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CONTENTS:

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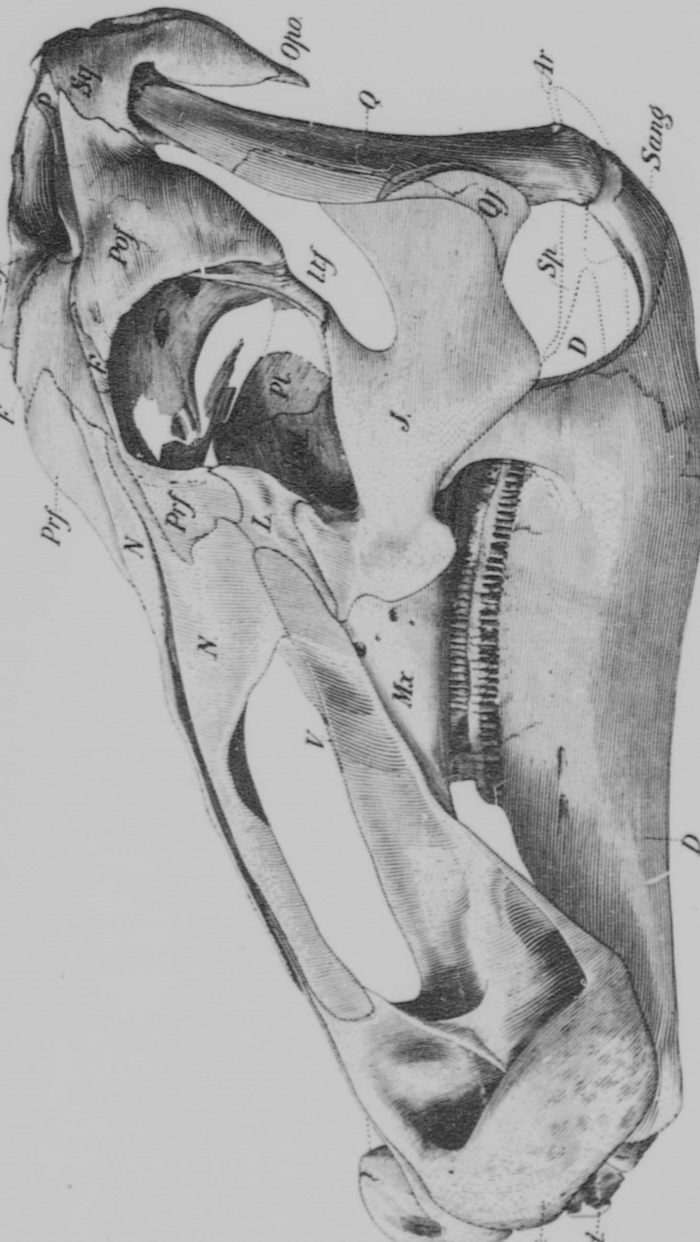
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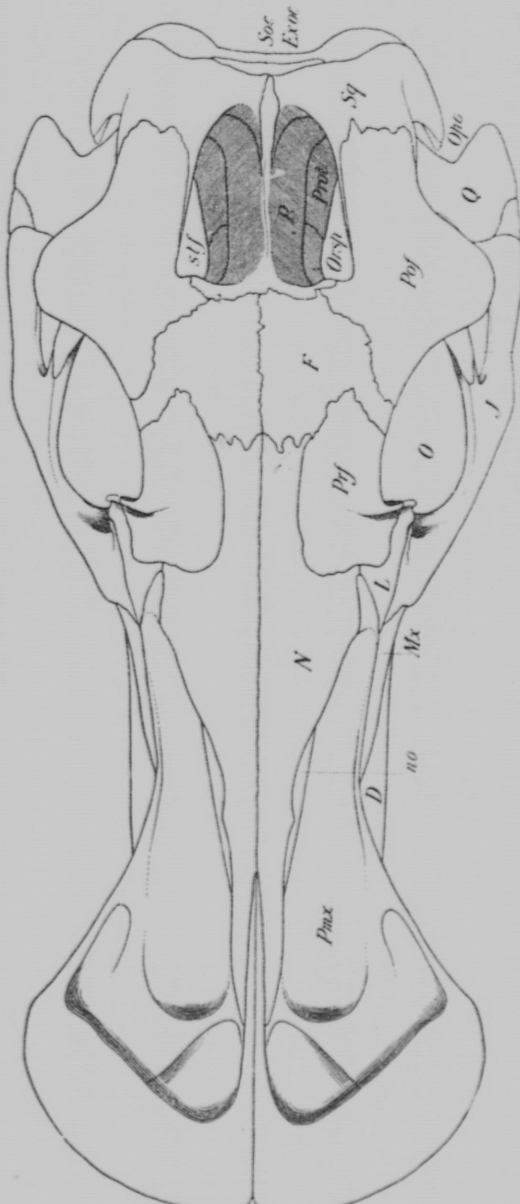
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THE OTTAWA NATURALIST

Vol. XXXI. OCTOBER, 1917. No. 7.

