TRANSACTIONS

OF

THE ZOOLOGICAL SOCIETY.

# I. *On the Axial Skeleton of the Struthionidæ.*

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In a paper read before the Zoological Society[1] in June 1872, the axial skeleton of the Ostrich was described in considerable detail, that it might serve as a type and standard for future comparisons. The present paper is offered as a first instalment of a series of such comparisons; and the genera selected are the allied ones, *Rhea*, *Dromæus*, *Casuarius*, *Apteryx*, and *Dinornis*, so that a general conception of the axial skeleton as it exists in the Struthionidæ may be arrived at.

It has not been thought desirable here to enter into the same amount of detail as in the description of the typical form, in order not to occupy an undue space in the Society's 'Transactions.' The detailed description of the type, already given, may facilitate further comparisons should they be desired. *Rhea*, however, appears so peculiar a form as to merit exceptional notice.

The specimens examined are all in the Museum of the Royal College of Surgeons; and the illustrations are thence taken by kind permission of the authorities of that Institution.

## THE AXIAL SKELETON OF *RHEA*.

In *Rhea* there are fourteen cervical, and three cervico-dorsal vertebræ (fig. 1, c & cd). There are both three dorsal and three dorso-lumbar vertebræ, the first two of the latter not being ankylosed to the sacrum. To these succeed about nine lumbar vertebræ, all ankylosed together; and these are followed by three sacral vertebræ, the expanded rib-like

[1] See Trans. Zool. Soc. vol. viii. p. 385.

AXIAL SKELETON OF *RHEA*.

Fig. 1.

Fig. 2.

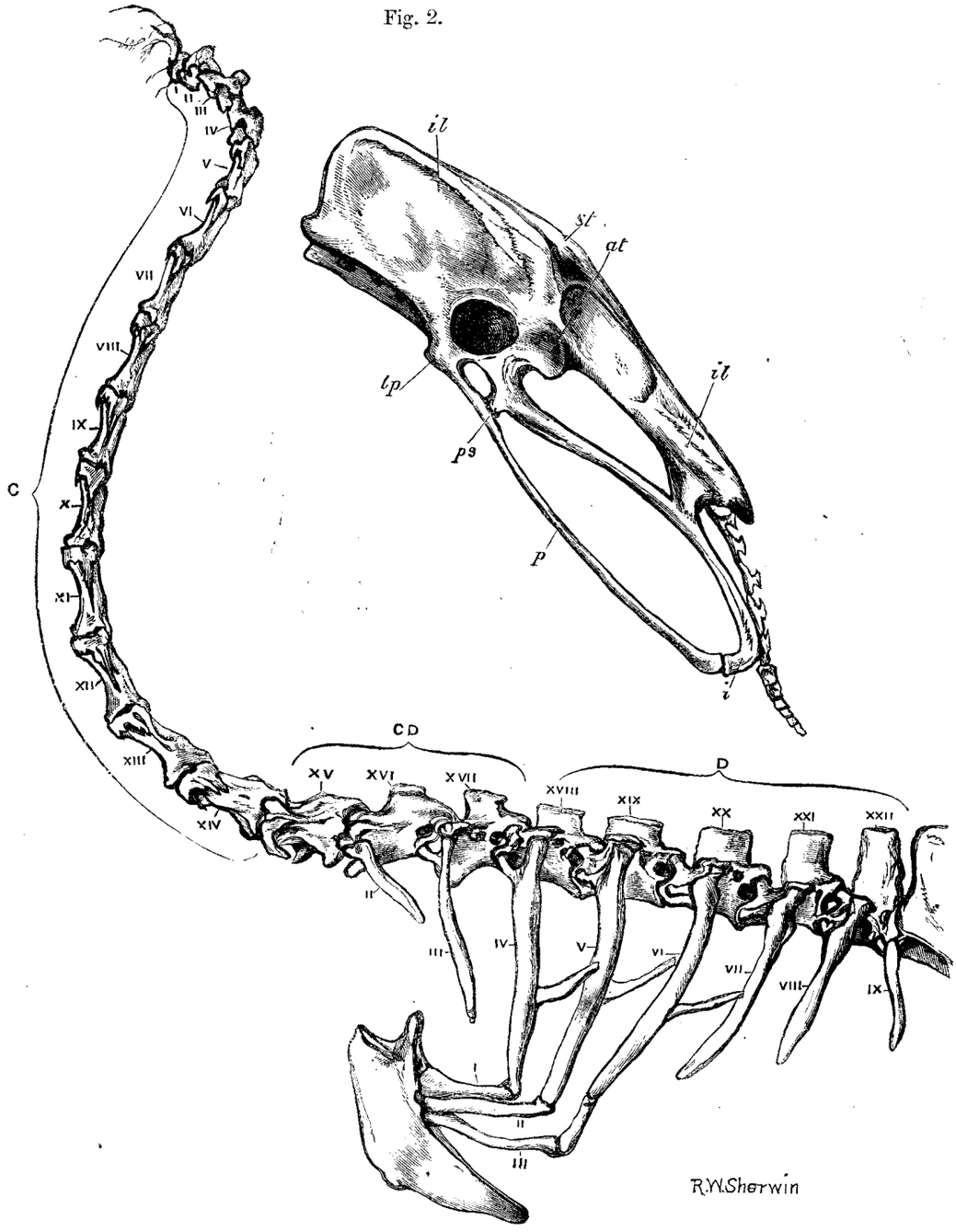



Fig. 1. Prepelvic part. C, cervical vertebræ; CD, cervico-dorsal vertebræ; D, dorsal and dorso-lumbar vertebræ.

Fig. 2. Pelvic and caudal parts. *at*, antitrochanteric process; *i*, ischium; *il*, ilium; *lp*, ilio-pectineal process; *p*, pubis; *ps*, interobturator process; *st*, supratrochanteric process.

processes of which abut against the ilia just behind the acetabula (fig. 8, XXXIII, *d* & *p*, and fig. 9, *p*). After these vertebræ there is a sort of gap, the nine anterior caudal vertebræ either becoming entirely absorbed between the ilia or never being distinctly developed. Five imperfect, half-absorbed vertebræ appear postaxiad of the ilia; and to them succeed six free and, in a sense, less incomplete vertebræ, which terminate the series. Thus there are but twenty-three vertebræ belonging to the first four categories, instead of twenty-seven as in *Struthio*.

## THE CERVICAL VERTEBRÆ.

ATLAS AND AXIS OF *RHEA* (natural size).

Fig. 3.

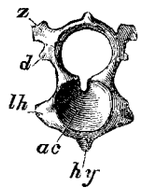



Fig. 3. Preaxial view of atlas.

Fig. 4.

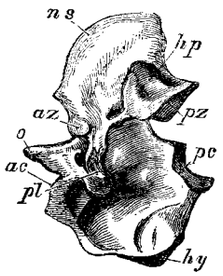



Fig. 4. Lateral view of axis.

*ac*, preaxial articular surface of centrum; *d*, diapophysis; *hy*, median hypapophysis; *lh*, lateral hypapophysis; *az*, præzygapophysis; *hp*, hyperapophysis; *ns*, neural spine; *o*, odontoid process; *pc*, postaxial articular surface of centrum; *pl*, pleural lamella; *pz*, postzygapophysis of axis; *z*, postzygapophysis of atlas.

The *atlas*, compared with that of *Struthio*, is relatively much more dorso-ventrally and less transversally extended. The cup for the occipital condyle is nearly complete, having but a very small and narrow dorsal excavation. The lateral hypapophysial processes (fig. 3, *lh*) are more marked, and the median hypapophysis relatively smaller. The diapophyses (fig. 3, *d*), though distinct, are very much, even proportionally, smaller. No hyperapophyses are distinguishable; nor is there any costal bony spiculum. Even in the very immature specimen in the Museum of the College of Surgeons (No. 1361 F), the neural laminæ are entirely ankylosed to the quasi-body, and show but a trace of their own dorsal union.

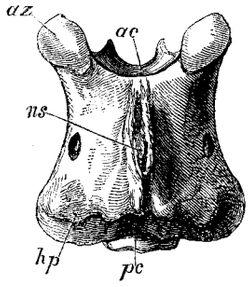
The *axis* (fig. 4) has a greater vertical extent than that of *Struthio*, while its antero-posterior excess over the atlas is much less. There is a pit below the odontoid process. The postaxial central surface is much more prolonged ventrad by the relatively much larger hypapophysis (fig. 4, *hy*), which also extends further towards the preaxial margin of the centrum. The neural spine (fig. 4, *n s*) is relatively shorter (pre- and postaxially) and higher. The postzygapophyses are still more in excess of the præzygapophyses than in *Struthio*. A very large pneumatic foramen is placed above the parapophysial root

of the pleural lamella; and the interzygapophysial ridge may be very conspicuously perforated.

The *third* vertebra is again relatively shorter and higher than in *Struthio*. Both articular central surfaces look more dorsad and ventrad respectively; and the lateral margins of the postaxial one are not, or but very slightly, concave. The hypapophysis extends more postaxiad; but the neural spine does not extend so much preaxiad as in *Struthio*. The postzygapophyses look entirely ventrad. The hyperapophyses are as large as in the axis and are grooved pre- and postaxially. The neural spine does not rise suddenly preaxially, and is hardly at all preaxially excavated. The interzygapophysial ridge is perforated, but not so conspicuously as in the axis.

FOURTH VERTEBRA OF *RHEA* (natural size).

Fig. 5.




Dorsal view. Letters as before.

The *fourth* vertebra is again much shorter relatively as well as absolutely than in *Struthio*, is more equal in length to the third, and more quadrate when viewed dorsally, its transverse diameters between the præ- and between the postzygapophyses being subequal. The neural spine is slightly excavated preaxially, but is deeply so postaxially.

The *fifth* vertebra.—The contrast as to length between this and the preceding vertebra in *Rhea* is something like that existing between the third and fourth vertebræ in *Struthio*. The neural arch is not more cut away preaxially than in the fourth vertebra. There is no hypapophysis, and hardly a trace of hyperapophyses. The neural spine (like that of *Struthio*'s fourth vertebra) is reduced in size, and is slightly and subequally excavated at both ends. The transverse diameter of the preaxial part of the vertebra (viewed dorsally) decidedly exceeds that of its postaxial end.

The *sixth* vertebra is much longer and more slender, and differs from the fifth much more than does the fifth from the fourth, the increase in length thus taking place later in the vertebral series in *Rhea* than in *Struthio*. The styliform ribs are very much shorter; but, as in *Struthio*, the catapophyses are first marked in this vertebra. The

neural spine is excavated, but not obliquely so, at each end. The ventral angles of the postaxial central articular surface are more drawn out than in the preceding vertebræ, or than in the sixth vertebra of *Struthio*.

The *seventh* vertebra.—All that has been said of the seventh vertebra of *Struthio* applies to that of *Rhea*, except that in the latter the rib is rudimentary, and the neural spine is much smaller.

The *eighth*, *ninth*, and *tenth* vertebræ also agree with those of *Struthio*, except that the neural spine is hardly excavated in the eighth, and in the others only behind, and that the ribs are rudimentary—although the pleurapophysial continuation of the parapophysis projects much more preaxiad than does the præzygapophysis, which is not the case in *Struthio*.

ELEVENTH VERTEBRA OF *RHEA* (natural size).

Fig. 6.

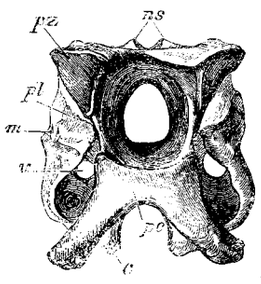



Fig. 6. Postaxial view.

Fig. 7.

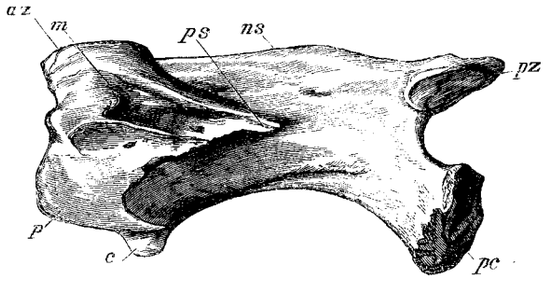



Fig. 7. Lateral view.

Letters as before (see p. 3), except that *c* denotes the catapophysis, *m* the metapophysis, *p* the parapophysis, and *ps* the rudimentary rib.

The *eleventh* vertebra.—This appears more or less to replace the eleventh, twelfth, and thirteenth vertebræ of *Struthio*. It is very like its predecessor, but is slightly more massive. Its neural spine is grooved above, the groove widening postaxially. The præzygapophysis projects but very slightly, if at all, preaxiad of the most preaxial part of the pleurapophysis. The ventral angles of the postaxial central surface are much drawn out (fig. 6); and thus (unlike *Struthio*) its ventral margin is greatly in excess of its dorsal margin, the ventral surface of the centrum being very concave transversely.

The *twelfth* vertebra seems to answer to the thirteenth and fourteenth vertebræ of *Struthio*, and differs from its predecessors as does the fourteenth vertebra of the Ostrich from its predecessors. Unlike the fourteenth vertebra of *Struthio*, however, it is still rather slender (pre- and postaxially lengthened), and the ventral angles of the postaxial surface of the centrum are greatly drawn out.

The *thirteenth* vertebra may be compared with the fifteenth of *Struthio*. The most noticeable differences are the still rudimentary condition of the styloid rib, the forked central postaxial surface, and the decided extension of the pleurapophysis preaxiad of the præzygapophysis. This vertebra is hardly less extended pre- and postaxially than is the twelfth vertebra; and its proportions are more slender than in *Struthio*.

The *fourteenth* vertebra, if compared with the sixteenth of *Struthio*, differs in that the ventral surface of the centrum is not of increased width, and that the styliform rib (though still very small) is rather more instead of less developed than is its preaxial predecessor. There is no trace of a hypapophysial ridge. The pleurapophysis still extends preaxially beyond the præzygapophysis.

## THE CERVICO-DORSAL VERTEBRÆ.

The *fifteenth* vertebra agrees with the eighteenth of *Struthio*, except that its preaxial central articular surface is almost divided into two lateral surfaces. The postaxial central surface widely diverges ventrally, and (as in the fourteenth vertebra) exhibits half its extent when the vertebra is laterally viewed. There is a hypapophysis, which springs from a single root, but tends to bifurcate laterally. The ribs are more developed than in any of the cervical vertebræ; they still extend preaxiad of the præzygapophyses. There is no true neural spine, the neural laminæ being medianly grooved pre- and postaxially.

The *sixteenth* vertebra, which may be taken as equivalent to the nineteenth of *Struthio*, is but very slightly larger than the fifteenth. The postaxial articular surface of the centrum differs greatly from that of its predecessor, there being no diverging ventral extensions, and its ventral margin being almost convex. The hypapophysis is relatively larger than in *Struthio*, extending the whole length of the ventral surface. It is much more inclined preaxiad, and both relatively and absolutely more extended ventrad. The neural spine may be said to bifurcate laterally, there being a deep median pre- and postaxial groove, thus differing greatly from the same part in *Struthio*.

The *seventeenth* vertebra has a hypapophysis somewhat larger relatively than the hypapophysis of the twentieth vertebra of *Struthio*. There is a stumpy neural spine, the preaxial surface of which is nearly vertical. The postzygapophyses are not entirely postaxial to the centrum. The præzygapophyses are hardly less extended laterally than in the sixteenth vertebra.

## THE DORSAL VERTEBRÆ.

The *eighteenth* vertebra differs from its predecessor much as the twenty-first of *Struthio* differs from its two predecessors. The neural spine is at once higher and

much longer pre- and postaxially, while its postaxial excavation is very much smaller. The central postaxial surface is medianly produced ventrad. The di- and parapophyses are as in the twenty-first vertebra of *Struthio*. The hypapophysis is smaller than in the seventeenth vertebra, but extends preaxiad much beyond the preaxial surface of the centrum.

The *nineteenth* vertebra has the neural spine more pre- and postaxially, but not more dorsally, extended than in the eighteenth vertebra. There are no fossæ beside it. The hypapophysis is very slightly produced. The diapophysial articular surface is placed medianly on the transverse process. The posterior zygapophyses do not extend postaxially beyond the centrum.

The *twentieth* vertebra exhibits the trace of a hypapophysis at each end of the centrum. It is very like its predecessors, the zyg-, di-, and parapophyses being of about the same size and relative position. The neural spine is rather shorter pre- and postaxially and a trifle higher. Its postaxial excavation is smaller.

