that border, one third of which bounds the part of the sternum converted by the deep notch, \( f \), into a “postmarginal” process, \( g \). The intermediate end of the sternum, \( x \), representing, though hardly homologous with, the “xipho id appendix,” in “Anthropotomy,” is terminally truncate, not extending so far back as the “postmarginal” processes: these resemble the same parts in Tribonyx in being unexpanded at the end, as is slightly the case in Ocydromus and Porphyrio. The sternal keel in Notornis (figs. 1 and 2, \( s \) \( s' \)) shows the same shallowness as in Tribonyx, with a further reduction of the anterior angle (fig. 2, \( s' \)), in which Notornis resembles Ocydromus. The transverse convexity of the sternum, reduced as it is in that genus, is relatively less in Notornis: it subsides almost to flatness in Apteryx.

Other comparisons with the smaller existing Rallines of New Zealand, notable either for loss or much reduced powers of flight, are carried out and well illustrated in the reduced figures (plates xx. and xxi.) of Prof. Jeffery Parker’s memoir.

These have led me to believe that the accompanying figures, front and side, of the sternum of Notornis, natural size (pp. 690, 691), may not be unacceptable, as tending to complement the illustrations of the osteology of the extinct Ralline which have previously appeared in the Society’s publications.

In its sternal modifications the larger form, Aptornis, though strictly ralline in the sum of its osteology, has departed further from the existing forms. Not only have the “postmarginal processes” disappeared, with great reduction of breadth of sternum, but the place of a keel is indicated by a mere low obtuse ridge.

Now, on the supposition that, with further atrophy of the pectoral muscles, the keel should disappear from the sternum and leave no trace, as it has done in several genera of birds otherwise structurally distinct, as, for example, in Struthio, Rheas, Dromaius, Casuarius, Apteryx, and Dinornis, are Aptornis and therewith Notornis to be

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1 Anatomy of Vertebrates, vol. ii. p. 24, fig. 15, \( e \).
3 Loc. cit. p. 245.
4 Trans. Zool. Soc. vol. iii. pl. 50. figs. 7-13; and vol. iv. pl. 4. figs 5-8.
5 Trans. Zool. Soc. vol. iii. (1848), plate 57. fig. 4.
6 Ib. ib. fig. 5.
7 Ib. ib. fig. 7.
8 Ib. ib. fig. 6.
likewise included in the subclass "Ratite" of a binary ornithological system?

On a conjectural ancestral relation of the keelless external character to the present advanced volant faculty of the Avian class, the Dodo had made some progress thereto from its assumed "ratite" progenitor: it had risen to the rudiment of a keel.

To this conclusion, however, another conjecture opposes itself. Dodos (Dididae), having gained in bulk and weight upon other geographically associated birds of their own family or genus, and finding sufficient sustenance on the ground, with convenience for nidification, had no call to exert the strenuous act of flight. The stimulus thereto, which we daily witness in birds about us, was wanting. There were no enemies, quadrupedal or bipedal, in the tract of land now reduced to the islands of Mauritius and Rodriguez, to disturb their wellbeing and threaten their existence.

I have elsewhere remarked, as bearing upon the interesting question of the relation of the simplified sternum to the genesis of Birds, that Pezophaps, the largest land-bird seen by the early settlers in the island of Rodriguez, "differed in no other respect from the class-rule in other birds, save in the inability to fly by the action of the fore limbs. There were no enemies, native to the island, able to take advantage of that disablement—Il ne s'y trouve aucun animal à quatre pieds, que des rats, des lézards, et des tortues de terre," writes Leguat in his interesting little book.¹ The 'Solitaires' had no call to practise or to endeavour to practise that hardest mode of locomotion to obtain sustenance or fulfil any of the conditions of preservation of the individual or of the species; they were never scared into the violent volant exercise."² The exiled Huguenots derived the best, if not largest, proportion of their animal food from the wingless birds of Rodriguez.

