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Phil. Trans. R. Soc. Lond. B 1888 **179**, 385-398
doi: 10.1098/rstb.1888.0014

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XIV. *On the Structure and Development of the Wing in the Common Fowl.*By WILLIAM KITCHEN PARKER, *F.R.S.*

Received January 13,*—Read January 27, 1887. Revised June 18, 1888.

[PLATES 62–65.]

INTRODUCTION.

OF late years, while the structure of the skull has greatly occupied me, the rest of the skeleton has been neglected in comparison. A quarter of a century ago, or more, the whole skeleton, in Birds especially, occupied much of my thought; and from an even earlier period I have never ceased to gather together embryos and young Birds of all kinds, which should some day serve for a renewal of the work.

In this short paper, dealing with a single region, and that principally in a single type, I give the first-fruits of a revised study of the Bird's skeleton. Many recent workers have dealt with the development of one part or other of the Bird's wing; but it seemed to me that we had from none of them a minute account of the successive changes in any one form. And now, having made such a study, I think I have not failed to draw some new facts from it.

I have carefully worked out the structure of the carpus in the Chick of seven days and older. I find that the two persistent carpals of the Bird's wing, the *radiale* and *ulnare* of authors, show evidence of being compound structures, probably containing within themselves remnants of an *intermedium* and a *centrale*. The distal row of carpal elements was particularly in want of further study. I have figured various stages in the development of the three elements which constitute it, and have traced them up to their final vestigial rudiments in the co-ossified "carpo-metacarpus" of the adult. All these points I have verified by an examination of many other, principally Gallinaceous, Birds.

Next, I have traced the development of the three metacarpal bones, with their changes in form and in position. In connection with them I find certain small cartilaginous elements, which soon lose their independence, but leave traces in the full-grown wing, viz. (*a*) a cartilage to the radial side of the first metacarpal, in the position occupied by the spur of many Birds, which calls to mind the *pre-pollex* described by

* Under the title "The Morphology of Birds" (see 'Proceedings,' vol. 42, p. 52).

BARDELEBEN, KEHRER, and others, in Amphibians, Reptiles, and even Mammals; (b) a cartilage to the ulnar side of the third digit, which probably is a remnant of the aborted fourth digit; and (c) certain cartilages of more doubtful nature developed in connection with the index finger, to its ulnar side, and afterwards fusing with it.

Lastly, I have made new observations on the small distal phalanges in the Fowl and other Birds, and on the rudimentary nails or claws of the second and third digits; and I have added a short revision of the structure of the wing through the Ratitæ.

Since GEGENBAUR* spoke the last weighty word upon the structure of the Bird's wing, no new facts have transpired to make us re-open the question of the homologies of the three digits with the pollex, index, and medius of other groups. Nothing in the skeleton, the muscles, or the development of the limb contradicts this acceptance, to the best of my knowledge. I take it for granted accordingly in this paper.†

The Development of the Carpus.

In the seven-days Chick, the hyaline cartilages of the wrist are still somewhat indefinite in outline, and imperfectly solid.

The elements which form subsequently the two permanent carpals are clearly visible (Plate 62, fig. 1, *c.u.*, and *i.r.*), and are developed in close relation with the extremities of the radius and ulna. The one to the radial side is very much the largest, as well as the most solid, of the carpal elements at this stage. Its distal end gives support to the pollex, and proximally it passes upwards in a great wedge between the radius and ulna. In the Fowl this element is from the first single, yet its shape and position at this period suggest that it contains in itself the equivalent of an *intermedium* as well as of a *radiale*. In certain Birds, *e.g.*, the Falcons, I have found that it actually divides afterwards into two sub-equal masses, and in one Bird at least, the Yellow Warbler (*Dendraca aestiva*), the *intermedium carpi* has been already figured‡ in such a position as to indicate its severance from the *radiale*. I look, then, upon the so-called *radiale* of the Fowl's wing as really a compound structure, and shall designate it as *intermedio-radiale* for the future.§

The element on the ulnar side, the *ulnare* of the adult, is a much smaller, sub-crescentic mass of cartilage, lying to the free side of the pointed extremity of the ulna, but wedging its way, towards the middle line of the carpus, into contact with the *intermedio-radiale*. The "ulnare" is known to have in many Birds a remarkable extension towards the centre of the carpus, and in some cases it has been found to be actually double. Long ago I found in one of the Palamedeæ, *viz.*, *Chauna chavaria*,

* 'Carpus u. Tarsus,' 1864.

† This view is however dissented from by OWEN, WYMAN, and COUES.

‡ MORSE, 'Annals Lyceum Nat. Hist., New York,' 1874, p. 146, fig. 44.

§ Both in this Bird and in the seven-days Chick we notice especially how the intermedial element is *wedged far up* between radius and ulna, as GEGENBAUR found it in *Menopoma*, *Emys*, and some others, but more abundantly in the hind limb.

two *ulnar carpals*, apparently an *ulnare* proper and a *centrale*. More recently, in a more normal Chenomorph, the Falkland Island Goose (*Chloëphaga poliocephala*), I found the ulnare nearly divided into two segments. And MORSE (*loc. cit.*) has already figured in the King-bird (*Tyrannus*) an independent nucleus, supposed to be the *centrale*, in close relation with the *ulnare* on its outer or radial side. I am inclined, therefore, to think that this ulnar carpal in the Fowl represents, like its radial fellow, two elements; and I propose to call it the *centralo ulnare*.*

The result at which we have arrived in regard to the fusion of *intermedium* and *centrale* with *radiale* and *ulnare* respectively is a somewhat surprising one. A study of the carpus in Amphibia and Reptilia seldom, if ever, shows an arrangement of parts which would lead naturally to such a coalescence. On the contrary, the ulnare and intermedium, the radiale and centrale are the parts that come into close relation. Ulnare and intermedium fuse together, for instance, in *Salamandra*, *Triton*, and probably in many Lizards; radiale and centrale in *Emys*. On this account GEGENBAUR (*loc. cit.*) dismissed the supposition that the large *radiale* of the Crocodile, which juts up between radius and ulna, had included the intermedium with itself. But the position and relations of this element are, perhaps, worth re-examining, though BAUR† declares that no trace of intermedium (*i.e.*, no distinct centre of ossification or separate cartilage) exists in the Crocodilia at any time.‡ In the Mammalia such a fusion of intermedium and radiale ("scapho-lunar") is, of course, a common thing.

In the distal region of the carpus the Fowl shows at no period more than three separate elements. In this earliest (7-day) stage, two only are recognisable (Plate 62, fig. 1, *d.c.*², *d.c.*³). The larger of these two lies in the middle of the carpus, and is in contact both with the intermedio-radiale and the centralo-ulnare. Its distal surface forms a concavity to receive the base of the second digit. An evident crowding of cells in the embryonic cartilage towards its radial side is the beginning of the formation of the first *carpale* (*d.c.*¹), which will be seen distinctly in the next stage. The third carpale (*d.c.*³) is already distinct, lying in close relation with the base of the third digit.§

In the next stage, on the 8th day of incubation (Plate 62, fig. 2), the various carpal elements are all more solid and definite in form. The *centralo-ulnare* is becoming bilobate, and has increased considerably in relative size, so as to be little less than the

* ROSENBERG ('Zeitschr. Wiss. Zool.,' vol. 23, 1873) comes to a different conclusion; he finds in the Chick a *radiale* and an *intermedio-ulnare*, but his statements regarding the distal part of the carpus are very different from mine. His paper contains a copious bibliography, and a summary of previous authors' views.

† 'Zool. Anzeiger,' 1885, No. 208.