## THE DORSO-LUMBAR VERTEBRÆ.

The *twenty-first* vertebra rather resembles the twenty-fourth of *Struthio*; but the neural spine is much less high, even relatively. There is no trace of a hypapophysis postaxially; but there is a rudiment at the preaxial end of the centrum. The di- and parapophysial articular surfaces are about as remote from each other as in the twentieth vertebra. When the vertebra is viewed dorsally no radiating lamellæ are to be seen, thus differing from the twenty-fourth vertebra of *Struthio*.

The *twenty-second* vertebra appears to answer to the twenty-fifth of *Struthio*, which it greatly resembles, except that its neural spine is less high, though it is much longer and more slender than in the preceding (twenty-first) vertebra. A vertical ridge distinctly divides, medianly, the postaxial neural excavation.

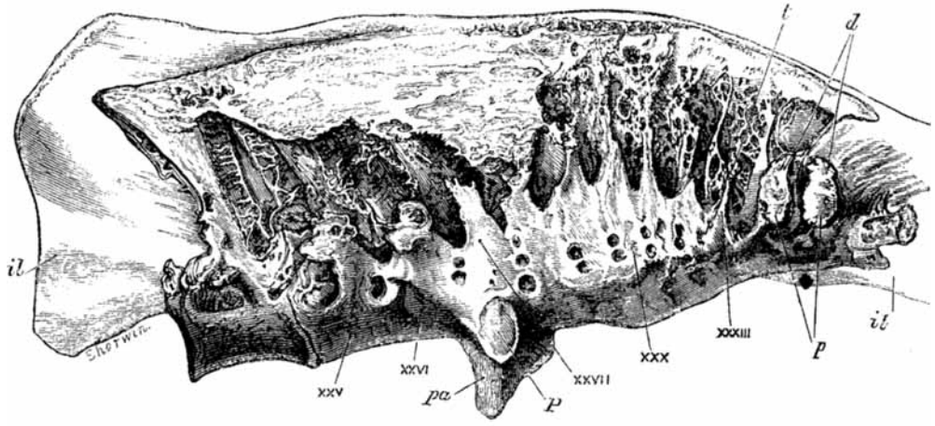
The *twenty-third* vertebra differs from its predecessor in that it is shorter pre- and postaxially. Its neural spine is higher and more slender, the preaxial surface of its centrum is less concave, and the di- and parapophysial articular surfaces are less remote one from another.

## THE LUMBAR VERTEBRÆ.

The *twenty-fourth* vertebra is the first postdorsal vertebra which has no distinct rib. It appears to answer to the twenty-eighth of *Struthio*, but differs in that its neural spine is not higher than its predecessor's, that its transverse processes incline preaxiad instead of postaxiad, and that the neural arch is so cancellous and imperfectly ossified.

SACRUM OF A YOUNG *RHEA*.

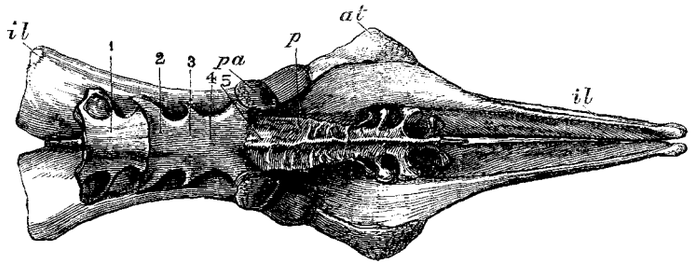
Fig. 8.




Lateral view (natural size).

*d*, diapophyses of 34th and 35th vertebræ; *il*, ilium; *pa*, large parapophysis of 27th vertebra; *P*, its articular surface for ilium; *p*, parapophyses of 34th and 35th vertebræ; *t*, transverse process of 33rd vertebra.

Fig. 9.




Ventral view ($\frac{1}{2}$ natural size).

*at*, antitrochanteric process; *il*, ilium; *pa*, parapophysis of 27th vertebra; *p*, parapophyses of 33rd, 34th, and 35th vertebræ; 1, 2, 3, 4, and 5 indicate the 24th, 25th, 26th, 27th, and 28th vertebræ respectively.

The *twenty-fifth* vertebra (fig. 8, XXV, and fig. 9, 2) forms a part of the solid sacral mass. A single large foramen is placed between its neural arch and that of its serial successor.

The *twenty-sixth* vertebra (fig. 8, XXVI, and fig. 9, 3) exhibits no sign (as in the immature *Struthio*) of a union by suture of its neural arch with its centrum. Two superimposed foramina open, from the neural canal, between the neural arch of this vertebra and that of the twenty-seventh.

The *twenty-seventh* vertebra appears to answer to the thirty-first of *Struthio*; but it differs from it in that it sends a larger truncated parapophysial surface (figs. 8 & 9, *pa*) ventrad and postaxiad to abut against the preacetabular process of the ilium. This is possibly, but not probably, formed (as in *Struthio*) partly by an adjacent preaxial parapophysial process of the twenty-eighth vertebra. Two small superimposed neural

foramina are placed between this vertebra and its successor. The diapophysis has aborted or has become fused with the neural spine.

The *twenty-eighth* vertebra (fig. 9, 5) seems to answer to the thirty-second vertebra of *Struthio*, but is not concave either ventrally or laterally. I am unable to say whether its neural arch is deplaced or not. There is no diapophysis; and the parapophysis may be absent, or it may (as in No. 1361 E) be present as a process abutting against the preacetabular process of the ilium, like the parapophysial process of the twenty-seventh vertebra, but considerably smaller than the latter in all its proportions.

The vertebræ from the *twenty-ninth* to the *thirty-second* inclusive[1] are devoid of transverse processes, but have a pair of superimposed neural foramina at the postaxial ends of their neural arches. A median hypapophysial keel extends postaxially, beginning beneath the thirtieth vertebra. The last (thirty-second) vertebra may send a thin parapophysial lamella to abut against the ilium, and so resemble the vertebræ of the next category. These vertebræ without transverse processes might be distinguished as LUMBO-SACRAL VERTEBRÆ, a category not present in *Struthio*, in which genus these vertebræ have parapophyses, as have also the more postaxial lumbar vertebræ.

## THE SACRAL VERTEBRÆ.

The *thirty-third* vertebra.—This is the first vertebra which normally develops a transverse process (fig. 8, *t*), abutting against the postacetabular (or rather, here, *supra*-acetabular) part of the ilium. This transverse process seems, in the young, rather diapophysial than parapophysial in its nature; but with age the plate descends to a lower level. There is a strong median subvertebral keel.

The *thirty-fourth* vertebra. In this vertebra the parapophysis becomes more conspicuous (fig. 8, *p*). In the young it is seen to form (as in *Struthio*) in conjunction with the diapophysis (*d*) a flattened surface for the ilium. The vertebra is generally smaller than is its serial predecessor; but the median subvertebral keel is well developed.

The *thirty-fifth* vertebra is like its predecessor, but smaller generally, while the united di- and parapophysial surface (on each side) is larger.

With age, as the adult condition is gradually attained, the sacral vertebræ become drawn relatively preaxiad through the much less rapid rate of increase of the last five lumbar vertebræ (twenty-eighth to thirty-second). Thus these vertebræ become rather supraacetabular in position, as in *Struthio*, than postacetabular; and thus the vertebral column hardly appears, as it does in *Struthio*, at the bottom of the acetabulum when the pelvis is viewed laterally.

## THE SACRO-CAUDAL VERTEBRÆ.

The *thirty-sixth* vertebra.—In the young this vertebra has a tolerably developed centrum and a transverse process (formed of both di- and parapophysis) abutting

[1] It may be the 28th to the 32nd, or only the 29th to the 31st, that are thus devoid of transverse processes.

against the ilium, though the neural arch and spine are quite rudimentary. At a more advanced stage (as seen in No. 1057[1]) all that remains in an osseous condition is a long and narrow body with a pair of transverse processes of very cancellous texture. Postaxial to this vertebra the vertebræ become atrophied in the adult to such a degree that merely a long narrow osseous band, of very cancellous structure, represents the bodies, (from that of the thirty-seventh to the forty-fourth inclusive) of the vertebræ; and these have diverging parapophysial processes of similar unsubstantial texture.

The *thirty-seventh*, *-eighth*, and *-ninth* vertebræ are elongated vertebræ enclosed between the posterior parts of the ilia. Behind these and above the ischia are four (in No. 1057), or five (in Nos. 1361 & 1361 F) vertebræ, which gradually become less imperfect as we proceed postaxially—the bodies broadening out and the neural spines getting shorter, thicker, and more stumpy,—the ultimate vertebræ more or less ankylosing with the ischia.

## THE CAUDAL VERTEBRÆ.

The *forty-fifth*, *-sixth*, *-seventh*, *-eighth*, *-ninth*, and *fiftieth* vertebræ.—Postaxial to the ischia are six vertebræ, which gradually diminish postaxially. None have transverse processes. The first three, sometimes the first five, have more and more minute neural arches. The last vertebra is grooved dorsally; and sometimes the last three are so grooved.

The last apparent vertebra, the *pygostyle*, is not dorso-ventrally expanded into an osseous plate, as it is in *Struthio*, but is cylindrical and short, not being twice the length of the vertebra preceding it (fig. 2). It looks as if made up of only two vertebræ ankylosed together.

## THE PELVIS.

In the adult the pelvis consists of twenty vertebræ and two ossa innominata.

When viewed *preaxially*, its aspect differs greatly from that presented by the pelvis of *Struthio*, on account of the absence of the descending pubes and pubic symphysis, in *Rhea*, as also because the ischia curve inwards, converge, and unite together just postaxiad to (and, of course, on the ventral side of) the acetabula, and thence contiuue onwards, so united, postaxiad. The iliac roof of the first pelvic vertebra is much more concave on each side than in *Struthio*. The ilium also sends out a sharper process (the supratrochanteric process) above each trochanteric process (fig. 2, *st*).

When viewed postaxially, the same absence of a pubic symphysis and the presence of an ischiatic one produces a very great difference of aspect from this point of view also. Again, the summit of the pentagonal mass is horizontal, owing to the crest of the ilium not rising dorsally as much as in *Struthio*.

Viewed *laterally*, the part which was, in the description of the pelvis of *Struthio*,

[1] In the Museum of the College of Surgeons.

compared with a bird's skull, has the beak smaller and the cranium less dorsally convex, while the upper of the two anterior bars (*i. e.* the *ischium*) joins the beak by ossification of the ligament uniting it with the ilium. Moreover the pelvis differs from that of *Struthio* in that the two bars (ischium and pubis) extend postaxiad beyond the ilium to a greater degree, and do not curve ventrad distally. The supratrochanteric process is also decidedly preaxiad to the antitrochanteric process, instead of slightly postaxiad as in *Struthio*. The ilio-pectineal process is much shorter; and the vertebral column is scarcely to be seen through the acetabulum; while the latter cavity is placed nearer the middle (pre- and postaxially) of the total length of the ilium. The os innominatum is much less deep dorso-ventrally in proportion to its pre- and postaxial extent. The pre-acetabular part of the ilium has its external surface more concave than in *Struthio*, as is also the preaxial margin of the ilium.

Viewed *dorsally*, the pelvic ribs are relatively larger than in *Struthio*. The antitrochanteric processes project at about the middle of the ilium's length pre- and postaxially and behind the anterior third of the total length of the pelvis. Just in front of the processes the supraacetabular processes project strongly outwards, relatively as well as absolutely much more so than in *Struthio*. In *Rhea* only three processes are seen to extend postaxiad (instead of five as in *Struthio*), all joining together distally. The median process of these three (ilia and ischia in one) expands distally so that its lateral margins are concave. No vertebral spines are visible in the adult (as they are in *Struthio*), the two ilia ankylosing together dorsally in the adult, and even in the immature (*e. g.* in No. 1361 E) meeting together, though in the very young (*e. g.* in No. 1361 F) the lumbo-sacral and sacral spine-tips come to the surface between the ilia from a little preaxiad to a little postaxiad of the preacetabular process. The two lateral processes above spoken of are, of course, the two pubes, each pubis forming a gentle curve (not so bowed outwardly as in *Struthio*) with a convex external margin and a concave internal one.

The transverse diameter of the pelvis is pretty uniform. It is greatest between the ends of the pelvic ribs, and next greatest across the pubes. The posterior ends of the ilia do not diverge as in *Struthio*.

When viewed ventrally, the most striking differences between the pelvis of *Rhea* and that of *Struthio* are, the greater size of the pelvic ribs in the former, the fact that but three bony processes extend postaxiad, and the binding of the sacro-caudal vertebræ and the postaxial parts of the ilia by the medianly united ischia. Also the iliopectineal eminences are smaller, and the centra postaxiad to the sacral vertebræ are aborted.

Although there are from three to five *lumbo-sacral* vertebræ (*i. e.* without parapophyses and between the lumbar and sacral vertebræ), yet they are so closely approximated antero-posteriorly as to leave but a very small fossa between them on each each side and the adjacent acetabulum.

### The Ilium (figs. 2 & 8, *il*).

This bone extends itself over twenty-two vertebræ, namely from the twenty-third to the forty-fifth inclusive. Compared with the same bone in *Struthio*, its dorsal margin is more convex, its anterior margin more concave (the ventral preaxial angle being more prominent), and the postacetabular part is not so much in excess of the preacetabular portion. It would taper preaxiad but for the ossification (before mentioned) of the ilio-ischiatic ligament which causes it to expand vertically towards its distal end. The gluteal lines do not descend (ventrad) so much as in *Struthio*; and the stronger supra-acetabular process comes to jut out more horizontally as well as more strongly, making, with its fellow of the opposite side, a flat rhomboidal surface on the dorsum of the ilium. The ilia are flattened against the included postacetabular vertebræ to a remarkable degree.

### The Pubis (fig. 2, *p*).

This bone is like what that of *Struthio* would be if the latter were sharply cut off at the postaxial end of the ischium; only it is not quite so much bowed outwards. There is, of course, no pubic symphysis. In the young it does not join the ischium distally, but quite resembles the osseous part of the pubis of the young Ostrich when the symphysial part is all cartilaginous.

### The Ischium (fig. 2, *i*).

This bone is very slightly, if at all, shorter than the pubis, and ankyloses postaxially both with that bone and with the ilium. It seems to form about the ventral third of the antitrochanteric process. It also slightly ankyloses with the pubis more proximad, so as to cut off the anterior part of the obturator foramen as a separate and much smaller foramen (fig. 2, between *lp* & *ps*). The two ischia unite together postaxially a little behind the acetabulum, and thence expand transversely as they proceed postaxiad, forming an elongated sheet of bone (concave in both directions on its ventral surface) beneath the sacro-caudal vertebræ. At its distal end it sends down a process, curving at first ventrad and then preaxiad, which ankyloses with the extreme distal end of the pubis. Thus, as it were, the outer ridge of the ischium of *Struthio* is drawn out, while the surface between the (here relatively approximated) dorsal and ventral ridges coalesces with the corresponding surface of its fellow of the opposite side.

## THE VERTEBRAL RIBS (fig. 1).

There are nine vertebral ribs, the first and last becoming in the adult (as in *Struthio*) ankylosed transverse processes. The fourth, fifth, and sixth of these bones unite with sternal ribs. (See fig. 1.)

The *first* rib is attached to the fifteenth vertebra, and ankyloses with it in the adult. It is very small, triangular, and very little longer than broad.

The *second* rib is much as in *Struthio*, but somewhat shorter relatively. There is no noticeable convexity on its postaxial margin.

The *third* rib has its capitulum rather larger, compared with that of the second rib, than is the case in *Struthio*. Its shaft is more vertical. The tubercular surface is but little larger than is that of the second rib. The postaxial margin is proximally concave, then slightly convex.

The *fourth* rib is remarkably different in its curvature from that of *Struthio*; and its excess in length over the third rib is less. Owing to this curvature, it seems to be rather the tuberculum than the capitulum which carries on proximad the general curvature of the rib. This curvature is slightly sigmoid, and there is no "angle," the prominence being preaxiad and below the capitulum instead of, as in *Struthio*, postaxiad and below the tuberculum. The vertebral margin is as sharply concave as in the third rib. The articular surface of the tuberculum is not much larger than in the third rib. The preaxial margin of the shaft is proximally convex, then more or less concave. The postaxial margin is at first markedly concave, then (distad) slightly convex. Both margins are sharp, the lamella of bone (described in *Struthio* as being on the ventral preaxial side of a ridge running down from the capitulum) of the proximal part of the shaft projecting strongly preaxiad and scarcely at all postaxiad, thus doing away with an "angle" (such as exists in *Struthio*), and producing a curious preaxial convexity, whence a ridge is continued on proximad, over the divergence of the tuberculum and capitulum, right up to the vertebral margin and preaxial edge of the tuberculum, as is the fifth rib of *Struthio*. There is an articulated uncinate process; but its distal portion is not bent dorsad, but continues on obliquely in one line with the proximal part, the direction being mainly postaxiad, but slightly dorsad.