The advent of Man, with or without a subservient carnivorous quadruped, is an intelligible cause of the extinction of species, especially of birds attracting his hunger by their size and unable to escape by flight. Thus the huge wingless Dromornis³, like Diprotodon, has become known to us only by the osseous remains in Australia. The smaller Emu and Cassowary are there restricted in range and numbers, and seem to be gradually passing away.

The fact of a range of variety in size has been determined in the individuals of many species. Such variety affecting a Cereopsis Goose to the degree shown by Onemiornis⁴ would, in a corresponding degree, render the act of flight more difficult and laborious. Consequently, if that act were not needed for the acquisition of food, it might seldom or never be exercised in the absence of any enemy from which it would offer a way of escape. By long disuse of the wings, continued through successive generations, those organs, agreeably

¹ Voyage et Avantures de François Leguat, &c. 12mo, à Londres, 1708.
² Memoirs on the Extinct Birds of New Zealand, and on those of Mauritius, Australia, &c. 4to, 1878. Appendix III. p. 5.
with Lamarck's theory of the 'Origin of Species,' would become enfeebled, and ultimately atrophied to the degree exemplified in *Apteryx* and *Dinornis*. The legs, then monopolizing the functions of locomotion, would attain, through the concomitant force and frequency of exercise, proportional increase of power and size. Under these conditions may be comprehended, by *vera causa*, the origin of the great flightless Anserine which is entered as a "species" in Ornithological Catalogues under the name of *Cnemiornis calcitrans*. It has become such through no choice or selection, but by a combination of circumstances enforced, with operative conditions of organic vitality, first taught us by the immortal author of the 'Philosophie Zoologique.'

The same course of cogitation, so guided, leads to the same conclusion as to the origin of *Notornis*, of *Aptornis*, of *Dinornis*. The tendency to variation in size and proportions, after the reduction and loss of wings, leads to the minor modifications of such flightless genera.

The genus *Notornis* is now known to be represented by species, living in the present generation of New-Zealand colonists, in localities nearly one hundred miles apart, and which have belonged to a once gregarious family.

The first captured specimen of the species, *N. mantelli*, was taken by seal-fishers (1847) near the coast of "Duck Cove," Resolution Island, Dusky Sound; the second specimen was caught (1869) at "Deas Cove," Secretary Island, Thompson's Sound; the third specimen, which afforded the subject of Prof. Jeffery Parker's memoir, was caught (1881) by a rabbit-hunter in Captain Hankinson's "Run," on "Bare-patch Plains," east of "Te anau" Lake,—all in the South Island of New Zealand.

In 'Phillip's Voyage to Botany Bay,' a large ralline bird was noticed on what is now "Norfolk Island," under the name of *Fulica alba* (1789, p. 160). A good coloured plate of the same species is given in Surgeon White's 'Voyage to New South Wales,' 4to, 1790, with a brief notice at p. 238, under the name of "*Gallinula alba*" (the "plates" are not numbered in this work). In size and shape of head and beak, in the reduced proportions of the wings, in the strength of the legs and feet, in the carpal spur, and the colour of the beak, this bird seems but a variety of *Notornis mantelli*; it is at least a species of the same genus, as von Pelzeln has pointed out in 'The Ibis' of 1873, p. 44.

But no "Redbill" or "Takahe" has since rewarded a naturalist's quest in "Lord Howe's" or "Norfolk Island." A species of the New-Zealand genus *Ocydromus* (*O. sylvestris*, Sclater) still exists there, and is said to be easily captured.

The Wood-hens flourish in both South and North Islands of New Zealand, as in the smaller tract nearer the Antarctic latitudes; but they are severally represented by modifications noted as *Ocydromus earli*, *O. australis*, and *O. sylvestris*.

