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On the Stylohyoid Bone of Naumann's Elephant (*Elephas naumanni* Makiyama) from Lake Nojiri

By

Norihisa Inuzuka, Yoshikazu Hasegawa*, Hiroshi Nogariya**
and Tadao Kamei

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Abstract

The find of the hyoid bone in fossil state has been very rarely reported hitherto. Recently, a part of Proboscidean hyoid bone was unearthed from the bottom sediments at Lake Nojiri, central Japan. That is identified as the stylohyoid bone of Naumann's elephant (*Elephas naumanni* Makiyama) which is commonly known from the Late Pleistocene deposits in Japan. Comparing the present specimen with the hyoid bones of Asiatic, African and fossil elephants, it is distinguishable in having some peculiar characteristics, viz. the presence of the angulus of the posterior ramus etc..

Introduction

Since the time of the first excavation in 1962 it has been renowned that numerous fossil bones of elephant and deer have been unearthed from the bottom sediments at Lake Nojiri in northern part of central Japan. Most of them were referable to the fossil bones and teeth of Naumann's elephant (*Elephas naumanni* Makiyama) and those of Yabe's giant deer (*Shinomegaceros yabei* Shikama). As to the geological age of the main fossil horizon, the Nojiriko Formation from which the fossil bones were obtained is the deposits of the latest Pleistocene. Therefore, it may be sure that those extinct animals were the inhabitants in the later half of Würmian. The radio-carbon dating provides the range of those fossil animals to 35,000–16,000 years B. P.. (Kamei and Taruno, 1973).

It was unique that, at the time of the fifth excavation of 1973, well-preserved parts of Proboscidean hyoid bone were found from the I-C-9 grid at Tategahana, one of the localities of the north-west shores of the lake. The materials were composed of a pair of the stylohyoid bones.

It would be worth to note that Y. Hasegawa, one of the authors, first gave the suggestion at the time of excavation that the present materials were referable to the hyoid bone of Proboscidean fossils. Later, the members of the fossil vertebrate research group of the Nojiri-ko Excavation Research Group have made examination

* National Science Museum, Tokyo
** College of Humanities and Sciences, Nihon University, Tokyo

carefully for those materials and have got a conclusion that they are the stylohyoid bone of *Elephas naumanni* MAKIYAMA. In fact, it was the first discovery of the hyoid bone of Proboscidean fossil in Japan. Furthermore, it may be true that the occurrence of such material as hyoid bone of fossil elephant has not frequently been known in the world. In this regard, the object of this study was to describe the material from Lake Nojiri and to study it in comparison with other hyoid bones of living and some fossil elephants. But, as all of the specimens of the livings used here belong to the materials of immature stage, it was impossible to examine them from the view point of ontogeny. Therefore, the results of comparative study are compelled to be insufficient, and many problems left here untouched should be solved in future.

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Description

a. Hyoid Bone of Elephant

The hyoid bone is usually designated as the skeleton of the base of tongue and is situated between the lower jaw bone and the thyroid cartilage of the larynx. This bone consists of several small bones and serves special functions to connect the skull with the thyroid cartilage. In general, it is well-known that the shape of the bone differs from each other in various kinds of animals. Among them, the hyoid bone of the elephant is known in having peculiar shape dissimilar to other (FLOWER, 1966). It can be divided into two parts as shown in Fig. 1A. The one part is composed of the basal hyoid bone (*Basihyoideum*) and the thyrohyoid bone (*Thyrohyoideum*) which can be correspond respectively to the body (*Corpus*) and the greater horn (*Cornu majus*) in the case of *Homo* (Fig. 1B). The other part consists mainly of the stylohyoid bone (*Stylohyoideum*) and the tympanohyoid bone (*Tympanohyoideum*), both of which correspond to the styloid process (*Processus styloideus*) of *Homo*.

