MEMOIR
ON THE
GENUS PALAPTERYX,
WITH
DESCRIPTIONS OF ADDITIONAL REMAINS AND SPECIES OF
DINORNIS.

The publication of the Descriptions of the successively discovered remains of Dinornis, in the 'Proceedings' and 'Transactions' of the Zoological Society of London, during the years 1839 and 1843, was speedily followed by the collection in New Zealand, and the transmission to this country of many additional and highly interesting parts of the skeleton; some referable to the species of Dinornis therein defined, some to species of which no remains have hitherto been described, and others indicative of the new genus of gigantic wingless Birds, for which I have proposed the name of Palapteryx.

The specimens in question have been discovered not only in the 'North Island' of New Zealand, from which those previously described were exclusively obtained, but also from the 'Middle Island,' or as it is sometimes termed, the 'South Island'; and all the bones from this locality are less altered, and appear to be much more recent than those from the North Island. The friendly correspondents through whose kindness I am indebted for the rich additional materials which form the subject of the present memoir, or for information respecting the Dinornis, are Captain Sir Everard Home, Bart., R.N.; the Hon. Wm. Martin, Chief Justice of New Zealand; Sir Wm. Hooker, F.R.S.; the Ven. Archdeacon Williams, Corr. Z.S.; William Swainson, Esq., F.R.S., F.L.S., the distinguished naturalist; Colonel William Wakefield; J. R. Gowen, Esq., a Director of the New Zealand Company; Rev. William Cotton, M.A.; Rev. Richard Taylor, M.A.; the Rev. William Colenso*, M.A.; Dr. Mackellar; and Percy Earl, Esq.

I propose first to describe the bones, the homologues of which have not before been described, and which extend our knowledge of the generic characters of the skeleton of the Dinornis, and afterwards those which characterise additional species.

Amongst the specimens of parts of the skeleton not known when the foregoing memoirs were printed, are two mutilated crania, defective unfortunately in the mandibles, and showing little more than the walls of the cranial cavity; but, nevertheless, highly interesting and instructive. The larger specimen (Plate XVI, figs. 1—4) was obtained by

* This gentleman has published a very instructive and interesting memoir on the Moa (Dinornis) in the Tasmanian Journal, No. VII. 1843, to which the editor has appended an abstract of my memoir in 'Zool. Trans.' vol. iii. p. 32. Mr. Colenso's memoir is reprinted in the 'Annals of Natural History,' August 1844.
the Ven. W. Williams from the bed of a mountain-stream descending to the coast at Poverty Bay, North Island, and is referable by its size to the *Dinornis struthoides*. The smaller specimen (Pl. XXXI, figg. 3—6) was obtained by William Swainson, Esq., from the North Island, probably in the vicinity of the Bay of Islands, and has belonged to a species distinct from the preceding, and agreeing in size with the *Dinornis dromioides*. Both specimens have the ferruginous tint and great weight, arising from infiltration of a salt of iron (peroxide), which characterized the specimens from the North Island described in the former memoir; but the cancelli of the bone contain only a little of the dry powdery alluvium of the streams into which the specimens have been washed.

**Cranium.**

The cranium referred to *Dinornis struthoides* agrees pretty closely in size with the same part of the skull of the Ostrich, as will be seen by reference to Plate XVI., in which it is figured from four points of view, of the natural size; but it is broader in proportion to its height, especially in the occipital and inter-orbital regions. It is, in fact, remarkably depressed, subquadratc, with two large lateral emarginations for the temporal fossae (ib. 6, c), and both in size and shape it is more like the corresponding part of the head of the Dodo (ib. fig. 5) than that of any existing Struthious species: but the upper surface of the cranium of *Dinornis* is gently and equably convex above, the cerebral hemispheres not raising their bony covering above the level of the rest of the calvarium, as in the Dodo; and the frontal region, though more elevated than in the existing Struthious birds, is less suddenly raised than in the Dodo. The length of the present fossil is three inches, but half an inch at least of the anterior border of the os frontis has been broken away: its breadth across the mastoids is three inches and a quarter, but the breadth across the post-orbital angles appears to have been greater. The breadth between the temporal fossae, which are large and deep, is two inches five lines; its vertical diameter at the deepest part, from the upper occipital ridge to the under surface of the basi-sphenoid, is one inch and a half. From the occipital region the depth of the cranium gradually decreases to the anterior boundary of the cerebral cavity. The great occipital foramen (fig. 1, i") is subcircular, and seven lines in diameter,—that of an Ostrich being five and a half lines across: its plane is vertical, and the single occipital condyle (ib. 1) projects freely backwards, upon a short peduncle, beyond the upper margin of the foramen. No existing bird presents this peculiarity: the Dinornis in this respect resembles some of the Chelonian Reptiles. The broad and low occipital surface of the skull slopes forwards as it rises to join the upper surface. This inclination, with the slight depth and great breadth of the occiput, and the almost flat upper surface of the skull, forms the most peculiar features of the present cranium. The occipital region above the foramen magnum is divided by three short obtuse vertical ridges into four depressions (fig. 3, d), the two median ones being half the breadth of the two lateral ones, which are deeper than usual: each depression is bounded above by a
curved border, which does not rise above the level of the calvarium to form a crest, but
defines by a festooned line the occipital from the coronal surface. A broad and deep
depression separates the condyle on each side from the par-occipital processes (4, 4) which
form the posterior boundary of the tympanic cavity (fig. 4, 28). The broad basi-sphenoid
descends vertically for a third of an inch below, and at right angles with, the basi-
occipital, separated from the condyle by two small but deep depressions; this develop-
ment of the base of the skull is peculiar to the Dinornis among Birds, and resembles
that in the Crocodile.

All the sutures of the cranium are obliterated, but the foramen for the third division
of the fifth nerve shows that the ali-sphenoid (figg. 2 & 4, 6) ascended, as in other birds,
to meet the parietal (ib. 7), in order to form the so-called temporal fossa. The upper
boundary of each temporal fossa is well-defined, but not elevated into a ridge: a smooth
and very slightly convex surface of the cranium, one inch and ten lines in breadth,
intervenes between them: a continuation of the same surface, a flattened tract formed
by the parietal and mastoid (fig. 3, 8, 8), four lines in breadth, separates the temporal (6)
from the occipital fossae (d). A cellular air-diploë, from two to six lines thick, divides
the outer from the inner table of the cranium.

The mutilated base of the present specimen exposes the upper border of the pituitary
depression, bounded posteriorly by the groove in the basi-sphenoid (fig. 4, 5) common
to the converging carotid canals, and anteriorly by the groove which lodged the optic
chiasma, and from which the optic foramina (fig. 4, o, o) are continued outwards and
forwards to the orbits (11', 11'). The outlets of the optic foramina are separated by an
interspace of one inch: the Apteryx, amongst existing birds, approaches nearest to the
Dinornis in this peculiarity; but the Dodo most probably still more closely resembled
the Dinornis in the distinctness of and distance between the external outlets of the optic
canals. These foramina, in the present cranium, are smaller than those in the skull of
the Ostrich, and indicate it to have had smaller eyes, in which respect it must have
resembled the Dodo. The olfactory foramina are subcircular, three lines in diameter,
single, on each side, as in other birds, and at the anterior end of the cranial cavity separated
by an interspace of two lines: the olfactory cavities (fig. 4, 18) extend backwards behind
these foramina, upon the under surface of the cranium, to within four lines of the optic
groove, a feature which, with the large size of the olfactory nerves, indicates a develop-
ment of the organ of smell approaching that most remarkable one in the Apteryx. Of
the other outlets of the cerebral nerves, those for the ninth pair (the pre-condyloid fora-
mina, see fig. 1) are alone remarkable for any increase beyond the ordinary size. The
foramen rotundum (n, n, fig. 4) is distinct from both foramen ovale and foramen opti-
cum. The articular depression (fig. 4, 28) for the tympanic or quadrate bone is imper-
forate, eight lines long, from three to four lines wide, bounded externally by a short
angular process of the mastoid.

The form of the inner surface of the cranium shows that the cerebral hemispheres
were smooth, low, not rising higher than the cerebellum, but convex and expanded anteriorly: the proportion of the cavity to its great posterior outlet indicates the brain to have been smaller in proportion to the spinal chord than in any Struthious or other existing bird. There is no bony falx: the vertical ridge on the fore-part of the 'os petrosum,' for the attachment of the tentorium, is less produced than in the Apteryx: there are no horizontal ridges of bone continued forwards from the os petrosum to define the fore and upper part of a fossa for the optic lobe on each side, as in the Ostrich and most other birds.

The depressions on the occiput for the insertion of the nuchal muscles indicate the force with which they must have habitually operated upon the head; and the unusual size and depth of the temporal fossæ equally indicate the great strength of the gripe of the bill: such a combination of powerful muscles of the head and the beak accords with the indications which the vertebrae of the neck and the short and strong metatarsi afford, of habits of scratching and uprooting vegetables for food.

