STUDIES IN TASMANIAN MAMMALS, LIVING AND EXTINCT.

Number II.

Section 1.

The History of the Genus *Nototherium.*

Section 2.

The Osteology of the Cervical Vertebræ of *Nototherium mitchelli.*

By

H. H. Scott (Curator of the Launceston Museum)

and

Clive E. Lord (Curator of the Tasmanian Museum).

Plates VI. and VII.

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SECTION 1.

THE HISTORY OF THE GENUS *NOTOTHERIUM.*

In the middle of last century the first fossil remains of the extinct gigantic marsupial fauna of Australia were discovered. Although subsequent discoveries gave rise to the opinion that their distribution must have been a wide one, it was not until the year 1910 the first remains of these animals were discovered in Tasmania. This, and subsequent discoveries in the island, have all been of the one genus—*Nototherium*—but there appears to be no valid reason why the discovery of the remains of such marsupials as *Diprotodon* and *Thylacoleo* may not be anticipated. This view is strengthened by the fact that the species recently obtained at Smithton is *Nototherium mitchelli*, the typical mainland form, and not *N. tasmanicum*, which, up to the present, has only been discovered in this island. The discovery is also another link in the chain of evidence, showing that the subsidence of Bass Strait must have been of quite recent date—geologically considered.

In continuation of our previous note on the discovery of an almost complete skeleton of *Nototherium mitchelli* (1) we propose to review briefly the history of the genus. This is essential in order that our facts may be presented in a clear light. Incidentally, it will be necessary to deal with the various side issues which arose as *Nototherian* remains were slowly recovered from the Pleistocene formations of Australia, and eventually Tasmania also.

On 13th April, 1831, a paper (dated at Sydney, 14th October, 1830) was read before the Geological Society of London (2). It was entitled, "An account of the lime-"stone caves at Wellington Valley, and of the situation "near one of them, where fossil bones have been found," by Major Thomas L. Mitchell, F.G.S., J.C., Surveyor General of New South Wales.

In this description it is pointed out that the Wellington Valley is 170 miles west of Newcastle, on the eastern coast of Australia. The rock through which the valley has been excavated was limestone, resembling, in external characters, the carboniferous series of Europe. The rugged surface of the limestone tract abounded in cavities. One large cave descends at first with moderate inclination, and at about 125 feet from the mouth the floor is thickly covered with fine, dry, reddish dust, in which a few fragments of bones occur. About eighty feet from the mouth of the cave is another cavity. Here the surface itself consists of a breccia full of the fragments of bones. Near the lower part of the fissure (the whole extent of which was not explored), were three layers of stalagmitic concretion about two inches in thickness and three inches apart, the spaces being occupied with a red ochreous matter, with bones in abundance imbedded both in stalagmite, and between the layers of it. In describing the bones it was stated that the bones, with two exceptions, belong to animals at present known to exist in the country. "Along with the remains just mentioned "were found two bones, not agreeing with those of any of "the animals at present known to exist in New South "Wales. The first, and larger, is supposed to belong to the "elephant. The second bone is also obscure and imper-"fect, but seems to be a part of one of the superior "maxillary bones of an animal resembling the Dugong; "it contains portion of a straight tusk pointing directly "forward."

In 1838 Mitchell published his work on "Three Expeditions into the interior of Australia (3). The issue we have been able to refer to is a copy of the second edition, published in 1839. Commencing at page 359, in Vol. II., he gives an account of a detailed examination of the Wellington Valley Caves, together with geological maps and sketch sections. He states that the particulars concerning the animal remains referred to in his paper read before the Geological Society, had derived great additional importance from the discoveries made by Professor Owen.

Several plates were included, by Mitchell, in order to illustrate the bones, as well as a letter from Professor Owen. In the epistle, headed "The Royal College of "Surgeons, May 8th, 1838," the Professor stated, *inter alia*, "Genus Diprotodon. I apply this name to the genus "of Mammalia, represented by the anterior extremity of the "right ramus, lower jaw, with a single large procumbent "incisor. . . This is the specimen conjectured to belong "to the Dugong, but the incisor resembles the corres-"ponding tooth of the wombat in its enamelled struc-"ture and position. . . But it differs in the quadrilateral "figure of its transverse section, in which it corresponds "with the inferior incisors of the hippopotamus."