The *fifth* rib has, again, a singularly different curvature from that of *Struthio*. The capitulum and tuberculum diverge at a rather more acute angle than in the fourth rib; otherwise it generally agrees with the fifth rib of *Struthio*.

The *sixth* rib has also a reversed curvature compared with that of *Struthio*. The capitulum and tuberculum diverge much as in the fifth rib; and the uncinate process is as long as that of the rib last named. The proximal prominence is more marked, causing the preaxial margin distad to it to be more concave than in the fifth rib.

The *seventh* rib is free distally, and is much shorter than the sixth, and rather so than the fourth. Its shaft also is more curved. The capitulum and tuberculum also form a wider angle than in the sixth rib, namely about 75°. The pneumatic foramen is of about the same size as in the sixth rib; but the articular surface for the diapophysis is not so large. The preaxial prominence of the preaxial margin is slightly more marked still; and the concavity of the preaxial margin is more marked also. There is no uncinate process.

The *eighth* rib is again more curved than in *Struthio*. In length it is intermediate between the second and third ribs. The capitulum is about as long compared with the tuberculum as in the seventh rib. The preaxial frontal convexity is still very marked. There is no trace of an uncinate process.

The *ninth* rib articulates with the twenty-third vertebra, and seems to correspond with the tenth rib of *Struthio*. Being more preaxially directed, it diverges more from the eighth rib than does the tenth from the ninth in *Struthio*. It is also more equal to its predecessors in length than is either the ninth or the tenth of the last-named genus. The preaxial prominence is again very marked, but there is no preaxial concavity distal to it. The rib is more flattened than is either the ninth or the tenth of *Struthio*, and, once more, it is more curved.

## THE STERNAL RIBS (fig. 1).

Of these there are apparently but three. It may be that a minute one exists preaxiad of these three; but, if so, it is not to be found in the specimens examined.

The *first* sternal rib seems to answer to that described as the second in *Struthio*. It is rather longer than the second vertebral rib, but is not so slender as the corresponding one in *Struthio*. Its outer surface is convex; its inner surface is flattened. It joins the fourth vertebral rib, and belongs to the eighteenth vertebra (fig. 1, I).

The *second* rib has its proximal end quite rounded; otherwise it resembles the third sternal rib of *Struthio* (fig. 1, II).

The *third* rib does not exceed the first in length by half the length of the latter. Its distal end is absolutely less expanded dorso-ventrally than is that of the second rib. Its postaxial surface is hardly more excavated than is that of the second rib. In other respects this bone resembles the fourth sternal rib of *Struthio* (fig. 1, III).

## THE STERNUM.

STERNUM OF *RHEA* ($\frac{1}{3}$ natural size).

Fig. 10.

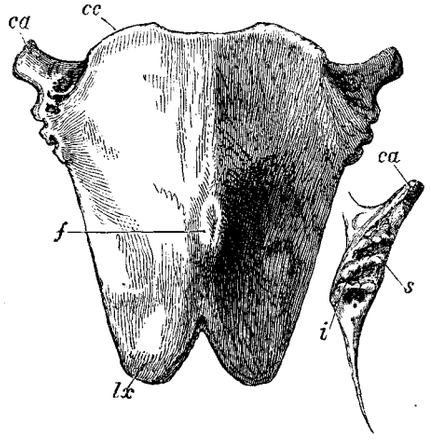



Fig. 11.

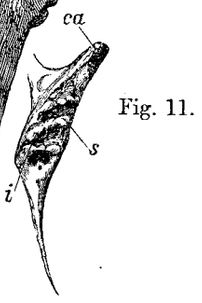



Fig. 10. Ventral view. Fig. 11. Lateral view.

*cc*, coracoid grooves; *ca*, costal angles; *f*, median ventral prominence; *i*, a ventral articular surface; *s*, a dorsal articular surface; *lx*, lateral xiphoid processes.

This bone is narrower in proportion to its pre- and postaxial length than in *Struthio*. The coracoid grooves are not nearly so approximated; and their dorsal margins project but little, if at all, preaxiad beyond their ventral margins. The costal angles are narrower in proportion to their length. There is no median preaxial projection. The lateral xiphoid processes are small, and project but little postaxiad, leaving but a moderate notch (and no median xiphoid process) between them. The sides of the sternum are less concave. The median ventral prominence (fig. 10, *f*) is not flattened. Each pleurosteon has but three articular surfaces; and each of these has a deep excavation postaxial to it. The ventral facet of each articular surface exceeds the dorsal one in size; but they are most nearly equal in the third articular surface.

## VERTEBRAL PARTS AND PROCESSES.

The *centra* resemble generally those of *Struthio*, except as to which are the ones which became ankylosed. These parts may all but abort altogether, as in the anterior caudal vertebræ.

The *neural laminæ* do not show such signs of shifting as in the lumbar vertebræ of *Struthio*. The neural arches may entirely abort, while the centra still exist in an imperfect manner, as in the anterior caudal vertebræ. The substance of the laminæ may be so cellular as to be most extremely imperfect in development, as in the lumbar and sacral vertebræ. Diapophyses may be quite absent, if not blended with the spinous processes, as in the last six presacral vertebræ.

The *neural spines* are most expanded, pre- and postaxially, in the dorsal vertebræ. They may be laterally bifid, as in the third cervico-dorsal vertebra. The zygapophyses are developed as in *Struthio*; and the metapophyses offer no great differences.

*Hyperapophyses* are only conspicuous in the second, third, fourth, and fifth vertebræ.

*Diapophyses* and *parapophyses* are occasionally absent where they are present in *Struthio*, notably in the last five lumbar vertebræ. No such processes abut against the ischium.

The *pleurapophyses* of the cervical region differ greatly from those of *Struthio* by their shortness and non-styloid form.

*Hypapophyses* are nowhere distinctly paired.

*Catapophyses* are found preaxiad to the fifteenth vertebra.

The vertebræ are raised above (*i. e.* dorsally to) the acetabula.

The *vertebral ribs* have a different twist from that existing in *Struthio*.

The *uncinate processes* do not seem to be more than three in number.

AXIAL SKELETON OF EMU.

Fig. 12.

Fig. 13.

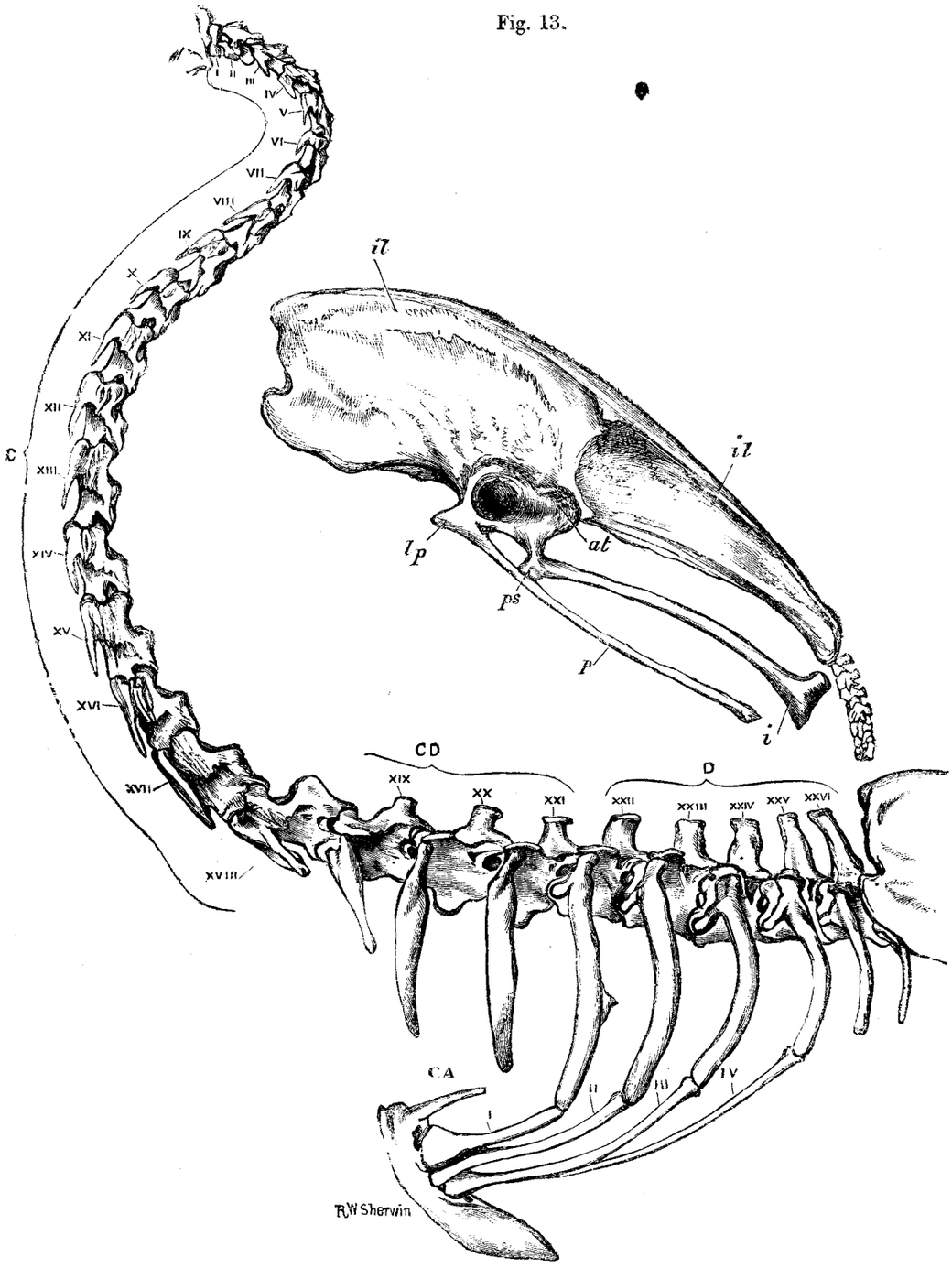



Fig. 12. Prepelvic part. Fig. 13. Pelvic and caudal parts.

C, cervical verterbæ; CD, cervico-dorsal vertebræ; D, dorsal and dorso-lumbar vertebræ: CA, costal angle. Letters of pelvic part as in fig. 2.

## THE AXIAL SKELETON OF *DROMÆUS* (figs. 12 & 13).

In *Dromæus* there are seventeen or eighteen cervical and three or four cervico-dorsal vertebræ; there are three or four dorsal and but two dorso-lumbar vertebræ; to these succeed eight lumbar and three sacral vertebræ, followed by ten or eleven sacro-caudal and eight or nine caudal vertebræ. Thus there are about fifty-four vertebræ in all; and of these as many as twenty-six or twenty-seven belong to the first four categories, thus differing from *Rhea* and agreeing with *Struthio*, as is also the case with the last category (the caudal vertebræ), which are, within one or two, as numerous as in the African genus.

## THE CERVICAL VERTEBRÆ.

ATLAS AND AXIS OF EMU (natural size).

Fig. 14.

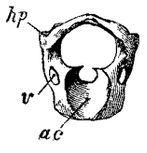



Fig. 15.

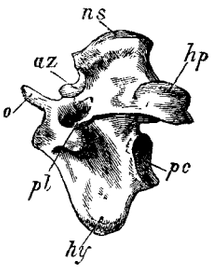



Fig. 14. Preaxial view of atlas; *v*, foramen enclosed by costal spiculum. Fig. 15. Lateral view of axis.

Here and subsequently the letters refer to the same parts as in the corresponding illustrations of *Rhea*, except where differences are specified.

The *atlas* differs from that of *Struthio* as does that of *Rhea*, except that the median dorsal notch is larger, that there is no hypapophysis, and that there is a costal spiculum on either side. The neural arch is somewhat more axially extended than in either of the other genera; and the diapophyses are even smaller than in *Rhea*. The dorso-ventral height of the whole bone, compared with its breadth, is intermediate between that existing in the other genera, though more like that of *Rhea*.

The *axis* exceeds the atlas in axial length still less than it does in *Rhea*; and its relative dorso-ventral extent is yet greater. There is also no hypodontoid pit for a ligament. The postaxial central surface is still more prolonged ventrad by the relatively still longer hypapophysis, which is vertically grooved at its root postaxially, and extends quite to the preaxial margin of the centrum, where it extends still further ventrad and quite as suddenly. The neural spine is relatively as well as absolutely shorter (axially) and may be higher than in *Rhea*; but the pneumatic foramen is smaller, and

the interzygapophysial perforation minute. The postzygapophyses with their hyperapophyses extend more postaxiad than in either of the other genera.

The *third* vertebra agrees in its proportions with that of *Rhea*, and differs from that of *Struthio*, except that the styloid rib is relatively longer than even in *Struthio*. The neural spine is excavated in front (slightly) as well as postaxially. The hyperapophyses are more grooved dorsally than in *Rhea*, while the interzygapophysial foramen is larger than that of the axis instead of smaller. The metapophyses are already marked.

The *fourth* vertebra quite agrees with that of *Rhea*, except that the rib is longer, and that the neural spine (as in *Struthio*) is so grooved both pre- and postaxially that the median part is much reduced. The metapophyses are larger than in either of the other genera.

The *fifth* vertebra contrasts, as to length, less with the fourth than in *Rhea*, the cervical vertebræ increasing more gradually in length, and never attaining such a relative development axially as in either of the other two genera. The transverse diameter of the preaxial part still more exceeds that of the postaxial part than in *Rhea*; the rib is relatively much longer. The interzygapophysial ridge may or may not be perforated; but the metapophyses are more strongly marked than in the fourth vertebra.

The *sixth* vertebra differs only slightly from the fifth in length. The neural arch and spine assume the characters of those of the thirteenth cervical vertebra of *Rhea*. The interzygapophysial ridge is only minutely perforated. The rib here, as throughout, is longer than even in *Struthio* relatively to the axial extent of its supporting vertebra, extending to, or beyond, the most preaxial part of the postaxial central articular surface in all the cervical vertebræ. The metapophyses are still stronger; and catapophyses begin to appear; and they diverge ventrad much less than in *Rhea*.

The *seventh* vertebra presents similar characters to those of the sixth; but the metapophyses are again stronger, and the interzygapophysial ridge is large and perforated, the lamella forming a canal which passes ventrad and postaxiad on each side of the neural lamina.

The following vertebræ, from the *eighth* to the *eleventh*, present characters similar to those of the seventh; only the neural spine grows somewhat longer, though being still short and stumpy, even in the eleventh vertebra.

In the *twelfth* vertebra the development of the neural spine is much like that of the sixteenth vertebra of *Struthio*. From this vertebra postaxiad, the interzygapophysial ridge may or may not be perforated.

The vertebræ from the *thirteenth* to the *seventeenth* inclusive are all much more alike than is the case in *Rhea*; they gradually, however, become larger and more massive, the neural spines rising very slightly. The catapophyses approximate together in the seventeenth vertebra, still, however, remaining distinct, as do those of the last cervical (fourteenth) vertebra of *Rhea*, and not uniting as in the last cervical (seventeenth) vertebra of *Struthio*.

## THE CERVICO-DORSAL VERTEBRÆ.

The *eighteenth* vertebra is like the first cervico-dorsal (fifteenth) of *Rhea*, except that the preaxial central surface is not nearly divided medianly, and that the postaxial central surface does not diverge ventrad, the ventral margin being scarcely at all concave, though more in excess of the dorsal margin than in *Struthio*, while the degree to which it is visible in profile is also intermediate. The hypapophysis bifurcates distally, though having a single root. It does not extend so much ventrad, relatively, as in *Rhea*. The rib may be rather more or rather less developed than in the preceding vertebra. It may, in the adult condition (as *e. g.* in No. 1358), be unankylosed. The præzygapophyses exceed the preaxial extension of the parapophyses more than in *Struthio*, and much more than in *Rhea*. The neural spine is not dorsally grooved, but is excavated both pre- and postaxially.

The *nineteenth* vertebra, compared with the sixteenth of *Rhea*, has the postaxial surface of its centrum less different from its predecessor; yet its ventral does not so much exceed its dorsal margin. The hypapophysis is much more like that of *Struthio* than that of *Rhea*. The neural spine is not grooved dorsally. The diapophysis is more axially extended. The parapophysial articular surface is deeper and more dorso-ventrally extended; and that of the diapophysis is also rather more concave.