To compare the present materials with those elements stated above, it is easy to understand that the present materials of peculiar shape from Lake Nojiri are referable to the stylohyoid bone of the elephant. The stylohyoid bone of the elephant is usually connected upwardly to the temporal bone of the skull through the intermediation of the tympanohyoid bone. It is characteristic that the bone branches off ventrally in antero-posterior direction. Moreover, as the stylohyoid bone seems to be composed of three parts, the following nominations are given to

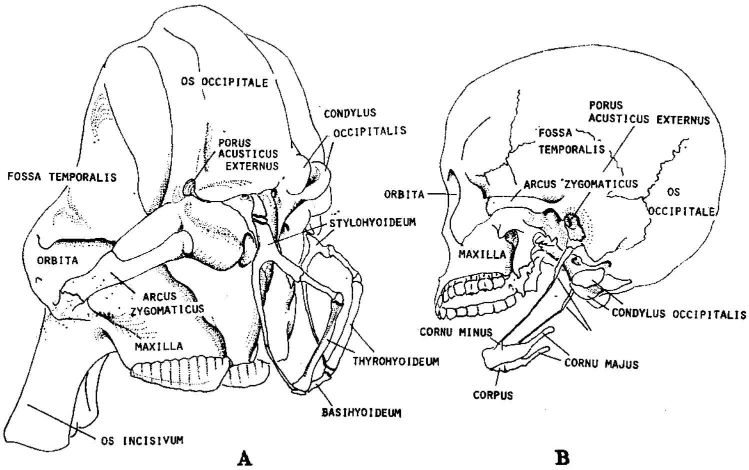


Fig. 1. Status of the hyoid bone in *Elephas* (A) and *Homo* (B).

those three parts tentatively in this paper. Namely, the inferior ramus is designated to the branch which extends to the ventral side in the frontal position, the posterior ramus is to the branch which protrudes posteriorly and the superior ramus is to the dorsal side branch which has the articulation to the tympanohyoid bone.

The inferior ramus is generally longer than the posterior ramus. From the distal end of the former the styloglossus muscle arises and raches to the both sides of the tongue to serve function to the movement of the tongue. In the neighbourhood of this place, the stylohyoid and stylopalatal ligaments arise, being in contact with both the basal hyoid bone and the soft palate. The stylopharyngeal muscle, one of the muscles which is active in the service to expand the pharynx, originates from the posterior border in the middle of the inferior ramus.

The stylohyoid muscle arises from the anterior border near the junction of the inferior and the posterior rami and attaches to the basal hyoid bone, crossing over a slip of the digastric muscle. According to SABAN (1968), however, in Asiatic elephant (*Elephas maximus* LINNE) lacks such stylohyoid muscle.

The shape of the posterior ramus varies greatly from animals to animals. In the cases of *Bos* and *Equus*, the parts which correspond to the posterior ramus of the stylohyoid in *Elephas* are represented by a simple process called as the stylohyoid angle or the muscular angle of the great cornu (SISSON, 1970). In the same manner, this process has been named by some authors variously as the posterior process (EALES, 1926), talon du stylohyal or talon posterieur (GASC, 1967). From this posterior ramus, a part of the digastric muscle arises. It is well-known that both the digastric and stylohyoid muscles stated above achieve importance in animals in connection with mouth opening and swallowing.

b. Stylohyoid Bone of Naumann's Elephant, *Elephas naumanni* MAKIYAMA

The stylohyoid bone of *Elephas naumanni* MAKIYAMA has a distinctive feature, unlike those of other elephants, in having a small erected process at the internal posterior border of the posterior ramus. For convenience to describe, this small process is named tentatively as the "angulus of the posterior ramus."

As the specimens dealt with have been unearthed in the same place, it is highly probable that they belong to a pair of the hyoid bone of one same individual. Although those two bone materials differ slightly from each other in shape and size, a result of careful examination on the materials of the livings suggests that such difference is to be within a limit of variation in one individual. Nevertheless, one may further propose some objections in dealing with them as the materials of the same one individual, because they have still some differences respectively both in morphology and in degree of preservation.