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1 Loc. cit. p. 245.
2 A copy of White's figure is given in 'The Ibis,' 1873, pl. x.
Notornis is extinct in the North Island, but it still lingers, as we have seen, in the South Island of New Zealand. A perfect skeleton of the Norfolk-Island "Redbill" might show modifications, with claims to specific distinction from N. mantelli, like those which have been founded on the osseous remains of the extinct Moas of both North and South Islands of New Zealand. Hitherto I have not received remains of the genus Dinornis from any of the outlying tracts of land which may be conceived to have once formed, with the two New-Zealand islands, parts of a southern continent. Apteryx, like Ocydromus, is still represented by existing species in both North and South Islands. Considering the restricted powers of locomotion of the several genera above cited, it may be inferred that the lands yielding examples of such flightless birds were not, in their primitive days, separated by such breadths of ocean as that which divides the South Island from Lord Howe's Island, or as that known as "Cook's Straits." We may conceive the lapse of time since the geological forces occasioned such divisions of a southern continent to have been so considerable as to have allowed the conditions originating technical species to have led to the modifications which distinguish the Northern from the Southern Moas, Kivis, and Wekas, and the Southern Notornis from that which inhabited the land of Norfolk Island. Lamarck's hypothesis of the way of work of the secondary evolitional cause of Species, by the influence, viz., of circumstances exciting or checking the exercise of parts, is more intelligible, more applicable in connexion with observed facts, to the before-cited ornithic cases than is Darwin's or Wallace's 'Natural Selection.'

Passing from the origin to the extinction of species, I may remark that the accomplished naturalist and ornithologist Professor Emile Blanchard, referring to the abundance of remains of Dinornis in the South Island of New Zealand, writes:—"Aussi est-il difficile de croire que la destruction totale de ces remarquables créatures ait été accomplie par les Maories toujours clairsemés sur le littoral de l'Ile du Sud. Selon certaine probabilité, les événements physiques ont été la cause première de cette destruction;" and he infers that "L'extinction de ces oiseaux gigantesques serait une nouvelle preuve de l'effondrement du continent austral".

But it is not easy to conceive that birds commanding, like the Moas, great powers of traversing dry land, would permit themselves to be submerged, for example, with the sinking proportion of their continent which has separated the North from the South Island of New Zealand. The Maories may have decreased in numbers in the portion so severed which was less favoured by climate and fertility. But this would be likely to quicken their quest and improve their ways of capture and slaughter of their great feathered flightless game. The discovery in the grave of the ancient chief, interred at "Kai Koras" in the South Island, of the egg of Dinornis ingens on his lap, placed there, probably, for sustenance during his journey to the "next world," testifies, with the scorched bones and fragments

2 Memoirs on the Great Wingless Birds of New Zealand &c. p. 318, pl. cxvii.
of baked eggs in the stone ovens exposed beneath several feet of superficial soil, that the great wingless birds supplied the immigrant Polynesians with their staple animal diet, until that source was exhausted through such extirpation.

Returning to my more usual field of work (the skeleton), I would remark that the sternally-reduced Rallines do not offer in the rest of their organization a much greater degree, if any, of difference from Struthio than Apteryx presents. In Dinornis, as in Apteryx, the breast-bone has shrunk in length rather than in breadth, and the postmarginal notches, f, with the corresponding processes, g, are retained. Rudiments of these notches and processes are visible in Struthio, with a relative breadth of the keelless breast-bone approaching that in Dinornis. In the less broad, longer, triangular shape of the sternum, devoid of both notches and processes, Rhea comes nearest to Aptornis, and there is no trace of a manubrial process in either. The non-articular portion of the anterior border of the sternum is relatively greater in Aptornis than in Notornis (fig. 1, e); in this respect the larger extinct Coot more resembles both Apteryx and Dinornis. In Struthio and Dromaius the coracoid cavities, b, almost meet upon the fore border of the sternum. In Casarius the tripartite character of that border is the same, as regards the relative lateral extent of the articular (b) and non-articular (c) portions, as in Notornis (fig. 1).