‡ In *Chamaeleon*, STECKER states that an intermedium is present at an early stage, but disappears without coalescing with any other element. 'Sitzber. k. Akad. Wiss.,' Vienna, 1877, Abth. 1; *cf.* Dr. GUSTAV BORN, "Carpus und Tarsus der Sauria," 'Morphol. Jahrb.,' vol. 2, 1876, pp. 1-27, pl. 1.

§ The distal row of carpalia in Birds was detected by BORN (*l.c.*).

intermedio-radiale. The three distal carpalia are now all distinct, the middle one being still the largest, the inner the least. They form an arched row with a concavity towards the manus, so that the middle metacarpal (*mc.*³) is wedged in between the first metacarpal and the third distal carpal.

Already at the end of the tenth day (Plate 62, figs. 3, 4) important changes have taken place, involving some *displacement of parts* in the carpus. The small first distal carpale (*d.c.*¹) has been arrested in its growth, and is now only one-tenth as large as the second; and it has been, so to speak, thrust out of its place by the great second metacarpal, on the flexor or inner side of which it is developed. The third distal carpale, also comparatively small, being about one-third the size of the second, belongs to the ulnar side of the wrist, where it lies, a slender rod of cartilage, at the base of the third digit, looking at this stage from its elongated form more like a metacarpal than a carpal element. Its slender distal end soon unites with the proximal end of the third metacarpal.

We may now pass over two or three stages in which other parts of the limb undergo important development, while the carpus remains little changed. At hatching the carpus is still devoid of any centres of ossification, and my first figure which shows these is that of the Chick thirty-three days old (Plate 62, fig. 10). Here we see that the *centro-ulnare* contains a large bony centre, while the *intermedio-radiale* is still purely cartilaginous. The third distal carpale shows a small bony nucleus. The small first distal carpale, somewhat increased in size, has acquired a pyriform outline, its smaller end being turned towards the pollex.

In ten or twelve days more, that is to say in the Chick of six weeks old (Plate 62, fig. 11), the intermedio-radiale has acquired a small round bony centre near its outer or radial edge; and the second or median distal carpale has a large oval core of bone. The third distal carpale is conspicuous, with a long oval bony centre.

In a Chicken three-quarters of a year old (Plate 62, fig. 12, and Plate 63, fig. 1) the wing is still far from perfect, as I have elsewhere shown to be the case of the skull also. While the Chick at hatching-time is as ripe as a Pigeon a fortnight after hatching (though proportionately much less in size), after eight or nine months of growth it is still as undeveloped as a Pigeon a month or five weeks old. The two large permanent carpal bones, those, that is to say, of the proximal row, now alone remain distinct. The second and third distal carpals have united with one another and with the metacarpus, but may still be distinctly seen from both flexor and extensor surfaces. The displaced first carpale is now ossified, and shows conspicuously as an oblong lobe of bone, placed transversely across the flexor surface of the base of the middle metacarpal.

In the full-grown Hen (Plate 63, figs. 2, 3) all the original outlines of the distal carpals have become obliterated.

A number of other Gallinaceous Birds, to which I shall refer in treating of the metacarpus, show no important discrepancies in the structure of the carpus. They

vary somewhat in the relative sizes of the carpal elements, and the period at which these ossify. In the Argus Pheasant, for instance (Plate 63, figs. 9, 10), the intermedio-radiale, which ossified late in the Fowl, contains its ossifying centre at the time of hatching, before any of the other carpal elements. In the newly hatched Partridge, both intermedio-radiale and centralo-ulnare are ossifying; in the Quail, neither; and so on. The figures show these and other points sufficiently well. But with all this variability in detail, the essential features are constant in all the forms examined; and so, though we get no great help from these Gallinaceous Birds in elucidating the compound nature of the proximal carpals, the number, position, and ultimate fate of the three distal carpals are made clear.

The Carpus in the Ratitæ.

The following is a brief review of the composition of the carpus in Ratite Birds.

In *Dromæus ater* (Plate 65, fig. 4) I can find no trace of carpal elements either in the young or adult bird.

In *Apteryx Owenii* (Plate 65, fig. 5) and *A. australis* I find no visible carpals in the adult*; the three fused metacarpals unite by a synchondrosis with the radius and ulna.

In *Casuarius galeatus* (adult, Plate 65, fig. 6) I find a small triangular *ulnare* wedged in upon the ulnar side of the wrist-joint. No other carpal element is perceptible. †

In *Struthio* (Plate 64, fig. 12) we have a much more normal wing. A very instructive preparation of the wing of a young Ostrich exists in the Hunterian Museum. Here we see the *radiale* and *ulnare* distinct and separate, and the latter already ossified. Wedged in between and below them is a mass of bone as large as both together, which represents the distal carpals. Probably it originated in the embryo in three segments; but we have no evidence here of any such displacement of the first of these as we have studied in the Carinate bird. ‡

The wing of *Rhea* has been figured in a young specimen by Dr. R. O. CUNNINGHAM. § The large distal carpal mass seems to show signs of having been in three parts, and is independent of the metacarpals. In the adult (Plate 65, fig. 1) there is to be seen on the flexor surface of the proximal end of the second metacarpal, a nodule of bone, which, from the analogy of the typical Carinate wing, may I think be the displaced

* WIEDERSHEIM ('Lehrbuch,' p. 186) speaks of a *radiale* both in *Apteryx* and *Casuarius*. OWEN also speaks of a carpal ossicle in *Apteryx*. I cannot find it in the adult. I hope that this and other points will soon be settled in the embryo of *Apteryx* by my son, Prof. T. J. PARKER.

† MECKEL found the carpus of a Cassowary containing one ossicle (*ulnare*) in one wing, and two in the other (MECKEL'S 'Archiv,' vol. 13, p. 229, 1830). STANNIUS found one invariably ('Lehrbuch,' p. 259.)

‡ ALIX describes minutely the somewhat peculiar shape of the *ulnare* in the Ostrich ("Sur l'appareil locomoteur de l'Autruche," 'Bull. de la Soc. Philom.,' 1867, also 'App. locomoteur des Oiseaux,' Paris, 1874, p. 321).

§ 'Zool. Soc. Proc.,' 1871, pl. 6A.

first *carpale*. The other two distal carpalia are quite obsolete. The *radiale* and *ulnare* are free bones, but unlike their counterparts in the Carinatae in shape. The *ulnare* is here a simple transversely elongated bone; the *radiale* is much larger, and constricted half-way across by a deep fissure or cleft. This anomaly demands further study of the embryo for its elucidation; it is not unlikely, to my thinking, that the two portions of the forked "*radiale*" will be found to answer, the smaller to the *radiale* proper, the larger and inner segment to the *intermedium*.

The Metacarpus.

Anatomists since CUVIER have generally recognised the Avian metacarpus as consisting of three coalesced elements, the metacarpals, namely, of the pollex,* index, and medius, which are all very distinctly (if rather diagrammatically) figured in the Chick by GEGENBAUR ('Carpus u. Tarsus,' Plate 3, fig. 3).

The following is an account of the growth and ossification of these elements in the Chick:—

In the Chick of the 7th day (Plate 62, fig. 1) the three metacarpals are completely separate. That of the pollex is about one-third the length of the next in order, and is unossified. The second is the largest; its middle third is ossifying; and in the same region the little rod-like bone is bowed inwards and away from the third digit to form the lanceolate space for the interosseous muscles. The third metacarpal is a little shorter than the second, and only two-thirds as thick: it also is ossifying in its middle third.