Left stylohyoid bone (coll. no. 5NC9-13, Fig. 2A; Fig. 3A, B; Pl. 5, Fig. 1: Pl. 6, Fig. 1; Pl. 7, Figs. 1, 3): The bone is more or less complete in preservation. It looks like reversed Y figure in shape. As the distal portions of all rami turn about

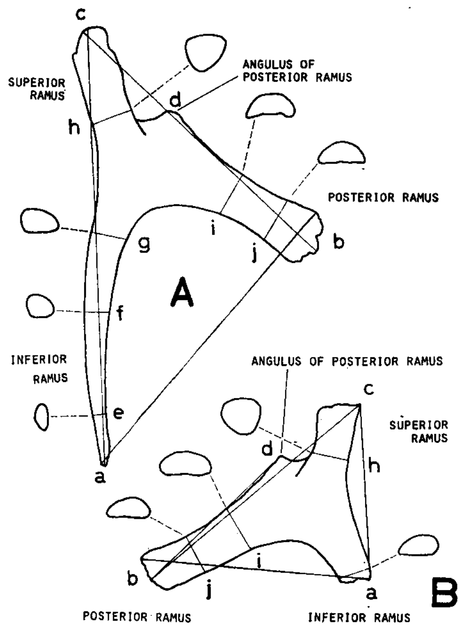


Fig. 2. The stylohyoid bones of *Elephas naumanni*, showing the points for measurements and the forms of cross sections of rami. A, Outer lateral view of left stylohyoid bone; B, Idem of right stylohyoid bone.

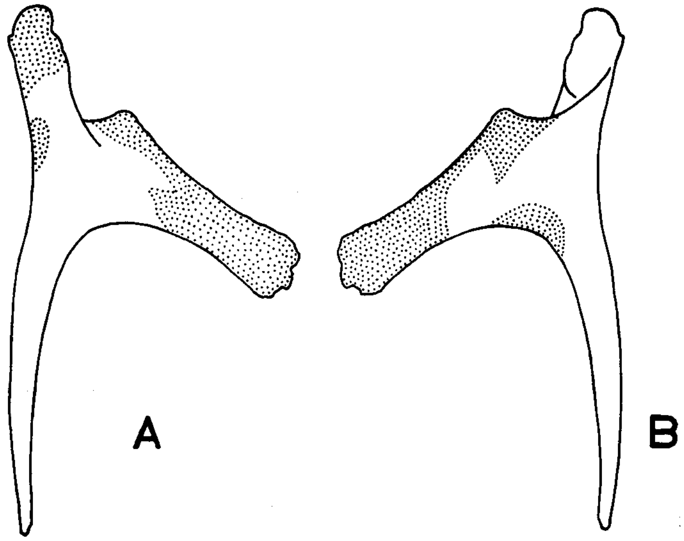


Fig. 3. Diagrams to show the distribution of tuberosity in the left stylohyoid bone of *Elephas naumanni*. A, Outer lateral; B, Inner lateral.

slightly to the outside, the external surface of this bone seems to be somewhat concave as a whole. The distal end of the inferior ramus is damaged in some extent, but the distal extremities of both the posterior and the superior rami are rather well preserved. The rugged surfaces for attachment to the cartilarge bone are observed in those portions. A plane-like portion is formed in the area where three rami meet, but a certain ridge can be observed along the border from the superior ramus to the angulus of the posterior ramus. The area of the tuberosity is shown by the stipple in Fig. 3.

The inferior ramus is much depressed and longest among three rami. Near the branching it is thick in fore-and-aft direction and thin transversely from side to side. But the nearer the apex, the more it twists anticlockwise. Accordingly, as the twisting attains to make right-angle with the initial direction at the extremity, the relation of the thickness observed tends to turn upside down. Though the curvature is very small, the inferior ramus seems to bend slightly backward in general. The ridges can be seen along anterior-external, anterior-internal and posterior-internal borders in the neighbourhood of branching, but near the extremity of the inferior ramus, a ridge which runs along anterior-internal border tends to take obtuse angle in cross section and shifts its position to the external side. Moreover, a ridge along the posterior border becomes to join with that of the external border, and therefore, there can be seen only two, internal and external ridges at the distal portion of the inferior ramus.

Consequently, the configuration of the rami in cross section varies in following manner. In the neighbourhood of the branching, it resembles a compressed right-angled triangle of which the base equates the internal surface. Near to the apical part, it tends to take obsolete or spindle form with a long axis extending from internal to external side.

The posterior ramus is relatively short and thick. It tends to be twisted very slightly by the angle of about 5° to the left. Except a slight outward bending near the place of branching, it is rather straight as a whole. The ridges are observed on both the anterior-internal and posterior borders stretching from the branching area to the extremity. As the external side of the ramus is formed to be convex, the cross section of the ramus presents a semi-circular shape in general. The internal side of the ramus is slightly concave at the middle part, owing to a distinct swelling formed by anterior and posterior ridges.