A NEW GENUS AND SPECIES OF CRESTLESS HADROSAUR FROM THE EDMONTON FORMATION OF ALBERTA.*

By Lawrence M. Lambe, F.R.S.C.
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The Edmonton formation of the Cretaceous as developed on Red Deer river, Alberta, although not as rich in ceratopsian dinosaurs as the earlier Belly River beds, abounds in well preserved remains of hadrosaurs belonging to such recently described genera as *Saurolophus*, *Cheneosaurus* and *Hypacrosaurus*, forms which succeeded the crested *Stephanosaurus* and *Prosaurolophus* of Belly River times.

It has become evident that a non-crested hadrosaur of large size, represented by excellent and comprehensive material in the Geological Survey collections from the Edmonton formation of Red Deer river, belongs to a genus and species not hitherto described. The purpose of this paper is to give a preliminary description of this new form, with particular reference to the skull, reserving for the future a fuller account of its osteology which the excellent state of the material will permit.

This new genus is represented in the collections by the remains of two individuals of the same size including the skull in each case.

The first specimen (type) consists of the skull (figured in plate II) with the following important parts of the skeleton:—most of the vertebræ, in place, back to the sixth caudal; one hind limb lacking a few phalanges; one humerus; both pubic bones; one ischium; the greater part of the right ilium; and some ribs. Collection of 1912, Edmonton formation, Red Deer river, Alberta, from opposite the mouth of Three Hills creek, at 200 feet above the river level. Cat. No. 2288.

The second specimen (paratype) includes:—the skull, without the premaxillaries and the predentary; all the vertebræ with the exception of those behind the fifth caudal; and the fore and hind limbs lacking some of the bones of the feet. It is possible that the right

*Communicated with the permission of the Acting Deputy Minister of Mines.

ilium is not present. The bones of this individual are splendidly preserved and occurred scattered over a small area in a gray, clayey sandstone which is easily removed, leaving the surfaces in good condition. The elements composing the top of the skull behind are preserved together otherwise the skull is naturally disarticulated. Collection of 1916, Edmonton formation, Red Deer river, from 7 miles north-west of Morrin, in sec. 16, tp. 31, R. XXI, on the west side of the river, 90 feet above the level of the river. Cat. No. 2289.

The drawings for the figures accompanying this article are the work of Mr. Arthur Miles.

EDMONTOSAURUS REGALIS gen. et sp. nov.

Type of genus and species. Skull, with the skeleton largely represented. Cat. No. 2288. Discovered by L. Sternberg.

Paratype. A nearly complete skeleton, including the skull. Cat. No. 2289. Discovered by G. F. Sternberg.

Geological horizon and locality. Edmonton formation (upper Cretaceous), Red Deer river, Alberta, Canada.

Generic and specific characters. Skull moderately elongate, high and broad posteriorly, flat in the frontal region, laterally compressed behind a low, greatly expanded snout. Orbit large. A large, pocket-like recess developed within the postfrontal, leading from the orbit. Lateral temporal fossa restricted above. Palatine and pterygoid rising, at a high angle, inward. Ectopterygoid external to the maxillary and pterygoid, connecting the two. Mandible deep and strong, very slightly decurved in front. Teeth with a rounded apical outline in lateral aspect, keeled, and with smooth borders; in 48-49 vertical rows in the dentary, and 51-53 in the maxillary. Ischium long, bluntly pointed distally. Femur slightly longer than the tibia. Humerus nearly as long as the ulna. Cervical and dorsal vertebræ opisthocœlus, in a marked degree in the former. Dorsal spines of moderate size, increasing slightly in height backward in the series. Sacrum composed of eight vertebræ. Animal of robust build, about 40 feet long.

Edmontosaurus approaches most closely *Diclonius* Cope, one of the principal characters distinguishing the two being found in the shape of the skull which in *Edmontosaurus* is high and in *Diclonius* greatly depressed. The name *Diclonius* is here reserved for *D. mirabilis* Cope, from the Lance formation of Dakota, sometimes referred to as *Trachodon mirabilis* a genus and species insecurely established by Leidy in 1856, on a tooth from the Judith River beds of Montana. No characters can at present be assigned to Trachodon beyond those derived from the single mandibular tooth which constitutes the type.

Edmontosaurus rivalled in size its bulky contemporary *Hypacrosaurus*. It appears, however, not to have been as large as *Prosaurolo-*

phus, from the Belly River formation of Alberta, if the skull in the Hadrosauridæ* can be considered a criterion of the size of the animal as a whole.

In the paratype the canium proper (brain-case), the squamosals, postfrontals, prefrontals, lachrymals and nasals are preserved together, the other elements of the skull (with the exception of the premaxillaries, predentary, vomer, and right articular which were missing) were all found in a disarticulated state, free from each other and with practically no distortion. In the type skull (figure II) the premaxillaries are in position, the vomer is partially preserved, but the predentary is badly damaged. From the two specimens, therefore, we have full information relative to all the elements of the Edmontosaurus skull except the predentary and the vomer.

The paratype reveals the exact shape of the brain cavity and the position of the cranial nerves. In it are preserved without distortion the palatines, pterygoids, and ectopterygoids, three elements of which little has hitherto been known in the Hadrosauridæ.

In plates II and III, two aspects of the skull are given showing the relative position to each other of the elements seen from these particular viewpoints.