Compared with the Ostrich, the occipital condyle is smaller in the Dinornis in proportion to the great foramen: the cranium of the Ostrich is narrower, loftier and more convex posteriorly, and much more contracted anteriorly. The form of the cerebral hemispheres must have differed greatly in the two gigantic Struthious birds here compared. In the Ostrich the cerebrum is pyramidal, tapering forwards to a point; in the Dinornis it must have been square-shaped and broadly convex anteriorly.

Amongst the Grallatorial birds the cranium of the Gigantic Crane (Ciconia Argala) alone equals the present fragment in size, and resembles it in the expanse and degree of convexity of the upper surface; but it differs, like the Ostrich, in having a more sessile occipital condyle, which is larger in proportion to the foramen: the plane of the foramen inclines in the Argala, as in most other existing birds, from below upwards and backwards; and there is a similar inclination in the plane of the supra-occipital surface, which more nearly than in the Ostrich equals in breadth that of the Dinornis; but it is of greater height. The under part of the occipital condyle is on a level with that of the basis cranii in the Argala, as in most other birds: in the Dinornis it is raised above that level, or rather the level is carried by the above-mentioned development of the basi-sphenoid below it. The supra-occipital crest is more developed in the Argala, and the upper part of the skull is indented anterior to it. The temporal fossæ are much smaller, and more posterior in position, extending to the occipital ridge in the Argala. The optic foramina are more approximated and the cranial cavity is more contracted anteriorly in the Argala. The articular cavities for the quadrate bones are perforated, and more transverse in position in the Argala, as in the Ostrich, than in the Dinornis. The anterior condyloid foramina in both the Argala and the Ostrich are scarcely half the size of those in the Dinornis, and are situated nearer the condyle.

The Apteryx has a more hemispheric occipital condyle than the Dinornis, and the plane of the occipital foramen differs in the same degree from that of the Dinornis, in
regard to its slope, as in the Argala and Ostrich: the occiput in the Apteryx is narrower, higher, almost vertical, with the middle part produced backwards into an angular projection and perforated on each side: the upper region of the head is much more lofty and convex than in the Dinornis; the mastoid process is much smaller in proportion to the par-occipital process: the temporal surfaces resemble those in the Dinornis in their antero-posterior extent, but do not impress the sides of the cranium; the orbits are much smaller, and the olfactory cavities much larger in the Apteryx than in the Dinornis; but it is interesting to find the nearest approach to these peculiarities of the existing Struthious bird of New Zealand made by the extinct Struthionidae of the same island.

The cranium of Dinornis, referable by its size to the D. dromioides, was kindly transmitted, with other bones of the same genus, for my examination by Mr. Swainson*. It has suffered nearly the same kind and degree of mutilation as the larger cranium; the basi-sphenoid, with all the rostral part of the skull, having been broken away; but the supra-orbital ridges and fore-part of the frontal region of the cranium are more entire (Plate XXXI, figg. 4—6). The breadth of the cranium across the mastoids is two inches, seven lines; the length to the anterior border of the os frontis (not entire in the larger specimen) is two inches, eight lines; the breadth across the post-orbital angles is two inches, two lines; the breadth between the temporal fossæ is one inch, nine lines.

The smaller size of the present cranium, as compared with the preceding specimen, does not depend upon the immaturity of the individual: not only are the sutures almost as completely obliterated (and this takes place much later in Struthious birds than in birds of flight), but the ridges defining the attachment of the muscles are as strongly marked, and indicate not only a full-grown but an old bird.

The large size and vertical plane of the foramen magnum; the broad, low, supra-occipital region (figg. 4 & 5, 3), sloping from below upwards and forwards; the almost flat parietal surface (ib. 7), continued directly forwards into the broad, downward sloping frontal region (ib. 11); the wide and deep temporal fossæ (ib. 6); the small orbits (ib. 11') and expanded olfactory chamber (fig. 6, 18);—all repeat the peculiar generic characters of the cranium of Dinornis which are exhibited in the larger specimen.

The specific distinction of the smaller cranium is shown by the less produced and sessile occipital tubercle (figg. 4 & 5, 1); by the absence of the two fossæ on the back-part of the descending plate of the basi-occipital; by the wider temporal fossæ, divided behind from the occipital surface by a common ridge (fig. 5, r), not by a flattened tract;—and if the value of this difference should seem to be diminished by the known changes in the development of the temporal muscles in the progress of age, it applies in the present instance in favour of the specific distinction of the smaller cranium; for the less

* In the note accompanying the specimens that eminent Ornithologist says, "They are from the North Island. . . . . I have no idea that this strange group of Birds is any longer in existence, notwithstanding all the stories of the natives and others. If any may be alive they will probably be found in the Middle Island, which may be almost said to be uninhabited, except on the coast."
extent of the temporal fossa and the concomitant distance of its boundary from that of the occipital fossa, which might be interpreted as characters of immaturity, are present in the larger, not in the smaller cranium; and they are associated also in the larger cranium with a development of muscular ridges and impressions which forbid the supposition that that cranium has belonged to a young individual of the gigantic Dinornis. I conclude therefore that the Dinornis dromioides had relatively larger temporal muscles and a stronger bite than the Din. struthoides. The upper boundaries of the depressions are better defined in Din. dromioides, and there is a vertical ridge marking off the anterior third of the depression (ib. 6), like that which may be seen in the cranium of the large Storks and some other birds, but of which there is no trace in the cranium of Din. struthoides.

The articular surface on the mastoid for the os tympanicum is broader, flatter and shallower anteriorly in Din. dromioides than in Din. struthoides; and, in both, the lower angle of the mastoid is much less produced below the outer side of the articular cavity than in the Ostrich or Emeu; but the mastoid process in the Apteryx is much less in comparison with the par-occipital process than it is in the Dinornis.

The posterior angles of the supra-orbital ridge (ib. 12) are not entire; but the rugged surface has more the character of a sutural than a fractured one; and the presence of distinct posterior frontals in a nearly mature skull of an Emeu (Dromaius Novœ Hollandiœ) (ib. fig. 1, 12, 12) at the same part, leads me to suspect that these paraphysial elements of the frontal vertebra may have remained permanently separate osseous pieces in Dinornis, as in the Reptilia.

The anterior border of the os frontis shows two deep angular depressions (fig. 5, 15) for the articulation of the nasal bones, which are thus proved not to have become ankylosed to the frontals, as in the Apteryx, Emeu, and most other birds, but to have remained distinct throughout life, as in the Turkey and some other Gallinacea.

The extent of the supra-orbital ridge is eleven lines, and is, therefore, proportionally much less than in the Emeu or any Struthious bird, except the Apteryx, and apparently also the Dodo: the very slight transverse concavity of the roof of the orbit (fig. 4, 11') and its longitudinal convexity are characters which are intermediate between those of the Apteryx, where the orbital cavity is singularly small and indistinct, and those of the larger existing Struthionidae, and they combine, with the diameter of the optic canals, to show that the eyes of Dinornis were relatively smaller than in the Emeu and Ostrich.

Part of the inter-frontal suture, usually the last of the proper cranial sutures to disappear, may still be seen in the outer table of the skull of the Dinornis dromioides: there is no trace of it in the skull of the Din. struthoides.

_Tympanic Bone._

The third portion of a skull formed part of a small collection of bones of Dinornis from
the North Island, transmitted by my esteemed friend the Rev. William Cotton, M.A., whose zealous co-operation in the advancement of the natural history of the remote colony which benefits by his more important labours, deserves the warmest praise.

The portion in question is the left os tympanicum (os quadratum of ornithotomists), with the upper or mastoid articular end broken away, but with the orbital process and inner part of the articular surface for the mandible entire (Plate XXXI, fig. 7). From its size, which is double that of the same bone of the Ostrich (ib. fig. 8), it is referable to the *Dinornis giganteus*. In the breadth and flatness of the articular surface (c) for the inner division of the mandibular condyle, it resembles the tympanic of the Emeu more than that of the Ostrich; but in the length and slenderness of the orbital process (a) it more resembles the Apteryx (fig. 9, a) than any other existing Struthious bird. The corresponding process in the tympanic of the Ostrich and Emeu is shorter and broader. The upper articular extremity is wanting in the fossil, but its shape may be judged of by that of the cavity in the skull (Pl. XVI. fig. 4, 28) adapted for its reception. The figures preclude the necessity of further verbal description of the present interesting fragment: if the length of the entire skull bore the same proportion to the os tympanicum in the *Dinornis giganteus* as in the Ostrich or Emeu, it could not be estimated at less than one foot three or four inches in the stupendous extinct wingless bird of New Zealand; but if the form of the beak should have resembled that of the Dodo or approximated to that of the Apteryx, the total length of the skull of the *Dinornis giganteus* would exceed the above-estimated admeasurement.