The superior ramus is the shortest among those three rami but very thick from inside to outside. No torsion and curvature can be observed in this superior ramus. The ridge which corresponds to the extention from the inferior ramus runs along the anterior-external border. That ridge is short but reaches virtually to the central part of the posterior ramus. Furthermore, a wide but short sulcus develops conspicuously between the ridge stated above and the other ridge which runs from the anterior-internal border to the angulus of posterior ramus. The anterior-internal border forms a marginal edge of the surface which is the attachment for the cartilage bone. That sulcus runs on the hind surface of the ramus from upper internal to lower external.

The superior ramus forms a triangle shape in the cross section of which the vertex faces to the external side. It seems that every angles of the triangle are rather rounded. The plane for articulation at the apical portion of the ramus is eliptical in form and is perpendicular to the axis stretching from the extremity of the lower anterior-external to the extremity of the upper interior-posterior of the ramus. A kind of tuberculate structure can be seen on the external side of the ramus at the place near the apex.

Right stylohyoid bone (coll. no. 5NC9-14, Fig. 1B; Pl. 5, Fig. 2; Pl. 6, Fig, 2; Pl. 7, Figs. 2, 4): In comparison with the former material, the right stylohyoid bone is rather ill preserved. Most of the inferior ramus and the apical portion of the superior ramus have been lost. Owing to the weathering process, a fibrous texture has been exposed on the surface and the tuberositas is rather obscure in this material. A ridge is indicated in the area along the posterior border of the inferior ramus. The internal side of the ramus presents conspicuous flat border (see the cross section shown in Fig. 2, B.).

The posterior ramus is distinctive in having two edges which are represented by the anterior and posterior margins. It twists to the right with angle of about 5°, but is nearly straight. Near the branching the ramus tends to turn about to the external side. The cross section of the ramus exhibits a sort of bow shape of which the convex side faces to the external side. Along the internal side a swelling portion extends more than 45 mm in length from the angulus of the posterior ramus, while at the middle of it a pit-like depression with the depth of about 1 mm is observed.

The superior ramus is stout and short without any torsion and turn. The ramus is enclosed by distinct four planes, viz., internal, external, anterior and posterior sides. All of the boundary areas made by those four planes are represented by weakly developed ridges. Therefore, the cross sections of the ramus are shown as rounded trapezium forms with round edges.

c. Stylohyoid Bone of Asiatic Elephant, *Elephas maximus* LINNÉ

The materials observed belong to a part of immature feamle skeleton which is kept in the National Science Museum, Tokyo. According to the observation on accessible state of dental eruption, the teeth of the elephant are estimated to be early $M\frac{1}{1}$ stage viz. about ten years old (HASEGAWA, 1972). As it is evident that those paired materials belong to one same individual, it was easy to examine the variation of left and right stylohyoid bones within one individual. Besides them, the tuberositas can be clearly observed in those materials, and therefore, they provide some useful informations about the state of muscle attachment.

Left stylohyoid bone (Fig. 4 A, Fig. 5 A, C): From posterior view, it is clear that the posterior and superior rami are arranged in a straight line. On the other hand, the inferior ramus tends to turn externally. The distribution of the tuberositas is indicated in Fig. 5 A, C.

The inferior ramus turns in a certain extent to the left near the point imediately below the branching of rami. Due to this torsion, the rotation of ramus is given to continue to the distal portion with very slight torsion angle. Just below the area of bifurcation, the ramus bends rather strongly to the ventral side. The cross section of the ramus varies from the proximal to the distal extremities, from long eliptical through subtrianglar to circular shapes (Fig. 4 A).

The posterior ramus bends gently backward. The ridge seems to be shifted to the left near the portion of the posterior end. By the internal dorsal (or posterior) border, the sulcus extends along the whole length and reaches up to the region of the superior ramus. The tuberositas is developed in the inside of this sulcus and spreads out near the distal end. The cross section of the ramus is eliptical, but near the distal end it becomes semi-circular with flat dorsal side.