By the eighth day (Plate 62, fig. 2) the two larger metacarpals are getting a well-defined ectosteal sheath, but the pollex is still wholly cartilaginous. The metacarpal of the pollex is still opposite to its own carpale, but the other two metacarpals are as it were wedged into the carpal region, and have displaced the outer carpale.

A reference to the figures on Plate 62 will make plain the progress of ossification and the change in the relative size of these metacarpal elements. It will be seen that at the time of hatching (fig. 9) the metacarpal of the pollex is quite destitute of an osseous centre, and that, at that period, it seems to form part of the general mass of cartilage in which the distal carpals and the proximal extremities of the metacarpals have for the most part lost their independence.

In the Chick of a month old (fig. 10) the first metacarpal is well-ossified, and coalescing with its larger neighbours.

* CUVIER, 'Leçons,' 1st edit., vol. 1, p. 314. 'L'os du métacarpe porte, au côté radial de sa base, sur une apophyse particulière, ou même un petit os séparé, un os stiloïde qui tient lieu de pouce.' See also 2nd edit., vol. 1, p. 438. The *metacarpale pollicis* is treated by TIEDEMANN, WIEDEMANN, and even STANNIUS ('Wirbelth.,' p. 259) as an apophysis merely. HEUSINGER (MECKEL'S 'Archiv,' vol. 6, p. 548, 1820) calls attention to its distinctness in Raptores, and especially in Owls; he mentions having seen it almost completely separate in one- and two-day-old Pigeons, and completely separate in an Owl of about the same age.

In connection with these three well-known and generally recognised metacarpals there exist at least three inconspicuous vestiges, which I have carefully studied in the hope of finding in them evidence of missing digits. More than one author has sought, and fancied that he had found, traces of additional metacarpal elements; and I have tried to trace the development of the several structures which have seemed to others to be of this nature.

In very many Birds (most Gallinacei, many Passerines, &c.) the interosseous space between the metacarpals of the index and third finger is partially crossed by a bony process jutting out from the former bone (Plate 63, fig. 1, *mc.*^{2'}). It is connected with the insertion of the *extensor carpi ulnaris* (SELENKA; *flexor metacarpi radialis*, TIEDEMANN, HEUSINGER, &c.) This structure HEUSINGER* long ago looked upon as a rudimentary metacarpal of an aborted middle finger. He describes it as present in a more or less obvious state in almost all Birds, and he found it a distinct and separate ossicle on one occasion in a six-months-old Hen. The flattened proximal phalanx of the index, which sometimes juts forwards into a free point on its ulnar side, and is sometimes partially divided by a longitudinal groove or even by unossified vacuities,† contains, according to him, the coalesced rudiment of a phalanx of the same missing digit.

This so-called metacarpal rudiment is not to be found in the earliest Chick that I have examined, but it appears on the tenth day as a lanceolate patch of true cartilage on the ulnar side of the second metacarpal, about its own length from the proximal end of the large rod, and one-fifth of the length of the latter. Its inner side is flattened against the main rod, while its outer edge projects over the next or third metacarpal (see Plate 62, fig. 3, *mc.*^{2'}). Already by the twelfth day this structure is arrested in its development, and forms now a simple oval patch lying well between the two larger metacarpals. By the fourteenth or fifteenth day (Plate 62, figs. 7, 8) it appears smaller; in my preparation of the Chick six weeks old it is still a distinct piece of hyaline cartilage that seems to have kept pace in its growth with its larger neighbour; but it is much reduced in the young Fowl of nine months. My preparations do not show a separate centre of ossification for this process, but it must have one, at least occasionally, for besides HEUSINGER'S case in the Fowl already quoted, I have myself found it as a separate centre of bone in a fledgling of *Muscicapa grisola*. I have found it under very similar conditions in a large series of Gallinaceous Birds, but I have no evidence of its existence in Ratitæ.‡

When my abstract of this paper was read and published§ I advocated the view that

* "Beitrag zur Metamorphose des Vogel-Flügels," MECKEL'S 'Archiv,' vol. 6, 1820, p. 546. See also *ibid.*, vol. 7, p. 189.

† According to SELENKA, in *Caprimulgus, Larus, Sterna, Phaëthon* (BRONN, vol. 6, p. 76); see Note to p. 394.

‡ I see no trace of it in MARSH'S figure of *Apatornis*, the only Odontornith in which the metacarpus is well known.

§ 'Roy. Soc. Proc.,' vol. 42, 1887, p. 52; 'Nature,' Feb. 3, 1887.

this structure represented an intercalary metacarpal, though I was not then aware that the same theory had been advanced before. But I am disinclined to urge the same view now. The late development of the part, its failure usually to form an independent osseous centre, its close association with the tendon of a certain muscle, its absence in Ratitæ, above all the want of any indication in near Reptilian allies of such an aborted digit, stand in the way of accepting or repeating my theory of a year ago.

Two other vestigial structures attract attention. About the same time as the last-named rudiment appears, that is to say, about the tenth day, there is seen on the radial side of the base of the first metacarpal a piece of rather solid fibro-cartilage, which afterwards further solidifies into an arcuate nodule (*mc.*^{1'}). At the time of hatching it is still distinct and somewhat larger, and even in the Chick of six weeks old it is recognisable; but, thereafter, it fuses with the metacarpal of the pollex, helping to form its tubercle on the radial side.* This apophysis, which occupies the position of the spur† that so many Birds possess on the radial side of the wrist, may possibly be a surviving remnant of a pre-pollex. It is very constant in all the Gallinaceous Birds that I have studied, but I have not found it yet among the Ratitæ.

A third remnant appears also about the tenth day on the ulnar side of the base of the metacarpal, and towards the flexor side of the manus (*mc.*^{3'}). It lies nearly opposite the junction of the carpal and metacarpal, and is about two-thirds as long as the accessory cartilage already described on the ulnar side of the index; it consists of hyaline cartilage. On the twelfth day (figs. 5, 6) it is twice as large as on the tenth, and in shape is flattish, sublanceate, but with a broader part below. It remains perfectly distinct through all the stages of incubation. In the Chick of a month old it is still obvious, but seems to be rotating slightly towards the flexor side, towards the angle of junction of the second and third metacarpals.

This cartilage, which is very distinct, constant, and well defined, and which does not appear to be in close relation with the origin or insertion of any particular muscle, may fairly, I think, be taken as the remnant of the next missing digit on the ulnar side.‡ I find it as a separate style of bone in the Toucan, and as a bony bridge in the Cariama.

HEUSINGER (*loc. cit.*) also describes a rudimentary fourth metacarpal, but the process supposed by him to be of that nature seems rather to be the one that I have shown to represent the third distal *carpale*.

The Phalanges.

Further, I have carefully examined the developing digits of many Chicks, especially among the Gallinæ and Ratitæ, with the object of reviewing the number of phalanges

* For the insertion chiefly of the *supinator longus*.

† So remarkably developed in the Palamedeæ, certain Geese, Plovers, and Jacanas.