**Vertebrae.**

Through the kindness of Dr. Mackellar I have been enabled to compare and describe some remarkably perfect specimens of cervical and dorsal vertebrae of the *Dinornis*, which formed part of a collection of bones obtained by that gentleman in the Middle Island, from a superficial turbary formation on the coast, submerged at high tide, near the settlement at Waikawaite: these specimens are now deposited in the Museum of Natural History of the University of Edinburgh.

The first of these vertebrae (Plate XXXII. figg. 1, 2 & 3) to be noticed is a cervical, with all its parts as sharp and unmutilated as if it had been artificially macerated. From the absence of a neural spinous process, as well as from the longer and more slender proportions of the body, compared with any of those described and figured in the preceding memoir (pp. 97—99), the present vertebra must have come from a more advanced part of the neck, and have belonged to a species at least as large as the specimen in Pl. XVII. figg. 1—3. From the analogy of the Apteryx it might be the eighth or ninth cervical, since in that bird the spinous process begins to be developed in the vertebra above and below these; but the proportions of the vertebrae and the analogy of the Emeu indicate it to have come from a part nearer the head.
In the length of the posterior zygapophyses or articular processes (Pl. XXXII. s') and the depth of the triangular depression between them, the present vertebra bears more resemblance to the cervical vertebrae of the Emeu than to any in the neck of the Ostrich, the Rhea, or the Apteryx: but the pleurapophysis or process representing the cervical rib (ib. pl) is not so pointed or prolonged as in the Emeu; it more resembles that in the Apteryx: the breadth or depth of this process, the large relative size of the canal which it overarches and completes, and the ridges and furrows on the outer surface, bespeak the strong development of the cervical muscles and the great strength of the neck.

The characteristic conformation of the cervical vertebrae in the class of Birds is well-displayed in the present specimen, and the particular modifications characteristic of the Dinornis are better elucidated by the figures than by verbal description.

The next cervical vertebra (Pl. XXXII, figg. 4 & 5), like the foregoing, is from the part of the neck where the neural spinous process ceases to be developed, there being in its place a flat surface (s) behind a rough shallow depression for the attachment of the strong, short, elastic ligament: the difference of size and conformation of the present, as compared with the foregoing vertebra, is obviously not such as depends on mere difference of position in the same neck, or in the neck of the same species, but clearly indicates a difference of species in the birds to which they have respectively belonged. The present vertebra may well, from its size, have come from the anterior third part of the cervical series in the Dinornis giganteus; the preceding from the corresponding part of Dinornis ingens. In assigning the vertebra (Pl. XVII, figg. 1—3, p. 109) to the largest species of Dinornis, I was influenced by the ordinary proportions of those bones in other birds: the present specimens prove that the strength of the neck was greater and the cervical vertebrae relatively larger in the genus Dinornis, and the above-cited vertebra must be assigned to Din. ingens rather than to Din. gigas.

The costal process (Pl. XXXII, pl) here presents a similar breadth and depth and external sculpturing: the upper and posterior margin is produced into a short obtuse point. From the base of this part a ridge extends obliquely upwards and backwards to that of the posterior zygapophysis or oblique process (ib. s'), parallel with the shorter and stronger ridge from the anterior oblique process (ib. z) to the base of the spine: between these ridges there is a deep depression opening at the bottom into the cancellous structure of the bone. This foramen pneumaticum is not present in the smaller cervical vertebra (ib. figg. 1—3). The rudimental spinous process (ib. fig. 5, s) forms a transverse barrier across the front of the depression between the posterior oblique processes, which depression is broader and more rounded at the bottom than in the preceding vertebra, and is quadrate, not triangular, in the present vertebra.

The largest vertebra in Dr. Mackellar's collection is an inferior cervical one (Pl. XXXIII.), corresponding with that of the smaller species of Dinornis figured in Pl. XVII, figg. 7, 8 & 9, in the presence, as in the Apteryx, of a compressed haemal or inferior spinous process. In this character both species of Dinornis more resemble the small existing Struthious
bird of New Zealand than the larger species of New Holland. In the Emu, for example, the inferior spinous process begins not to be developed until the dorsal series of vertebrae, with articular cavities for ribs, commences.

The anterior articular surface of the body (Plate XXXIII, figg. 2 & 3, a) bends down upon the under part of the vertebral body, where the lower angles of the reniform surface are produced backwards. The diapophyses or transverse processes (ib. d) developed from the base of the anterior oblique processes (ib. z) seem not to have been connected by a costal process with the produced margins of the anterior and under part of the body (a), but to have been divided from these by an open groove on each side. The perforated depression (i, fig. 1) is smaller than in the foregoing cervical vertebra, and the posterior boundary ridge of the foramen pneumaticum is shorter and more obtuse. The base of the superior spine is strongly impressed before and behind by a rough surface for attachment of the inter-spinal elastic ligaments: the antero posterior extent of this spine (g) and of the inferior one (h) is shown by dotted lines in fig. 1. Both having been broken off in the specimen, these and the other fractured surfaces of the vertebra show the very coarse and loose cancellous texture of the bone.

In a similar-sized more perfect posterior cervical vertebra of Dinornis giganteus, in the collection of Mr. Percy Earl, obtained from the same deposit and locality, the strong spinous process is entire: it is four-sided and truncate at the summit, four inches high from the fore-part of its base, one inch in the antero-posterior diameter of the base, and ten lines in the transverse diameter.

A fragment of a vertebra, from the same collection, of nearly the same size, and probably a little anterior in position, differs from the preceding in having only a very shallow imperforate depression, where the deep perforated pit exists at the sides of the neurapophyses in the foregoing vertebra: the neural spine has scarcely been developed above the level of the posterior zygapophyses or articular processes in this fragment.

Dr. Mackellar’s collection contained two very perfect specimens of dorsal vertebrae of smaller species of Dinornis, presenting several peculiarities characteristic of the genus. The first of these (Pl. XXXIV, figg. 1 & 2) is from the middle of the dorsal region of probably the Dinornis ingens. It is not carinate inferiorly, as in the corresponding vertebra of the smaller species, figured in Pl. XVII, figg. 6—9, and the lower border of the anterior articular surface of the body is less produced in proportion to that of the posterior surface. The depression leading to the cancellous structure between the transverse and posterior oblique process in the small dorsal vertebra above cited is wanting in the present large one; but the pneumatic foramen (Pl. XXXIV, f) between the costal depression (c) and transverse process (b) is present. The proportionate breadth of the body of the vertebra; the broad outspread oblique processes (ib. fig. 2, z, z'); the thick, obtuse and almost horizontal transverse processes (ib. b); the strong spinous process, as broad transversely as antero-posteriorly;—all exemplify the generic characters of the vertebrae of Dinornis.
The rough ligamentous tract on the fore and back part of the neural spine is produced into a median ridge (s), making the transverse section of the middle of the spine hexagonal; two inches and a half of the spine remain, measured from the bottom of the rough tract; the height would probably have exceeded three inches in the perfect vertebra.

A dorsal vertebra (Pl. XXXIV. figs. 3 & 4) of the same size, and from the same or nearly the same region of the spine, shows the pneumatic foramen between the transverse and posterior articular process, as in the small vertebra (Pl. XVII. figs. 6—9), but not that between the transverse process and the costal depression, as in Pl. XXXIV. fig. 1, f: it further differs from that vertebra by the larger proportional size of the zygapophyses (ib. z, z) and the somewhat more slender spine (ib. s): the ridge continued from the side of the base of the spine to the transverse process (ib. b) is sharper.

A middle or posterior dorsal vertebra of a smaller species of Dinornis resembles the larger one in the absence of the pneumatic foramen between the posterior oblique and transverse processes, and in the relative size of the posterior and anterior articular processes: the spine is entire, the rough front and back surfaces are not carinate, but convex; the summit of the spine flat and truncate.

The figures in Plate XXXIV. supply the points of comparison omitted in the verbal description, in a better and more applicable form. I suspect one of the larger dorsals to belong to the Din. ingens, the other larger one to the Din. crassus; the present vertebra may well belong to the Din. struthoides.