The length of the superior ramus is as same as that of the posterior ramus. The tuberositas can be seen in the anterior half of both the internal and external sides, and is especially developed along the anterior border continuously to the portion

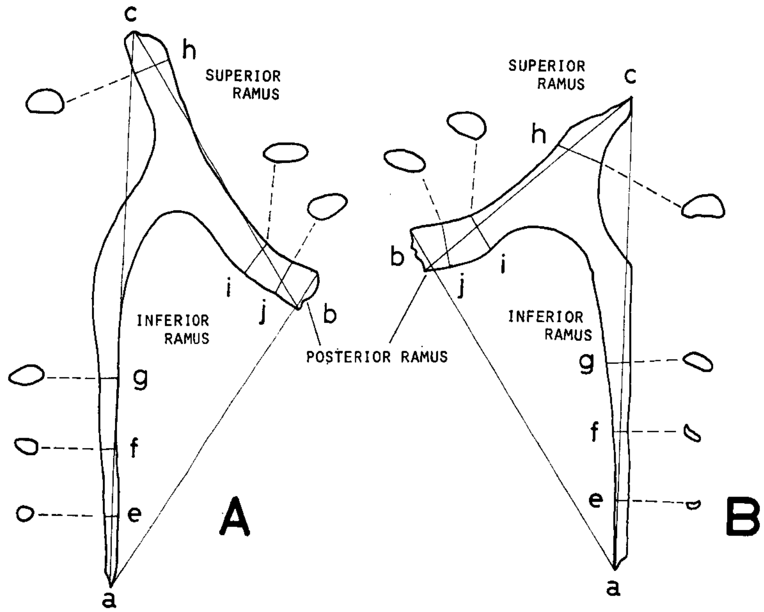


Fig. 4. The stylohyoid bones of *Elephas maximus*, showing the points for measurements and the forms of cross sections of rami. A, Outer lateral view of the left stylohyoid bone; B, Idem of the right stylohyoid bone.

of the inferior ramus. The cross section of the ramus is semi-circular in form of which the internal side is flat.

Right stylohyoid bone (Fig. 4 B, Fig. 5 B, D): Generally speaking, one may notice that the superior ramus is relatively short. Moreover, it is characteristic that the inferior ramus meets at right angle with the line connecting the superior and posterior rami. The inferior ramus bends acutely imediately below the bifurcation. It extends straight to the distal end, but twists to the right with the angle of about 10°. On the external side, the ridge runs behind from the anterior border of the branching to the distal end. On the internal side, the ridge which has a position nearby the posterior border runs from the distal end to the proximal portion, about 75 mm in length. The cross section of the ramus is shown in depressed form in the area between the proximal and the middle portions, but at the distal portion, it is represented by thick and short crescent form.

The posterior ramus is continuous from the superior ramus on the straight, but it bends slightly to the ventral side near the posterior end. The cross section of the ramus is eliptical in general, but the internal side of it is rather flat. The ramus develops the tuberositas all over the external surface.

The upper extremity of the superior ramus is the continuation of the dorsal and

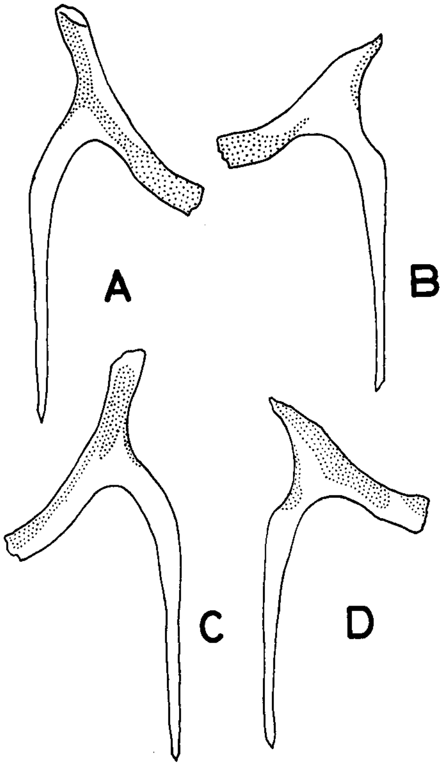


Fig. 5. Diagrams to show the distribution of tuberosity in the stylohyoid bones of *Elephas maximus*. A, Outer lateral of the left side bone; B, idem of the right side bone; C, Inner lateral of the left side bone; D, idem of the right side bone.