‡ ROSENBERG (*l.c.*) has also found evidence of an additional (fourth) metacarpal on the ulnar side. See also JEFFRIES, 'Nuttall Orn. Club Bull.,' vol. 6, p. 6, 1881.

present either in a perfect state or rudimentary, and also to determine the presence or absence of rudimentary claws on other digits besides the pollex.*

In many Birds, *e.g.*, the Passerinæ, the pollex of the first digit has only one phalanx attached to its short metacarpal, the second has two, and the third only one phalanx. In others, *e.g.*, Plovers, Gulls, Cormorants, &c., an additional or unguis phalanx is found on the first and second digits; and in some Birds, *e.g.*, *Numenius*, during the embryonic state, a small semi-distinct nucleus is seen on the end of the aborted phalanx of the third digit.† According to current statements of authors, a nail or claw is frequently found on the thumb, on the index occasionally, but on the third digit never. SELENKA ascribes a claw on the second phalanx of the pollex to most Gallinæ, many Raptores, Grallatores, and Natatores, *Hirundo*,‡ and others. NITZSCH says it is absent in the Owls, very large in *Vultur (Neophron) percnopterus*, large in the Crane, short and bent in the Stork, thinner and longer in the Herons, but absent in the smaller Egrets, present in the Solan Goose, smaller and inconstant in the Gulls and Terns. The index claw is said to exist in most Ratitæ (*Casuarius* [PERRON], *Rhea* [NITZSCH], *Struthio* [PERRAULT], *Apteryx* [OWEN]), and in *Palamedea cornuta*. I find an embryonic claw on the index finger in all the Gallinacæous Birds that I have examined, and in *Dromæus*, as well as in the Ratitæ above-named. And I find both in the young Ostrich and in *Rhea*, a small claw upon the end of the third digit.

In the seven-day Chick the diminutive fingers, formed of small, round, scarcely chondrified phalanges, are surrounded by a common web, and are all turned inwards, or towards the radial side. A notch separates the pollex from the second digit. On careful manipulation, we can see in the pollex *two* phalanges (Plate 62, fig. 1, *dg.*¹, *dg.*²), *three* in the second digit, and *two* in the third; and these numbers are not exceeded in the wing of any kind of adult Bird.

By the eighth day the distal phalanx of the third digit has already disappeared by fusion with the proximal one; the distal phalanx of the second digit is indistinct; but that of the pollex is plainer than before.

* The number of phalanges is always understated in the text-books. WIEDERSHEIM ('Lehrbuch,' p. 195) says, "Die Phalangenzahl ist eine sehr beschränkte, indem dem ersten und dritten Finger je nur eine, am zweiten zwei vorhanden sind." And the same author says elsewhere ('Biolog. Centralbl.', vol. 3, p. 656, 1884), "Die Zahl der Fingerglieder ist eine sehr beschränkte, indem *schon im Fœtus* am ersten und dritten Finger je nur eine, am zweiten nur zwei zur Anlage kommen, und auch später in derselben Zahl persistiren!" OWEN ('Comp. Anat.') gives a similar account of the general condition, but describes the Ostrich correctly as an exception. STANNIUS ('Lehrbuch,' pp. 259, 260) mentions the occasional presence of a second phalanx in the pollex, and a third in the index, but without specifying instances (Cf. NITZSCH, 'Osteogr. Beitr.', p. 89). SELENKA (BRONN, vol. 6, p. 75, 1869) states that a second phalanx occurs in the pollex of Diurnal Raptores, Gallinacæ, most Grallatores and Natatores, and *Cypselus*; and a third in the index of *Anser*, *Cygnus*, *Anas*, *Mergus*, *Colymbus*, *Scolopax*, *Grus*, *Struthio*. ALIX mentions a third phalanx in the index of the Tinamou ('App. locom', p. 323).

† BRONN, 'Klassen u. Ordnungen,' vol. 6, p. 75.

‡ This statement appears to be copied from NITZSCH, 'Osteographische Beiträge,' 1811, "Ueber das Nagelglied der Flügelfinger," pp. 98-97; and *Hirundo* is a mistake of the transcriber for *Cypselus*.

On the tenth day the pollex is still larger proportionately than in its adult condition. The proximal joint has a thick shoulder like its own metacarpal, to which it is hinged by a very perfect condyle; its middle third (or nearly) has a long shaft. The distal joint is no longer a flat sub-discoid part, but is a long and slender *claw core*, one-third as long as the proximal joint; it is beginning to be covered with horn. The first of the three phalanges of the second digit is very thick at its radial edge, and is bevelled at its ulnar, which is somewhat notched to receive the third digit.* The terminal phalanx is a small curved segment, ready to become the core of a claw.

The proximal phalanx of the third digit is one-half the length and one-third the width of that of the second.

On the twelfth day the claw-segment of the pollex is not so well developed, and that of the index is indistinct.

Passing to the young Fowl, three-quarters of a year old (fig. 12), we find the distal phalanx of the pollex now forming the bony core of a claw. That of the index is a mere rough point, without a separate bony centre, and that of the third digit has disappeared.

In the Partridge, on the fourth or fifth day of incubation, a claw is also to be seen on the distal phalanx of the pollex, which, however, is unossified.

In the ripe embryo of the Quail, the claw of the pollex is distinct; the distal phalanx of the index is scarcely separate; and the third digit has only a single phalanx.

In a ripe embryo of *Gallus Sonneratii*, the distal phalanx of the pollex is a well-developed unguis, with a horny sheath or claw.

In the Turkey (embryo, half ripe), the distal segment of the pollex has a spatulate form, which form in *Phasianus versicolor* (two-fifths ripe) (Plate 63, figs. 4, 5) appears as a sub-circular disc. In the latter species, the distal segment of the second digit also is an oval flat plate of cartilage. This state of things, with more or less dilatation of the distal segment *before* the nail-sheath is developed, is constant in the Carinatae.

In the Silver Pheasant (Plate 64, fig. 1), the claw on the pollex is not formed at the time of hatching, nor are the distal segments distinct in the other digits.

Metacarpus and Phalanges in Ratitæ.

Of all existing Ratitæ the wing is most degraded in the Emeu, which in this respect approaches most nearly to the recently extinct *Dinornis*, in which no trace of a wing has yet been found. In a six weeks old Emeu chick the first metacarpal is about

* I have more recently found that in some Birds, at least in the Gulls, Auks, and Guillemots, this flattened portion on the ulnar side of the first phalanx of the index, to which some of the primary quills are attached, does develop from a distinct tract of true cartilage. It soon loses its independence. (See 'Roy. Soc. Proc.,' vol. 43, 1888, pp. 322-325; and 'Nature,' Feb. 2, 1888.) (*Of. supra*, p. 391.) I have also shown that in long-winged Birds an additional accessory cartilage is present near the *ulnar side* of both the first and second digits, near their end. In that paper, p. 323, line 16 from the top, for "arm" read "also"; and p. 324, line 4 from the top, for "*policephala*" read "*poliocephala*."

half the length of the second, and ends close to it in a point; the index finger possesses the normal number of phalanges, namely three, the last of which is enclosed in a sharp and curved claw. In the old bird (Plate 65, fig. 4) the three phalanges and claw of the index are still distinct, but the metacarpal of the first is very small, and that of the third is suppressed. The wings of an adult are about the size of those of a Jay or a Bower-bird; in the young chick, with legs the size of those of a Turkey, the wings are no larger than a Wren's.

In the Cassowary (*Casuarus galeatus*), Plate 65, fig. 6) there is an evident third metacarpal fused with the second and first, and larger even than the second, the three rays being marked off by fissures. More perfect than the Emeu in this, it is yet less perfect in having only two phalanges in the index, of which the distal one is covered with a strong claw, curving towards the ulnar side.*

In *Apteryx Owenii* (Plate 65, fig. 5) the first metacarpal, less than half the size of the second, ends in a free point, as in the Emeu. Near the distal end, on the ulnar side, the large second metacarpal has a thin flange, which may be the masked rudiment of the third—a condition very different from that which we have just seen in the Cassowary. The index finger has *only* two short phalanges, and the falcate distal one bears a sharp curved claw.