The *twentieth* vertebra has its hypapophysis more like that of *Struthio* than that of *Rhea*, although, as in the last-mentioned genus, it extends much postaxiad. The transverse processes are more axially extended, and the neural spine is smaller, than in *Rhea*'s seventeenth vertebra, which this one otherwise much resembles.

The *twenty-first* vertebra has its hypapophysis as large as that of the twentieth vertebra, except when (as in No. 1358) an extra intercalated vertebra alters the relations. The transverse process is rather more, and the neural spine rather less extended axially. The postaxial excavation of the neural spine is less in defect of that of the preceding vertebra than in *Rhea*; otherwise the characters of this vertebra are much like those of the first dorsal vertebra in that genus. As in *Struthio*, there is a pit on each side of the preaxial surface of the neural spine. This pit is serially homologous with the interzygapophysial canal.

## THE DORSAL VERTEBRÆ.

The *twenty-second* vertebra has a very small hypapophysis, though a larger one than in the other two genera. The diapophysial articular surface is preaxiad to the middle of the transverse process. The neural spine is not so axially extended as in the preceding vertebra, but more dorsally. There is a deep fossa on each side of the preaxial surface of the neural spine. The postzygapophyses do not extend postaxiad of the centrum.

The *twenty-third* vertebra has no hypapophysis at either end of its centrum. The

par- and diapophysial processes are more distant from one another than in the preceding vertebra. The neural spine is higher, but not shorter axially. The postaxial excavations of the neural spine are much as in the twenty-second vertebra. The preaxial fossæ of that spine are deep.

The *twenty-fourth* vertebra has no trace of a hypapophysis, even in front; otherwise it differs from the twenty-fourth vertebra of *Struthio* as does the twenty-first vertebra (first lumbar) of *Rhea*, except that the neural spine is more slender, the transverse process more extended axially, and the parapophysial surface larger. The preaxial fossæ of the neural spine are deep; and it is more excavated postaxially than in *Struthio*.

## THE DORSO-LUMBAR VERTEBRÆ.

The *twenty-fifth* vertebra is sometimes (as shown in fig. 12) a dorsal vertebra. It may have its neural spine higher than the corresponding vertebra of *Rhea*; but it is never so high as is that of *Struthio*. The neural spine's postaxial excavation is not divided by a vertical ridge. There is no sharply defined concavity beneath the præzygapophyses, and no excavation beneath the transverse process; otherwise this vertebra is like the twenty-second vertebra of *Rhea*.

The *twenty-sixth* vertebra resembles the twenty-third of *Rhea*, except that the preaxial articular surface is higher dorso-ventrally and more concave. There is no deep fossa ventrad and external to the præzygapophysis.

## THE LUMBAR VERTEBRÆ.

The *twenty-seventh* vertebra apparently answers to the twenty-fourth of *Rhea* and to the twenty-eighth of *Struthio*. It may be a dorso-lumbar vertebra. It has no conspicuous rib, and is the first trunk-vertebra so distinguished. It becomes ankylosed to the sacral mass, as does its predecessor also. It differs from the twenty-fourth vertebra of *Rhea* in that its ventral surface is less concave. In the young the transverse process is directed less preaxiad than in the adult; and there is a rudimentary rib (as in No. 1358 A) beneath it, directed outwards and postaxiad and greatly expanded at its distal end, where it unites with the inside of the ilium (fig. 16, XXVII, *pl*).

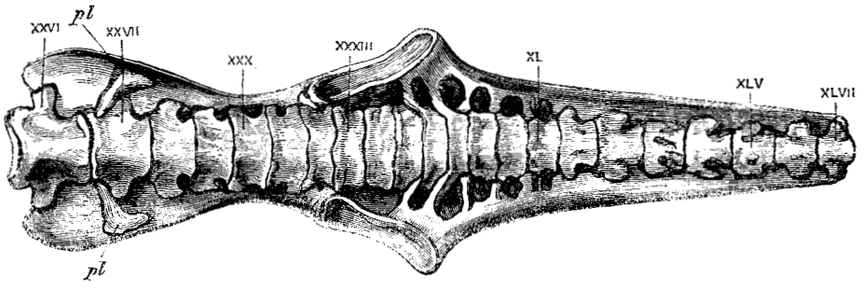
The *twenty-eighth* vertebra has its neural spine fused with that of the two preceding and the four succeeding vertebræ into one great mass of cellular diploë. Its transverse process is smaller than is that of the twenty-seventh vertebra; and there is no rudimentary rib even in the young.

The *twenty-ninth* and *thirtieth* vertebræ can only be distinguished as differing from the twenty-sixth and twenty-seventh of *Rhea* in that they have smaller transverse processes, and that the thirtieth sends no process to the præacetabulum.

The *thirty-first* vertebra is quite like its preaxial predecessor, thus differing from both the twenty-eighth of *Rhea* and the thirty-second of *Struthio* (fig. 16).

SACRUM OF EMU (natural size).

Fig. 16.



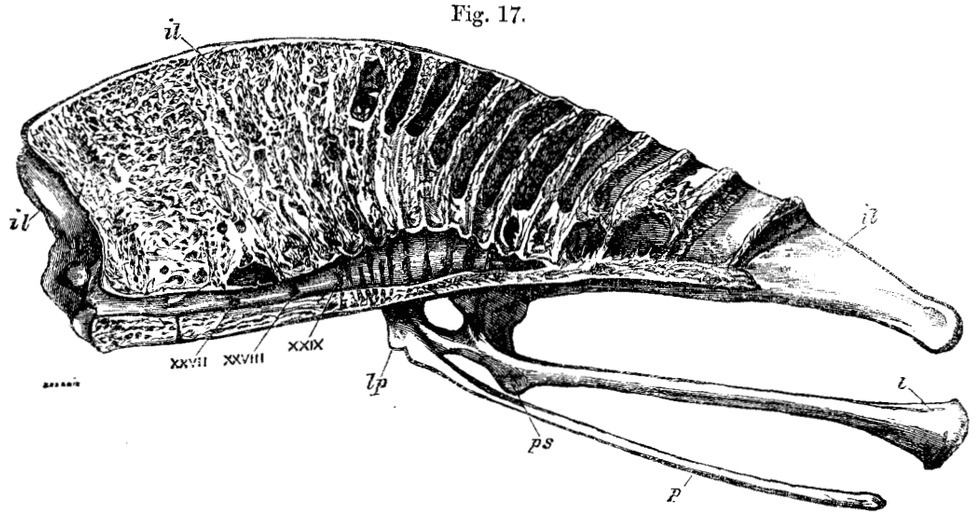

Ventral view. (Specimen No. 1358 A.)

The *thirty-second* and *thirty-third* vertebræ are about equal in size. They closely blend together, and together send down a thick process, which ankyloses with the preacetabular part of the ilium, ischium, and pubis.

The *thirty-fourth* (or eighth lumbar) vertebra has no transverse process visible on its ventral aspect. It may therefore be reckoned as a LUMBO-SACRAL vertebra. Its ventral surface is medianly somewhat keeled axially. An extra, or ninth, lumbar vertebra is intercalated in some skeletons.

SACRUM AND PELVIS OF EMU ($\frac{1}{2}$ natural size).

Fig. 17.




Vertical antero-posterior section. (Specimen No. 1387.)

## THE SACRAL VERTEBRÆ[1].

The *thirty-fifth*, *thirty-sixth*, and *thirty-seventh* vertebræ all send out small transverse processes to abut against the postacetabular part of the ilium. These pro-

[1] The sacral vertebræ are reckoned as three in number, only from analogy with *Struthio*.

cesses are almost subequal in size; but the most postaxial is axially broadest. There is hardly a trace of a median keel. These vertebræ are not raised up above the acetabulum as they are in *Rhea*.

## THE SACRO-CAUDAL VERTEBRÆ.

These vertebræ, which are those from the *thirty-eighth* to the *forty-seventh* (or *forty-eighth*) inclusive, differ much from those of *Rhea* by their more substantial ossification. From *Struthio*'s vertebræ (thirty-ninth to forty-sixth) they differ in that their transverse processes are more like the transverse processes of the sacral vertebræ. Thus, when the pelvis is viewed ventrally, there is no break behind the sacral transverse processes; but the openings between the transverse processes become smaller and more distant postaxiad, owing to the gradually increasing axial breadth of the successive transverse processes. The bodies of these vertebræ are well ankylosed; and their spines become rapidly shorter as we proceed postaxially. They never ankylose with the ischia.

## THE CAUDAL VERTEBRÆ.

The caudal vertebræ (that is to say, those from the *forty-eighth* to the *fifty-fifth* inclusive) differ greatly from those of *Rhea*, and even exceed those of *Struthio*, in the development of their transverse processes, which project outwards and postaxiad. Their development, however, is irregular both as regards size and direction. Each neural spine is flattened dorsally, and vertically grooved postaxially. The first and, sometimes, also the next two caudals have strongly projecting postzygapophyses, which, however, do not attain the vertebra towards which they tend.

The *pygostyle* is irregular and subcylindrical, and very unlike that of *Struthio*. It is about twice the length of the vertebra preceding it, and looks like three small and diminishing vertebræ ankylosed together.

## THE PELVIS.

In the adult the pelvis consists of twenty-one or twenty-two vertebræ, as well as of the ossa innominata.

Viewed *preaxially* and *postaxially* it differs from the pelvis of *Rhea* in the non-union medianly of the ischia, and the non-descent of the postaxial part of the ilium, as also in the less concavity between the supra- and antitrochanteric processes.

When viewed *laterally* the whole ilium is more convex dorsally than in *Rhea*, and the postacetabular part of the ilium more so than even in *Struthio*. The ischium and ilium almost join at their distal ends postaxially. The supratrochanteric process is very slightly postaxiad to the antitrochanteric one. The acetabular opening is much smaller

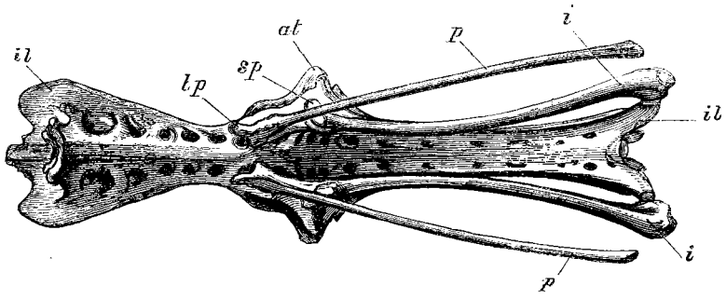
than in the preceding genera; but the vertebral column is seen behind it as in *Struthio*. The preaxial margin of the ilium is still more concave than in *Rhea*.

When the pelvis is viewed *dorsally* the supraacetabular processes nearly hide the antitrochanteric processes. Eight serial openings are visible in the middle of the post-acetabular part of the ilium. The surfaces between these apertures are composed of the flattened summits of the sacro-caudal neural spines interposed between the more postaxial parts of the two ilia. The pubis appears, thus viewed, very slightly, if at all, concave inwards; but the ischium is slightly concave outwards. The posterior ends of the ilia diverge as in *Struthio*, thus differing from *Rhea*.

Viewed *ventrally*, this complex bone presents five pieces proceeding postaxially as in

PELVIS OF EMU ($\frac{1}{4}$ natural size).

Fig. 18.




Ventral view.

*at*, antitrochanteric process; *i*, ischium; *il*, ilium; *lp*, ilio-pectineal process; *p*, pubis; *sp*, interobturator process.

*Struthio*; but, as in *Rhea*, the ilio-pectineal eminences are smaller than in the African genus; but the ischia are more visible medianly, thus differing from *Rhea*. The pre-acetabular part of the pelvis is relatively greater than in either of the other genera; and the number of transverse processes there is greater. Also the transverse processes are broader generally, and fill up the middle of the more postaxial half of the ventral surface of the pelvis with almost continuous ossifications. The sacral transverse processes are much smaller than in *Struthio*, but are much better ossified than those of *Rhea*, as are also the more postaxial transverse processes. The fossa left between the one (34th) or two lumbo-sacral vertebræ and the adjacent acetabulum on each side is very small and inconspicuous.

### The Ilium (figs. 13 & 18, *il*).

The ilium extends over the vertebræ from the twenty-sixth to the forty-fifth inclusive. It is like that of *Rhea*, except in the points already noticed, and that it is much less flattened against the postacetabular vertebræ than in *Rhea* and less so than in *Struthio*.

THE PUBIS (figs. 13 & 18, *p*).

This bone does not join the ischium, but ends freely distad, as it does in the young *Rhea*. It projects least postaxiad of the three pelvic bones.

THE ISCHIUM (figs. 13 & 18, *i*).

This bone also ends freely distad, as it does in the young *Rhea*. Its ridges are conditioned as in *Struthio*. It expands slightly distad in both directions, as a hammer. It is the pelvic bone which extends furthest postaxially, yet very little beyond the ilium.

## THE VERTEBRAL RIBS (fig. 12).

There are nine vertebral ribs, the last of which becomes ankylosed with the pelvis in the adult. The fourth, fifth, sixth, and seventh vertebral ribs join sternal ones.

The *first* rib is much longer than broad. It remains unankylosed in the adult, and is attached to the nineteenth vertebra.

The *second* rib is broader than in *Rhea* or *Struthio*. It has a convexity on its postaxial margin, a little below the tuberculum.

The *third* rib is broader and more convex than in *Rhea* or *Struthio*. The tubercular articular surface is a good deal larger than in the second rib. The postaxial margin is convex dorsally, and ventrally concave.

The *fourth* rib is like that of *Rhea*; but the uncinate process may be absent or present, when it is short and broad.

The *fifth* rib is very like its predecessor, but is slightly shorter and more curved, and the angle formed by the capitulum and tuberculum is rather more obtuse. There may or may not be a short, thick uncinate process.

The *sixth* is like that of *Rhea*, and is shorter and more curved than its predecessor. There is no uncinate process.

The *seventh* rib differs from that of *Rhea* in that it is not free distally. It is rather slighter, shorter, and more curved than its serial predecessor, while its diapophysial surface is quite as large. Its preaxial prominence is not *more* marked.

The *eighth* rib is but very slightly, if at all, longer than the second rib. The preaxial convexity does not project much; but the ridge which crosses that part where the head and tubercle diverge is very strong.

The *ninth* rib, which may be articulated with or ankylosed to its vertebra, is shorter, more slender, and less curved than its predecessor. It is more curved than in *Struthio*, and less so than in *Rhea*.

## THE STERNAL RIBS (fig. 12).

Of these there are four; and they increase in length postaxiad with very much greater rapidity than in *Rhea*, the third being twice the length of the first.

The *first* sternal rib is rather shorter than the second vertebral rib, and is rather more slender and curved than in *Struthio* or *Rhea*. The two distal articular surfaces are blended together to form one long articular groove; and the same is the case in all the other sternal ribs. It joins the fourth vertebral rib, and belongs to the twenty-second vertebra.

The *second* sternal rib is also longer, more slender, and more curved than in either *Struthio* or *Rhea*.

The same greater elongation and slenderness may be also predicated of the *third* and *fourth* sternal ribs. The fourth rib does not always attain the sternum, but may (as in No. 1358) be applied to the postaxial surface of the third rib, ending distally in a point.

## THE STERNUM.

STERNUM OF EMU ($\frac{1}{3}$ natural size).

Fig. 19. Fig. 20.

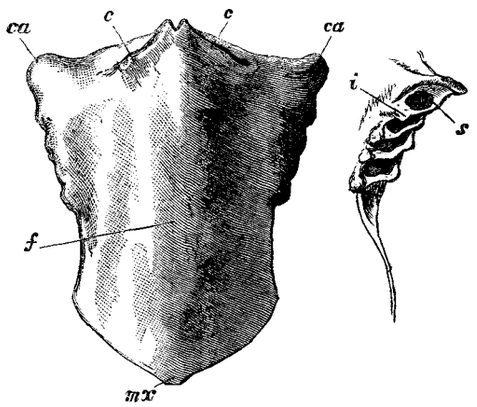



Fig. 19. Ventral view. Fig. 20. Lateral view.

The sternum much resembles that of *Rhea*. The coracoid grooves, however, are approximated and very differently conditioned. Their dorsal margins extend so far preaxiad of their ventral margins that their dorsal boundary thus forms a large part of the sternum on each side. The two ventral margins together produce a prominence on the preaxial part of the sternum; and at the preaxial end of this prominence is a very slight and irregularly shaped notch. There are no lateral xiphoid processes or median postaxial notch. There is an elevated, but not flattened, tract of bone at about the middle of the ventral surface. There are on each side four continuous articular surfaces, with a deep excavation behind and in front of each. The costal angles (fig. 12, CA) are

extremely long, and project inwards and postaxially in a way not to be found in *Struthio* or *Rhea*. The inner surface of the sternum is not so concave in either direction as in the last-mentioned genus.