The skull of *Edmontosaurus* is large and massive, triangular in outline as seen from the side, high posteriorly, and narrowing down to the front. As viewed from above it is broad behind and in front, and greatly constricted behind the snout. Its posterior height is greater than its half-length. Its posterior breadth slightly exceeds the full lateral expansion of the snout, and is a little less than its half-length. The orbit is large, the quadrate long, and the great development of the premaxillary bones in front, to form the horizontally expanded snout, is remarkable. Viewing the skull from the side one is impressed by the depth and robustness of the mandible.

The principal bones of the skull with some of their main characteristics are briefly as follows:—

Frontal. Rather flat, of irregular shape, longer than broad, and entering narrowly into the formation of the orbital rim. Posteriorly it meets the parietal, externo-posteriorly the postfrontal, and anteriorly the nasal and prefrontal.

Postfrontal. Of considerable size, gibbously protrudent outward, somewhat triangular in superior aspect as well as when viewed from the side. Is in contact with the frontal, parietal, squamosal and jugal, extensively overlapping the squamosal. It forms the posterior curve of the orbital rim. A remarkable feature of this bone is the development within it of a deep pocket-like recess leading back from the orbital cavity. Following the presence of this large recess the lateral

*The name Hadrosauridae proposed by Cope in 1869 (1871) has precedence to Trachodontidae used by Lydekker in 1888 and later by Marsh in 1890.

temporal fossa is restricted in its upper half-length, and the ascending process of the jugal is relegated to a position on the inner side of the pocket well-removed from the outer surface of the skull.

Prefrontal. Is in contact with the frontal, nasal and lachrymal, and forms the supero-anterior curve of the orbital rim. It overlaps the nasal to a considerable extent, and slightly overlaps the lachrymal. Its inner surface in advance of the orbital rim is excavated, leaving the bone thin.

Nasal. This bone is long and narrow, very slender in its anterior half-length, and relatively broad behind. It is in contact with the frontal, prefrontal, lachrymal, maxillary and premaxillary. Anteriorly the nasal pair are separated for about one-fourth of their length by the upper premaxillary limbs. The front termination of the bone is but slightly in advance of the anterior end of the narial opening. The contact with the maxillary is effected by a process running forward from the lachrymal contact, completing the enclosure of the posterior end of the narial opening within the nasal.

Lachrymal. Is wedge-shaped, twice as long as high, thickest behind, thin toward the front. Is in contact with the nasal, prefrontal, jugal, maxillary and premaxillary. Supero-anteriorly it is largely hidden beneath the end of the lower premaxillary limb. Its posterior border is protrudent and fully enters into the formation of the orbital rim. Above its sutural union with the jugal it lies external to and closely against the thin, elevated apex of the maxillary. In inner aspect the bone is seen to owe its posterior thickness to the development of an internal ridge which runs upward and slightly backward from the hinder end of the jugal contact and is prolonged thinly above between the nasal and the prefrontal. This ridge has a large perforation which marks the passage forward of the lachrymal canal.

Premaxillary. Consists of an anterior portion expanding outward from which are given off a long lower limb and a relatively short upper limb. The lower limb passes back over the maxillary and terminating narrowly overlaps the lachrymal and nasal. The two upper limbs separate the nasals anteriorly. The front border of the anterior expansion is recurved, roofing over an extensive cavity which opens backward on to an unevenly depressed floor. The bone does not anywhere attain any great thickness. The two premaxillaries together have an anterior breadth apparently little less than the maximum posterior breadth of the skull.

Jugal. Is long, thin, and plate-like, obtusely angulated in lateral outline below, and deeply emarginated above by the orbit and the lateral temporal fossa. It connects antero-superiorly with the lachrymal, anteriorly with the maxillary, posteriorly with the quadrato-jugal and the quadrate, and superiorly, behind its midlength, with the postfrontal by means of a long, ascending process which passes on the inner side of the inner wall of the postfrontal pocket.

Quadrato-jugal. A thin, subtriangular plate, extensively overlapped by the jugal. Posteriorly it connects with the quadrate which is emarginated to receive it.

Quadrate. A transversely compressed, nearly upright bar from whose inner surface a large, thin flange is directed inward and forward It is in contact antero-externally, below its midlength, with the quadrato-jugal, with the pterygoid internally by means of the flange, with the squamosal superiorly, and with the surangular and articular (mandibular cotylus) at its lower end. A spur from the squamosal descends on and is suturally united with the anterior border of the quadrate below its head.

Ectopterygoid. Connects the maxillary and pterygoid, lying for the most part external to both. Is longer than high, and is thin and overlapping except in a small inwardly thickened area which fits inward into the postero-maxillary notch suturally uniting the maxillary and pterygoid. It is broadest behind, where it flares thinly over the pterygoid, and extends narrowly forward in the postero-external, concave area of the maxillary. The upper and lower borders of the bone, where it begins to broaden posteriorly, fit into two grooves in the maxillary, one in the lower surface of the postero-maxillary process, the other curving downward round the posterior end of the maxillary ridge.