Strictly speaking, of course, this related to the genus Diprotodon, rather than to Nototherium, but as we hope to deal with the question of the *Nototheria* in relation to geological time at a later portion of this historical series, the remarks of Mr. (afterwards Sir) Thomas Mitchell are of interest. It also explains the inception of Mitchell's connection with Palæontology. He was of opinion that the caves had been probably twice immersed, and that in general the plains of the interior had been under the sea at one time. The accumulation of animal remains were very much broken. No entire skeleton was discovered, and very rarely were any two bones of the same animal found associated.

In the Report of the British Association for 1844 (4) appears the first reference to *Nototherium* * as distinct from *Diprotodon*; Professor Owen making two species from the material that was available to him at the time—the first of these being *Nototherium inerme*, and the second *N. mitchelli*. The collection available to the learned Professor was not large. It came from the Condamine River, and was collected by Sir Thomas Mitchell, C.B., who appears to have taken a keen interest in the collection of such fossils as these. From the study of the available data, the genus was founded in the belief that these animals, unlike the *Diprotodon*, had no tusks. The mistake was due to the lack of sufficient material, and also to the mutilated character of the specimens used as the types.

In 1845 Professor Owen received from Leichhardt and Boyd the mandibular ramus of a young *Nototherium*, showing the germ of an incisor [5] together with other specimens. The inclusion of the incisive tusks necessitated a revision of the genus. This was the first emendation of the type.

In 1856 the first skull was discovered that could be relegated to this genus; it came from the Darling Downs, and was minus the mandible. Mr. W. S. Macleay, of the Australian Museum, named this skull *Zygomaturus trilobus*, in a popular report of the discovery contributed to the local press during August, 1857.

Professor Owen protested against the new classification, and eventually a cast of the skull and photographs, giving details, reached him. The cast came later than the photographs, so that we can omit the report upon the former, and bring the matter down to 15th June, 1871, when Professor Owen's real work upon the cast was read before the Zoological Society, constituting Part V. of his series upon the Fossil Mammals of Australia. In this monograph he recapitulated all the published facts, claimed that the skull from which the cast was made was that of *Nototherium mitchelli*, and that, *ipso facto*, *Zygomaturus trilobus* was eliminated. As a consequence, the latter designation was allowed to lapse until Mr. C. W. De Vis, M.A., of Queensland, elevated it to the rank of a genus. De Vis' work in this connection will be considered later. In the year 1877, Owen published his paper on the Extinct Fossil Mammals of Australia in two quarto volumes, adding some notes to the genus Nototherium, and giving a woodcut of a humerus (Pl. CXXVII.), which he felt justified in relegating to this genus. The humerus really had nothing whatever to do with the genus *Nototherium*, but its resemblance to the same bone in *Phascolomys*, served to link it to the Phascolomyidæ in all classifications from that day until 1910, when the real humerus was discovered in Tasmania [6], together with the rest of a skeleton (*N. tasmanicum*), thus settling the matter at rest once and for all. One effect of this incorrect relegation was that any robust *Nototherian* humeri that were found were naturally relegated to *Diprotodon minor*, a species founded by Professor Huxley in 1862 [7]. The late Dr. Stirling, F.R.S., of South Australia, was a strong supporter of Huxley's species, *D. minor*, but, with the coming to light of the true *Nototherian* humerus, felt the wisdom of going through the South Australian fossil humeri provisionally related to that species, but his attention being fully claimed by Ethnological Studies, he never again published upon the question.

In 1882 Professor Owen described (8) a distal end of a femur which he thought might belong to the Genus *Nototherium*; this also—in 1910—was shown to be incorrect, and we may assume that some of the changes rung by taxonomists upon the *Nototherian* remains discovered from time to time, found support upon the departure of the real femur from that incorrectly relegated to it, the more so as the real femur is exceedingly similar in outline to that of *Diprotodon*.

This practically ends Professor Owen's connection with the genus.

In the year 1874, Professor Frederick McCoy, of the Melbourne University, figured (9) some *Nototherian* tusks (from Back Creek, Victoria), in a comprehensive study of *Diprotodon* and *Nototherian* dentition.

The next important developments of the generic history of this species were due to Mr. C. W. De Vis, M.A. who first relegated a humerus to *Nototherium* that departed so much from Owen's specimen that Lydekker, in his British Museum Catalogue (10), published in 1877, relegated it to *Diprotodon*, without question, but it is to-day, on the face of it, apparent that De Vis was correct in this matter.