**Sternum.**

From the turbary deposit near Waikawate Mr. Earl obtained nearly an entire sternum (Pl. XXXV. figs. 1—3) of one of the larger, if not of the largest species of Dinornis. It appeared to have been fractured by the instruments employed in digging out the bones, and reached me in two pieces, one including the articulations for the sternal ribs (r, r) and for the coracoid (ib. fig. 2, e, e) of the right side, with rather more than half the body of the sternum, and with the border of the right posterior wide notch (e) entire, showing its size and shape, but with part of the anterior border and the anterior (a) and posterior (p) angular processes broken away: the left portion of the same sternum included the two posterior articular surfaces for the ribs and upwards of three inches of the posterior angular process, with part of the entire border of the left posterior emargination (e): the base (x) of a process from the middle of the posterior border of the sternum indicated the characteristic configuration of this part of the bone. The anterior border (fig. 2), about half an inch thick, and rounded, is shown by the right moiety to have extended almost straight to beyond the middle of the bone. The outer surface of the sternum is gently convex, without the smallest trace of a median crest or keel; the inner surface is slightly concave, deepest near the anterior angles. The main body of the sternum consists of a light cellular layer of bone, with a thin, smooth, compact outer and inner table, the whole averaging three lines in thickness, and thinning off to the posterior margin.
The following are the dimensions of this mutilated but instructive bone:

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This, the largest sternum which has hitherto been discovered in the class of Birds, is relatively the smallest in proportion to the body, if it belong to the *Dinornis giganteus*. That it belongs to the genus there is no room for doubt, since it was found associated exclusively with the abundant remains of different species of *Dinornis*, and especially with those of *Din. giganteus*. In its small relative size, its shortness as compared with its breadth, its shield-shape and the total absence of a keel, it demonstrates the want of a power of flight in the genus *Dinornis*, and its closer relationship to the Cursorial or Struthious order. The following are comparisons of the present sternum with the modifications of form which that bone presents in the different genera of that strictly terrestrial order.

The sternum of the Ostrich (*Struthio, Pl. XXXV. fig. 4*) is larger in proportion to its breadth; the hind-part is narrower, instead of being, as in Dinornis, broader than the fore-part; the sternum of the Ostrich is more convex, and is a much thicker bone, especially at the middle prominent part of the body of the bone which transmits the weight of the trunk upon the sternal cushion or callosity, upon which the Ostrich rests when prone on the ground. The coracoid grooves (*ib. c, c*) are considerably larger in the Ostrich, extending from the outer angle, close to the middle of the anterior border, which is thin and sharp; the costal articulations (*ib. r*) are broader, much deeper, and occupy a much greater proportion of the lateral borders of the sternum. The posterior angles (*ib. p*) are prolonged backwards, but not so far as in the Dinornis, and there are two emarginations (*ib. e, e*) on each side between the angles and the middle line, to which a cartilaginous, and, in old Ostriches, a semi-osseous xiphoid appendage (*x*) is attached.

In the *Rhea* the sternum (*Pl. XXXV. fig. 5*) deviates more than in the Ostrich by its greater length, median convexity and posterior contraction, from that of the Dinornis: it further differs in the absence of posterior angular prolongations and the presence of a posterior median marginal notch (*e*); but the coracoid cavities (*e, e*), though considerably larger than in the Dinornis, are more confined to the anterior angles than in the Ostrich.

The coracoid cavities have a similar position, but rather smaller relative size, in the sternum of the Cassowary (*ib. fig. 6*), which however differs as much as that of the Rhea from the sternum of the Dinornis in its greater length as compared with its breadth, and especially in its contraction to the posterior margin, where the angles are rounded off and the middle part slightly produced.
In the Emu (Dromaius) the sternum (ib. fig. 7), with the same general form as in the Cassowary, further differs from that of the Dinornis in the approximation of the coracoid grooves (ib. c, c) so as to come into actual contact at the middle of the anterior border.

Of the sternum of the Dodo we as yet unfortunately know nothing, although we may as reasonably expect the osseous remains of that extinct bird to reward the search of naturalists and collectors in the islands of Mauritius and Rodriguez, as the similar quest in New Zealand has been followed by the recovery of the bones of the Dinornis.

In the Apteryx however we find a sternum (ib. fig. 8), which, with the same general Struthious characters, very closely corresponds with the particular modifications of that of the Dinornis. It has the same small proportional size to the body; nearly the same superior breadth as compared with the length, the same slight degree of convexity, and the same characteristic expansion and marginal configuration posteriorly. In the sternum of the Apteryx described at p. 34 and figured in Pl. IX. figg. 2 & 3, two small subcircular spaces remained unossified in the body of the sternum; in two more mature specimens which I have subsequently received, ossification has obliterated these spaces, where however the bone is thin and diaphanous, and the sternum presents only the two deep posterior emarginations, bounded by a middle xiphoid prolongation and the two angular elongated processes (p, p), as in the Dinornis. These processes in the Apteryx are relatively broader, thinner, and are subincurved: in the Dinornis they seem, from the remains of the one on the left side, to be straight, and become thicker and narrower.

The costal articular surface occupies a greater proportion of the lateral margin of the sternum in the Apteryx than in the Dinornis, though it is less than in the Ostrich. The coracoid groove has the same relative position and size in the Apteryx as in the Dinornis, but has a different form: in the small existing wingless bird it is an oblique notch, formed by a small process projecting upward and forward from the outer surface of the sternum near the antero-external angle: in the Dinornis (ib. fig. 2, c) it is an oblique depression, as if the end of the thumb had been pressed into the same part of the bone when soft. The anterior and lower border of the depression is not produced beyond the level of the bone; but in the example before me it is notched, as if for the passage of vessels to the joint.

Whether the antero-external angle (a) is prolonged so far in Dinornis as in Apteryx, the fracture of that part in the present specimen does not allow to be determined. The anterior margin between the coracoid articulations in the Apteryx is deeply excavated, whilst in the present species of Dinornis it is almost straight. Four smooth depressions with three well-marked rough surfaces (r, r', r'') for the attachment of sternal ribs, characterise the anterior two-thirds of each lateral border in the Dinornis. The outer surface of the sternum in the Dinornis shows the impressions of the decussating bands and fibres of the aponeurotic periosteum, with which it was covered when recent.

A part of a young Apteryx, kindly transmitted to me by Dr. Robert Hunter, demonstrates that the sternum is developed, as in other Struthionidae, from two lateral centres,
whence the ossification radiates, and converging to the middle line, there produces confluence of the primitively separate halves. We cannot doubt, from the close conformity of the sternum of the adult Dinornis with that of the Apteryx, that it was developed in the same way, and not, as in the Gallinacea, from more numerous separate centres, notwithstanding the rasorial proportions of the metatarsus.

**Bones of the Extremities.**

Although the title of a former Memoir* referred to five species of *Dinornis*, determined from the osseous remains transmitted by Archdeacon Williams from the North Island of New Zealand, a sixth species was indicated in the Memoir itself, under the name of *Dinornis dromioides*, by the characters of a femur†, the only bone of the extremities referable to that species which I at that time possessed.

I have since received from the North Island, by the kindness of Mr. Cotton, two other femora, agreeing in size and characters with the one referred to the *Dinornis dromioides*, together with two tibiae and a metatarsal bone, of a size in respect of breadth of extremities and circumference of shaft suited to those femora, and differing from the homologous bones in all other known species of *Dinornis* by being more slender in proportion to their length and longer in relation to the femur; thereby approaching more nearly to the proportions of the leg-bones in the Emeu and other large existing *Struthionidae*, and confirming my conjecture founded upon the characteristic proportions of the femur itself‡.

The species which I have called *Dinornis ingens* was founded principally on the characters of a femur and tibia. I have since received a tarso-metatarsal bone from the North Island, through the kindness of Mr. Colenso, and from the Middle Island there have been transmitted femora, tibiae and tarso-metatarsals of apparently a more robust variety of *Dinornis ingens*, together establishing most satisfactorily the former existence of at least one species of *Dinornis* of the stature of nine feet.

The richest accessions to the osteology of this extraordinary genus of wingless birds have been made by Mr. Percy Earl, an enterprising naturalist, to whose exertions zoology is indebted for the recovery of the most perfect remains from the soil of New Zealand. These were discovered by Mr. Earl in a turbarry deposit on the sea-coast of the Middle Island, near the settlement of Waikawaite. The deposit is overflowed by the sea at high-tides, and had been covered by a bed of sand and shingle; but this bed having been swept away by storm-waves a short time before Mr. Earl’s arrival, the black

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† “The femur of nine inches in length, with similar proportions of the tibia and metatarsus, which latter would probably be relatively longer”—(the comparison is with *Dinornis didiformis*)—“gives the height of five feet to the species, which from its similarity of size to the Emeu I have called *Dinornis dromioides*.”—Ib. p. 264, pl. 22.
‡ Ib. p. 252.
bed of peat was exposed, to which Mr. Earl’s attention was attracted by observing some bones projecting from its surface. These and many other bones, obtained by digging close to the surface, or at a moderate depth in the peat, all belonged to species of *Dinornis*.

Commencing with the leg-bones referable to known species, I first select for description the femur of the *Din. giganteus*, of which hitherto only the shaft has been described; but I have now had the opportunity of examining four perfect specimens contained in the collections of Dr. Mackellar and Mr. Percy Earl.

The femur of the gigantic *Dinornis* closely accords with the generic characters of the bone, as given in the preceding memoir (pp. 86, 87). The rough surface for implantation of a muscle at the middle of the fore-part of the proximal end is well-marked, and there is an obtuse prominence from the middle of the rotular concavity (Pl. XXXVI, fig. 2, r) above the transverse ridge which divides this from the lower inter-condyloid space. The back-part of the proximal extremity of the bone is entire and imperforate, as in the other species of *Dinornis*. Its dimensions are given in the ‘Table of Admeasurements’: the length precisely accords with that conjecturally assigned to the femur of the Gigantic species in the former memoir (p. 86, Table of Dimensions of Femora, f. 1 and Note*).