posterior surface. As the internal side of the ramus is flat, the cross section of ramus seems to be semi-circular of which the external side is convex. The ramus develops the tuberositas especially on the anterior border which is continuous from the inferior ramus.

d. Stylohyoid Bone of African Elephant, *Loxodonta africana*(BLUMENBACH)

The materials observed are those kept in the National Science Museum, Tokyo. They belong to a part of the immature individual skeleton. From the view point of the eruptive stage of teeth by LAWS (1966), this elephant is estimated as three years old. It is characteristic that the inferior ramus of this stylohyoid is very long. The inferior ramus is also very thin and the length of it is nearly as twice as the total length of the posterior and superior rami. The posterior and superior rami make jointly a straight line, and from the middle of which, the inferior ramus is branched off.

Left stylohyoid bone (Fig. 6 A, Fig. 7 A, C): In the proximal portion of the inferior ramus, two ridges can be observed at the anterior and posterior borders respectively. Among them, the ridge of the anterior border tends to run externally. On the other hand, in the apical portion, another ridge can be seen on the internal side, which runs obliquely from the anterior border to the back side and joins to meet with those two ridges stated above. When it reaches to the posterior-internal border, the cross section of the ramus becomes to be similar to a right-angled triangle of which the external side meets in right angle with the posterior side.

Succeedingly, the posterior border of the inferior ramus tends to run nearby the external side and also the anterior border of the ramus goes in the reach of the external side. And yet the internal border runs obliquely to the anterior side. Therefore, the cross section of the ramus looks like a regular triangle of which the base corresponds to the anterior side. Near to the apex, the height of the ridge on the anterior external border becomes low relatively. At the same time, as the width of other two ridges increases more and more, the cross section of the ramus forms consequently bow shape of which the internal side is flat.

As described above, the inferior ramus has ridges in complicated fashion hard to be explained by simple twisting. But, as a whole, it seems that it twists with the

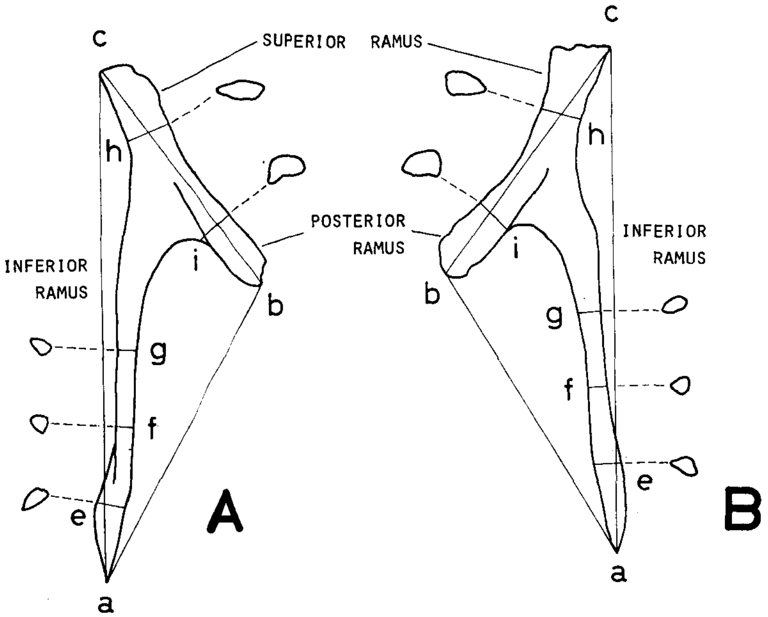


Fig. 6. The stylohyoid bones of *Loxodonta africana*, showing the points for measurements and the forms of cross sections of rami. A, Outer lateral of the left side bone; B, Idem of the right side bone.