Later on, in August, 1887, De Vis created a new genus for extinct *Nototherian* animals, calling it *Owenia*, which was later changed to *Euowenia*; this was communicated to the Royal Society of Queensland (11), the material being a skull and mandible, and the specimens were much crushed. Some of our own controversial material—yet to be presented—will revolve around this, and De Vis' subsequent taxonomic efforts at reconstruction.

In December of the same year (1877), he contributed a paper to the Linnean Society of New South Wales (12), making a new species of *Nototherium*, namely, that of *Dunense*.

By far the most important addition to the literature of this subject added by De Vis was a paper published in 1891 (13), in which, while confirming and re-naming the genus *Owenia*, he suggested a complete revision of the taxonomy of three extinct animals. This opens up several questions, and must be dealt with in some detail, as it recapitulated all published data, and questioned the correctness of even type specimens and their subsequent associations with more perfect specimens. De Vis' contentions may be summed up as follows:—

1. The skull claimed by Owen was not the correct cranium of *Nototherium* at all, and still stood generically distinct under the name of *Zygomaturus*, with characters duly detailed.

2. That Lydekker's creation of a family *Diprotodontidæ* was unwise, and that the only family that really existed was that of *Nototheriidæ*, of which *Diprotodon* was a genus.

3. That the family just named included the following genera:—

NOTOTHERIIDÆ

Dentition:

General characters: Posterior upper incisors small. Premolars, except in *Zygomaturus*, subtriangular, unicuspid; with a posterior talon. Molars transversely bilobed, the upper without longitudinal ridges, talons anterior-posteriorly narrow. Scapula long and narrow. Ilia greatly expanded. Limbs gressorial, approximately equal; their proximal bones elongate, simple. Foot broad, tail short, tapering.

Synopsis of Genera.

Nototherium.

Incisors: Upper premolars subtriangular, unicuspid; cranial habit and length of muzzle moderate. Crowns of first incisors contiguous, or slightly diverging, the lower incisors proclivous. Posterior upper incisors on the edge of the jaw; cusp of premolar with a shallow posterior cleft.

Diprotodon.

Posterior upper incisors near middle line of the jaw; cusp of the premolar with a deep lateral cleft.

Zygomaturus.

Upper premolar oval, tuberculated; cranial habit very massive, with short expanded muzzle.

Euowenia.

Incisors: Crowns of first incisors above and below widely diverging, with a similar strong double curvature.

Some parts of the above contention had been published by De Vis prior to the extenso notes given above, and the late Richard Lydekker (14) answered it, taking up the following ground: That the cast used by Professor Owen showed that the two premolars were not the same, one at least agreeing with the very class of tooth that De Vis had accredited to the genus *Nototherium*, and that apparently the other tooth did not belong to the original skull from which the cast was made. We hold a copy of this cast, and the two premolars agree with Lydekker's statement, but for the present we pass this item over. In 1894 De Vis described (15) a mandible of *Zygomaturus*, and with some warmth defended his position, again claiming that only a single family existed, namely, *Nototheriidæ*, and that *Zygomaturus* was a genus of that family.

The year 1911 brought out a description of the humerus, and parts of the skull of *Nototherium tasmanicum* in "The Tasmanian Naturalist," by Messrs. H. H. Scott and K. M. Harrissen (16). In 1912 saw the description of *Nototherian* teeth (17), by L. Glauert, F.G.S., from specimens found in Western Australia, in which *Zygomaturus* was claimed as a synonym of *N. mitchelli*.

The same year some teeth from King Island gave evidence of Professor Owen's *Nototherium victoriæ*, being more than a mere individual variation of the type *N. mitchelli*, and later on a monograph on *Nototherium tasmanicum* was published by the Geological Survey of Tasmania (18). In the latter, the author (H. H. Scott) claimed *Zygomaturus* as a sex mystery, and suggested that as a working hypothesis, all weak and flat-tusked animals be regarded as females, the stouter tusked animals be called the males.