In the young Coot the sternum is ossified from two transversely parallel centres. These first harden the primitive cartilaginous expanse near the costal borders, c; and it may be remarked that the respiratory movements pressing thereon precede the muscular actions of flight. In the Gallinae the keel, which forms the chief part of the breast-bone, is ossified from a separate centre, and the pair of slender bifurcate bony tracts beyond the costal borders have each a centre of ossification, distinct from the parial centres, common to the class, from which the main sternal plate is ossified. But these five points of ossification are exceptional in the class of birds, and relate to adaptive peculiarities of form in a particular group. They have been viewed as the rule of avian sternal development, and the two pairs of centres in the Common Fowl have been homologized with the hyo- and hyposternals of Chelonia; but this only shows how an embryology misconceived may mislead in the quest of homologies.

The New-Zealand birds afford instructive examples of the progressive loss of the volant faculty, with concomitant modifications of the parts of the skeleton giving origin to the pectoral muscles. The keel progressively shrinks from Porphyrio to Tribonyx, thence to Notornis, Aptornis, Stringops, Apteryx, Dinornis. But the modifications are adaptive, and accompany a sum of organic characters truly indicative of natural affinity; which sum, as it forbids the Kivi to be associated in the same order with the Wood-hen, or Stringops with either, equally removes Apteryx from Aptornis, and the latter

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1 See the admirable works on the Birds of New Zealand, by Walter L. Buller, C.M.G., Sc.D., F.R.S.; especially his 'Manual' on the subject, Svo, 1882.
extinct wingless birds from *Dinornis*. So, likewise, with parts of the skeleton which are connected with the sternum.

The coracoid in *Ocydromus, Notornis, Aptornis,* and *Apteryx* unites with the scapula at angles progressively detracting from the power of the muscles inserted into the humerus for the raising and protracting the wing. The coracoids, besides change of position, also lose in relative size, especially in their proximal or sternal breadth; consequently they require shorter grooves for articulation with the sternum; and as the loss proceeds from the mesial angle outwards a greater space intervenes between the sternal ends of the coracoids. Tracing the flightless birds from the Kivis to the Wood-hens, this interspace progressively decreases; tracing the volant species onward or upward, we find in some of the best flyers that the fore border of the sternum ceases to co-expand with sternal expansions of the coracoids, the articular grooves decussate, and the mid part of the fore border of the breast-bone shows a double articular groove.

The clavicular arch, or "merry thought," manifests a concomitant loss of strength, becomes filamentary, resumes its typical character of parial "collar-bones," and finally disappears.

But these gradations, with concomitant fall to keelless breast-bones, are related physiologically, narrowly or specially, to corresponding proportions of parts of the osseous and muscular systems, and, to similar degrees, with final loss of volant power. The food, the oviposition, the nidification, and other habits of flightless terrestrial birds may show no corresponding samenesses. Such vital differences, with the several corresponding totalities of avian organization, disperse or rank the so-called "Ratite" birds, in a natural and philosophical system of Ornithology, into different reduced, perhaps extinct, groups or orders of the class; and the well-marked modifications of form and proportion in keelless sternums, exemplified in plate 57 of the third volume of our 'Transactions,' may help to point the way towards the group to which their several possessors may be shown by future found remains to be naturally affined.

2. On a Collection of Birds from the Isle of Ceram made by Dr. Platen in November and December 1881. By Dr. **Wilhelm Blasius, C.M.Z.S.**

[Received November 13, 1882.]

Dr. Platen, the traveller and naturalist, who has of late years become favourably known to the scientific world by his collections in Malacca, Borneo, and other places of the Indo-Malayan region, made in the month of November of last year a stay of nearly four weeks at Lokki, on the island of Ceram, going there from Ambon. He collected on this occasion forty-nine skins of birds, which have been transmitted to my friend Mr. A. Nehrkorn of Riddagshausen, and by him kindly given to me for identification and classification.