In the Hunterian preparation of a young Ostrich's wing already referred to (Plate 64, fig. 12), the pollex has two phalanges, the index three, and the third digit two,† a number very uncommon among the Carinatae. *Each digit possesses a claw*, that of the third digit being very small.‡

In *Rhea* (Plate 65, fig. 1) the first metacarpal is one-third, and the third almost three-fourths, the length of the second. The third metacarpal extends beyond the second, as in Carinatae. The first digit only is perfect in the adult, and has a well-formed claw. The second has two phalanges, of which the first has the usual flange on the ulnar side, and the second has a small claw. Inside the claw there probably was in the embryo the normal third phalanx. The third digit has one phalanx, flat and twisted; also a very small claw, in which doubtless the embryo had a second phalanx.

* D'ALTON ('Skel. d. straussartig. Vögel,' 1827, p. 17), MERREM ('Abh. d. Berliner Akad.,' 1816-17, p. 179), and MECKEL ('Archiv,' vol. 13, p. 231) give the same number of phalanges for the Indian Cassowary; and all agree in finding no trace of the first and third digits. Recently, however, I have dissected and figured the wing of a ripe embryo of *Casuarus Bennettii*, and find, besides two proximal and one distal carpal—the latter *in three lobes*, a small first metacarpal and a larger third metacarpal, and *three* phalanges attached to the large second metacarpal.

† These two phalanges in the third digit of the adult bird are recorded by ALIX ('Appareil locomoteur,' p. 323). See also the same author's "App. locom. de l'Autruche d'Afrique," 'Bull. de la Soc. Philomath.,' 1867. OWEN describes the same number of phalanges in the young bird, probably from the same specimen ('Comp. Anat.,' vol. 2, p. 73), but overlooks the claw of the third digit.

‡ Neither NITZSCH nor HUXLEY admits more than two claws. The cartilage may grow beyond the second bony phalanx in the third digit (see WRAY, 'Zool. Soc. Proc,' 1887, pp. 283-284, fig. 1).

LIST OF ABBREVIATIONS.

- c.u.* Centro-ulnare.
*d.c.*¹ First or radial distal *carpale*.
*d.c.*² Second distal carpale.
*d.c.*³ Third distal carpale.
*dg.*¹ First or proximal phalanx.
*dg.*² Second phalanx.
*dg.*³ Third phalanx.
h. Humerus.
i.r. Intermedio-radiale.
*mc.*¹ First metacarpal, or metacarpus pollicis.
mc.^{1'} Accessory cartilage of ditto (pre-pollex?).
*mc.*² Second metacarpal, or metacarpus indicis.
mc.^{2'} Accessory cartilage of ditto.
*mc.*³ Third metacarpal.
mc.^{3'} Accessory cartilage, probably a rudimentary fourth metacarpal.
r. Radius.
rd. Radiale.
u. Ulna.
ul. Ulnare.

DESCRIPTION OF THE PLATES.

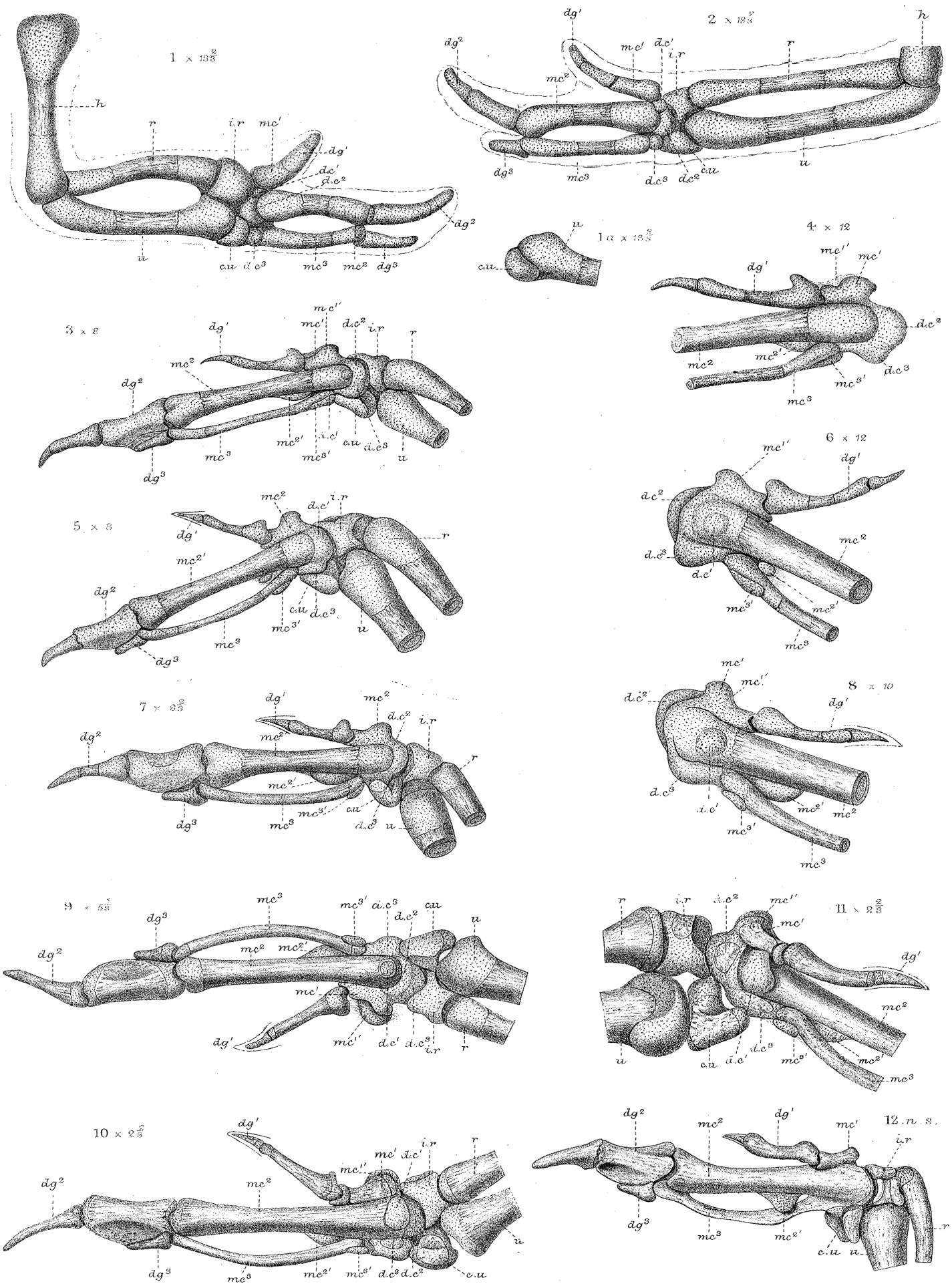
N.B.—Figs. 7–10 of Plate 65 will be described in a future paper; the whole of this piece of research is referred to in the “Abstract” (‘Roy. Soc. Proc.’ vol. 42, pp. 52–58*), but only part is given in the present paper.