Maxillary. Connects suturally with the premaxillary, nasal, lachrymal, jugal, palatine, pterygoid and ectopterygoid bones. Is roughly triangular in lateral outline, highest at midlength, and thickest at about midlength below the large, rugose, external surface of attachment for the jugal. The inner face is rather flat in comparison with the varied relief of the outer one. The superior border slopes down from the apex to either end terminating in thin processes of which the anterior one is the larger. The anterior portion of the border is shallowly grooved, for a considerable distance in advance of the apical elevation, for the reception of the spur directed forward from the lower border of the nasal. The postero-superior border is in sutural contact with the lower edge of the palatine. The robust, rounded posterior end is clasped by the lowermost part of the pterygoid whose anterior border, in its upward course to reach the palatine, passes on the inner side of the postero-maxillary process. The ectopterygoid fills the emargination below this process, and extends narrowly and thinly forward for some distance in a depressed area of the external face below the postero-superior border. A less pronounced depression of the external face below the antero-superior border receives the ascending lower premaxillary limb. The teeth are in fifty-one to fifty-three vertical rows occupying about seven-eighths of the total length of the bone.

Pterygoid. Is a thin bone of complicated shape in contact with the quadrate, palatine, maxillary, ectopterygoid, basisphenoid, parasphenoid and probably the vomer. It consists mainly in its upper part of an anterior and a posterior alar extension directed upward and forward, and upward and backward respectively. Both wings are thin and narrow rapidly upward. From either end of the base a short extending spur is developed. Internally the bone is strengthened by two large flanges, united above, and diverging downward to opposite ends of the base. At the centre of the superior border, between the wings, is an inwardly facing concave surface for attachment to the process of the basisphenoid. Sutural union with the quadrate is effected by the application of the external face of the posterior wing to the inner face of the flange of the quadrate, also the posterior basal spur fits into a narrow concavity at the base of the flange of the quadrate, further strengthening the union of the two elements. The anterior basal spur curves outward and forward on the posterior end of the maxillary, and a short distance higher up the postero-maxillary process passes externally back on the anterior border. Above the maxillary contact the front edge of the anterior wing for its full height is overlapped externally by the posterior border of the palatine. Above the anterior basal spur is a moderately large surface marking the external application of the posterior expansion of the ectopterygoid. The upper end of the anterior wing is apparently applied to the parasphenoid, and probably effects a junction with the hinder end of the vomer.

Palatine. Is irregularly triangular in lateral outline, is highest in front, and narrows downward and backward to the nearly straight base. It is plate-like, and is suturally united to the maxillary, jugal and pte oid, and in position extends upward at a high angle inwardly above the postero-superior border of the maxillary. The anterior border is moderately thick and shallowly emarginated in its upper half to form the posterior border of the posterior nares. Antero-inferiorly is a roughened surface for contact with the jugal within the lower front angle of the orbit. Behind the jugal contact the palatine rests on the postero-superior border of the maxillary back to and slightly on to the posterior maxillary process. Thence forward and upward it out wardly overlaps the front border of the anterior wing of the pterygoid, rising to as great a height as that element. Infero-posteriorly it develops a thin internal process between which and the main termination of the bone the ascending anterior border of the pterygoid fits. Antero-superiorly it apparently has no connection with the vomer, the pterygoid intervening.

Vomer. This element appears to have been slender throughout and devoid of any considerable expansion. It is known in Edmontosaurus only from a small portion preserved in the type skull, plate II; the piece is over 125 mm. long and lies in the midline of the skull under the posterior half-length of the narial opening. It apparently connected in front with the maxillaries on the inner side of their anterior processes, and behind with the pterygoids on the interno-superior surface on the height of their anterior wings. It appears to have been narrow between the maxillary processes and to have had a slender termination in advance of them. Whether the vomer bifurcated behind and reached the pterygoid on either side in this manner, or united with the pair by a horizontal expansion has not been ascertained. It is estimated to have had a length in the figured skull of over 400 mm.

Angular. Is long, narrow, and thin, and is in sutural contact with the splenial, surangular, and dentary, running forward from a short distance in advance of the hinder end of the surangular, on the inner side of that bone, to a point on the dentary about in line with the midlength of the dental magazine. In lateral aspect it inclines slightly upward in one-third of its length posteriorly. Viewed from above it has a flattened sigmoid curve, suiting itself to the inner convexity of the surangular and the concavity of the lowermost part of the dentary. Superiorly, for its posterior half-length, it meets the lower border of the splenial.

Splenial. A moderately thin bone, shorter than the angular, applied anteriorly to the inner face of the dentary, and posteriorly to the inner face of the articular. Its lower border is in contact with the angular. It is deepest near the front where its superior border curves outwardly over the supero-internal termination of the dentary behind the dental magazine; farther forward it narrows rapidly to a point in contact with the dentary below the hindermost dental foramina. In the posterior two-thirds of its length it lessens but slightly in depth backward, and apparently terminated with a rounded lateral outline. It reaches farther back than the angular and is in contact with it for nearly the whole of the latter's half-length. Its inner face is moderately concave in a longitudinal direction.

Surangular. Is large and robust in comparison with the angular, splenial and articular, in conjunction with which it adds considerably to the length of the mandibular ramus, as the lowermost element of the mandible behind the dentary. It is through this bone, with a slight assistance from the articular, that the attachment of the mandible to the quadrate is effected. It articulates in front with the dentary, postero-superiorly with the articular, and laterally on the inner side with the angular. It consists of an oblong main portion, longer than broad, from which is given off antero-exteriorly a thin, ascending process. Anteriorly it overlaps the thin, lower posterior termination of the dentary. Postero-internally the main portion of the bone extends thinly backward, facing upward and inward beneath the articular. Toward the inner border a thin flange, rising from the upper surface passes forward external to the articular. The mandibular cotylus occupies the postero-external angle of the main portion of the bone.

