

ON THE LIMB-BONES OF *NIPPONOSAURUS SACHALINENSIS*
NAGAO, A JAPANESE HADROSAURIAN DINOSAUR*

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ONE PLATE

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No remains of dinosaurian reptiles had been discovered from Japan before 1934. Toward the end of November of that year a large specimen of a trachodont or hadrosaur, a group of Cretaceous herbivorous dinosaurs, was quite unexpectedly found at the Kawakami Colliery of the Mitui Mining Company, Toyohara-gun, Saghalien. The material, which includes more than a half of the skeleton and a few fragments of the skull belonging to one individual, was named *Nipponosaurus sachaliensis* and described in detail in the Journal of the Faculty of Science, Hokkaidô Imperial University¹.

“The animal fell on a mud bottom not far from the coast; numerous fragments of plants some of which are doubtless terrestrial in origin, are contained in the matrix. Some disturbance of the bones was brought about by the action of waves before the entombment in sediment, and although the entombment was rapid enough to prevent a great collapse of the skeleton, most of the bones were found disarticulated and more or less dislocated.

“Fortunately, however, the crushing of the bones had not been great, and most of them were discovered close together. It is evident that the full specimen had represented an almost complete skeleton with the skull before the excavation from the bed-rock; the missing bones may have been lost by careless removal from the rock” (p. 186).

The material of 1934 lacks various parts, especially the four limbs except for the two femurs, the left tibia and ulna together with the metatarsals and a few fragments of the phalanges. Hence the nature of the limbs was far from being determined at that time.

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¹ T. Nagao: *Nipponosaurus sachalinensis*, a New Genus and Species of Trachodont Dinosaur from Japanese Saghalien. Jour. Fac. Sci., Hokkaidô Imp. Univ., Ser. IV, Vol. III, No. 2, 1936, pp. 185-220, pls. XI-XXII.

The writer had an opportunity to visit the colliery last summer with the purpose, if possible, of obtaining the remaining bones, and was very fortunate in collecting almost all the bones left at the first excavation, including the bones of the four limbs. The writer wishes to express his cordial thanks to the officials of the colliery especially to Mr. M. Kitazima, chief engineer, who assisted the writer in the excavation and supplied all facilities for the work.

In the present note the writer intends to describe the bones of the four limbs and wishes to contribute to our knowledge of the osteology of the limb-bones of Trachodontidae (Hadrosauridae).

FORE LIMB

The ulna and radius of both fore feet have been obtained in the second excavation together with the bones of the manus. The left humerus is represented by a small portion of the distal end, the right humerus having been lost.

The radius and ulna are very slender and long. The former is a shaft-like bone with somewhat sinuous lateral view; it is expanded proximally in two directions making the articular aspect L-shaped. The olecranon process is rounded, strong, and low. The distal end of the bone is moderately expanded, narrow anteriorly and wider posteriorly. The radius is a more slender bone than the ulna, cylindrical and gently expanding towards the distal extremity with a semicircular articular surface; proximally it expands more rapidly to the edges of the articular facette.

Measurements :	Ulna	Radius
extreme length	265 mm. (left)	253 mm. (left)
	260 mm. (right)	248 mm. (right)

The carpal bones are not represented in the material.

MANUS

The construction of the manus in Trachodontidae (Hadrosauridae) has been occasionally discussed. The osteological characters of this part of the skeleton were stated by O. C. Marsh and later more in detail by Barnum Brown, L. M. Lambe, and W. A. Parks.

Marsh¹, describing a remarkably well preserved and nearly com-

¹ O. C. Marsh: The Dinosaurs of North America. 16th Ann. Rep., U. S. Geol. Surv., 1896.

plete specimen of *Claosaurus annectens* (Marsh) from the Lance formation of Wyoming, concluded that the four digits preserved are I-IV, the fifth being entirely wanting, and, moreover, that digit I is rudimentary. The phalangeal formula of the manus given by him is as follows:

- Digit I two phalanges—without a hoof
- II three phalanges—with a hoof
- III three phalanges—with a hoof
- IV three phalanges—with a hoof.

Brown¹, who discussed in detail the construction of the manus for the first time, examined another nearly complete skeleton of Marsh's species from the same locality and came to a different conclusion in 1912, as shown below:

- Digit II 3 phalanges—with a hoof
- III 3 phalanges—with a hoof
- IV 3 phalanges—without a hoof
- V 3 phalanges—without a hoof.

Unlike Marsh, he considered, the four digits as II-V, I being wanting, a conclusion accepted by later authors from the relationship of these digits to the bones of the fore arm.

Next year Lambe² published a paper on the manus of a trachodont from the Edmonton formation of the Red Deer River, Alberta. According to his reconstruction, the phalangeal formula is as follows:

- Digit II three phalanges—with a hoof?
- III three phalanges—with a hoof
- IV two phalanges—with a hoof
- V two phalanges—with a hoof.