The circumference of the middle of the shaft exceeds that of the fragment there described, and indicates the Gigantic Dinornis of the Middle Island to have been a stronger and more robust bird than that represented by the bones from the North Island, described in the former memoir. In Plate XXXVI. the proximal (fig. 1) and distal (fig. 2) extremities of this noble bone are figured of the natural size.

Fine tibiae of *Din. giganteus* in both Dr. Mackellar’s and Mr. Percy Earl’s collections supplied, by the perfect state of their articular ends, what was defective in the more ancient and rolled bones from the North Island. The head of the tibia is characterized in Birds by the flat or sinuous, or sometimes slightly convex articular surface (Pl. XXXVII. a, a) adapted to the inner condyle of the femur, by the large size of the tuberosity (ib. t) which divides this from the smaller sloping articular surface applied to the inner side of the outer condyle, and by the ‘epicnemial’ ridge (b), which is commonly broad and more or less produced upwards from the anterior and outer part of the proximal surface of the tibia. From the outer, usually more or less obtuse, angle of the epicnemial ridge a short ‘ectocnemial’ ridge (k) is commonly continued downwards upon the outer part of the shaft: a compressed prominent ‘procnemial*’ ridge (p) is continued further down the fore-part of the shaft of the tibia.

The proximal end of the tibia of the Gigantic Dinornis (Pl. XXXVII, fig. 1) agrees, like

* To facilitate and make more intelligible the comparisons of the tibiae in the different species of *Dinornis* and other birds, I have proposed the above names for the well-marked and constant processes and ridges which have not before received any distinct appellations in Comparative Anatomy.
that in the smaller species, with the modifications of the ornithic type presented by most
Grallæ and Gallinæ (ib. fig. 4, Ciconia Argala), but differs considerably from the cor-
responding part in the Ostrich (ib. fig. 2). In this largest of existing Struthionidae the epine-
memial process (b) does not rise above the level of the proximal surface of the tibia, but
extends directly forwards, sends out a compressed and prominent procnemial ridge (p) and
a short thick obtuse process (k) from its outer side in place of the ecto-
cnemial ridge. In the Dinornis the posterior articular tuberosity (fig. 1, t) is divided,
by a wider and deeper depression than in the Ostrich, from a smaller anterior prominence
to which a fibular ligament is attached (fig. 4, l): this depression in the Dinornis receives
the inner prominent division of the outer condyle of the femur; the posterior tibial tuber-
osity rising into the space between that and the inner condyle, whilst the fore-part of
the outer condyle rests upon the inner side of the ascending tibial ridge: this occasions
a closer interlocking of the tibia and femur than in the Ostrich. The only difference in
the dimensions of the tibiae of the Dinornis giganteus from the North and Middle Islands
is a slight increase of the breadth of the distal end of the more recent and better-preserved
bones from the latter locality (see the 'Table of Admeasurements, p. 137.') I subjoin
to the figure of the well-preserved proximal end of one of these tibiae from the Middle
Island, figures of the same parts of the tibia in the Ostrich (fig. 2), Emeu (fig. 3), and
Gigantic Crane (fig. 4), all of the natural size.

The tarso-metatarsal bones of the Dinornis giganteus from the Middle Island are more
generally and sensibly stronger in proportion to their length than the femora or tibiae,
compared with those from the North Island; but I cannot venture to infer from this
evidence alone more than a stronger variety of the species: the degree of difference is
accurately given in the 'Table of Admeasurements, p. 137.'

A new species might with more reason be founded on the bones of the hind extremity
from the Middle Island, which agree in length with those of the Dinornis ingens, since
they surpass in thickness in a somewhat greater degree their homologues from the North
Island. This difference I have not only been able to appreciate with regard to the
femur and tibia on which the species D. ingens was founded*, but also with regard to
the tarso-metatarsal bones, having received one specimen from the North Island, trans-
mittted by Mr. Colenso, which presents intermediate dimensions between the tarso-
metatarsal bones referred to Dinornis giganteus and Dinornis struthoides, and having
compared it with three tarso-metatarsals of similar length in the collection of Mr. Percy
Earl. These differences will be appreciated by the 'Table of Comparative Dimensions';
but I shall here notice these stronger bones from the Middle Island as belonging to
Dinornis ingens, var. robustus, until other parts of the skeleton, especially the skull, may
arrive, although the following differences of form are observable in the homologous
bones of the extremities from the two localities.

In the femur of the robust variety of *Dinornis ingens* from the Middle Island, the upper tuberosity of the two posterior ones is nearer the lower than the upper end of the bone; in the femur of the *Din. ingens* from the North Island it is nearer the middle of the shaft. In the *Din. ingens* from the Middle Island the inner contour of the femur descending from the head is less concave: the outer expanded surface of the proximal end of the bone forms an obtuse angle with the posterior surface, not a right angle, as in the *Din. ingens* from the North Island. In the *Din. ingens* from the Middle Island the great trochanterian ridge extends more boldly out, its contour is more convex, and it is relatively larger. The same may be observed with regard to the antero-external prominence of the outer condyle: the length of shaft included between the lower end of the trochanterian prominence and the upper end of the external condyloid prominence is four inches nine lines in the robust variety, and five inches five lines in the femur from the North Island.

The proportions of the tarso-metatarsal bone of the *Dinornis ingens*, as exemplified in the bone (Pl. XL, fig. 1) sent by Mr. Colenso from the North Island, are nearly those of the *Din. struthoides*. In the tarso-metatarsal bone of *Din. giganteus* the antero-posterior thickness of the shaft is greater. The anterior surface of the upper half of the shaft, below the perforated depression, shows a slight longitudinal concavity in *Din. ingens*. Towards the inner side of the posterior part of the lower half of the shaft there is a rough tract of three inches in length, and at its lower end a rough oval depression (ib. d), about one inch by nine lines. The surface in the tarso-metatarsal bone of the Apteryx for the attachment of the back-toe occupies the corresponding place: the *Dinornis ingens* therefore, by this mark of resemblance to the Apteryx, may belong to a genus (*Palapteryx*) distinct from *Dinornis*. The accuracy of the reference of the tarso-metatarsal bone, m 2, in the preceding Memoir (p. 82) to a young individual of the *Dinornis giganteus*, is well-illustrated by the present bone, in which the shaft, from the perforated proximal anterior depression to the beginning of the clefts of the distal articular trochleæ, is precisely the same as in m 2; the tarso-metatarsal in the *Dinornis ingens* manifesting all the characters of age, by complete confluence of its primitively distinct elements, as well as by the strong and rough lateral ridges for ligamentous and aponeurotic attachments; whilst m 2, with the same length of shaft, shows, as described in the former Memoir, the still open fissures between the proximal ends of the three constituent metatarsals.

The species, which I have called *Dinornis casuarinus*, is most satisfactorily determined by ten femora, five of the left and five of the right leg; by eleven tibiae, five of the left and six of the right leg; and by six tarso-metatarsal bones, most of which bones have been obtained from the Middle Island, at the locality and turbary deposit near Waikawaite.

I have figured one of the bones of this species from the North Island in the preceding Memoir, viz. a mutilated femur (Plate XXIII, fig. 1), which I at first regarded as belonging to a young individual of the *Dinornis struthoides*. The acquisition of so many
entire femora, tibiae and tarso-metatarsal bones, evidently belonging, by their proportional size and exact co-adaptation of articular surfaces, to the same species of bird, has enabled me to detect specific characters in the femur and tibia, by which this species, for which I propose the name of *Dinornis casuarinus*, clearly differs from both *Dinornis struthoides* and *Dinornis didiformis*. But I may be permitted to observe, that the reference of the solitary mutilated femur to the young of the *Din. struthoides*, which I am now enabled to correct, was a mistake on the safe side: the caution which refrains from multiplying specific names on incomplete evidence being less likely to impede the true progress of zoological science than the opposite extreme.

The specific characters of *Din. casuarinus* (Pl. XXXVIII.) and its distinction from *Din. dromioides*, with which it most nearly agrees in size, and especially in length, will be most prominently brought out by combining the descriptions of the bones of both species.

The femur of the *Din. casuarinus* very little exceeds that of the *Din. dromioides* in length, but rather more in the circumference of the shaft, and very considerably in the development of the two extremities. The head is relatively larger, as Pl. XXIII. of the foregoing Memoir shows: the tuberosities below the middle of the back-part of the shaft are more developed: the rotular interspace between the condyles is both wider and deeper: the posterior half of the internal condyle is relatively much larger. But both the internal and the external longitudinal narrow ridges are more marked in *Din. dromioides* than in *Din. casuarinus*.

The well-marked differences between the femora of these nearly similarly-sized species will be readily appreciated by comparing Pl. XXXVIII. with Pl. XXII. The specimen figured in Pl. XXXVIII. is rather less than other femora of the same species from the same locality.