The discovery, in 1920, of a very perfect skull, and most of the skeleton of a large *Nototherium* at Smithton, by Mr. E. C. Lovell—taken in conjunction with the former discovery of a skeleton in 1910—gives such an opportunity for a revision of the above that we propose to review the whole question in detail. This latter can only be effectively undertaken after the osteological data have been presented, so for the present we content ourselves with the statement that having proved that the mandible from the Boyd Collection (Brit. Mus. Coll.

32050) is identical with the jaws of *Zygomaturus*, Owen's determination of *Nototherium* as a genus stands good, and De Vis' dissensions rule out. At the same time, the evidence to date of writing tends to show that the real position is this:—

1. That the mandible from the Boyd's Collection, of which we hold an accurate cast, came from a male animal, and that the first *Zygomaturus* skull (and, therefore, Owen's cast, Brit. Mus. Coll. 33259) was a female.

2 Owen's so-called "female" jaws, we will deal with later, just recalling as we pass along that Owen made this determination with a strong reservation, and published his note with a query appended to it.

3. That De Vis afterwards obtained male skulls of his so-called "*Zygomaturus*" which depart—in sex variation—rather strongly from those of the female, and that in the circumstances the position he took up is readily understood. In going over this matter it is also evident that De Vis' contentions did good work, and are even now assisting to solve the problem of these ancient giant marsupials.

4. If the Boyd's collection mandible is placed side by side with the mandible of the latest discovery from Smithton, they will be found to agree *in toto*, while the skull itself agrees exactly with De Vis' determination of *Zygomaturus*, and departs from Owen's cast in exactly the way De Vis claimed.

5. Being practically certain (evidence yet to be given) that our animal was a male, the sex differences square all other outstanding points between Owen and De Vis—and *Zygomaturus*, as reconstructed by the latter, becomes a sex variation, and not a taxonomic one.

SECTION 2.

THE OSTEOLOGY OF *THE CERVICAL VERTEBRÆ*.

As we duly point out in our published [19] introductory note, the cervical vertebræ of *Nototherium mitchelli* are of special morphological interest, combining in fact the maximum of strength with the minimum of bulk and weight. The especial features are these:—

1. The vertebræ are thin and wide, with enormous pre and post zygapophyses.

2. The centra are transversely oblong, thus giving an enormous neural canal—since the neurapophyses are so spaced as to embrace the whole area thus yielded.

3. The intervertebral pads were reduced to the smallest possible thickness, and accordingly the long zygapophyses functioned strongly.

4. The neural spine of the atlas (when the neck muscles were all in action) blocked against the spine of the axis, thus converting the whole series into a practically solid mass, and broke the shock of the act of ramming a foe. The remaining features will be detailed *in extenso*.

The lower border of the atlas is not completed by a bony bar below, the space being equal to 30 mm. The top of the neural canal, which in antero-posterior extent equals 30 mm., is still marked by the reticulations of the *dura mater*, indicating the perfect preservation of the bone. Both neurapophyses are perforated by a foramen, set in a deep channel (that girdles the rims of the anterior condylar cups) leading backwards and outwards to the incomplete inter-vertebral arterial foramen, thus obviously tracing the course of that artery.

Below the first-named foramina, and therefore between the occipito-axian articular cups, are two large scars some 15 mm. in diameter for the attachment of the great transverse ligament, essential to the setting of the odontoid process of the axis. Across that process runs a deep groove, also 15 mm. wide, marking the passage of the ligamentous band, and its synovial sac. The rest of the internal atlantean, neural, area is roughened by the attachment of capsular ligaments. The incompletion of the atlantean bony ring leaves room for conjecture as to muscular and ligamentous dispositions in this area, for the roughened apex of the odontoid process demands a strong central odontoid ligament. The spine of the atlas—whose unique function has already been cited—is divided into two areas, one that fits the axian spine, and an anterior muscular attachment surface apparently for powerful 'rectus capitis homologues. The crowding out from this area of any fascia of the ligamentum nuchæ, as is usual among animals with heads carried horizontally, left this part of the spine free for the needs of the special adaptation that we find to obtain. Some kind of pad must have existed between these two spines, either muscular, cartilaginous, or ligamentous, but in the macerated bones the slightest compression of the cervical series, as a whole, jams the two spines firmly together. This special adaptation is, as far as we know, unique. In a monograph upon *Nototherium tasmanicum*, this action of the two anterior cervical spines in Nototheria was noted in the following terms:—"During "normal vertebral articulation, the aborted spine of the "atlas worked against this point in the axis, both being "flattened and roughened, as if for a loose kind of syndes-"mosal union." (20)

The posterior edges of the atlantean neurapophyses are groove-scarred for 35 mm. on either side, to receive interspinalis muscles, and ligaments that filled a fossa in the atlas 40 mm. wide × 40 mm. high; indeed, the whole under portion of that spine is thus excavated. This bold excavation of the neurapophyses continues throughout the cervical series, and when the seventh is reached, in spite of its apparent thinness, it yet yields a muscular and ligamentous attachment fossa, 70 mm. wide and 20 mm. deep.