Articular. This element, as yet not fully known, is higher than broad, thinnest below in its more posterior part, and extends forward as a moderately thin bone wedged in between the surangular and the outer face of the splenial. Below it is supported by the surangular. Supero-externally it supplies a surface as its contribution to the mandibular cotylus. The bone is preserved, in part, both in the type skull, and in the disarticulated skull, Cat. No. 2289.

Dentary. Is large, with three-eighths of its length in front edentulous, deeply excavated posteriorly by the mandibular fossa, and with the dental magazine occupying nearly one-half the length of the bone. The coronoid process is robust and placed far back. The dentary attains its greatest breadth across this process. For the full length of the magazine it is deep and moderately thick. The edentulous part is comparatively thin with a gradually lessening depth forward, is longitudinally concave internally, and curves abruptly inward in front, with a lowering of the superior border, to meet the opposite dentary in a ligamentous connection behind the predentary. The mandibular fossa excavates the coronoid process behind, and internally is continuous with the Meckelian groove which lessens in depth in its forward course near the lower border of the bone, and disappears in advance of a point in line with the front end of the magazine. Behind the magazine the dentary ends in a laterally compressed, pointed process, internal to the mandibular fossa. This process is covered on its inner face, and embraced above, by the anterior end of the splenial. Posteriorly, beneath the Meckelian groove, is a narrow surface marking the internal application of the angular as far forward as a point nearly beneath the midlength of the magazine. Posteriorly below the dentary is transversely broad, thin and obtusely pointed at its termination, underlapping the surangular so that the floor of the mandibular fossa is continuous with the upper front surface of the surangular. The narrow symphysial surface is deeply grooved from front to back. The dental foramina, corresponding in number to the vertical series of teeth, are conspicuous internally below the magazine. At the anterior end externally is a rather large foramen behind which are six or seven smaller ones at irregular intervals back to the front of the magazine. Still farther back are a few other foramina in the outer face of the bone.

In the dentary there are forty-eight or forty-nine vertical series of teeth with four or five and sometimes the stump of a sixth in each series. The individual teeth are largest at the midlength of the magazine and decrease in size toward either end of it, the posterior ones being considerably shorter but only slightly narrower than those in front. The inner enamelled tooth-surfaces, in lateral aspect, are nearly lozenge-shaped in outline, with the longer diameter vertical, and fit closely together quincuncially in a mosaic which is almost half covered from below by the thin alveolar wall. There are about 230 teeth in each dentary, this being many less than the number (406) ascribed to *Diclonius mirabilis* by Cope in his description of that species in 1883.

MEASUREMENTS OF THE SKULL OF EDMONTOSAURUS.

	Mm.
Length of type skull measured in a straight line from the posterior edge of the opisthotic to the middle of the anterior premaxillary border	1114
Horizontal length of same from anterior premaxillary border to a point vertically below the edge of the opisthotic (paroccipital)	1066
Length of quadrate	420
Breadth of skull (paratype) between the external convexity of the postfrontals behind the orbit. (The size of the skull in the type and paratype is about the same)	428
Length of mandibular ramus of paratype without predentary	908
Length of dentary of paratype	780

EXPLANATION OF PLATES.

Plate II—Left lateral aspect of the type skull of *Edmontosaurus regalis*, one-seventh natural size.

Plate III—Superior aspect of skull of *Edmontosaurus regalis*, one-seventh natural size. This view is taken from above with the skull in the position in which it is shown in plate II, viz., with the line of the teeth practically horizontal.

ABBREVIATIONS:—*Ar*, articular; *D*, dentary; *Ex. oc.*, exoccipital; *F*, frontal; *J*, jugal; *L*, lachrymal; *l.t.f.*, lateral temporal fenestra; *Mx*, maxillary; *N*, nasal; *no*, nasal opening; *O*, orbit; *Opo*, opisthotic; *Orsp*, orbitosphenoid (alisphenoid); *P*, parietal; *Pof*, postfrontal; *Pal*, palatine; *Pmx*, premaxillary; *Prd*, predentary; *Prf*, prefrontal; *Prot*, proötic; *Pt*, pterygoid; *Q*, quadrate; *Qj* quadrato-jugal; *Sang*, surangular; *Soc*, supraoccipital; *Sp*, splenial; *Sq*, squamosal; *s.t.f.*, supratempotal fenestra; *V*, vomer.

THE RED-TAILED HAWK IN MANITOBA.

BY NORMAN CRIDDLE, TREESBANK, MAN.

The Red-tail is one of the most beautiful of our Canadian hawks and in Manitoba among the semi-wooded areas, is still one of the commonest. That it is still numerous is due to the fact that its more secluded haunts have enabled it to escape much of the persecution to which the misinformed public have subjected its close allies, the Rough-legged and Swainson's hawks.