All the phalanges were thought by him to be represented in the material, except the terminal phalanx of digit II which was lost but restored as hoofed. Thus the manus is figured to have four broad hoofs.

Later Parks³, in 1919, describing a specimen of *Kritosaurus in-*

¹ B. Brown: The Osteology of the Manus in the Family Trachodontidae. Bull. Am. Mus. Nat. Hist., Vol. XXXI, 1912, p. 105, figs. 1, 2.

² L. M. Lambe: The Manus in a Specimen of Trachodon from the Edmonton Formation of Alberta. Ottawa Naturalist, 1913, p. 21, Pls. I-III.

³ W. A. Parks: Preliminary Description of a New Species of Trachodont Dinosaur of the Genus *Kritosaurus*. *Kritosaurus incurvimanus*. Trans. Roy. Soc. Canada, third Ser., Vol. XIII, 1919, p. 51, figs. 1-13. W. A. Parks: The Osteology of the Trachodont Dinosaur *Kritosaurus incurvimanus*. Univ. Toronto Studies, Geol. Ser., 1920, p. 5, pls. I-VII and text-figs. 1-22.

curvimanus from the Belly River formation of the Red Deer River, Alberta, discussed the osteology of the manus. The specimen was in a very good state of preservation, the manus being represented by its complete elements in their original position. According to him, the phalangeal formula of this species is as shown below (fig. 5):

- Digit II three phalanges—the third with a pointed hoof
- III three phalanges—the third with a blunt hoof
- IV three phalanges—the third small and probably carrying a nail; without a hoof
- V four phalanges—without a hoof.

Similar features are also well shown in a specimen of *Parasaurolophus walkeri* Parks from the same formation described by the same author in 1922¹, which preserved both manus in a remarkably excellent state, save for the terminal bone (the fourth) of digit V which had been lost.

Attention may be drawn to the fact that the osteological features are identical in the two quite different forms, belonging to the two sub-families, *Kritosaurus* of non-crested Hadrosaurinae (Trachodontinae) and *Parasaurolophus* of crested Lambeosauria.

In the specimen of *Nipponosaurus sachalinensis* from Saghalien, the bones of both manus have been found more or less scattered, some being much displaced. Hence it is very difficult to reconstruct the manus, putting each bone in its original position, and to determine the phalangeal formula. Fortunately enough, however, most bones of the left manus are preserved in our specimen except those of digit V, and being provided with other conditions, the restoration is possible with some certainty. It will be seen that the phalangeal formula of the present specimen is quite identical with that of both *Kritosaurus* and *Parasaurolophus* described by Parks.

The present material includes six metacarpals of which two pairs are identical with each other and the remaining two present two different bones belonging to each manus. Besides these, twelve phalanges are preserved, of which three have been found independently and far apart from the others. The remaining nine bones were discovered close together with three metacarpals, and hence these bones can be regarded as belonging to one of the manus, probably to the

¹ W. A. Parks: *Parasaurolophus walkeri*, a New Genus and Species of Crested Trachodont Dinosaur. Univ. Toronto Studies, Geol. Ser., No. 13, 1922, p. 5, pls. I-IX and text-figs. 1-9.

left manus, since they have been found in close association with the left ulna and radius. The bone considered here as metacarpal III of the right manus was found with the above cited three metacarpals but directed differently from the latter ones.

Thus, of the six metacarpals discovered, three belong to digits II, III and IV of the left manus; the other three certainly are metacarpals II, III and V of the right manus, the last one being the shortest of all. Among the nine phalanges presumably of the left manus, there are two triangular bones different from each other; these are most probably the bones of the second row of phalanges, one belonging to digit II and the other to digit III. There are also two terminal bones with a broad hoof, which without doubt represent the third bones of digits II and III respectively, while a small rounded bone is clearly identified with the terminal phalanx of digit IV in *Kritosaurus*, *Parasaurolophus*, and *Claosaurus*. This bone, somewhat flattened above, has been considered to bear a nail rather than a well developed hoof. The large quadrate phalanx belongs without doubt to the first row of III. Another smaller and somewhat rectangular bone represents most probably the second row of IV.

As to the two triangular bones, it is doubtful whether the pointed side was directed outward as shown in the figure of *Claosaurus* or inward as in *Parasaurolophus* and *Kritosaurus*. However, since in most characters available the manus of the present specimen is closely similar to that of *Kritosaurus* and *Parasaurolophus*, it may not be absurd to suppose that these three species are identical in the arrangement of the triangular bones. The above circumstances and other conditions indicate that in our species digits II and III were curved inwards as in the two species of the Belly River formation. From a close examination of the present material, the writer believes that the reconstruction shown in the annexed plate is most reliable.