Plate.	Fig.		Number of times magnified.
62	1	Wing of Chick; 7 days' incubation; outer view . . .	$13\frac{2}{3}$
„	1A	Part of same; inner view	$13\frac{2}{3}$
„	2	The same; 8 days' incubation; outer view	$13\frac{2}{3}$
„	3	The same; 10 days' incubation; inner view	8
„	4	Part of same; outer view	12
„	5	The same; 12 days' incubation; outer view	8
„	6	Part of same; inner view	12
„	7	The same; 2 weeks' incubation; outer view	$6\frac{2}{3}$
„	8	Part of same; inner view	10
„	9	The same; 2 or 3 days old; inner view	$5\frac{1}{3}$
„	10	The same; 33 days old; inner view	$2\frac{2}{3}$
„	11	The same; 6 weeks old; inner view	$2\frac{2}{3}$
„	12	Wing of young Fowl; $\frac{3}{4}$ year old; outer view	nat. size.
63	1	Part of wing of young Fowl; $\frac{3}{4}$ year old, inner view	nat. size.
„	2	Do. of old Hen; outer view	nat. size.
„	3	Part of same; inner view	nat. size.
„	4	Wing of <i>Phasianus versicolor</i> ; $\frac{2}{5}$ ripe; outer view	8
„	5	Part of same; inner view	8
„	6	Wing of same species; nearly ripe; outer view	$5\frac{1}{3}$
„	7	Part of same; inner view	$5\frac{1}{3}$
„	8	Part of same; inner view	21
„	9	Wing of <i>Argus giganteus</i> ; ripe; inner view	4
„	10	Part of same; outer view	6
„	11	Wing of <i>Euplocamus Horsfieldii</i> ; inner view	$5\frac{1}{3}$
„	12	Part of same; outer view	8
„	13	Wing of <i>Euplocamus melanotis</i> ; $\frac{2}{3}$ ripe; inner view	$6\frac{2}{3}$

* P. 58, line 11 from bottom, for “always” read “never, so far as I know.”

Plate.	Fig.		Number of times magnified.
64	1	Wing of <i>Nycthemerus argentatus</i> ; ripe; outer view . . .	$5\frac{1}{3}$
„	2	Part of same; inner view	$5\frac{1}{3}$
„	3	Part of same; inner view	21
„	4	Wing of <i>Lophophorus impeyanus</i> ; ripe; inner view . . .	$5\frac{1}{3}$
„	5	Wing of <i>Perdix cinerea</i> ; 1 week old; outer view . . .	4
„	6	Wing of <i>Coturnix dactylisonans</i> ; ripe; inner view . . .	$6\frac{2}{3}$
„	7	Part of same; outer view	$6\frac{2}{3}$
„	8	Wing of <i>Meleagris gallo-pavo</i> ; $\frac{1}{2}$ ripe; outer view . . .	$6\frac{2}{3}$
„	9	Part of same; inner view	$6\frac{2}{3}$
„	10	Wing of <i>Gallus Sonneratii</i> ; ripe; inner view	$6\frac{2}{3}$
„	11	Part of same; outer view	10
„	12	Wing of <i>Struthio camelus</i> ; $\frac{1}{2}$ grown; outer view . . .	nat. size.
„	13	Part of 3rd digit of same	4
65	1	Wing of <i>Rhea americana</i> ; adult; inner view	nat. size.
„	2	End of 2nd digit of same	4
„	3	Part of 3rd digit of same	4
„	4	Wing of <i>Dromæus ater</i> ; adult; outer view	$\frac{2}{3}$ nat. size.
„	5	Wing of <i>Apteryx Owenii</i> ; adult; outer view	4
„	6	Wing of <i>Casuaris galeatus</i> ; adult; outer view	nat. size.
„	7	Palate, partly dissected, of <i>Dromæus irroratus</i> ; nearly ripe	nat. size.
„	8	Pelvis of embryo of <i>Casuaris Bennettii</i> ; lower view . . .	$1\frac{1}{3}$ nat. size.
„	9	The same; upper view	$1\frac{1}{3}$ nat. size.
„	10	The same; side view	$1\frac{1}{3}$ nat. size.

Parker.

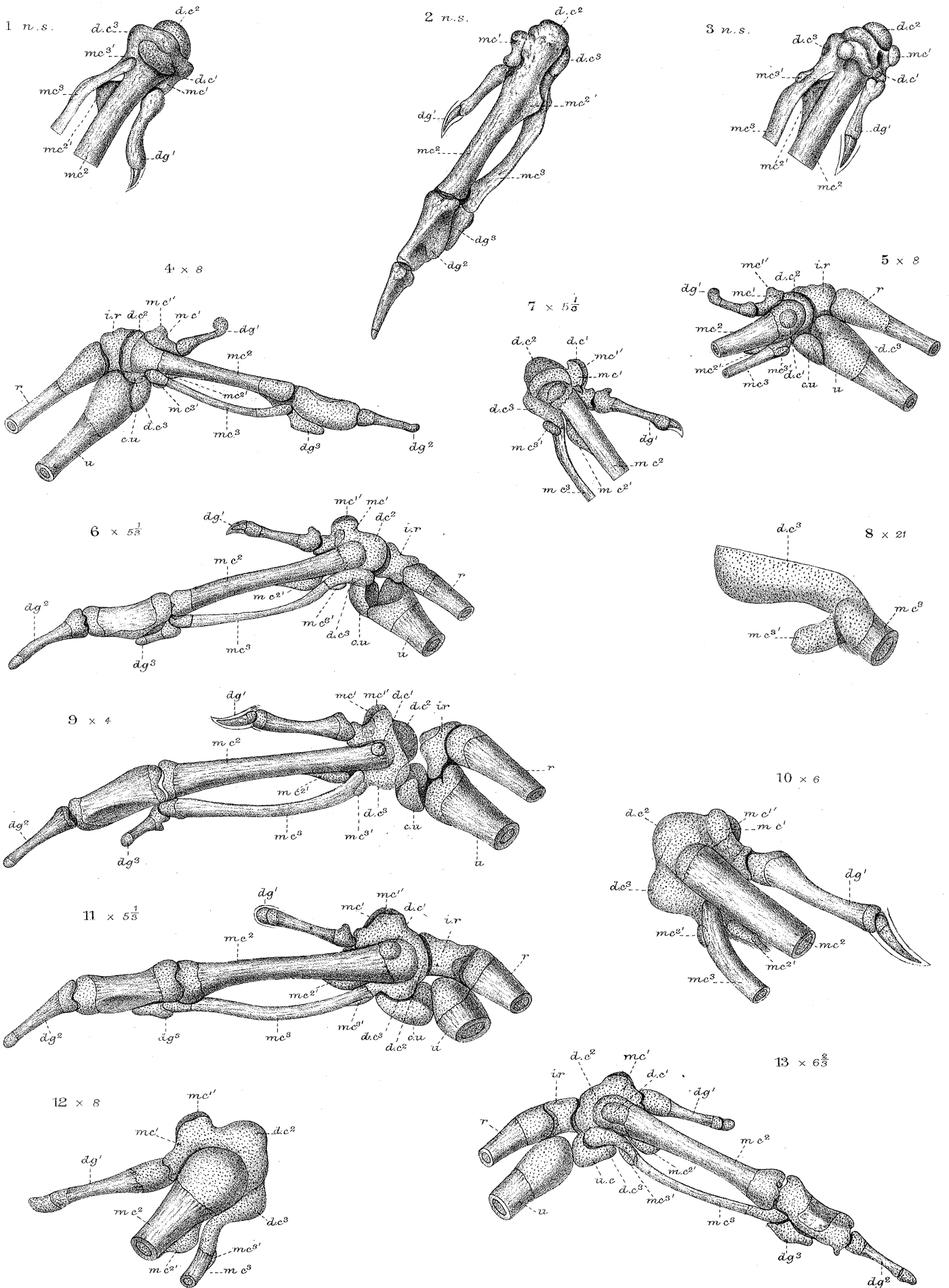


W.K.P. del. ad nat. Parker & Coward lith.

West, Newman & Co. imp.

Gallus domesticus.