This enormous padding of muscles and ligaments, added to the great strength of the zygapophyses, enabled what would otherwise be a weak neck to withstand enormous shocks, and was a special evolution of the marsupial skeleton. To give stress to this point it may just be added that the fourth cervical is only 34 mm. thick, measured through the centrum, but the processes for interlocking bring its total up to 65 mm.

The vertebra-artereal foramina are completed by bone in the third and subsequent vertebræ; are nearly completed in the axis, and indicated only in the atlas; the sizes of these are given in the table of measurements appended hereto. In the specimen under examination, the right diapophyses is complete, and the left nearly so, the former enabling us to say that the muscular attachments were all of a very extensive character. Skullwards the homologue of the rectus capitis lateralis, and the superior oblique claimed large areas, while the scar upon the back of the process evidently related to a moiety of the levator anguli scapulæ. The similarity of such muscles as the latter, with those of man, related in part at least to the complete revolution of the arm in marsupials incidental to the manipulation of the pouch. On the other hand, the likeness ends when we come to deal with the ligamentum nuchæ, which in such animals as are here under consideration, require an elastic ligament of great length and power, together with freedom of the two anterior vertebræ. Accordingly, the ligamentum nuchæ may arise far down upon the lumbar region, fan out upon the first dorsal spine into two fascia, one of which rains down upon the five posterior cervical spines, and the other ascends to the occipital regions for insertion. In this *Nototherian* skull, the supra-occipital bone is deeply excavated by two fossæ to receive this important ligament, a low median bony bar acting as a central septum, the total area thus occupied by the fossæ is 125 mm. wide, and apparently 100 mm. in vertical extent.

A common occipito-cervical ligament, modified in the anterior spinal regions, must have existed, and other myological notes could no doubt be collected, but the above data chiefly interest us in the present study.

COMPARATIVE CERVICAL VERTEBRÆ. *Nototherium mitchelli* (No. 1). *Nototherium tasmanicum* (No. 2).

Name.	Height.	Width.	Diameter anterior centrum.	Height of neural canal anterior.	Width of neural canal anterior.	Across rims of articular cups of atlas.	Greatest length of Transverse processes.	Length of zygapophyses (platforms).	Antero-posterior length of spine of axis.
Atlas									
No. 1	100 mm.	242 mm.	No	No. 1, 77 mm	No. 1 56 mm.	125 mm.	73 mm.	37 mm.	65 mm.
No. 2	95 mm.	230 mm.	centrum	No. 2, 58 mm.	No. 2, 56 mm.	113 mm.	70 mm.	35 mm.	45 mm.
Axis	Mutilated					Vertebra arterial foramen			
No. 1	131 mm.	144 mm.	100 x 50 mm.	30 mm.	46 mm.	No. 1, 21 x 15	No. 1, 47 mm.	No. 1, 39 mm.	—
No. 2	157 mm.	126 mm.	95 x 40 mm.	20 mm.	40 mm.	No. 2, 15 x 15	No. 2, 39 mm.	No. 2, 38 mm.	—
Cervical 3	Mutilated								
No. 1	135 mm.	154 mm.	No. 1 75 x 47mm	31 mm.	47 mm.	20 x 17 mm.	47 mm.	39 mm.	—
No. 2	150 mm.	140 mm.	No. 2 64 x 49mm	21 mm.	46 mm.	15 x 15 mm.	39 mm.	35 mm.	—
Cervical 4	Imperfect								
No. 1	144 mm.	171 mm.	73 x 46 mm.	34 mm.	54 mm.	17 x 12 mm.	50 mm.	40 mm.	—
	Imperfect								
No. 2	140 mm.	160 mm	70 x 50 mm.	22 mm.	47 mm.	15 x 14 mm.	50 mm.	30 mm.	—
Cervical 5	Spines very								
No. 1	imperfect in	No. 1, 178 mm.	77 x 51 mm.	33 mm.	56 mm.	15 x 15 mm.	56 mm.	42 mm.	—
No. 2	both cases	No. 2, 164 mm.	74 x 51 mm.	25 mm.	55 mm.	15 x 15 mm.	54 mm.	29 mm.	—
Cervical 6		Imperfect					Imperfect		
No. 1	142 mm.	178 mm.	77 mm.	37 mm.	62 mm.	15 x 15 mm.	57 mm.	41 mm.	—
	Imperfect		Imperfect						
No 2	134 mm.	160 mm.	73 mm.	31 mm.	58 mm.	13 x 15 mm.	50 mm.	25 mm.	—
Cervical 7	Imperfect								
No. 1	141 mm.	188 mm.	85 x 58 mm.	41 mm.	70 mm.	17 x 17 mm.	60 mm.	35 mm.	—
	Imperfect								
No. 2	140 mm.	170 mm.	72 x ? mm.*	35 mm.	60 mm.	9 x 7 mm.	45 mm.	24 mm.	—