The left manus has thus preserved all members of digits II, III and IV, digit V being missing probably because of its divergent position. The first phalanges of digit II and IV are longer and narrower than the first bone of digit III which is very large, a condition well observable in the manus of *Parasaurolophus*. The same feature is also indicated by the much expanded distal end of metacarpal III. The first phalanx of digit IV has a well developed and rounded articular surface on the outer distal end showing a very free articulation with the second phalanx, a fact also indicated in *Kritosaurus incurvimanus*.

In the right manus only six bones are preserved, representing

metacarpals II, III and V; phalanges II', III' and IV'.

From the above statements it is evident that the present species is highly similar in osteological characters of the manus to *Kritosaurus* and *Parasaurolophus*. In this connection it may be remarked that, as stated in the present writer's paper referred to before, *Nipponosaurus* is most closely akin to *Tetragonosaurus* of the Belly River formation to which the Upper Ammonite bed from which the Saghalien specimen was derived, is almost equivalent. Crested *Parasaurolophus* and non-crested *Kritosaurus* have also been derived from the Belly River formation. Moreover, it is noteworthy that those two species are identical in the construction of the manus, even in detailed points, and quite different from the trachodonts of the younger Edmonton and Lance formations. It is very important to find a species in Japan parallel in the stage of development to the trachodonts of the nearly equivalent age of North America.

HIND LIMB

The bones of the hind limb, except the phalanges, have been described in detail in the paper cited above.

Femur. This bone is large and long, 533 mm. in length, heavy and massive with a long, straight shaft and abruptly much expanded extremities.

Tibia. The tibia is about 63 mm. shorter than the femur, being 470 mm. long with a straight shaft and expanded ends.

Fibula. This is a slender bone, moderately expanded proximally. There is preserved the astragalus of either foot.

PES

Regarding the hind foot, a common phalangeal formula is shown in all well preserved specimens of various genera belonging to this family. The digits are three in number, digits I and V being wanting. Digit II has three, III four, and IV five phalanges, and the terminal phalanx of each digit is much expanded distally and hoofed.

In the present material there are seventeen phalanges preserved, eight of which belong to the left pes and nine to the right. Most of them were found dissociated and more or less displaced. Five left phalanges were obtained in the first excavation. Among the right phalanges, all of digit II and the distal three of digit III were found in close association respectively, and make the reconstruction of the

pes quite easy. From these circumstances together with the form of each bone, there is no doubt about the restoration shown in the annexed plate. The third and the fourth phalanges of digit IV are the only bones not represented in the pes. In addition, the left pes lacks the middle two phalanges of digit III.