The most obvious distinction between the tibiae of the *Din. dromioides* and *Din. casuarinus*, in the relation of their thickness to their length, is shown in the 'Table of Ad-measurements' and in Plate XXXIX. figs. 1 & 2. The tibia of the *Din. dromioides* (fig. 1) is longer and more slender, corresponding with the character of the femur: the interspace between the ectocnemial tuberosity (*k*) and the procnenial crista (*p*) at the proximal end is less than in *Din. casuarinus*, and the procnenial ridge continued down from the crista does not so soon gain the middle of the anterior surface of the shaft, and is continued down the middle to the lower third before it inclines to the inner side: the tendinous groove leading to the osseous bridge (*f*) in front of the distal end is shorter and deeper. The orifice of the canal for the medullary artery is at the same distance from the top in the tibiae of both species. The antero-posterior thickness of the shaft of the tibia at its proximal third is markedly less in *Din. dromioides* than in *Din. casuarinus*. The difference in the plane and aspect of the surface between the anterior and fibular ridge in the *Din. dromioides* and *Din. casuarinus* is well-marked.

The proportions of the tarso-metatarsus of *Din. dromioides* (Pl. XL. fig. 2) are, as
those of the femur led me to conjecture*, more slender, and the bone is relatively longer, not only than in Din. didiformis, but also than in any other known species of Dinornis, not excepting the Din. ingens, to the tarso-metatarsal bone of which the present tarso-metatarsal from the North Island bears the nearest resemblance in general form and proportions, and in the important character of the rough oval surface (ib. d) indicative of the attachment of a back-toe, one-fourth from the distal end. Little needs to be added to the ‘Comparative Table of Admeasurements,’ and to the figures in Plate XL., for the exposition of the specific characters of this bone. In the form of the concavity at the middle of the fore-part of the upper half of the shaft it resembles the tarso-metatarsus of the Din. struthoides more than that of the Din. casuarinus, in which, as in Din. crassus, the same surface below the rough and perforated depression is flat or slightly convex.

The tarso-metatarsal bone of the Din. casuarinus (Pl. XL. fig. 3) is remarkable, not only for its great breadth, in proportion to its length, but also, like the femur, for the expansion of the distal end, and especially the production of the inner trochlear division.

On inspecting Mr. Percy Earl’s large collection of remains of Dinornis from Waikawaite, it was satisfactory to find with how little difficulty the bones could be selected which belonged to the species which had been named:—

\[
\begin{align*}
\text{Dinornis giganteus}, \\
\text{--- ingens,} \\
\text{--- struthoides,} \\
\text{--- dromioides.}
\end{align*}
\]

Of the second of these species, of which I had before seen only the femur and tibia from the North Island, Mr. Earl’s collection contained the tarso-metatarsal bones, besides very perfect specimens of femora and tibiae.

Thus it appears that four species of Dinornis, including the three most remarkable for their gigantic stature, were common to both the North and South Islands.

Mr. Earl’s collection did not contain any specimen of Dinornis didiformis or of Din. otidiformis; but after selecting those bones which agreed with the previously determined species, there remained a considerable number of most perfect specimens of femora, tibiae and tarso-metatarsal bones of unquestionably full-grown individuals, which differed as much in configuration and proportions from the previously determined species as these did from one another. The most abundant remains belonged to the species above

* "The femur f 16 cannot be regarded as belonging to a young individual of the gigantic species; there remains then no other conclusion than that it must represent a fifth distinct species, of which there are neither tibiae nor metatarsi in the present collection. I venture to surmise, that the tibia, and especially the tarso-metatarsus of this species, will be found relatively longer and more slender than in the Din. struthoides and Din. didiformis: so much may be anticipated from the more slender proportions of the femur, which moreover resembles the femur of the Emeu in some of the characters by which it differs from the above species of Dinornis.”
—Zoological Transactions, vol. iii. part 3, 1844, p. 252.
defined under the name of *Din. casuarinus*; but the most extraordinary species is that which I propose to call *Dinornis crassus*. It is intermediate in size between *Din. ingens* and *Din. struthoides*: with a stature nearly equal in height to that of the Ostrich, the femur and the tarso-metatarsus (Pl. XL, figg. 4 & 5) present double the thickness in proportion to their length: it must have been the strongest and most robust of Birds, and may be said to have represented the pachydermal type and proportions in the feathered class.

The species described under the name of *Din. casuarinus* combined the stature of the Cassowary with more robust proportions, and especially more gallinaceous character of the feet. The third new species is intermediate in size between the *Din. didiformis* and *Din. otidiformis*, and I propose to name it *Dinornis curtus*. Although the majority of the remains of *Din. casuarinus* have come from the Middle Island, a few specimens have reached me from the North Island. Remains of *Dinornis crassus* have hitherto been found only in the Middle Island, and those of *Dinornis curtus* are at present as exclusively from the North Island.

Of the *Dinornis curtus* I have received from Mr. Cotton the shaft of a femur, a little more complete than that of the *Dinornis otidiformis*, and apparently shorter in proportion to its circumference, but having the same relative superiority of general size, and especially thickness, which is manifested in the tibia and tarso-metatarsae of the *Din. curtus*.

The tibia of *Dinornis curtus* (Pl. XXXIX, figg. 3, 4 & 5) resembles that of *Dinornis casuarinus* in the extent and form of the ectocnemial process (k); in the distance between this and the procnemial crista (p), and in the position and course of the ridge continued thence down the fore-part of the shaft to the inner pier of the distal osseous bridge (f). It differs from *Din. casuarinus* and the other larger species of the genus in the lower position of the nutri-arterial foramen, which is nearly half-way between the two ends of the bone. The distal condyles resemble those of the tibia of the larger species much more than those of the smaller *Din. otidiformis*. The inner side of the shaft is more rounded, less angular than in *Dinornis didiformis* or *Din. casuarinus*, and the anterior surface slopes more abruptly backwards to the fibular ridge; the surface between the anterior ridge and fibular ridge being convex in *Din. curtus*, but almost plane in *Din. casuarinus*. The outer (fibular) division (o) of the distal condyle is less produced forwards than in *Din. didiformis*, but in this respect resembles that in *Din. casuarinus*; its transverse extent is however relatively greater. The tibia, and consequently the whole leg of *Din. curtus*, is shorter in proportion to the femur and the tarso-metatarsus than in the *Din. didiformis* or any other species, except probably the *Din. crassus*, of which only the femur and tarso-metatarsus have yet been obtained.

That *Dinornis curtus* is not the young of *Din. didiformis*, is proved by its tarso-metatarsal bone (Pl. XL, fig. 6). The tarso-metatarsal bone *m* 2, p. 79, (Pl. XXVIII, fig. 3,) proves that the homologous bone of a young *Din. didiformis*, of the size of that
of *Din. curtus*, wanting therefore one-fourth of its mature dimensions, as shown in Pl. XXVII, figs. 3 & 4, would exhibit the same imperfect coalescence of the proximal ends of the primitively distinct metatarsals which characterizes the above-cited tarso-metatarsal (m 2.) of the young *Din. giganteus*. In the tarso-metatarsal bone of the *Din. curtus*, figured in Pl. XL, fig. 6, the coalescence is as complete as in the corresponding mature bones of all the larger species of *Dinornis*. Besides, it differs from the tarso-metatarsal bone of the *Din. didiformis* not in size only, but in shape and proportions, the shaft being broader in proportion to the length of the bone.

The information derived from the specimens of *Dinornis* transmitted to this country since the publication of my first (1839) and second (1843) memoirs in the 'Transactions of the Zoological Society,' vol. iii., may be summed up as follows:—

Confirmation of the deductions as to the rudimental development of the wings in the genus *Dinornis*, by the discovery of the keel-less sternum, and the evidence it affords of the small size of the coracoid bones.

Confirmation that the species of this essentially terrestrial genus were heavier and more bulky birds in proportion to their height, more powerful scratchers, and less swift of foot than the Ostrich*, but in different degrees, according to the species.

Indications of an affinity to the Dodo in the shape of the cranium; but with evidence of a lower development of the *cerebrum*, whence the Dinornis may be inferred to have been a duller and more stupid bird.

**Confirmation of the species**—

1. *Dinornis giganteus*.
2. ——— *ingens*.
3. ——— *struthoides*.
4. ——— *dromioides*.
5. ——— *didiformis*.
6. ——— *otidiformis*.