REMARKS.—Owing to the mutilations to the spines of the Vertebræ of *Nototherium mitchelli*, no comparative measurements have been included in the table. Such data relating to *N. tasmanicum* appeared in the monograph on that specimen.

* Centrum imperfect in *N. tasmanicum*.

A study of the comparative table thus supplied will at once make manifest the superior bulk of the vertebræ of *Nototherium mitchelli*, and it only remains to contrast the *Nototherian* vertebræ with a normal marsupial type, to see the extent to which cervical specialisation has taken place.

In the wombat the neck vertebræ are upon the whole similar to those of the *Nototheria*, the neural spine of the axis being wide, with an angular superficial slope of 45 degrees. No special union exists between it and the atlantean spine, and the neurapophyses are not excavated for the implantation of powerful muscles and ligaments. What is true of the first two cervicals is equally true of the whole series, for the interlocking zygapophyses, with the usual supply of interspinalis muscles, and a normally sized ligamentum nuchæ, meet all the needs of the wombat's method of life, but it is otherwise with the *Nototheria*. In weakly horned animals (be they of stirpian or sexual segregation) the wombat cervical conditions are simply carried to a point sufficient to support the weight of the head with, but with small reserves for aggression; the spine (21) of the axis is of the same relative size as that of the wombat, and the neural spines are moderately excavated, thus exactly outlining to us the needs of the non-fighting animals. In *Nototherium mitchelli*, all such structures are carried a stage in advance, and power for power's sake is superadded. To show that this latter statement is not an ungrounded one, it must be remembered that the skull of such an animal as *Nototherium tasmanicum* is as large and weighty as that of *Nototherium mitchelli*, thus furnishing us with the ligamentous and muscular needs for its pose and support, and explaining why the other skull characters of fighting import exist in the skull of *Nototherium mitchelli* at all. When we come to deal with the comparative skulls, we shall have a lot to say upon this matter, it being only necessary to retain for the present the following salient facts in the foreground of our memories:—

1. The skulls of *N. mitchelli* and *N. tasmanicum*—at least—(with a possibility of that of other species) are equally large and weighty, yet their cervical vertebræ show marked differences. One being an exaggeration of the standard of the modern wombat *in about the same ratio of power* (*N. tasmanicum*), while the other shows an additional power with interspinalis muscles and paddings, suitable to the resisting of great shocks in the long axis of the head and vertebræ.

2. The above is an extension of our statement given in the former note to the effect that in an animal like *N. tasmanicum* the structures present could serve no greater purpose than the moderate resistance of force, but in *N. mitchelli* they are built up to a strength essential for conducting the fiercest aggressive warfare.

COULD A NOTOTHERIUM HAVE HORNED A FOE?