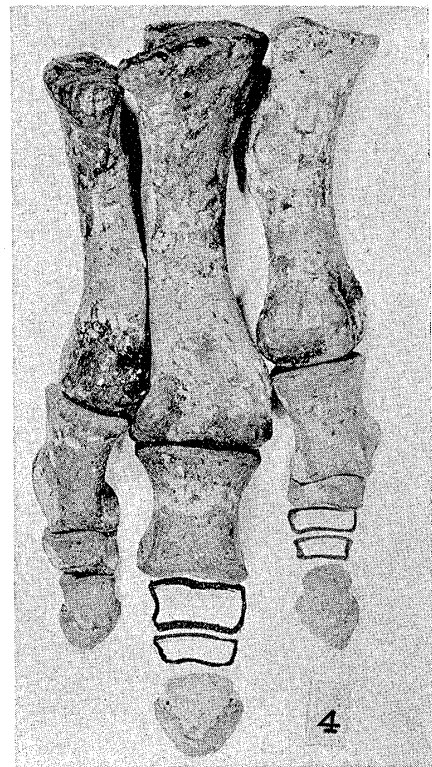
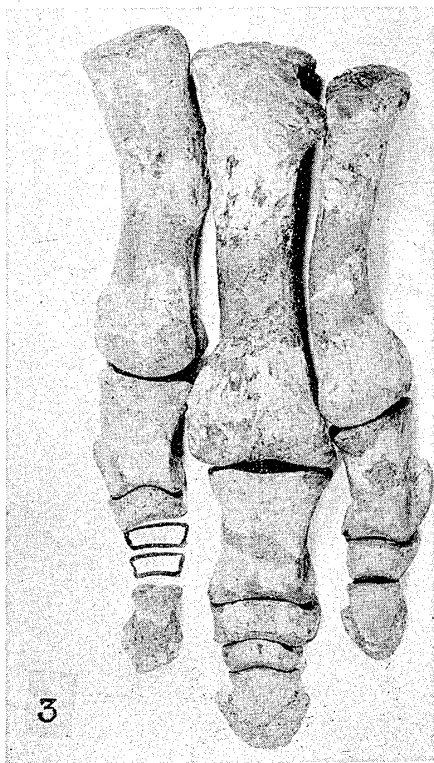
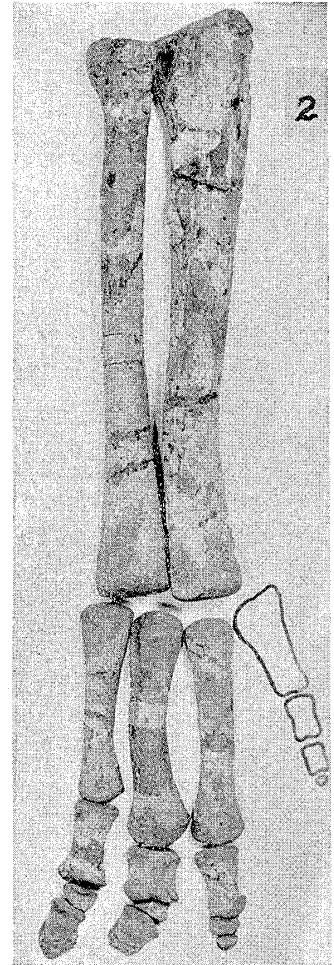
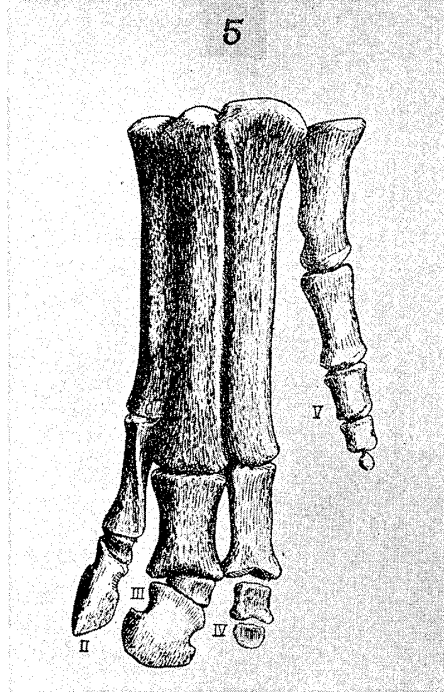
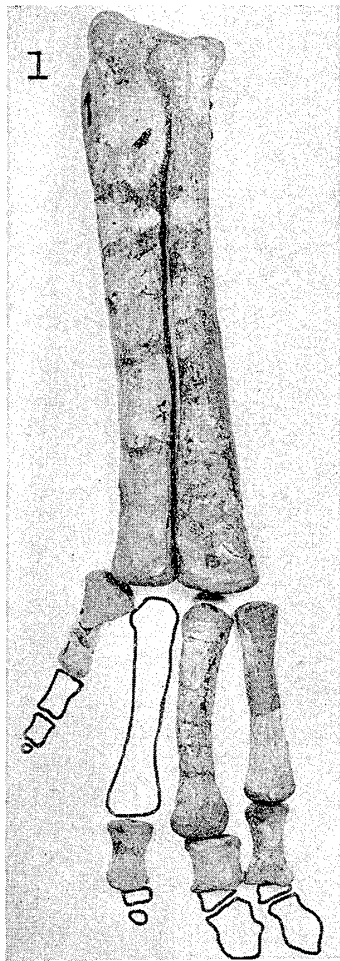
The construction of the pes is well shown by Parks in the specimen of *Kritosaurus incurvimanus* from the Belly River formation. The present specimen from Saghalien is quite similar to that species in the osteological characters of the hind foot, although some slight differences are observable between them. In the right pes of *Kritosaurus incurvimanus* figured by Parks, the first phalanx of digit III is shown to be much larger than the corresponding bones of the other two digits. In our specimen the same bone exceeds the other two bones in size only a little. Moreover, while the first phalanx of digit IV is somewhat smaller than the first phalanx of digit II in the American form, these two bones are nearly equal in size in the Japanese one.

Measurements of Hind Foot

	extreme length
Femur	520-533 mm.
Tibia	470-485 mm.
Metatarsal II	155 mm.
" III	190 mm.
" IV	158 mm.
Phalanx II ¹	63 mm.
" II ²	23 mm.
" II ³	47 mm.
" III ¹	67 mm.
" III ²	22 mm.
" III ³	15 mm.
" III ⁴	45 mm.
" IV ¹	60 mm.
" IV ²	13 mm.
" IV ³	?
" IV ⁴	?
" IV ⁵	48 mm.

PLATE 17

- Figs. 1-4. *Nipponosaurus sachalinensis* Nagao. Anterior views. One-fourth natural size.
1. Right fore arm and manus.
 2. Left fore arm and manus.
 3. Right pes.
 4. Left pes.
- Eig. 5. *Kritosaurus incurvimanus* Parks. Anterior view. About one-tenth natural size. Left manus (After Parks).



T. NAGAO: *NIPPONOSAURUS SACHALINENSIS*