## VERTEBRAL PARTS AND PROCESSES.

These portions of the skeleton generally resemble those of *Rhea*, except in the following points:—

The *centra* never abort; nor do the *neural laminæ*, as far as can be determined; but it is possible that they may do so in some part of the pelvis.

The *neural spines* of the cervical vertebræ are better-developed, but are not laterally bifid, though they are nearly so in some caudal vertebræ.

It is doubtful whether *diapophyses* are ever absent, save in the last presacral vertebræ.

*Hyperapophyses.* The interzygapophysial canals form conspicuous structures.

The *cervical* styloid *ribs* are well developed, and resemble those of *Struthio* and not those of *Rhea*.

*Catapophyses* are developed from the sixth to the seventeenth vertebra inclusive.

The *hypapophysis* is paired in the first cervico-dorsal vertebra.

The *vertebræ* are not raised above the acetabula.

The *vertebral ribs* are stouter than in *Rhea*, but with the same twist.

The *uncinate processes* do not seem to be ever more than two in number.

## THE AXIAL SKELETON OF *CASUARIUS*.

The axial skeleton of *Casuarius* so much resembles that of *Dromæus*, that a much less detailed notice of the former than of the latter is alone needed.

In *Casuarius* there are fourteen, fifteen, or sixteen cervical and four or three cervico-dorsal vertebræ; there are five dorsal and two or three dorso-lumbar vertebræ; to these succeed nine or ten lumbar and three sacral vertebræ, followed by nine, ten, or eleven sacro-caudal and eight or nine caudal vertebræ. Thus there may be from fifty-five to fifty-nine vertebræ in all; and of these as many as from twenty-five to twenty-seven belong to the first four categories, thus differing from *Rhea* and *agreeing* with *Struthio* and *Dromæus*. It also agrees with the last-named genus in the number of its caudal vertebræ.

## AXIAL SKELETON OF CASSOWARY.

Fig. 21. Fig. 22.

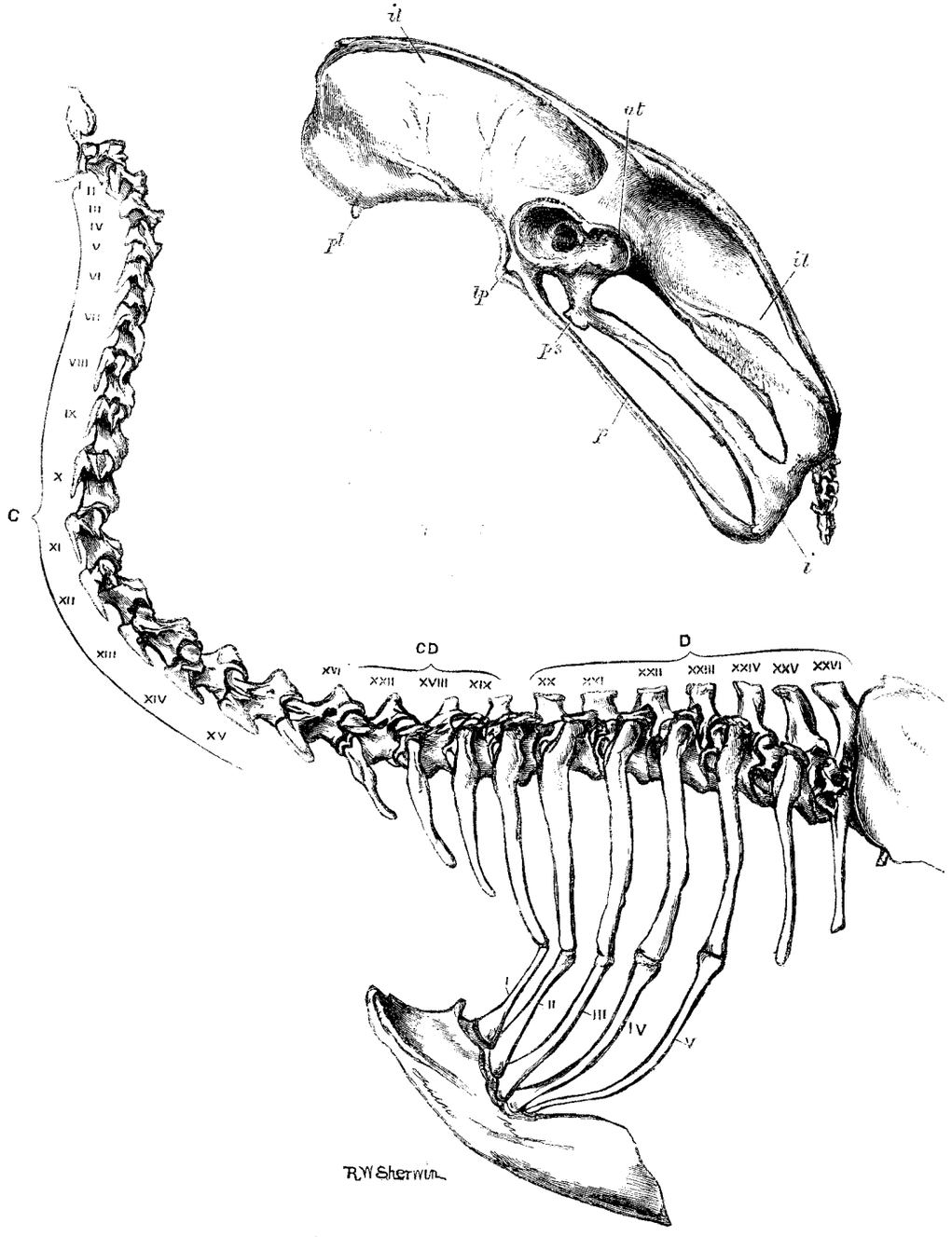



Fig. 21. Prepelvic part. Fig. 22. Pelvic and caudal parts. *pl*, pelvic rib.
Description as in figs. 1 & 2, p. 2.

The number of vertebræ in the different species appears to be as follows:—

| | *galeatus.* | *australis.* | *bennettii.* |
|---|---|---|---|
| Cervical vertebræ | 15 | 16 | 14 |
| Cervico-dorsal | 4 | 3 | 4 |
| Cervical and cervico-dorsal together | 19 | 19 | 18 |
| Dorsal | 5 | 5 | 5 |
| Dorso-lumbar | 2 | 3 | 2 |
| Vertebræ of first four categories together | 26 | 27 | 25 |
| Lumbar | 10 | 9 | 9 |
| Sacral | 3 | 3 | 3 |
| Sacro-caudal | 11 | 10 | 9 or 10 |
| Caudal | 9 | 8 | 9 |
| Sacro-caudal and caudal together | 20 | 18 | 18 or 19 |
| Total | 59 | 57 | 55 or 56 |

## THE CERVICAL VERTEBRÆ.

ATLAS AND AXIS OF CASSOWARY (natural size).

Fig. 23.

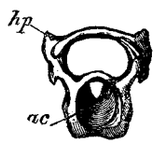



Fig. 24.

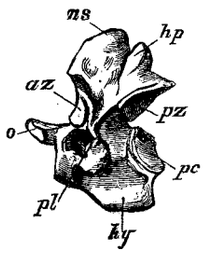



Fig. 23. Preaxial view of atlas. Fig. 24. Lateral view of axis. Letters as in figs. 3 & 4, p. 3.

The *atlas* (fig. 23) is very like that of *Dromæus*, but has no lateral spicula. The dorsal median notch may become a foramen, as in the specimen figured.

The *axis* (fig. 24) is also like that of *Dromæus*, but a little shorter still. The hyperapophysis is longer, especially in *C. bennettii*.

The *third* vertebra differs from that of *Dromæus* in that it is shorter axially, and that the styloid rib is much shorter and only about as long as that of *Rhea*. There may or may not be a perforation in the interzygapophysial ridge. There is a hyperapophysial keel.

The *fourth* vertebra is shorter than that of *Dromæus*, with a higher neural spine and a shorter and stouter styloid rib.

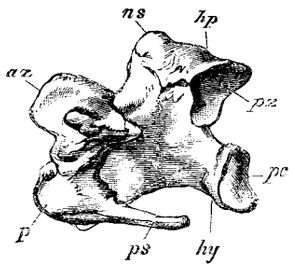
The *fifth* vertebra is like the fourth, except that it already displays both metapophyses and catapophyses.

In the *sixth* vertebra the hyperapophyses begin to blend with the lateral posterior portions of the neural spines.

The remaining cervical vertebræ, from the *seventh* to the *fourteenth* inclusive, are all nearly similar in form, but increasing in size, and with the styloid rib more developed as we proceed postaxially. In *C. galeatus* the more anterior cervical vertebræ have a

ELEVENTH VERTEBRA OF CASSOWARY (natural size).

Fig. 25.




Lateral view. Letters as before.

large perforation in the interzygapophysial ridge; but in all this lamella is very conspicuous.

## THE CERVICO-DORSAL VERTEBRÆ.

The *sixteenth* vertebra (the fifteenth of *C. bennettii*[1]) has its parapophysis extended preaxiad of the præzygapophysis. There are still two distinct catapophyses.

In the *seventeenth* vertebra the catapophyses closely approximate.

In the *eighteenth* vertebra the parapophysis is not so much preaxiad of the præzygapophysis. There is a hypapophysis, which bifurcates from a single root.

In the *nineteenth* vertebra the parapophysis is no longer preaxiad of the præzygapophysis. The hypapophysis may bifurcate, or (as in *C. bennettii*) it may be simple.

All these four cervico-dorsal vertebræ are scarcely shorter relatively than are the corresponding ones of *Dromœus*, and they are very much more like the latter than they are like their homologues in *Rhea*. The fossa postaxiad to the neural spine, however, is much smaller than in *Dromœus*, especially in the *eighteenth* and *nineteenth* vertebræ. The transverse processes are not so much expanded, axially, at their distal ends as they are either in *Dromœus* or *Rhea*.

[1] To prevent repetition, it may be here remarked, once for all, that *C. bennettii* has but fourteen cervical vertebræ, the number of the trunk-vertebra described is always one in advance of the number of the corresponding vertebra of *C. bennettii*.

## THE DORSAL VERTEBRÆ.

These vertebræ, the *twentieth* to the *twenty-fourth* inclusive, closely resemble the dorsal vertebræ of *Dromæus*; but it is only the first which has a hypapophysis, and that is single and median.

## THE DORSO-LUMBAR VERTEBRÆ.

These vertebræ, *the twenty-fifth* and *twenty-sixth* (the twenty-fifth, -sixth, and -seventh in *C. australis*), so closely resemble the corresponding vertebræ of *Dromæus* that the minute differences may be disregarded. The last dorso-lumbar vertebra becomes ankylosed to the pelvis.

## THE LUMBAR VERTEBRÆ.

The *twenty-seventh* vertebra (the twenty-sixth of *C. bennettii* and the twenty-eighth of *C. australis*) is part of the pelvic mass, and the first vertebra which has no conspicuous rib. It is still less concave ventrally than is its homologue in *Dromæus*; and its transverse process is still less directed preaxially.

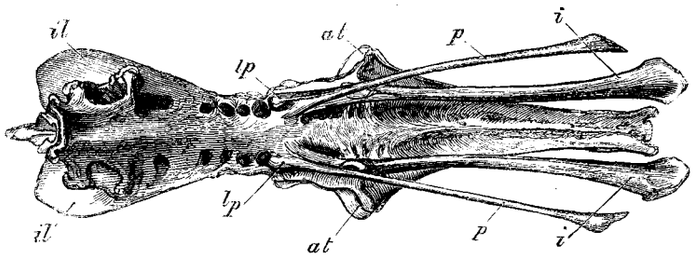
The next four vertebræ, the *twenty-eighth* to the *thirty-first* inclusive, seem quite to resemble the corresponding ones of *Dromæus*, except that they are less concave ventrally.

The *thirty-second* and *thirty-third* vertebræ differ from those of *Dromæus* in that their transverse processes do not blend together so early.

The *thirty-fourth*, *-fifth*, and *-sixth* vertebræ are devoid of transverse processes, and have them represented only by minute rudiments. They are the LUMBO-SACRAL vertebræ.

PELVIS OF CASSOWARY ($\frac{1}{4}$ natural size).

Fig. 26.




Ventral aspect. Letters as in fig. 18, p. 23.

## THE SACRAL VERTEBRÆ.

The *thirty-seventh*, *-eighth*, and *-ninth* vertebræ, or sacral vertebræ, must be so called because they seem to correspond in position with the sacral vertebræ of the preceding genera. They cannot, however, be separated off from the vertebræ which succeed them by any structural character, as can the vertebræ of *Struthio* and *Rhea*—as they all, as in *Dromæus*, send out similar transverse processes to abut against the postacetabular part of the ilium.

## THE SACRO-CAUDAL VERTEBRÆ.

The nine, ten, or eleven vertebræ which succeed the sacral vertebræ, *i. e.* (in *C. galeatus*) the vertebræ from the *fortieth* to the *fiftieth* inclusive, are quite like those of *Dromæus*. They gradually elongate as we proceed postaxiad; and their transverse processes become successively wider axially. Their spinous process becomes successively shorter and more and more inclined postaxiad.

## THE CAUDAL VERTEBRÆ.

The eight or nine caudal vertebræ (the *fifty-first* to the *fifty-ninth* inclusive, in *C. galeatus*) closely resemble the caudal vertebræ of *Dromæus*; but their transverse processes and their postzygapophyses are not quite so much developed as in that genus. The *pygostyle* is like that of *Dromæus*, cylindrical and irregular, and looking as if made of three small vertebræ ankylosed together (fig. 22).

## THE PELVIS.

When viewed *preaxially* the pelvis quite resembles that of *Dromæus*, except that (owing to the greater ventrad curvature of the postaxial part of the ilium) the ventral surface of the sacro-caudal vertebræ comes more into view, and except also that the concavity between the antitrochanteric and supratrochanteric processes is as great as in *Rhea*.

Viewed *laterally*, it only differs from that of *Dromæus* in that the dorsal margin of the postaxial part of the ilium is still more convex, in that the preacetabular part of the ilium is relatively greater, and in that the ischium and ilium may (as in *C. galeatus*) ankylose together at their distal ends.

Viewed *dorsally* and *ventrally*, the pelvis shows no noteworthy differences from that of *Dromæus*, except that the inner surface of the ischium presents an antero-posterior groove.

### The Ilium (figs. 22 & 26, *il*).

The ilium extends over from about twenty-three to twenty-five vertebræ, namely

from the twenty-fifth or twenty-sixth to the end of the sacro-caudal vertebræ. Its main peculiarities have been already noticed.

### The Pubis (figs. 22 & 26, *p*).

This bone may end freely at its distal end; it may, on the contrary, ankylose distally (as in *C. galeatus*) with the distal end of the ischium.

### The Ischium (figs. 22 & 26, *i*).

The ischium may ankylose distally with the ilium, as in *C. galeatus*; it may, on the contrary, end freely, as in *C. bennettii*, where it extends postaxially beyond the post-axial extremity of the ilium.

## THE VERTEBRAL RIBS (fig. 21).

These ribs are eleven or twelve in number, according as there are two or three dorso-lumbar vertebræ. The *first four* are not united to sternal ribs; but to these succeed *five* which are so connected. Finally, there are at least two, more postaxially placed, which end freely at their distal extremities; and there may be, as in *C. australis*, three such ribs.

Uncinate processes may be altogether absent, as in the specimens of *C. australis* and *C. bennettii*. There may be, however, three such processes on each side, attached either to the sixth, seventh, and eighth, or to the seventh, eighth, and ninth ribs respectively.

The vertebral ribs are flatter and broader than hitherto, and have a different twist. Those postaxiad to the third or fourth rib develop a blunt postaxially developed process, the process being situated near the proximal end of the shaft of each rib. Each rib (proceeding distad from the junction of the tuberculum with the capitulum) is bent with its convexity preaxiad. More distally its convexity is postaxially directed. The ribs are more like the ribs of *Dromæus* than they are like the ribs of any other of the existing *Struthionidæ*; but they are not so curved, and proceed more directly ventrad.

## THE STERNAL RIBS (fig. 21).

These bones present no marked differences from those of *Dromæus*, save that they increase somewhat more gradually in length postaxiad. The first joins the fourth or fifth vertebral rib, and belongs to the twentieth vertebra. The fifth may be twice the length of the first, or it may not reach the sternum.