In order to establish the fact that a *Nototherium* could have horned its foe, it will be necessary to carry our study of the cervical vertebræ forward to the occiput itself, and pay some attention to the muscular and ligamentous conditions that obtained there. As we are also dealing here with a heavy headed animal whose weapon was planted on the nose, and therefore removed from the neck by a distance of seventeen inches (433 mm.), as against 2 inches (50 mm.) in the case of a modern bull, we must expect to find exceptional conditions provided. A glance at the picture of the neck bones will demonstrate their ability to resist the shock of the act of ramming a foe, and now the study of the occiput proves that the act of violently thrusting upwards the head and revolving it, together with most perfect checks, to avoid dislocation of the neck, were duly provided, as note:—

1. The foramen magnum is transversely oval, 55 mm. in width, and 40 mm. in height, the occipital condyles being very heavy, as might be expected.
   The lower edges of the condyles are excavated by two enormous fossæ for the implantation of the rectus capitis muscles, essential to the uplifting and rotating of the head. These fossæ are 30 mm. long x 12 mm. wide, and would also lodge the atlanto-axoidean ligaments to relieve the muscles from strain, and to enable them to exert their full power.

2. The crest of the magnum foramen carries an extensive transverse attachment tract some 20 mm. long, for the reception of the central odontoid ligament, one of the most important factors to a war-like animal—since any failure of this and the next two ligaments noted would mean death when ramming a foe.

3. The next two surfaces, germane to our subject, are those for the implantation of the lateral odontoid ligaments, since such ligaments are the checks that saved the dislocation of the neck when the animal horned and tossed its foe. In our specimen the surfaces thus provided for are so massive as to simulate a third condyle, and shew that the bands of elastic ligament were over 15 mm. wide, and of considerable thickness. If these data are considered in the light of the evidence yielded by the study of the cervical vertebræ—always remembering the fact that the occiput was provided with a ligamentum nuchæ that covered a hundred millimetres of implantation surface—it will be obvious that everything of essential desiderata to a heavy animal wishing to horn its foe is thus provided for. Later on, we shall review the evidence in favour of a horn, figure the skull, and give description of all the cranial features relating to the method of life here assumed to have existed.

EXPLANATION OF PLATES.

Plate VI.

The vertical vertebræ of *Nototherium mitchelli*, showing the powerful zygapophyses and short stunted spine of the atlas, that can be compressed against the heavy spine of axis, during a forceful head thrust, thus converting the neck series into a solid mass of bone, muscle, and elastic ligament.

Plate VII.

To the left is the atlas vertebra. The central bone is the axis, tilted to display the excavation of the neural spine for the reception of interspinalis muscles, etc. To the right, the seventh cervical appears, showing wide neural canal, nature of processes, and excavated neurapophyses for the interspinalis muscles, and the elastic fascia of the ligamentum nuchæ.

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(9) Prodromus of the Palæontology of Victoria. McCoy.

(10) British Museum Catalogue Fossil Mammals, Vol. V., p. 161, footnote.

(11) Proceedings of the Royal Society of Queensland, Vol. IV., 1887.

(12) Proceedings Linnean Society of N.S.W., Vol. II.; second series.

(13) Proceedings of Linnean Society of N.S.W., Vol. VI.; second series.

(14) Annals and Magazine of Natural History, 1889, Vol. III.; sixth series, p. 149.

(15) Proceedings Royal Society of Queensland, 1894, p. 5.

(16) The Tasmanian Naturalist, Vol. II., part 4, page 1.