The favourite nesting sites of the Red-tail are along the wooded borders of rivers and streams, though the bird is by no means confined to such places, but is found breeding over much of the semi-wooded portions of the province. In general habits this hawk does not differ greatly from Swainson's hawk, to which reference was made by the writer in a previous volume of THE OTTAWA NATURALIST. It is, however, two or three weeks earlier in arriving from the South in spring time, commences to build earlier, and is far more a bird of woodlands than either Swainson's or the Rough-legged hawk. Moreover, it has never been found nesting upon the ground and rarely in isolated trees.

The nest of this species is composed of large and small twigs, well lined with the inner bark of aspen poplar, being a somewhat bulky structure. There seems a general tendency, on the bird's part, to seek a new nesting site each year. This, however, is not always done, some birds being known to occupy the same nest for two or more years in succession. The same nests have also been rebuilt and used after one or more years interval. There is reason to suspect that old nests would be much more frequently utilised were it not for the fact that the Western Horned owl habitually takes possession of these before the hawks return. Thus, the nests available for the latter depend upon the number of horned owls present in the vicinity.

The number of eggs laid by each female varies somewhat and seems to depend, at least to some extent, upon the food supply. In 1917, the six nests under observation close to the writer's home, contained but two eggs each and in only one of the six did the parents succeed in rearing more than one young though both were hatched in every instance. The first nest was discovered on May 6, containing two eggs. Other nests with eggs were located as late as June 14. It is difficult to account for the mortality among the young, though it is noteworthy that the deaths occurred while they were still quite small, and that the latest hatched, and consequently smallest, was invariably the one to die. Dead examples presented no indication of violence but seemed to show that, in all probability, death was due to starvation, the lack of food being due in its turn to a scarcity of ground squirrels (gophers) and to the unusual number of hawks nesting in the district.

The curious habit of the old birds in gathering a green leafy bough and placing it in the nest, characteristic of Swainson's hawk also, is very marked in the Red-tail, a fresh bough being gathered at least once daily during the time when the young are small. There has been some doubt hitherto as to the cause of this habit, but by observing the nestlings I am led to believe that the bough acts as a sun shade, as the young have been seen to repeatedly pull the bough over themselves and crouch beneath it. Doubtless it also acts as a shield and hides the young from their enemies. The leaves are also occasionally eaten.

As the young develop they acquire a good deal of boldness and defend themselves with both beak and claws. They have a habit of closely watching the intruder backing up meanwhile at the approach of a hand; then suddenly they leap forward with wings outstretched and it requires a rapid movement to escape their onslaught. The old birds make no efforts to defend their young, but fly high overhead uttering loud cries which are, at times, answered in a shriller key by the young beneath. In the fall these birds may be seen resting upon trees and telephone posts, looking very un-Red-tailed in appearance and superficially very like the young of Swainson's hawk. Towards the middle of October they make their way steadily southward and by the end of the month have practically all passed beyond our borders.

The food habits of hawks have been discussed on many occasions and the examination of stomachs by Fisher and others in the United States shows that all our large buzzard-like hawks, such as the Red-tail, Rough-legged and Swainson's hawks, are extremely useful. In discussing these from the standpoint of the prairie farmers, however, we have to take into consideration the fact that the prairie provinces are largely grain producing. Secondly, that they are infested by several species of ground squirrel which are quite unknown in eastern Canada and which take heavy toll from the grain fields. Thus our problems in regard to hawks are quite unlike those of the east and it seems a mistake to unite these in an article of this sort.

As the Red-tailed hawk is more an inhabitant of woodlands than the other species mentioned above it naturally follows that it is not so much a hunter of the plains, hence the prairie ground squirrels do not form so large a proportion of its food. They are, however, taken in quite large numbers and are supplemented by wood-loving kinds such as Franklin's ground squirrel, the common red squirrel and by mice. The food habits are also much more difficult to ascertain owing to the thorough manner in which the parents clean up the nest and to their habit of not leaving food nearby. Thus, unless one kills the birds and examines their stomachs, it is necessary to rely almost wholly upon the disgorged pellets overlooked by the parents, which unfortunately are practically absent during the early stages of the existence of the young. Details of pellets examined in 1917 are:

July 2—14 pellets collected beneath the nest of a pair of young; two made up of feathers and weed seeds from one or more vesper sparrows; four containing hair of voles and mice and odd bones of these rodents; the remaining pellets containing ground squirrel hair and a few bones chiefly of the striped species, *Cetillus tridecemlineata;* a few aspen leaves were also present.

July 10—Six pellets beneath the nest of a single nestling, chiefly made up of vole hair and with three sets of teeth of these animals, also bones and feathers of a young crow. Pellets from another nest taken on the same day, five in all, showed a few bird feathers, parts of two voles, much hair of the same rodents, ground squirrel hair and three tail tips of Franklin's ground squirrel.

July 31—Three pellets gathered containing hair and bones of ground squirrels, the former of *C. richardsoni* and *franklinii.* Odd bones and a tail of the last species were also located upon the ground. The young hawk had left this nest about ten days. Another nest from which the young had departed was examined on October 5; it contained broken pellets consisting of ground squirrel hair and bones.