## THE STERNUM.

STERNUM OF CASSOWARY ($\frac{1}{4}$ natural size).

Fig. 27. Fig. 28.

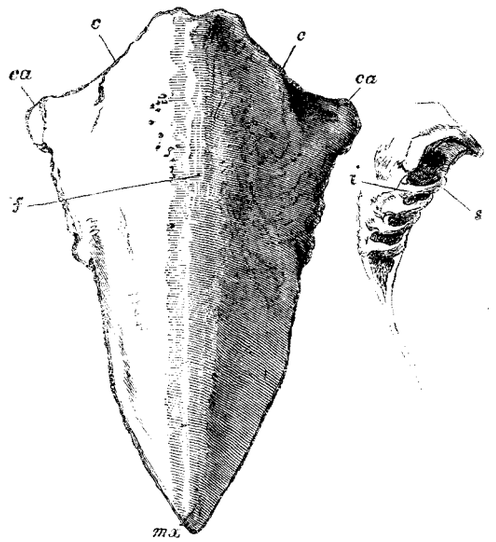



Fig. 27. Ventral view. Fig. 28. Lateral view.

This bone is exceedingly characteristic. It is very long, narrow, and boat-shaped compared with that of the other Struthionidæ. The costal angles are exceedingly short; and between the coracoid-grooves there is a very marked pit, which penetrates deeply into the bone and is an exaggeration of that minute notch which exists, in *Dromæus*, upon the median process between the coracoid-grooves. It agrees with the sternum of the last-named genus in not having any prominence on the ventral surface, and in having neither the ventral surface so convex nor the dorsal surface so concave as are these surfaces in *Rhea*. In all other respects it also agrees with the sternum of *Dromæus*, except that the costal angles (as above indicated) are so much smaller, and that the portion which is postaxial to the pleurosteon is more prolonged.

## VERTEBRAL PARTS AND PROCESSES.

These skeletal features in *Casuarius* quite resemble those of *Dromæus* in those points in which the latter have been said to differ from the vertebral parts and processes of *Rhea*, except that the catapophyses continue to the seventeenth vertebra, and that a bifurcating hypapophysis appears first at the eighteenth or third cervico-dorsal vertebra, as also that the cervical processes may be three in number or may abort altogether.

Compared with the axial skeleton of *Dromæus*, that of *Casuarius* has the cervical vertebræ shorter, axially, and has the catapophyses, hyperapophyses, and metapophyses more strongly developed, and making their appearance nearer to the preaxial end of the vertebral column. These various processes, together with the marked diapophysial ridges, give to the vertebræ an irregularity of surface which contrasts strongly with the relatively smooth elongated cervical vertebræ of *Struthio* and *Rhea*.

*Casuarius* is, in fact, evidently closely allied to *Dromæus*; and these two types are less specialized than are the diverging eccentric forms *Struthio* and *Rhea*.

## THE AXIAL SKELETON OF *APTERYX*.

The axial skeleton of *Apteryx* is so very distinct and different in form as well as in size from that of the other Struthionidæ, that much detail may be dispensed with. This is still more the case on account of the elaborate description and figures of the skeleton of this genus which have already been given in the 'Transactions' of the Zoological Society[1].

In *Apteryx* there are fifteen cervical vertebræ and one cervico-dorsal; there are four dorsal and also four dorso-lumbar vertebræ; to these succeed about eight lumbar and three sacral vertebræ, followed by three sacral and nine or seven caudal[2]. Thus there are forty-five or forty-seven vertebræ in all; and of these as many as twenty-four belong to the first four categories.

### THE CERVICAL VERTEBRÆ.

The genus *Apteryx* differs from all the preceding genera in the greater relative stoutness of the neck and production of its processes.

The *atlas* is exceptional in that the preaxial articular surface of its centrum is scarcely at all notched dorsally. It is also remarkable for its very long hyperapophyses. It has no neural spine any more than any other of the Struthionidæ. Transverse processes may be absent; or there may be a minute parapophysial process on each side. A rudimentary hypapophysial process may also be developed from the postaxial end of the ventral surface of the atlas.

The *axis* is even more exceptional, through its relatively enormous hyperapophyses and long neural spine, both processes relatively exceeding those of any other of the Struthionidæ. Indeed, in the hyperapophysis of the axis in *Apteryx*, diapophysial elements seem to be latent also, as may be seen by following the process postaxially through

[1] See vol. ii. p. 286, plates liv., lv.

[2] Seven in *A. owenii* and nine in *A. australis*.

the cervical vertebræ. There is also a small and rudimentary parapophysial process (*p*) on each side of the axis, projecting from about the postaxial end of the preaxial third of the outer surface of that bone. The axis has no hypapophysial process.

ATLAS AND AXIS OF APTERYX (natural size).

Fig. 29. Fig. 30.

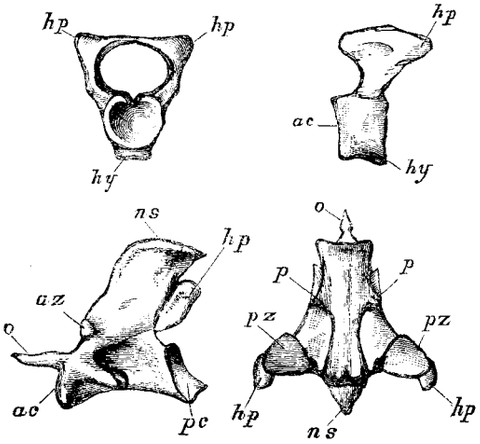



Fig. 31. Fig. 32.

Fig. 29. Preaxial view of atlas.
Fig. 30. Lateral view of atlas.
Fig. 31. Lateral view of axis.
Fig. 32. Ventral view of axis.

The *third* vertebra has a high neural spine and is the first to exhibit catapophyses. It has the hyper- and diapophyses still blended as in the axis; but in the *fourth* vertebra (which also has a high neural spine) traces may be detected of a separation between the hyperapophysial and diapophysial elements (fig. 34, *d* & *hp*).

In the *fifth* vertebra the separation is more easily to be traced; but in the *sixth* vertebra they have completely separated, the hyperapophyses becoming approximated to the postaxial part of the neural spine, and the diapophysis (containing also probably a latent metapophysis) beginning to stand out almost like an upper rib, approximating in length and projection postaxiad to the styloid rib, which projects postaxially ventrad from the more ventral portion of the same vertebra. This parapophysial rib, which answers to the styloid ribs of *Struthio*, *Dromæus*, and *Casuarius*, is longest from about the sixth to the tenth vertebra, though from the sixth to the seventh in *A. australis*, and from the sixth to the tenth inclusively in *A. owenii*, the diapophysis (the upper rib) in each vertebra surpasses in length its normal cervical rib.

The neural spine, which was still long in the fifth vertebra, becomes short in more postaxial vertebræ.

In the cervical vertebræ postaxial to the sixth, each pleurapophysial lamella connect-

VERTEBRÆ OF APTERYX (twice the natural size).

Fig. 33.

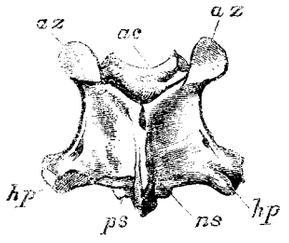
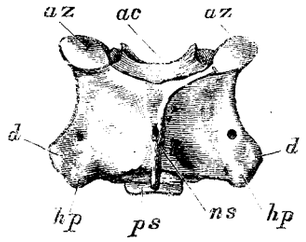



Fig. 34.



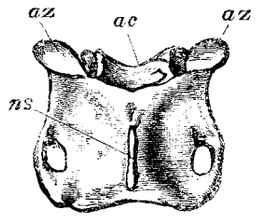




Fig. 35.

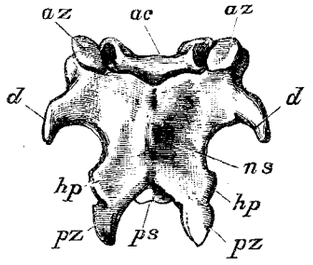



Fig. 36.

Fig. 33. Dorsal view of third vertebra.
Fig. 34. Dorsal view of fourth vertebra.
Fig. 35. Dorsal view of fifth vertebra.
Fig. 36. Dorsal view of sixth vertebra.

*ac*, preaxial surface of centrum; *az*, przygapophyses; *d*, the diapophysial element; *hp*, the hyperapophysial element; *ns*, neural spine; *ps*, postaxial surface of centrum; *pz*, postzygapophyses.

ing the diapophysis with the parapophysis develops a tubercular process on its outer surface, which projects postaxiad and increases the complexity of the skeleton of the neck (fig. 37). The process is in series with that part of each thoracic rib which proceeds distad from the tuberculum.

In the *tenth* and *eleventh* vertebræ (as in *A. owenii*, but not in *A. australis*) the catapophyses, which have been increasing in conspicuousness and mesiad flexion, from the fourth vertebra, unite together and form a subvertebral ring.

In the *twelfth* vertebra a median hypapophysial process begins to appear, and the hyperapophyses become more closely approximated to the posterior zygapophyses. These characters are more marked in the *thirteenth* vertebra, in which vertebra, in *A. owenii*, the hypapophysis attains its maximum of development, though in *A. australis* it is largest in the vertebræ from the fourteenth to the seventeenth inclusive.

In the *fourteenth* vertebra the hyperapophyses and posterior zygapophyses have become completely blended together, so that the former cease to be distinguishable; and this vertebra is moreover distinguished from all the cervical vertebræ which are

postaxial to the fifth, and from the penultimate cervical of all the other Struthionidæ by its very prolonged neural spine, which presents such a contrast to that of its preaxial predecessor.

FOUR VERTEBRÆ OF APTERYX (twice the natural size).

Fig. 37.

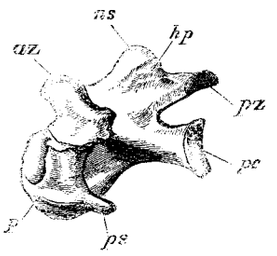
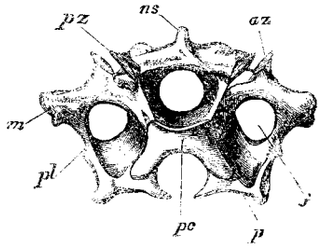



Fig. 38.



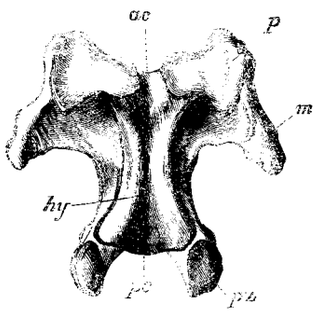




Fig. 39.

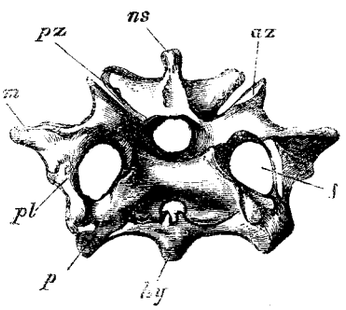



Fig. 40.

Fig. 37. Lateral view of seventh vertebra.
Fig. 38. Postaxial view of eighth vertebra.
Fig. 39. Ventral view of ninth vertebra.
Fig. 40. Preaxial view of eleventh vertebra.

*c*, Catapophysis; *d*, diapophysis; *f*, lateral foramen; *hp*, hyperapophysis; *ns*, neural spine; *p*, parapophysis; *pl*, styloid rib; *az*, præzygapophysis; *pz*, postzygapophysis.

In the *fifteenth* vertebra the neural spine is slightly higher. The diapophyses are still largely developed, and appear even longer than the parapophyses with their ankylosed pleural elements, which, however, appear to be mutilated in the specimens examined.

## THE CERVICO-DORSAL VERTEBRA.

This vertebra has an elongated neural spine of the same length as that of the last cervical vertebra. Its diapophysis is much axially extended; and it bears a single hypapophysis, the development of which in *A. australis* is still equal to that of any preceding vertebra.

## THE DORSAL VERTEBRÆ.

These vertebræ, the *seventeenth*, *eighteenth*, *nineteenth*, and *twentieth*, differ from the dorsal vertebræ of all other Struthionidæ in the great and the equal development of their neural spines, as also in the great relative axial extent of their diapophysial processes. In them the hypapophysis gradually diminishes postaxially in size, becoming quite rudimental in the nineteenth vertebra. The twentieth vertebra has the ventral surface of its centrum axially grooved. The last two dorsal vertebræ may be slightly ankylosed together ventrally.

## THE DORSO-LUMBAR VERTEBRÆ.

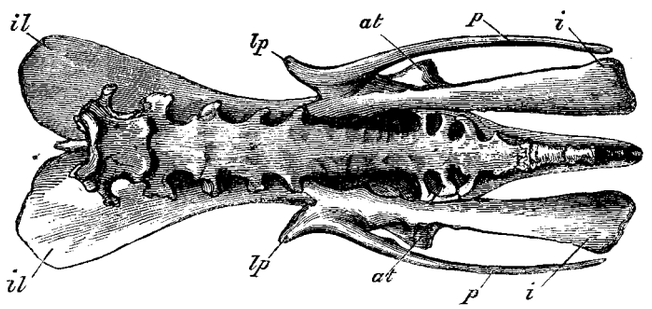
These vertebræ (the *twentg-first* to the *twenty-fourth* inclusive) are more in number than in any other of the Struthionidæ. They all have equally high neural spines; and these are equal in height to those of the dorsal vertebræ; also, like the latter, they are much extended axially. The diapophyses are similarly extended axially; and the centra are similarly antero-posteriorly grooved. The twenty-first vertebra may be slightly ankylosed ventrally to the twentieth.

## THE LUMBAR AND LUMBO-SACRAL VERTEBRÆ.

The vertebræ from the *twenty-fifth* to the *thirty-second* inclusive compose the lumbar region. They are, of course, all ankylosed into one mass, which on its ventral surface may be flat, or transversely concave, so as to present an axially directed groove. Transverse processes are present in the four or five most preaxial vertebræ, but not more postaxially (*i. e.* not in the lumbo-sacral vertebræ), none others being visible when the pelvis is viewed ventrally. Thus there comes to be a conspicuous narrow and elongated fossa on each side between the ilium and acetabulum and the vertebral column.

PELVIS OF APTERYX ($\frac{1}{4}$ natural size).

Fig. 41.




Ventral view.

## THE SACRAL VERTEBRÆ.

The three sacral (the *thirty-third*, *thirty-fourth*, and *thirty-fifth*) vertebræ are, in *Apteryx*, very distinct from both their preaxial predecessors and their postaxial successors. Each sends out on each side a transverse process to abut against the post-acetabular part of the ilium.

## THE SACRO-CAUDAL VERTEBRÆ.

The vertebræ of this category are fewer in number in *Apteryx* than in any other of the Struthionidæ, and are singularly compressed laterally. They are devoid of transverse processes, and are chiefly remarkable for the peculiarity of their position. Instead of ascending, as in *Rhea*, these vertebræ descend ventrad to the postaxial parts of the ilia. In spite of these, they are less ventrally extended between the acetabula than in any except *Rhea*; so that when the pelvis is held horizontally with one of the acetabula opposite the eye, about half the aperture of the acetabulum of the opposite side becomes visible. The nearest approximation to this condition is that found in *Casuarius*, though considerably less of the opposite acetabulum can thus be seen in that genus.

## THE CAUDAL VERTEBRÆ.

These vertebræ are from seven to nine in number—namely, seven in *A. australis* and nine in *A. owenii*. Transverse processes are present in the third, fourth, and fifth caudal vertebræ, especially in the two latter; and these help to produce a broadening-out of the fourth and fifth or the fourth, fifth, and sixth caudal vertebræ; so that the skeleton of the tail is wider towards its middle than it is either more pre- or more postaxially. This is a character not similarly marked in any other genus of the Struthionidæ.

The *pygostyle* is rather elongated, conical, irregular, and somewhat laterally compressed and flattened ventrally. It looks like three or four successively smaller and smaller vertebræ ankylosed together.

## THE PELVIS.

When viewed *preaxially* the pelvis is remarkable for the much greater divergence of the ilia, which form together a much more obtuse angle than in any other of the Struthionidæ. It is also remarkable for the much greater visibility of the ischia and pubes (owing to their extreme descent postaxially), and for the relatively much longer last rib.

Viewed *postaxially* the same peculiarities are noticeable, as also the postaxial descent of the ilia (which is much as in *Casuarius*), and the absence of supratrochanteric processes. The ilia are very much flattened against the postacetabular vertebræ included between them.