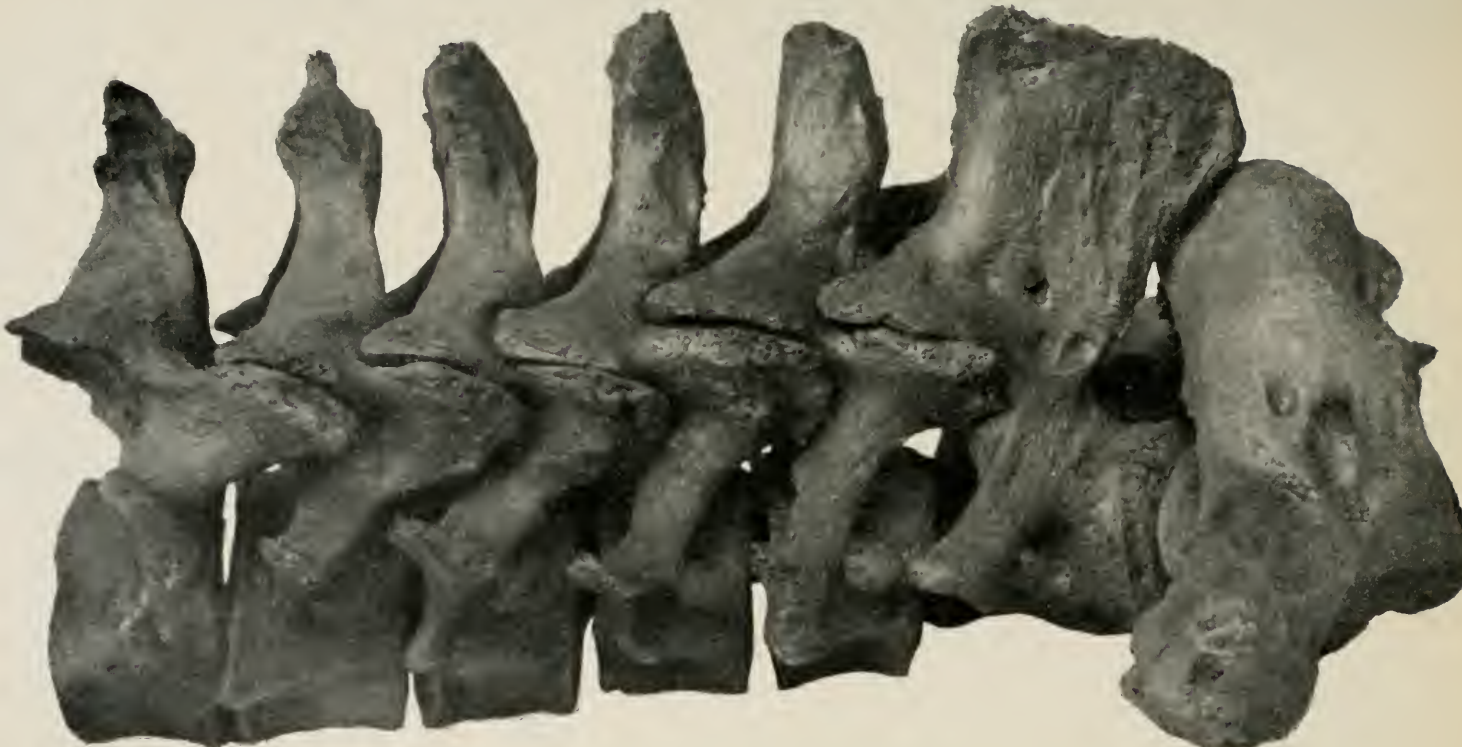
(17) Records of W.A. Museum, Vol. I., part 11, p. 39.

(18) Department of Mines, Tasmania. Geological Survey Record, No. 4, 1915. A Monograph of *Nototherium tasmanicum*, by H. H. Scott.

(19) Proceedings of the Royal Society of Tasmania, 1920, p. 13.

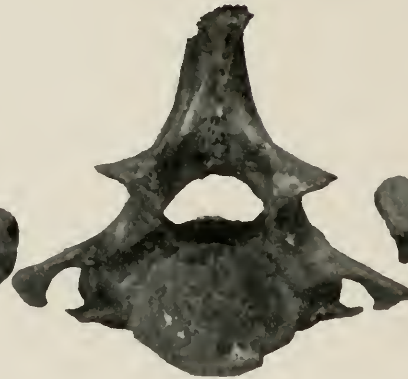
(20) Department of Mines Tas., Record 4, 1915. Monograph of *N. tasmanicum*, by H. H. Scott, p. 36.

(2[illegible] [illegible] Plate 16.

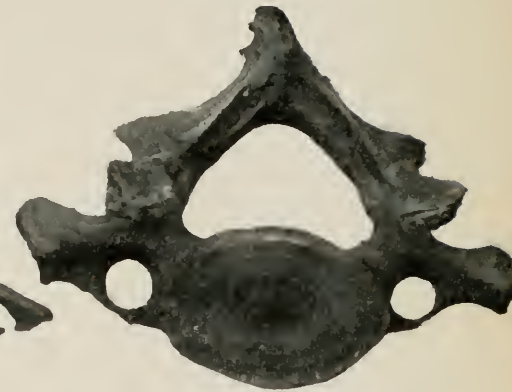


CERVICAL VERTEBRÆ, NOTOTHERIUM MITCHELLI.

ATLAS.



AXIS.



SEVENTH CERVICAL.

NOTOTHERIUM MITCHELLI.