These studies, as was mentioned above, relate to a single season's observations. Similar studies, covering a number of years show little variation in the kind of food consumed. The situation of the hunting grounds naturally influences the results inasmuch as these are apt to be frequented by a greater number of animals of one species in one place and another kind elsewhere. A shortage of some particular animal, such as ground squirrels, will have to be made up by the collecting of some other such as mice or birds, all of which have to be taken into consideration before we can arrive at a true knowledge of any hawk's food habits.

With regard to the relation of Red-tailed hawks to poultry, I have yet to learn of a single instance of these hawks having attacked poultry of any kind, though it is not at all an uncommon event to find them nesting within a few hundred yards of barnyards and poultry runs. Such is the evidence brought out by this investigation. The destruction of a few sparrows may be used against the hawks. The killing of a vastly greater number of noxious rodents leaves a large balance in the bird's favour. We can, therefore, come to but one conclusion, namely, that it is not only a friend to the farmer but also a useful ally as a conserver of our food supply.

WAS THE LOWER CAMBRIAN TRILOBITE SUPREME?*

By LANCASTER D. BURLING.

A new species of Lower Cambrian trilobite, *Paedeumias robsonensis*, has recently been described† from a single specimen which is unique among the thousands of specimens of known trilobites in its imperfection. The reason for the extraordinary perfection of the tests of previously discovered trilobites has apparently escaped critical observation though the late development of the ability to roll up into a ball has been appealed to as indicating that the trilobite was the supreme arbiter of the early Cambrian seas and needed no such protection. He has recently been deposed from this position, however, at least for the Middle Cambrian, and his title conferred upon *Sidneyia inexpectans* Walcott‡, a Merostome-like crustacean which has been described as armed with a truly formidable set of chelate appendages or claws (see figure 2). In the Lower Cambrian, however, nothing has hitherto been discovered that would dispute the claim of the trilobite to be the largest inhabitant of the seas, and the specimen of *Paedeumias* above mentioned is as large or larger than any other fossil so far discovered in the lower Cambrian rocks of the Northwestern Cordillera. It is further noteworthy in having the greatest number of ribs (44) ever discovered in a trilobite. Fifteen of these are of large size and their long spines almost completely encircle the remaining 29 (or more, the end is broken off) which are smaller and nearly equal in size.

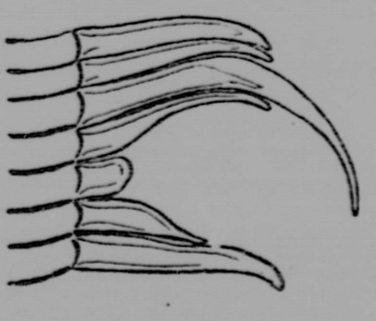

Fig. 1—Paedeumias robsonensis Burling. Outline of right half of the first seven ribs, shewing extent of injury. As can be seen by the photograph reproduced on plate I. Vol. XXX, opp. p. 53, the left half of these ribs is normal, with the exception that the fifth is slightly shorter than the fourth and sixth. The enlargement of the third rib is characteristic of the family to which the species belong. Three-fourths natural size.

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†Ottawa Naturalist, vol. 30, 1916, pp. 53-58, pl. I.
‡Nat. Geog. Mag., vol. 22, 1911, p. 511.

How does it happen that this trilobite has lost the ends of two of his largest ribs and that a third, which lies between them, has been cut off close to the central part of his body? And what light do we receive from the fact that the broken ends of these ribs have started to heal up and show fairly well developed terminations? (See figure 1).

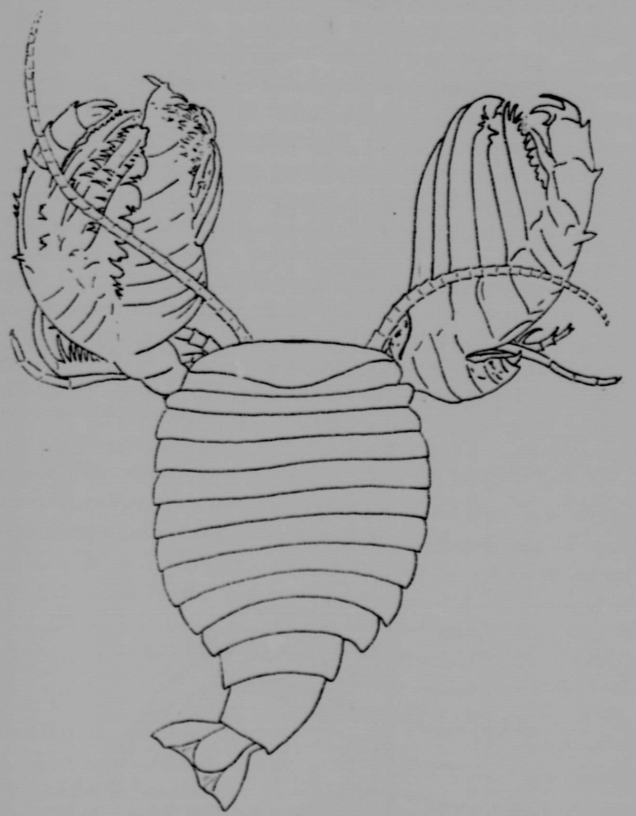

Fig. 2—Restoration of Sidneyia inexpectans Walcott. Made by grouping together a body and two claws found within the limits of the same Middle Cambrian faunule on the slopes of Mt. Field, British Columbia. The two claws are probably both rights or both lefts, one (left in the figure) showing one side, with the "thumb" in place, the other showing the reverse side of a claw probably belonging to the same side of the animal, with the "thumb" broken away. The individual portions after Walcott. One-half natural size.