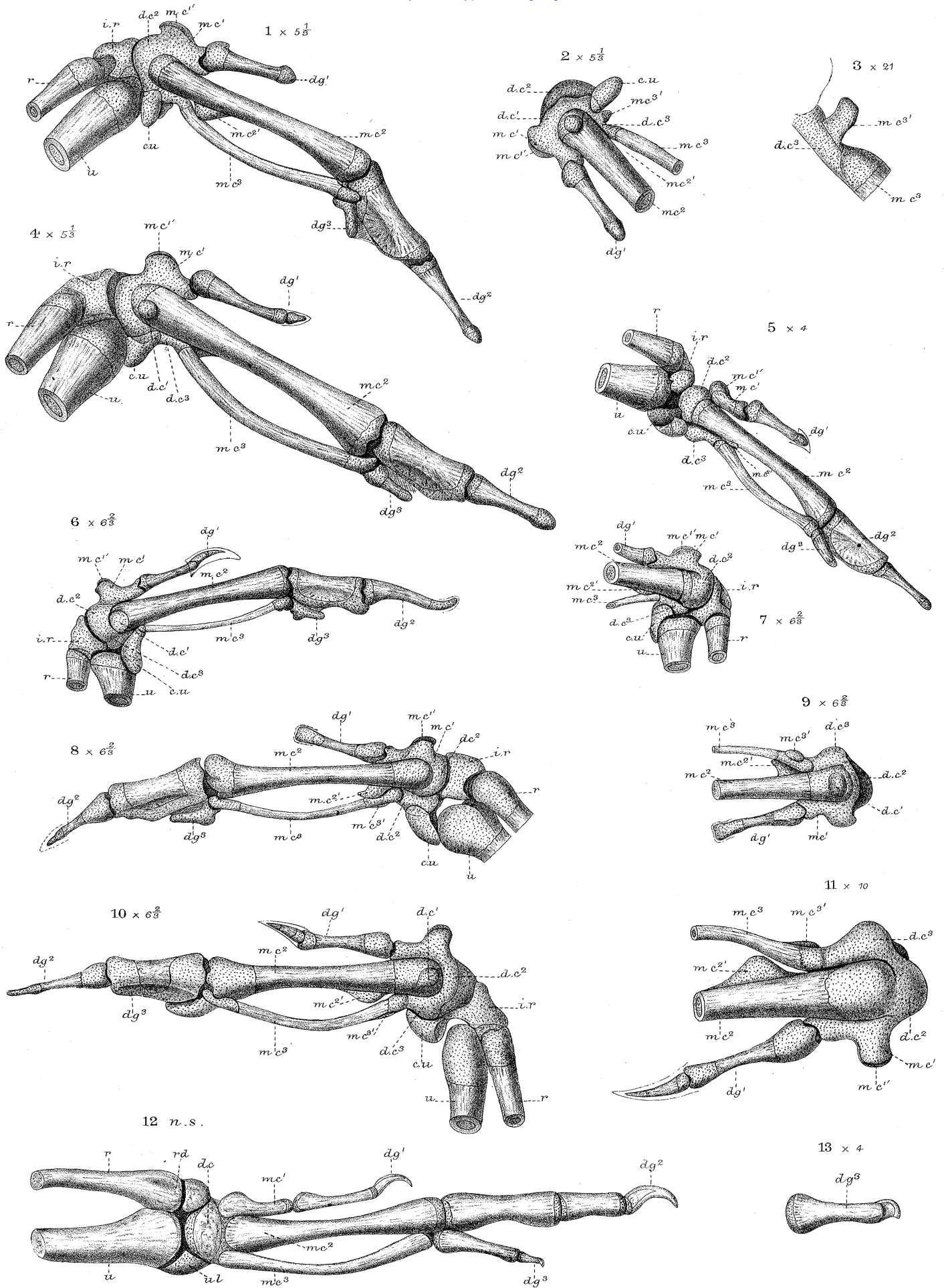
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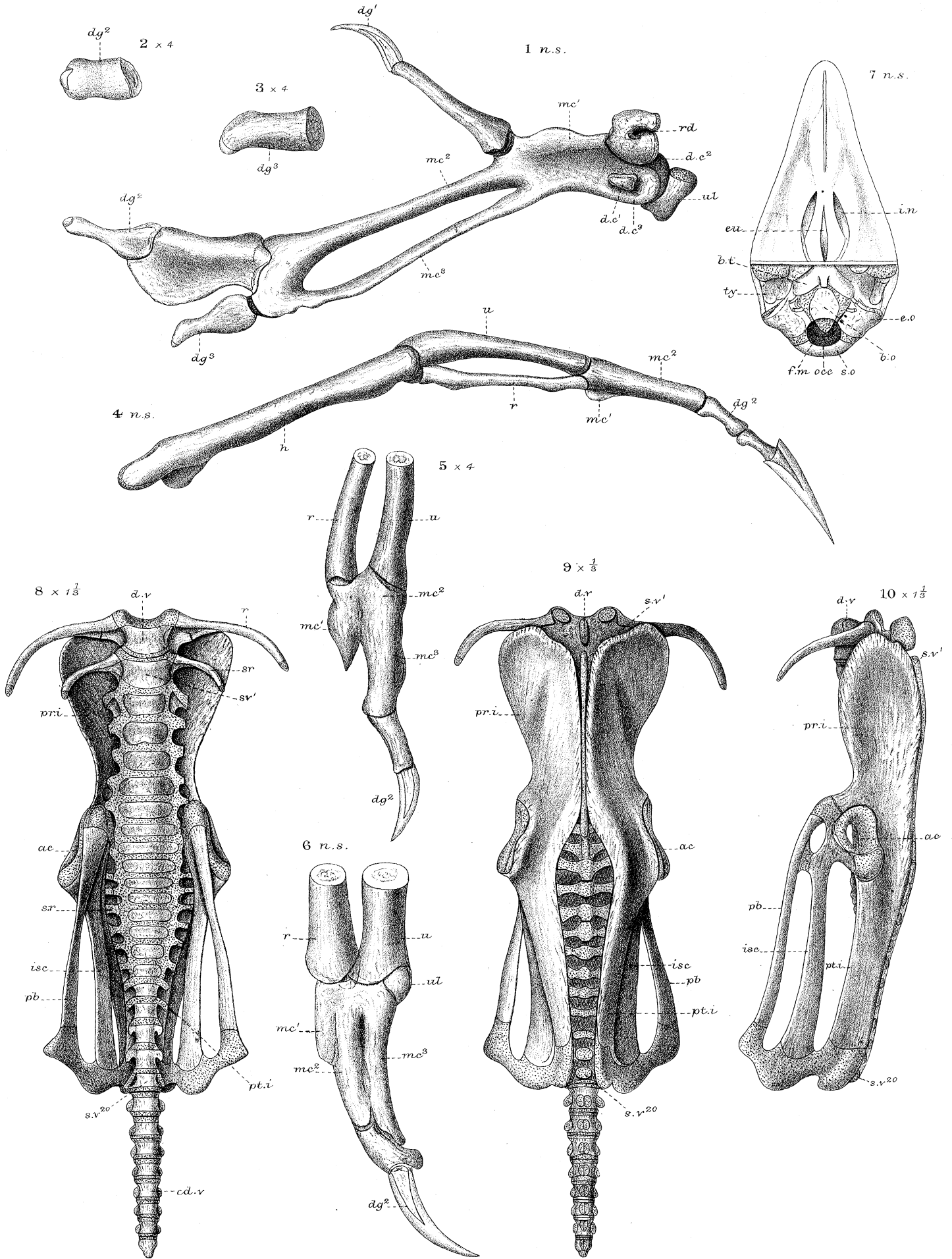
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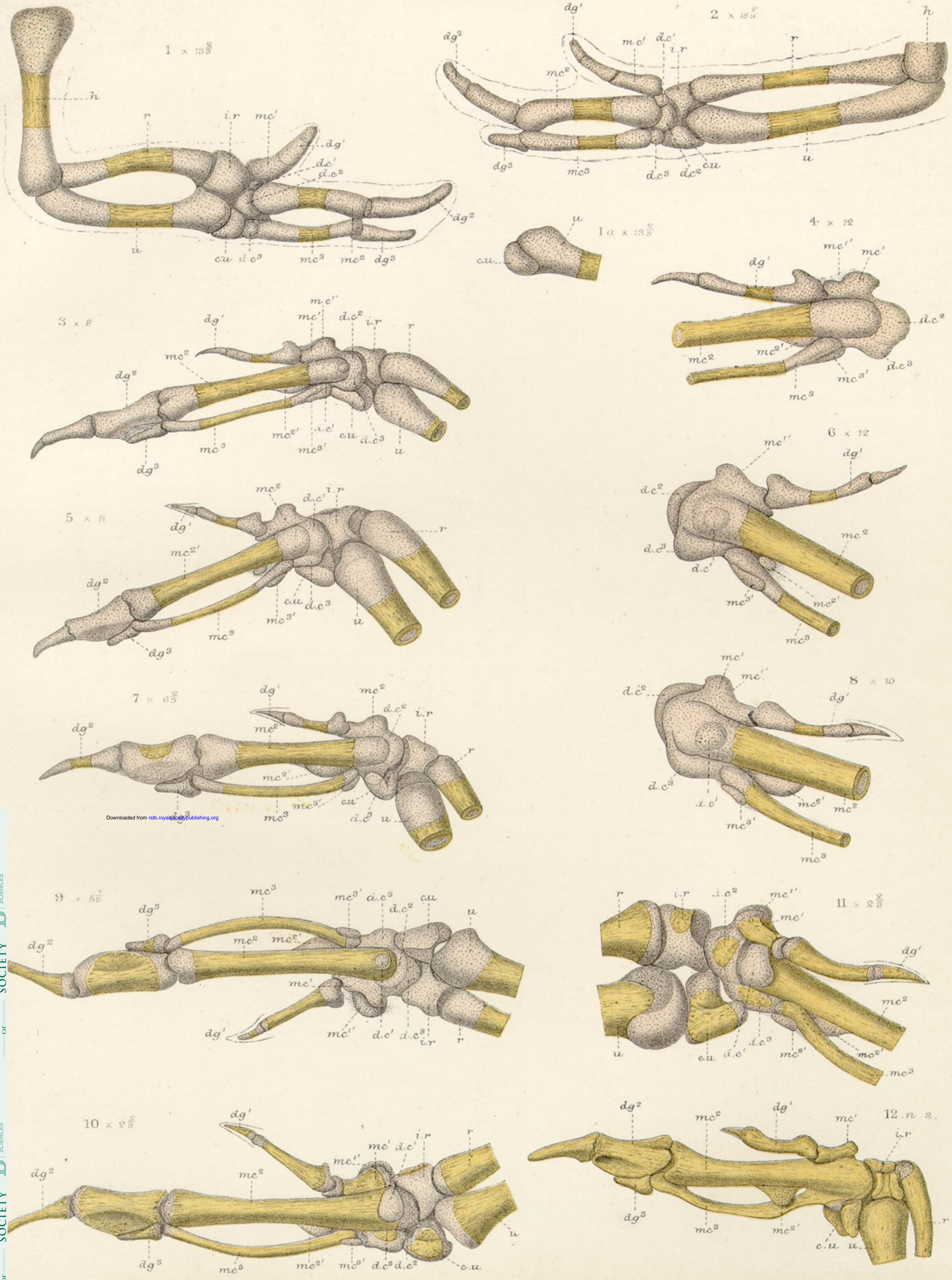
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Ratitæ.