* A correspondent of the 'Polytechnic Journal' for July 1843, commenting on my description of the fragment of the femur of the Movie, in the 'Proceedings of the Zoological Society,' November 1839, objects: "Neither does its femur furnish reason to conjecture that it was swift or slow of foot." (p. 7.) I have not however drawn any absolute conclusion as to the rate of locomotion of the Dinornis. My remark was merely comparative, as respected the Ostrich. In this large existing bird, which is remarkable for both its swift and long-sustained course, the femur is filled with air, like that of a bird of flight. In the fragment of femur which first indicated the genus *Dinornis*, I found the cavity of the bone much smaller than in the Ostrich, with evidence that it had contained marrow; the bony walls being thicker, the cancellous structure more extensive, and the whole bone heavier than in the Ostrich. The femur of the Dinornis therefore did furnish not merely 'reason for conjecture,' but grounds for legitimate physiological conclusion, that that extinct bird was heavier and less swift-footed than the Ostrich.

The proportions of the other bones of the leg which have since arrived establish the accuracy of the conclusion deduced from the structure of the femur; the metatarsal bones being in the Dinornis one-third shorter and thicker in proportion than in the Ostrich, thus rendering the legs more like those of the Apteryx, and consequently more like those of the Gallinaceous birds than in any of the existing large Struthious tribe.
Indications that *Dinornis ingens* and *Din. dromiooides* belong to a distinct genus, characterized by a back-toe, for which the name of *Palapteryx* is proposed.

Establishment of the additional species—

7. *Dinornis crassus.*
8. —— *casuarinus.*
9. —— *curtus.*

Evidence of well-marked varieties of *Dinornis gigas* and *Din. ingens*, those of the Middle Island presenting more robust proportions than those of the North Island of New Zealand.

The three smaller species, *Din. didiformis*, *Din. curtus* and *Din. otidiformis*, have hitherto been found only in the North Island; the *Din. crassus* seems to have been peculiar to the Middle Island; the other species are common to both Islands; but it would be premature to enunciate any absolute propositions respecting the relations of species to the two chief divisions of New Zealand in the present early period of the inquiry into its extinct Fauna, whilst the evidences appear to exist in such vast abundance and are likely so richly to reward the zeal of future collectors*.

* The Rev. Mr. Taylor has favoured me, through Capt. Sir Everard Home, Bart., R.N., with the following note respecting the Dinornis and Apteryx of New Zealand:

"Whanganui, February 14th, 1844.

"During a journey to Turakina last summer, I was led to the discovery of a large number of the Moa's bones, by accidentally observing a small fragment of a large bone, which, from its extremely cellular structure, led me at once to think it might belong to the Moa. I made the inquiry of a native, who not only confirmed my conjecture, but in reply to the further inquiry, whether such bones were frequently found, told me to look around, and see whether I could not perceive any others. Upon turning a little aside from the path, I noticed several little hillocks formed of bones scattered over the valley; I hastened to them, and so numerous were they that a few minutes sufficed to fill my food-box with choice specimens, emptying out my provision for that purpose, much to the astonishment of the natives, who could not imagine what was my object in loading them with these dry bones: at last they concluded it must be for medicine.

"I found these bones at the mouth of the Whaingaihu, where the sand had drifted over the valley, and I have no doubt there are still many similar heaps covered up by it; each heap was composed of the bones of several kinds of the Moa, as though their bodies had been eaten, and the bones of all thrown indiscriminately together; but such was the friable state they were in, that it was only the larger ones which would bear removal; the bones of the smaller kinds pulverized in the hand, and upon searching below the surface I found the whole one jumbled mass of decomposed bone: the subsoil was a loamy marl, beneath which was a stratum of clay, which chiefly forms the cliffs of this part of the western coast; it contains numerous marine shells, and very closely resembles the gault formation of the east coast of England. I have no doubt it was when that loamy marl was the surface-soil that the Moa lived: although by the river-side it is laid bare, in other parts it is covered by several strata of marine and freshwater deposit. I have found the bones of the Moa in this stratum not only in other parts of the western, but also on the eastern coast at the East Cape and at Poverty Bay, from whence in 1839 I procured a toe of this bird; but I have not heard of its being found north of Turakina.

"I have met with the remains of at least four varieties of the Apteryx family, of which it is highly probable three kinds are still in existence; the Kiwi, which is the smallest, being rather larger than the domestic cock, the male bird having a claw at the termination of its embryo wings; the Kakapo or Tarepo, which is about
No remnant of a *Dinornis* has yet been found in any of the contiguous islands, and I have in vain searched for such in the recent collections of post-pliocene fossils from Australia.

The extraordinary number of Wingless Birds, and the vast stature of some of the species, peculiar to New Zealand, and which have finally become extinct in that small tract of dry land, suggest it to be the remnant of a larger tract or continent over which this singular Struthious Fauna formerly ranged. One might almost be disposed to regard New Zealand as one end of a mighty wave of the unstable and ever-shifting crust of the earth, of which the opposite end, after having been long submerged, has again risen with its accumulated deposits in North America, showing us in the Connecticut sandstones of the Permian period the foot-prints of the gigantic birds which trod its surface before it sank; and to surmise that the intermediate body of the land-wave, along which the *Dinornis* may have travelled to New Zealand, has progressively subsided, and now lies beneath the Pacific Ocean.

The size of a turkey, and from its habits, nature and other circumstances seems so closely to resemble the Dodo, as to lead me to suppose it is the same; and lastly, a bird found in the southern parts of the Middle Island, answering to the Emeu, although perhaps not so high. The gigantic Moa, whose bones are fully as large, though not so ponderous, as those of the Elephant, is extinct, although everywhere traditions of its existence are to be met with, coupled with that of an equally enormous Land-Lizard: this large bird, though perhaps twelve or fifteen feet high, was not tall in proportion to its size. Although the articulations of the bones are many sizes larger than those of the Emeu, I have not yet met with a tibia longer than that of the Emeu of New South Wales."

Capt. Sir Everard Home adds, "I feel little doubt that the *Dinornis* exists in the Middle Island of New Zealand, which is very thinly inhabited and almost quite unknown; perhaps also in Stewart's Island, where it is said that the Cassowary (Moa?) is to be found."

"H.M.S. North Star, Sydney, April 13th, 1844."
## Table of Admeasurements of the Bones of the Leg.

### Dimensions of the Femora.

<table>
<thead>
<tr>
<th></th>
<th>Din. giganteus</th>
<th>Din. ingens</th>
<th>Din. crassus</th>
<th>Din. struthoides</th>
<th>Din. casuarius</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>16.0</td>
<td>13.9</td>
<td>13.0</td>
<td>12.0</td>
<td>11.0</td>
<td>10.2</td>
<td>9.6</td>
<td>8.4</td>
<td>8.1</td>
</tr>
<tr>
<td><strong>Breadth of proximal end (in the axis of the neck)</strong></td>
<td>5.6</td>
<td>5.5</td>
<td>4.10</td>
<td>5.0</td>
<td>4.2</td>
<td>4.4</td>
<td>3.5</td>
<td>3.1</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Breadth (transverse) of distal end</strong></td>
<td>7.3</td>
<td>5.10</td>
<td>5.2</td>
<td>5.3</td>
<td>4.3</td>
<td>4.4</td>
<td>3.9</td>
<td>3.7</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Circumference of middle</strong></td>
<td>7.9</td>
<td>7.1</td>
<td>6.1</td>
<td>6.8</td>
<td>5.6</td>
<td>5.6</td>
<td>5.0</td>
<td>4.9</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*perhaps not quite enough allowed for mutilated extremities.*

### Dimensions of the Tibiae.

<table>
<thead>
<tr>
<th></th>
<th>Din. giganteus</th>
<th>Din. ingens</th>
<th>Din. crassus</th>
<th>Din. struthoides</th>
<th>Din. casuarius</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>35.0</td>
<td>33.0</td>
<td>29.0</td>
<td>28.9</td>
<td>26.0</td>
<td>24.2</td>
<td>22.8</td>
<td>21.2</td>
</tr>
<tr>
<td><strong>Breadth of proximal end</strong></td>
<td>7.6</td>
<td>7.0</td>
<td>6.0</td>
<td>6.2</td>
<td>6.6</td>
<td>5.6</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Breadth of distal end</strong></td>
<td>4.0</td>
<td>4.8</td>
<td>3.7</td>
<td>4.0</td>
<td>4.0</td>
<td>3.7</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Circumference of middle</strong></td>
<td>6.0</td>
<td>6.0</td>
<td>6.6</td>
<td>5.3</td>
<td>5.6</td>
<td>5.0</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Fibular ridge extends down</strong></td>
<td>13.0</td>
<td>13.0</td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
<td>10.0</td>
<td>8.6</td>
<td>9.0</td>
</tr>
</tbody>
</table>

### Dimensions of the Tarso-metatarsals.

<table>
<thead>
<tr>
<th></th>
<th>Din. giganteus</th>
<th>Din. ingens</th>
<th>Din. crassus</th>
<th>Din. struthoides</th>
<th>Din. casuarius</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>18.6</td>
<td>18.0</td>
<td>14.6</td>
<td>13.9</td>
<td>8.6</td>
<td>8.0</td>
<td>8.0</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Circumference at the middle of the shaft</strong></td>
<td>5.6</td>
<td>6.0</td>
<td>5.6</td>
<td>4.6</td>
<td>4.8</td>
<td>4.3</td>
<td>4.2</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Breadth (transverse) of distal end</strong></td>
<td>5.1</td>
<td>6.0</td>
<td>5.6</td>
<td>4.6</td>
<td>4.0</td>
<td>4.0</td>
<td>3.10</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>Breadth of middle of shaft</strong></td>
<td>1.1</td>
<td>1.2</td>
<td>1.0</td>
<td>1.7</td>
<td>1.10</td>
<td>1.0</td>
<td>1.7</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Thickness or antero-posterior diameter of ditto</strong></td>
<td>1.6</td>
<td>1.6</td>
<td>1.5</td>
<td>1.13</td>
<td>1.2</td>
<td>1.1</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Breadth (transverse) of proximal end</strong></td>
<td>0.0</td>
<td>4.6</td>
<td>4.3</td>
<td>3.6</td>
<td>3.3</td>
<td>3.5</td>
<td>3.0</td>
<td>2.10</td>
</tr>
</tbody>
</table>

*The margins being broken and water-worn, the breadth is understated here, as at p. 79.*

† With a ridge at the middle of inner condyle at proximal end.