Viewed *laterally*, the slenderness of the pubis and breadth of the ischium are remark-

able, the ischium being much broader relatively than in any other existing genus of the family (though *Casuarius* is the nearest in this respect), and exceeding the pubis in breadth probably more than in any known form whether living or fossil, the pubis in *Apteryx* being very slender. The very faint development of the processes which tend to separate off the more preaxial part of the obturator foramen is also remarkable. These are more marked in *A. owenii* than in *A. australis*. There may be a small notch just postaxiad to the more or less slight interobturator process. The pubis and ischium may or may not unite distally; if ending freely the pubis extends very slightly postaxiad of the ischium; and both may extend a little postaxiad of the distal end of the ilium.

Viewed *dorsally* the same characters are to be noticed, and, in addition, the fact that the ilia do not quite meet together dorsad behind the acetabula, though they are not so open as in *Dromæus* and *Casuarius*.

Viewed *ventrally* the proportion borne by the breadth of the pelvis to its length is seen to be greater than in any other living genus of the Struthionidæ, though it exceeds the relative breadth found in them less than it falls short of the relative breadth found in *Dinornis*. The descent of the sacro-caudal vertebræ gives this part of the pelvis a peculiar appearance. The lateral fossa formed by the absence of transverse processes in the posterior lumbar vertebræ (fig. 41) may extend somewhat considerably in front of the acetabula or but very slightly so. The ilio-pectineal processes are very long.

### The Ilium (fig. 41, *il*).

The ilium extends over about fifteen vertebræ, namely from the twenty-second or twenty-third to the thirty-eighth vertebra. Its main peculiarities are its rounded dorsal margin, its descent postaxially, and the absence of a supratrochanteric process and the notable length of the ilio-pectineal process (fig. 41, *lp*).

### The Pubis (fig. 41, *p*).

This bone in *Apteryx* is more slender (even relatively) than in any other genus of *Struthionidæ*. It may or may not unite postaxially with the ischium, and it developes an interobturator process.

### The Ischium (fig. 41, *i*).

This bone is remarkable for its exceptional relative breadth and wide divergence distad from the ilium, in both which points it resembles *Dinornis*. It may or may not develop a rudimentary interobturator process.

## THE VERTEBRAL RIBS.

These ribs are nine in number; the second, third, fourth, and fifth are united to the sternum; and the sixth may also be so united. They differ from the ribs of every other genus of the Struthionidæ by their enormous relative width, as also in the short-

ness of their tubercula compared with their capitula, in harmony with excessive projection of the diapophysial processes of the dorsal and dorso-lumbar vertebræ. They are also quite exceptional in the number and great relative size of the uncinate processes which they bear, and which are seven in number. The direction of their curvatures is much as in *Casuarius*.

The *first* rib is much more slender and delicate than the others, even the last; but it nevertheless bears a large uncinate process.

The *second* and *third* lengthen and broaden, and also bear large uncinate processes.

The *fourth*, *fifth*, and *sixth* ribs are the broadest, and the sixth is also the longest, of the ribs. In common with the *seventh*, they support large uncinate processes.

The *eighth* and *ninth* ribs are devoid of any such process; but the ninth (and last) rib is both much longer and much thicker than is the first.

## THE STERNAL RIBS.

These ribs increase pretty regularly in length as we proceed postaxiad. They are all slender in *A. australis*; but in *A. owenii* the fourth is considerably broadened out, and the fifth rib is very much so. Nevertheless the breadth of these sternal ribs is not nearly so great as is that of the vertebral ribs they join.

## THE STERNUM.

The sternum of the *Apteryx* differs very greatly from that of any other living genus of the Struthionidæ; it is so short, so broad, and so thin, dorso-ventrally, at its costal margins. The coracoid-grooves are very short, small, and very far apart, while the preaxial margin of the sternum between them, far from presenting any median process, is strongly concave. The costal angles are short, and continued from the dorsal lip of each coracoid-groove. The pleurostea are very narrow, and bear four small articular surfaces for the sternal ribs. Postaxially the sternum exhibits a very long median process separated by two notches from the about equally projecting lateral xiphoid processes.

## VERTEBRAL PARTS AND PROCESSES.

The skeletal features in *Apteryx* much resemble those of *Casuarius*; but the rugosity of the spinal region is augmented by the great development of the diapophysial processes and lamellæ and the large hyperapophyses and catapophyses, the latter sometimes forming a subvertebral ring. The skeleton of *Apteryx*, however, is at once distinguishable by the very broad ribs, the numerous and large uncinate processes, the greatly and equally extended (axially) trunk-spines, the absent supratrochanteric processes, and the depressed (ventrad) sacro-caudal vertebræ. It is also distinguishable by its short and broad sternum, with very thin pleurosteon, and having a concave preaxial margin and three long postaxial xiphoid processes.

## THE AXIAL SKELETON OF *DINORNIS*.

The osteology of *Dinornis* has been in great part admirably described in the different memoirs of Professor Owen in the 'Transactions' of the Zoological Society (see vol. iii. plate 19. figs. 1, 2, 3, plates 20 & 20 A. fig. 1, also plate 43. figs. 1, 2, 3; vol. iv. p. 17 and plate 4. figs. 1–4, p. 159 and plate 47; and vol. vii. p. 115, plates 7, 8, 9). Nevertheless it is not yet possible to give a complete description of its axial skeleton, although the magnificent specimen of *D. didiformis* above referred to affords an extensive amount of information on the subject.

There appear to be fifteen cervical vertebræ and probably three cervico-dorsal, three dorsal, and two dorso-lumbar vertebræ. There are also some eight or nine lumbar and lumbo-sacral vertebræ, and three sacral; but the number of caudal vertebræ does not appear.

## THE VERTEBRÆ.

The *cervical* vertebræ in size and proportion of parts present a close general resemblance to those of *Dromæus* and *Casuarius*; but the fossæ postaxiad to the neural spines appear to have been yet larger. The neural spine of the axis is lofty; and those of the fourth, fifth, sixth, and seventh cervical vertebræ are so grooved axially that they bifurcate laterally. The hyperapophyses of the axis are about as large as those of *Dromæus* and *Casuarius*.

Catapophyses appear already at the fourth vertebra, and continue on till, in the last cervical, they are replaced by a median hypapophysis. The cervical styloid ribs were most probably developed much as they are in *Casuarius*.

The *dorsal* and *lumbar* vertebræ evidently had not equally elongated and much axially extended neural spines, as in *Apteryx*, but probably about as developed as in *Dromæus* and *Casuarius*.

The *lumbar* and *lumbo-sacral* vertebræ are broad; and the more postaxial of them (the lumbo-sacral) are devoid of transverse processes. The absence of these, occasions the presence of two large crescentic fossæ in the pelvis, one being internal to each acetabulum.

The *sacral* vertebræ send transverse processes to abut against the postacetabular part of the ilium as usual; but they are not sharply differentiated from the more postaxial vertebræ as they are in *Apteryx* and *Struthio*.

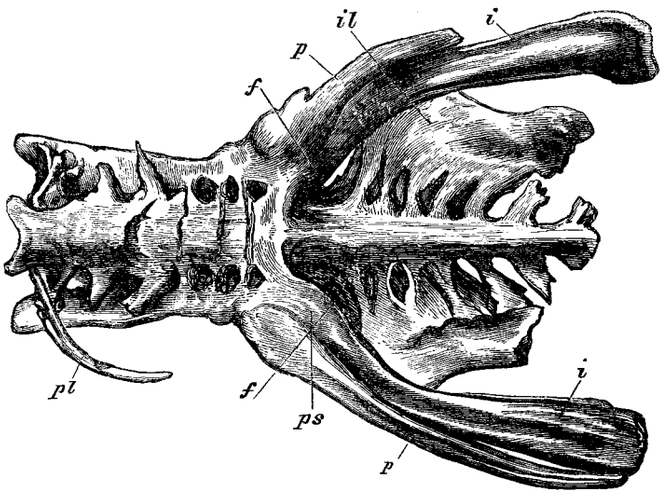
The *sacro-caudal* vertebræ are more dorsally situated with respect to the pelvis, as regards the acetabula, than in any of the Struthionidæ except *Rhea* and *Apteryx*, and closely resemble those of the last-named genus in this point, though they differ from them in not being ventrad to the postaxial portions of the ilia. These vertebræ send out transverse processes like those of the sacral vertebræ, and are thus hardly to be

distinguished from them by any osteological character, in which respect they resemble the sacro-caudal vertebræ of *Dromæus* and *Casuarius*.

No specimens of *caudal* vertebræ have been examined.

PELVIS OF DINORNIS ($\frac{1}{4}$ natural size).

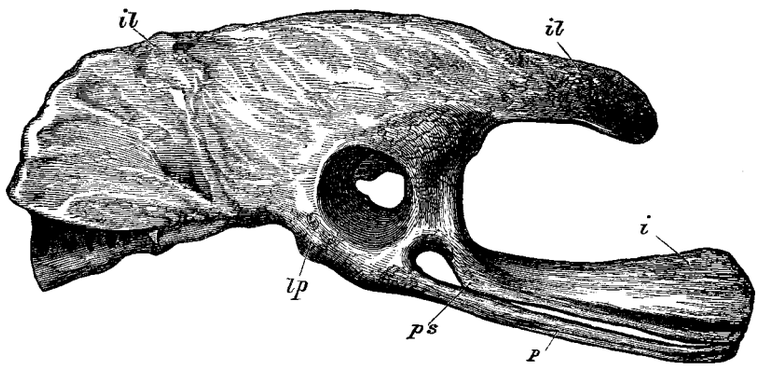
Fig. 42.




Ventral view. Letters as before, but in addition *f*, fossa internal to the acetabulum.

PELVIS OF DINORNIS ($\frac{1}{4}$ natural size).

Fig. 43.




Lateral view.

## THE PELVIS.

When viewed *preaxially*, the pelvis differs from that of *Apteryx*, and agrees with the same part in the other genera, in that the ilia form a less obtuse angle. It, however, agrees with that of *Apteryx* in the great extent to which the ischia and pubes come into view.

Viewed *laterally*, the close resemblance of this bone in the position and proportions of the ischium and pubis is striking, as also is the relation of the acetabula to the spinal column; for, as in *Apteryx*, a great part of the aperture of the opposite acetabulum can be seen through the nearer one. The ilia are much flattened behind the acetabula; so that what in the other Struthionidæ (except *Apteryx*) is the supratrochanteric process, is here but the external angle of this dorsally flattened expanse of bone. The ilium does not extend back either so far as the ischium or pubis; and the two latter bones slightly unite distad. The interobturator processes (tending to separate off the most preaxial part of the obturator foramen) are faint, and thus resemble those of *Apteryx*, though they are rather more marked than in that genus.

Viewed *ventrally* the pelvis is remarkable for its extreme breadth, exceeding in this respect all the other Struthionidæ, and this not only absolutely, but relatively also. Between the acetabula are the two large fossæ (fig. 42, *ff*) already spoken of as conditioned by the non-development of the transverse processes of the more postaxial lumbo-sacral vertebræ. These fossæ are subcrescentic, with the convexity of each crescent mediad. In the *Apteryx* they are more elongated; in *Dromæus* and *Casuarius* they are very small indeed. In the specimens examined the ilio-pectineal processes are very little developed, thus differing greatly from *Apteryx*.

Viewed *dorsally* the most noticeable distinctive feature is the excessive breadth of the more postaxial part of the pelvis.

The *ilium* has had its main characters already noticed.

The *pubis* is more slender relatively than in any genus except *Apteryx*, in which the slenderness is considerably more remarkable still.

The *ischium* in its dorso-ventral breadth, and in its great divergence ventrad from the ilium, closely resembles the ischium of *Apteryx*, and differs from that of every other genus of Struthionidæ.

## THE RIBS.

There appear to be eight *vertebral* ribs on each side; and of these the fourth, fifth, and sixth (or at least the fourth and fifth) join the sternum by the intervention of sternal ribs. In their curvature the vertebral ribs resemble those of *Casuarius*, but they are more slender and more equal in length. The third, fourth, fifth, sixth, and seventh are the longest, and are of very similar length and slenderness. There are no indications of uncinate processes. The sternal ribs seem also to be slender. They

may be three in number; or they may probably be only two, as appears to be the case in *D. elephantopus*.

## THE STERNUM.

The sternum of *Dinornis* is, as it were, an exaggeration of the sternum of *Apteryx*. The coracoid-grooves are all but obsolete, so exceedingly faint is the concavity formed by them on the costal angle. The pleurosteon is reduced to a small irregular surface postaxiad of the root of the costal angle, and may bear three articular surfaces, as in *D. rheides* and *D. didiformis*, or only two, as in *D. elephantopus*. There is no preaxial median process, groove, or fossa; but one straight rounded surface bounds the sternum preaxially. The costal angles are of moderate size. The lateral xiphoid processes are very prolonged and slender, extraordinarily so in *D. rheides*. They may be directed postaxiad in an almost parallel direction, as in the last-mentioned species; or they strongly diverge postaxiad as in *D. elephantopus*. The median xiphoid process is very large, and, of course, separated from the lateral xiphoids by great notches. It may be very wide at its root, as in *D. elephantopus*, or rather narrow as in *D. rheides*. It has always a more or less pointed postaxial termination.

| | *Struthio.* | *Rhea.* | *Dromæus.* | *Casuarius.* | *Apteryx.* | *Dinornis.* | *Struthionidæ.* |
|---|---|---|---|---|---|---|---|
| Number of cervical vertebræ ..... | 17 | 14 | 17 (or 18) | 14–16 | 15 | 15 | 14–17 |
| Cervico-dorsal .... | 3 | 3 | 3 | 4–3 | 1 | 3 | 1–4 |
| Both together .... | 20 | 17 | 20 (or 21) | 19 (or 18) | 16 | 18 | 16–21 |
| Dorsal ..... | 5 | 3 | 4 | 5 | 4 | 3 (or 2) | 2–5 |
| Dorso-lumbar .... | 2 | 3 | 2 | 2 (or 3) | 4 | 3 | 2–4 |
| Dorsal and dorso-lumbar together. | 7 | 6 | 6 | 7 (or 8) | 8 | 6 | 6–8 |
| All the first four categories together | 27 | 23 | 26 (or 27) | 26 (or 27 or 25) | 24 | 24 | 23–27 |
| Lumbar ..... | 8 | 9 | 8 | 10 (or 9) | 8 | 9 (or 8) | 8–10 |
| Sacral ..... | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Sacro-caudal .... | 8 | 9 | 9 (or 10) | 9 (or 10 or 11) | 3 | ? | 3–11 |
| Caudal ..... | 10 | 5 | 8 (or 9) | 8 (or 9) | 7 (or 9) | ? | 5–10 |
| Sacro-caudal and caudal together.. | 18 | 14 | 17 (or 19) | 18 (or 20) | 10 (or 12) | ? | 10–20 |
| Total ..... | 56 | 49 | 54 | 55 (or 59) | 45 (or 47) | ? | 45–59 |

## CHARACTERS COMMON TO *STRUTHIO* AND *RHEA*.

Axis vertebra with a hypapophysis, with or without well-developed hyperapophyses; cervical vertebræ greatly elongated; neural spines of cervical vertebræ small or almost obsolete; catapophyses commencing about the sixth vertebra; catapophyses never forming a ring; diapophysial lamella extending towards posterior zygapophysis, small

and inconspicuous; a conspicuous fossa on either side of preaxial part of neural spines either of the cervical or else of the dorsal vertebræ; sacral vertebræ plainly distinct from sacro-caudal vertebræ; ilium and ischium united or not; postaxial part of ilium not bent much ventrad; interobturator processes meeting; ischium joins pubis; either an ischiatic or a pubic symphysis; ischium not diverging much ventrad from ilium; marked ilio-pectineal processes; ischium not broad; pubis not very slender; skeleton of tail not broadening out medianly; sacrum narrow; distal articular surfaces of sternal ribs each in two parts; coracoid-grooves large; lips of each coracoid-groove subequal; no median sternal preaxial process.