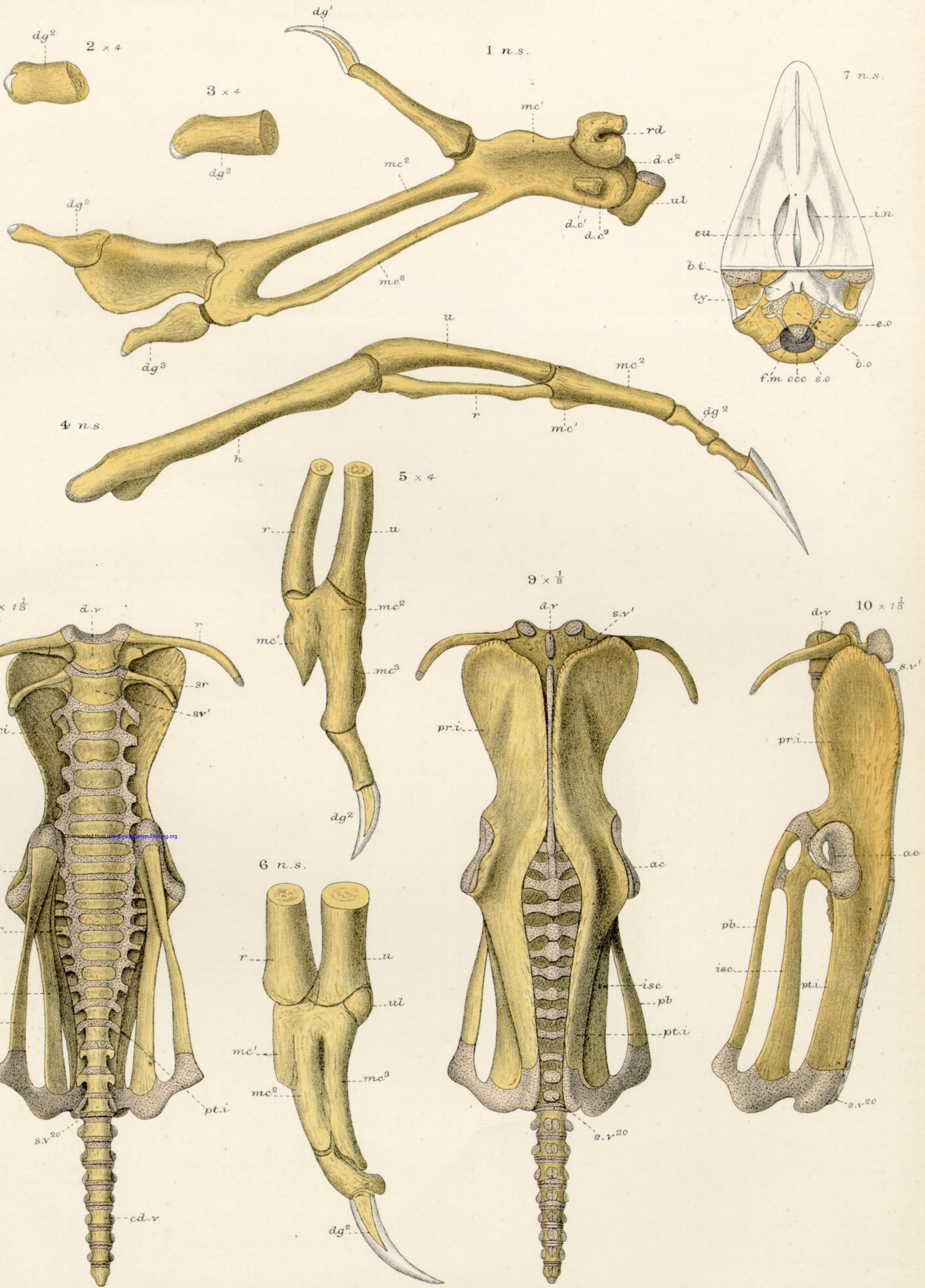
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Gallus domesticus.



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Ratitæ.