If we assume that the trilobite lost this portion of his anatomy while he was a very small animal, why was he so long about fixing up his lost ribs? Crustacea now have the power of rebuilding lost parts of their body, and this primitive crab has proven by his ability to heal the broken ends of his ribs that Cambrian trilobites possessed the same ability.* Therefore it must have happened very recently in his life history or all traces of the accident would have been removed. But if it happened such a short while ago the chunk must have been removed by a foe more voracious if not actually larger than himself and we are apparently justified in assuming the presence in the Lower Cambrian seas of animals capable of inflicting such an injury. The only other explanation is that he became pinned beneath material dropping from an overhanging ledge, and an apparent crowding and dwarfing of the ribs immediately adjacent to the cut lends a degree of plausibility to the idea that they were bruised at the same time.

So far as we can judge from the present appearance of the edges of the wound it was comparatively clean cut, and made by a jaw capable of cutting not only at the extreme tip but for some distance along each side, for the ribs next in front and back of the one in the middle are cut off diagonally. A *Sidneyia*-like crustacean (see figure 2) could hardly be expected to clip so symmetrical and clean a section. If we were to hazard a guess we would say that the most reasonable conclusion would be that it was the work of a fish. These, the earliest known vertebrates, are not known from rocks earlier than those of the immediately overlying system, the Ordovician, but ancient rocks are growing daily more responsive and such a guess is far within the range of probability.

PROGRAMME OF WINTER LECTURES, 1917-1918.

December 18, 1917—"Two Years in N. E. Greenland." Mr. Frits Johansen, Naturalist on the "Danmark" Expedition, 1906-1908.

January 8, 1918—"Mobilizing the Forests for War and Peace." Mr. Robson Black, Secretary of the Canadian Forestry Association.

January 22, 1918—"Diseases of Domestic Animals." Dr. S. Hadwen, Pathologist, Dept. of Agriculture, Ottawa.

February 5, 1918—"Local Snakes, Frogs and Salamanders: Their Relation to Agriculture." Mr. Clyde L. Patch, Victoria Memorial Museum, Ottawa.

February 19, 1918—"Fishing and the Canadian Fisheries, with Special Reference to the Atlantic Coast." Mr. W. A. Found, Superintendent of Fisheries, Ottawa.

March 5, 1918—"The Fur Seals." Mr. James M. Macoun, C.M.G., Victoria Memorial Museum, Ottawa.

March 19, 1918—"Naturalists and Tropical Diseases." Major J. L. Todd, Ottawa, lately Professor of Parasitology, McGill University. At the conclusion of this lecture the ANNUAL MEETING of the Club will be held.

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*Perhaps the quickness of this recovery in these early forms is the reason for the perfection of the forms which have hitherto been discovered.

WHY THE LEAVES CHANGE THEIR COLOR.

The change in the color of leaves in autumn is not, as many people suppose, due to the action of frost, but is a preparation for winter. All during the spring and summer the leaves have served as factories, where the foods necessary for the trees' growth have been manufactured. Ths food making takes place in numberless tiny cells of the leaf and is carried on by small green bodies which give the leaf its color. These chlorophyll bodies, as they are known, make the food of the tree by combining carbon taken from the carbonic acid gas of the air with hydrogen, oxygea, and various minerals supplied by the water which the roots gather. In the fall when the cool weather causes a slowing down of the vital processes, the work of the leaves comes to an end. The machinery of the leaf factory is dismantled, so to speak, the chlorophyll is broken up into the various substances of which it is composed, and whatever food there is on hand is sent to the body of the tree to be stored up for use in the spring. All that remains in the cell cavities of the leaf is a watery substance in which a few oil globules and crystals, and a small number of yellow, strongly refractive bodies can be seen. These give the leaves the yellow coloring so familiar in autumnal foliage.

It often happens, however, that there is more sugar in the leaf that can be readily transferred back to the tree. When this is the case the chemical combination with the other substances produces many-colored tints varying from the brilliant red of the dogwood to the more austere red-browns of the oak. In coniferous trees, which do not lose their foliage in the fall, the green coloring matter takes on a slightly brownish tinge, which, however, gives way to the lighter color in the spring.

While the color of the leaf is changing, other preparations are being made. At the point where the stem of the leaf is attached to the tree, a specal layer of cells develops which gradually sever the tissues which support the leaf. At the same time Nature heals the cut, so that when the leaf is finally blown off by the wind or falls from its own weight, the place where it grew on the twig is marked by a scar.

Although the food which has been prepared in the cell cavities is sent back to the tree, the mineral substances with which the walls of the cells have become impregnated during the summer months are retained. Accordingly, when the leaves fall they contain relatively large amounts of valuable elements, such as nitrogen and phosphorus which were originally a part of the soil. The decomposition of the leaves results in enriching the top layers of the soil by returning these elements and by the accumulaton of humus. That is why the mellow black earth from the forest floor is so fertile.—(From the Forest Service, U. S. Dep. Agric.)

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