## CHARACTERS OF *STRUTHIO*.

Total number of vertebræ fifty-six; cervical vertebræ seventeen; vertebræ with ribs ten; no lumbo-sacral vertebræ; sacro-caudal vertebræ eight; preaxial articular surface of atlas with a large dorsal notch; hyperapophyses of atlas moderate; hypapophysis of axis rather small; neural spine of axis moderate; neural spines of cervical vertebræ small but not obsolete; no neural spines bifurcating laterally; no neural spines aborted; hypapophysis developed from the eighteenth (first cervico-dorsal) to the twenty-first (first dorsal) vertebra; hypapophyses but little produced preaxially; a conspicuous fossa on each side of preaxial part of neural spines of dorsal vertebræ, but not of cervical; cervical ribs long and styliform; dorsal and dorso-lumbar neural spines but little axially extended, but considerably extended dorso-ventrally and not subequal in height; sacro-caudal vertebræ not at all raised dorsad of acetabula, but rather depressed ventrad; sacro-caudal vertebræ perfectly ossified; sacral vertebræ plainly distinct from sacro-caudal vertebræ; no lumbo-sacral vertebræ; caudal vertebræ ten; pygostyle a laterally compressed plate; ilium and ischium not united; supratrochanteric fossa not sharp and conspicuous, and placed somewhat postaxiad of antitrochanteric process; ischium joins pubis, but not at distal end of latter; no ischiatic symphysis; ischium extends a little postaxiad of ilium; pubis extends postaxially considerably beyond ischium, as well as ilium; a pubic symphysis; acetabula not ventrad of vertebral column, so that the acetabula cannot at all be seen through when opposite each other; ribs moderately wide, curvature as described; complete ribs five; uncinate processes three, their distal ends bent at nearly a right angle to their proximal parts; sternum about as long as broad; coracoid-grooves approximated, preaxial margin convex, but with no prominent median process, costal angles moderate, five costal articular surfaces in each pleurosteon.

## CHARACTERS OF *RHEA*.

Total number of vertebræ forty-nine; cervical vertebræ fourteen; vertebræ with ribs nine; sacro-caudal vertebræ nine; three or four lumbo-sacral vertebræ; preaxial articular

surface of atlas with only a minute dorsal notch; no hyperapophyses to atlas; hypapophysis of axis not very large; neural spine of axis not very high; hyperapophysis of axis well developed; neural spines of cervical vertebræ almost obsolete; those of fourth to seventh vertebræ abort; neural spines of thirteenth to sixteenth vertebra bifurcate laterally; hypapophysis developed from the last cervical to the second dorsal vertebra; hypapophyses narrow and preaxially produced; a conspicuous fossa on each side of preaxial part of neural spines from the twelfth to the fifteenth inclusive; cervical ribs short and not styliform; dorsal and dorso-lumbar neural spines rather much axially extended and subequal in height, but not nearly as in *Apteryx*; sacro-caudal vertebræ raised quite dorsad of acetabula, also very imperfectly ossified; sacral vertebræ plainly distinct from sacro-caudal vertebræ; caudal vertebræ only five; pygostyle very small and cylindrical; ilium and ischium united, but not at distal end of ischium; supratrochanteric process sharp and conspicuous, placed preaxiad of the antitrochanteric process; ischium joins distal end of pubis; an ischiatic symphysis; ischium extends much postaxiad of ilium; pubis extends nearly as much postaxiad as does ischium; no pubic symphysis; acetabula completely ventrad of vertebral column, so that both can be entirely seen through when opposite each other; ribs moderately wide, curvature different from that of *Struthio*; complete ribs only three; uncinate processes three, very long; sternum decidedly longer than broad, coracoid-grooves not approximated, preaxial margin a shallow concavity, costal angles rather long, three costal articular surfaces in each pleurosteon.

## CHARACTERS COMMON TO *DROMÆUS*, *CASUARIUS*, *APTERYX*, AND *DINORNIS*.

Hyperapophyses of axis well developed; cervical vertebræ short; cervical diapophysial lamellæ large and conspicuous; at least one lumbo-sacral vertebra; sacro-caudal vertebræ more or less raised above ventral margin of acetabula, but not above entire acetabula; sacro-caudal vertebræ well ossified; ilium and ischium not united postaxially[1]; ischium and pubis uniting distally or not; no ischiatic or pubic symphysis; no great difference between the postaxial extensions of ilium, ischium, and pubis; acetabula more or less seen through when opposite; distal articular surfaces of sternal ribs single; no prominence on ventral surface of sternum.

## CHARACTERS COMMON TO *DROMÆUS* AND *CASUARIUS*.

Hyperapophyses of atlas moderate; neural spine of axis rather high; hyperapophyses of axis well developed; cervical vertebræ rather short; neural spines of cervical vertebræ

[1] Save sometimes in *Casuarius*.

well developed and greatly excavated postaxially; no neural spines laterally bifurcating; catapophyses commence at about the sixth vertebra; they do not form a ring; hypapophyses well developed, but not much produced postaxiad; diapophysial lamella extending towards postzygapophysis, large and conspicuous; cervical ribs moderately long and styliform; dorsal and dorso-lumbar neural spines not much axially extended, and not subequal in height; sacro-caudal vertebræ raised in part more or less above ventral margins of acetabula; sacral vertebræ not plainly distinct from sacro-caudal vertebræ; caudal vertebræ eight or nine; pygostyle cylindroidal; ilium and ischium not united, but not greatly diverging; supratrochanteric process sharp and conspicuous, placed postaxiad of the antitrochanteric process; postaxial part of ilium very convex; interobturator processes meet or closely approximate; ischium extending more or less postaxiad of pubis; ischium equals or slightly exceeds ilium in postaxial extension; ischium not diverging much ventrad of ilium; pubis extending postaxiad as much as or less than ilium; ilio-pectineal processes moderate; ischium not broad; pubis not very slender; skeleton of tail not broadening out medianly; sacrum narrow; curvature of ribs much as in *Struthio*; uncinate processes not very long; sternum longer than broad; coracoid-grooves approximated and tolerably large, lips of each groove very unequal; no long xiphoid processes.

## CHARACTERS OF *DROMÆUS*.

Total number of vertebræ fifty-four; cervical vertebræ seventeen or eighteen; vertebræ with ribs nine; sacro-caudal vertebræ nine or ten; preaxial articular surface of atlas moderately notched dorsally; hypapophysis of axis much elongated; hypapophyses developed from the eighteenth or nineteenth to the twenty-third vertebra; a conspicuous fossa on each side of preaxial part of neural spines of dorsal vertebræ; sacro-caudal vertebræ raised decidedly dorsad of ventral margins of acetabula; interobturator processes meet; ischium not joining distal end of pubis; ischium extends very slightly postaxiad to ilium; pubis extends postaxiad less than ischium, and least of all the pelvic elements; acetabula so far ventrad of vertebral column that the ventral third of both can be seen through when opposite; ribs moderately wide; uncinate processes two or three; sternum not much longer than broad, preaxial margin with a median prominence, this prominence very slightly notched medianly, no postaxial median prominence; costal angles very long and singular, bent inwards; three or four costal articular surfaces in each pleurosteon.

## CHARACTERS OF *CASUARIUS*.

Total number of vertebræ from fifty-five to fifty-nine; cervical vertebræ fifteen or fourteen; vertebræ with ribs eleven or twelve; sacro-caudal vertebræ eight or nine; preaxial articular surface of atlas moderate, may become a foramen; hypapophysis of

axis extremely long; hypapophyses developed from eighteenth to twentieth vertebra; fossæ beside preaxial part of dorsal neural spines very small; sacro-caudal vertebræ raised scarcely at all dorsad of acetabula; postaxial part of ilium more convex; interobturator processes nearly meet, if not quite; ischium joining or not joining pubis; ischium extends as far postaxiad as ilium; pubis extends back as much as ilium; acetabula only so far ventrad of vertebral column that a minute portion of both can be seen through when opposite; ribs very wide, more straight than in *Dromæus*; uncinate processes about three, but may be absent; sternum very much longer than broad, no median prominence to preaxial margin, obtuse median postaxial prominence, a very deep median pit between coracoid-grooves, costal angles short, pleurosteon with four or five costal articular surfaces.

## CHARACTERS COMMON TO *APTERYX* AND *DINORNIS*.

Cervical vertebræ fifteen; vertebræ with ribs nine; hyperapophyses of axis large; neural spines of axis lofty; hyperapophyses of axis moderate or extremely large; cervical vertebræ short; neural spines of cervical vertebræ generally more or less well developed; catapophyses may form a ring; diapophysial lamella extending towards postzygapophysis, large and conspicuous, or extremely so; cervical ribs moderate or small; sacro-caudal vertebræ slightly raised dorsad of ventral margin of acetabulum; ischium and pubis uniting distally or not; supratrochanteric process absent or inconspicuous; postaxial part of ilium inclined somewhat ventrad; interobturator processes very slightly developed; ischium and pubis diverging from ilium postaxially very greatly ventrad; ischium very broad, especially postaxiad; pubis more or less slender; acetabula so far ventrad of vertebral column that their ventral halves, or more, can be seen through when opposite; fossa on each side of lumbo-sacral vertebræ conspicuous; sternum broader than long; coracoid-grooves minute, very slightly marked and widely separated; no median process projecting from preaxial margin of sternum, costal angles moderate, long median and lateral xiphoid processes.

## CHARACTERS OF *APTERYX*.

Size much smaller than that of any other known genus of Struthionidæ. Total number of vertebræ from forty-five to forty-seven; sacro-caudal vertebræ three; preaxial articular surface of atlas scarcely at all notched dorsally, hyperapophyses very long; a minute hypapophysis to atlas; no hypapophysis to axis; neural spine of axis very high; hyperapophyses of axis extremely large; cervical neural spines not bifurcating laterally; catapophyses commence at the fifth vertebra; in the tenth and eleventh vertebræ they form a ring; hypapophyses developed from the twelfth cervical to the third dorsal

vertebra; hypapophyses not largely developed relatively; diapophysial lamella extremely large and conspicuous, developing conspicuous postaxially extending processes; cervical styliform ribs small; dorsal and dorso-lumbar neural spines exceedingly extended axially and subequal in height; spine of last cervical greatly more extended dorso-ventrally than that of its preaxial predecessor; sacral vertebræ plainly distinct from sacro-caudal; sacro-caudal vertebræ bent much ventrad of ilia; caudal vertebræ seven or nine; pygostyle conical; supratrochanteric process absent; ilia diverging ventrad at a very obtuse angle; interobturator processes absent or rudimentary; pubis exceedingly slender; ischium extending as much or slightly more postaxiad than ilium; pubis extending postaxiad slightly more than ischium; ilio-pectineal processes very largely developed; skeleton of tail broadened out medianly; sacrum narrow; vertebral ribs exceedingly wide, far wider relatively than in any other genus of Struthionidæ; uncinate processes seven, and very large; fossæ beside lumbo-sacral vertebræ, linear; preaxial margin of sternum gently concave, no sharp or deep median notch, pleurosteon with four articular surfaces for sternal ribs.

## CHARACTERS OF *DINORNIS*.

Hypapophysis of axis probably large; hyperapophyses of axis moderate; neural spines of cervical vertebræ well developed and deeply excavated postaxially; neural spines of fourth, fifth, sixth, and seventh cervical vertebræ bifurcating laterally; catapophyses commencing at the fourth vertebra; hypapophyses commence at fifteenth (last cervical) vertebra; diapophysial lamella extending towards postzygapophysis, large and conspicuous; cervical ribs probably moderately long and rather styliform; dorsal and dorso-lumbar neural spines not much axially extended, and probably not subequal in height; sacro-caudal vertebræ not bent ventrad of ilia; spine of last cervical not greatly more extended dorso-ventrally than that of its preaxial predecessor; sacral and sacro-caudal vertebræ not plainly distinct; ilia not diverging ventrad at a very obtuse angle; interobturator processes present and approximating; ischium and pubis unite slightly at their distal ends; ilium more postaxially extended than either ischium or pubis; ilio-pectineal processes very little developed; pubis not extremely slender; sacrum broad; supratrochanteric processes inconspicuous; ribs very narrow and straight; no uncinate processes (?); fossæ beside lumbo-sacral vertebræ, large and subcrescentic; preaxial margin of sternum straight and rounded, only two or three costal articular surfaces in each pleurosteon, which is very small outside of and postaxial to each costal angle.

## SUMMARY AND CONCLUSION.

On reviewing the characters hereinbefore given, it will, I think, appear that the axial skeleton of *Dromæus* presents us with the least specialized and differentiated type, round which, as it were, cluster the genera *Casuarius*, *Apteryx*, and *Dinornis*, which all agree with the Emu in differing from both *Struthio* and *Rhea* in the much less elongated condition of their cervical vertebræ, as well as the greater ruggedness occasioned, in those bones, by the great development of the various processes and the diapophysial ridges. They also all differ from the two genera last named in the absence of either a pubic or an ischiatic symphysis, and in the nearly equal projection postaxiad of ilium, ischium, and pubis, all three. In these two latter characters the pelvis resembles the undeveloped condition of the pelvis in the young of *Struthio* and *Rhea*. Again, the four genera first named agree in not having more than one articular surface at the distal end of each sternal rib, and in not having any prominence on the ventral surface of the sternum.

Again, it will, I think, be admitted that the genera *Dromæus* and *Casuarius* seem, thus considered, to be very closely allied, while *Dinornis* exhibits a considerable affinity to *Apteryx*, although intermediate between the last-mentioned genus and *Casuarius*. Thus the New-Zealand genera agree to differ from the others in the divergence postaxially of the ischium and pubis from the ilium, in the considerable expansion of the distal end of the ischium and the greater slenderness of the pubis. They also differ in that the supratrochanteric process is absent or inconspicuous, in the more ventral situation of the acetabula in relation to the sacro-caudal vertebræ, as also in the excess of the breadth of the sternum over its length, the minuter size of the coracoid-grooves and their remoteness one from the other, as also in the presence of long median and lateral xiphoid processes.

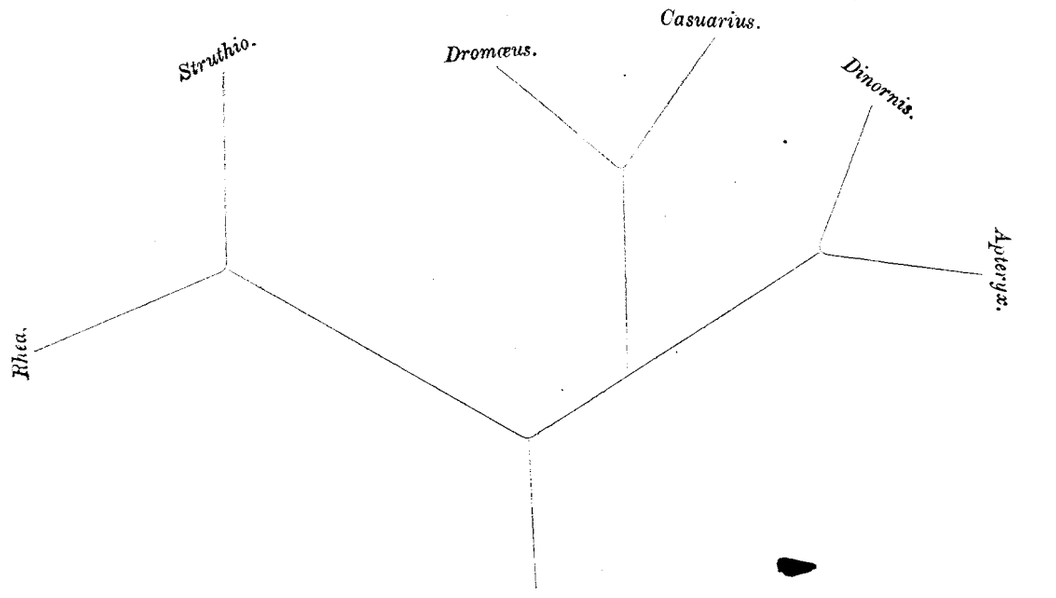
Of the two genera *Struthio* and *Rhea*, the latter seems especially aberrant in the abortion of the sacro-caudal vertebræ, and in carrying those characters in which the cervical vertebræ generally of *Struthio* differ from the other Old-World forms to a still greater degree. Thus, while *Rhea* seems the most aberrant genus in one direction (judging, of course, from the axial skeleton only), *Apteryx* seems the most divergent in another.

These affinities seem to agree, in the main, with those pointed out by Professor Garrod [1], who represents *Struthio* and *Rhea* as agreeing to differ from the other existing

[1] P. Z. S. 1874, p. 120.

Struthionidæ in having long sacculated cæca coli and no aftershaft to the contour-feathers; while *Apteryx* differs from *Casuarius* and *Dromæus* in having the cæca coli well developed, an extra femoro-caudal muscle, and an ambiens of extra size.

Fig. 44.




The affinities of the Struthious genera, as manifested by their axial skeleton, may, perhaps, then, be represented as shown in the accompanying diagram (fig. 44).