† Perhaps not enough allowed for water-worn margins of trochlear.

### Average Dimensions of Bones of Dinornis in comparison with those of existing Struthionidae.

<table>
<thead>
<tr>
<th></th>
<th>Din. giganteus</th>
<th>Din. ingens</th>
<th>Din. crassus</th>
<th>Din. struthoides</th>
<th>Din. casuarius</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
<th>Din. dromioidei</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length of femur</strong></td>
<td>16.0</td>
<td>13.6</td>
<td>11.0</td>
<td>12.0</td>
<td>11.0</td>
<td>9.0</td>
<td>10.2</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>Circumference of ditto</strong></td>
<td>7.3</td>
<td>6.10</td>
<td>5.3</td>
<td>6.8</td>
<td>4.2</td>
<td>3.7</td>
<td>4.9</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Length of tibia</strong></td>
<td>35.0</td>
<td>28.10</td>
<td>18.6</td>
<td>25.0</td>
<td>16.0</td>
<td>19.0</td>
<td>21.0</td>
<td>16.3</td>
</tr>
<tr>
<td><strong>Circumference of ditto</strong></td>
<td>6.6</td>
<td>6.0</td>
<td>4.3</td>
<td>5.0</td>
<td>3.4</td>
<td>4.9</td>
<td>4.9</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>Length of metatarsus</strong></td>
<td>18.6</td>
<td>14.0</td>
<td>16.0</td>
<td>8.6</td>
<td>12.0</td>
<td>15.0</td>
<td>8.0</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Circumference of ditto</strong></td>
<td>5.6</td>
<td>5.0</td>
<td>3.7</td>
<td>4.8</td>
<td>4.3</td>
<td>3.0</td>
<td>4.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>
DESCRIPTION OF THE PLATES.

PLATE XVI.

Fig. 1. Back view of the cranium of *Dinornis struthioides*.
2. Side view of ditto.
3. Upper view of ditto.
   1. Basi-occipital.
   1'. Occipital condyle.
      r. Superoccipital ridges.
      d. Superoccipital impressions.
4. Paroccipital process.
5. Carotid canal in basisphenoid.
6. Foramen ovale in alisphenoid.
   n. Foramen rotundum.
   o. Foramen opticum.
7. Parietal portion of cranium.
8. Mastoid process.
11. Frontal portion of cranium.
11'. Orbital plate of frontal
18. Æthmoidal cavities for organ of smell.
28. Articular depression for os tympanicum.
   n. Nostrils. (All the figures are of the natural size.)

PLATE XXXI.

Fig. 1. Upper view of the skull of the Emu (*Dromaius Novæ Hollandiæ*).
2. Under or base-view of ditto, wanting the lower jaw and right tympanic bone.
4. Side view of cranium of *Dinornis dromioides*.
5. Upper view of ditto.
6. Under view of fore part of cranium of ditto. The small numerals indicate the same parts as in Plate XVI.
7. Portion of os tympanicum of *Dinornis giganteus*. 
Fig. 8. Os tympanicum of Struthio camelus.

9. Os tympanicum of Apteryx australis.
   a. Anterior or orbital process.
   b. External or zygomatic process.
   c. Inferior or mandibular articular surface.

**PLATE XXXII.**

Fig. 1. Side view of an upper or anterior cervical vertebra of Dinornis ingens.
2. Front view of the same vertebra.
3. Upper view of the same vertebra.
4. Side view of an upper or anterior cervical vertebra of Dinornis giganteus.
5. Upper view of the same vertebra.
   a. Anterior articular surface of the body.
   n. Neural canal.
pl. Pleurapophysis, or ankylosed cervical rib.
   s. Rudiment of spinous process.
   v. Canal for vertebral artery.
   z. Prezygapophysis, or anterior oblique or articular process.
z'. Postzygapophysis, or posterior do. do.

**PLATE XXXIII.**

Fig. 1. Side view of an inferior cervical vertebra of Dinornis giganteus.
2. Front view of the same vertebra.
3. Under view of the same vertebra.
   a. Anterior articular surface of the body.
   a'. Its continuation upon the lower part of the body.
   c. Parapophysis, or lower transverse process, from the body of the vertebra.
   d. Diapophysis, or upper transverse process, from the neural arch.
   e. Prezygapophyses.
   f. Postzygapophyses.
   g. Superior or neural spine.
   h. Inferior or hæmal spine.
   i. Pneumatic orifice.
4. Side view of ungual phalanx or claw-bone of a large species of Dinornis.
5. Upper view of the same phalanx.
6. Back view or articular surface of the same phalanx.

**PLATE XXXIV.**

Fig. 1. Side view of a dorsal vertebra of Dinornis crassus.
2. Front view of the same vertebra (minus the spine).
Fig. 3. Front view of a dorsal vertebra of *Dinornis ingens*.
4. Under surface of the body of the same vertebra.
   b. Diapophysis.
   c. Costal articular surface.
   f. Foramen pneumaticum.
   n. Neural canal.
   z. Prezygapophyses.

**PLATE XXXV.**

Fig. 1. Mutilated sternum of *Dinornis giganteus*, half natural size.
2. Anterior border of the same sternum, natural size.
3. Costal border of the same sternum, natural size.
4. Reduced view of the anterior surface of the sternum of the Ostrich (*Struthio camelus*).
5. Ditto ditto *Rhea americana*.
6. Ditto ditto *Casuarius galeatus*.
7. Ditto ditto *Dromaius ater*.
   a. Anterior angles.
   c. Coracoid depressions.
   m. Anterior border.
   e. Posterior emarginations.
   r. Costal articular surfaces.
   x. Xiphoid prolongation or appendage.

**PLATE XXXVI.**

Fig. 1. Proximal end of femur of *Dinornis giganteus*, natural size.
2. Distal end of the same femur, natural size.
   r. Rotular surface.
   f. Fibular surface.
   t. Tibial surface.

**PLATE XXXVII.**

Fig. 1. Proximal end of tibia of *Dinornis giganteus*, natural size.
2. Ditto ditto *Struthio camelus*, ditto.
3. Ditto ditto *Dromaius Novæ Hollandiæ*.
4. Ditto ditto *Ciconia Argala*, ditto.
a. Inner condyloid surface.
\( t \). Inter-condyloid tuberosity.
\( b \). Epicnemial ridge.
\( p \). Procnemial ridge.
\( k \). Ectocnemial ridge.
\( l \). Fibular ligament (fig. 4).
\( f \). Head of fibula (fig. 4).

**PLATE XXXVIII.**

Fig. 1. Back view of femur of *Dinornis casuarinus*, natural size.
2. Proximal end of same femur.
3. Distal end of same femur. (The letters indicate the same parts as in Plate XXXVI.)

**PLATE XXXIX.**

Fig. 1. Front view of tibia of *Dinornis dromioides*.
2. Ditto ditto *Dinornis casuarinus*.
3. Ditto ditto *Dinornis curtus*.
4. Proximal end of the same tibia.
5. Side view of distal end of the same tibia.
(All the figures are of the natural size.)

\( a \). Inner condyloid surface.
\( t \). Inter-condyloid tuberosity.
\( b \). Epicnemial ridge.
\( p \). Procnemial ridge.
\( k \). Ectocnemial ridge.
\( f \). Trochlear bridge and foramen.

**PLATE XL.**

Fig. 1. Back view of tarso-metatarsus of *Dinornis (Palapteryx) ingens*.
2. Ditto ditto *Dinornis (Palapteryx) dromioides*.
3. Ditto ditto *Dinornis casuarinus*.
4. Ditto ditto *Dinornis crassus*.
5. Distal extremity of the same bone.
6. Front view of mutilated tarso-metatarsus of *Dinornis curtus*.
\( d \), figs. 1 & 2, rough surface for attachment of metatarsal bone of back toe.