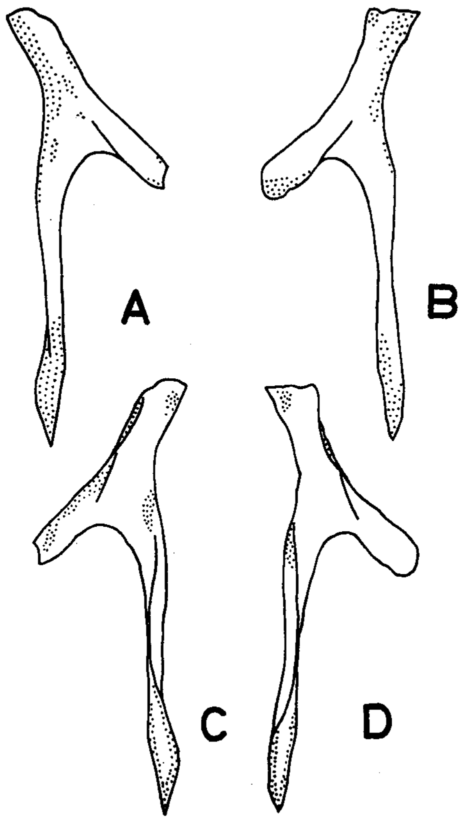


Fig. 7. Diagrams to show the distribution of tuberosity in the stylohyoid bones of *Loxodonta africana*. A, Outer lateral of the left side bone; B, Idem of the right side bone; C, Inner lateral of the leftt side bone; D, Idem of the right side bone.

angle of 45° turning to the right. As the curvature of the ramus is rather gentle, it is better to say that the ramus is rather straight.

The posterior ramus is also rather straight, but it bends slightly to the posterior with slight twisting turning to the left. The superior ramus has no twisting. On the external side, the anterior border of the posterior ramus makes a ridge which extends to the central portion of the superior ramus. A ridge can be observed throughout the hind portion of the posterior and superior rami. The tuberositas is observed on that area. On the external side of the posterior rami, a ridge runs from the rear side of the posterior ramus to the central part of the superior ramus, and at the middle part of it, a tuberositas can be recognized but faintly.

Right stylohyoid bone (Fig. 6 B, Fig. 7 B, D): The external feature is nearly symmetric to the left stylohyoid bone with respect to the median plane. But the present material is different in having a sulcus which runs along the hind border of the posterior and superior rami. In a pit of sulcus, there can be seen some tuberositas. The angle between the apical plane of articulation and the shaft of the superior ramus is less than that of the counterpart.

Measurements

The results of measurements are shown in Table 1.

Table 1. Dimensions of the stylohyoid bones in *E. naumanni*, *E. maximus* and *L. africana*.

	E. naumanni left	*E. naumanni* right	*E. maximus* left	*E. maximus* right	*L. africana* left	*L. africana* right
Greatest distance between inferior ramus and posterior ramus (a-b) (mm)	129	80	114	115	95	93
Greatest length of superior and posterior rami (b-c) (mm)	125	107	94	81	71	74
Greatest length of superior and inferior rami (a-c) (mm)	169	72	155	141	134	130
Length from Angulus to extremity of posterior ramus (b-d) (mm)	79	72	—	—	—	—
Antero-posterior & medio-lateral diameters at e (mm)	5.5×10	—	4.5× 4	5× 3	8× 3	7× 4
idem at f (mm)	10× 9	—	6.5×4.5	6× 3	4× 4	5× 4
idem at g (mm)	15× 9	14× 7	10× 6	9× 4	5.5×3.5	5.5×3.5
idem at h (mm)	16×14	15×15	13×10	15× 7	12× 5	10.5×5.5
idem at i (mm)	19×10	19× 9	14× 8	13× 7	10× 5	10× 6
idem at j (mm)	18× 8	16× 8	13× 8	14× 7	—	—
Angle between anterior margin of superior-inferior rami and ventral margin of posterior ramus	75°	80°	90°	90°	50°	50°

Comparison

Based upon the description stated precedingly, the comparison of the morphology of the stylohyoid bone among three elephants, namely, *Elephas naumanni* MAKIYAMA, *E. maximus* LINNE and *Loxodonta africana* (BLUMENBACH), is given below (Fig. 8). And also ,the stylohyoid bone of *E. melitensis* FALCONER figured in the report by ADAMS (1874) is refered for comparison (Fig. 9).

As for the general shape of stylohyoid, it is characteristic that each ramus in *E. naumanni* is relatively thick as compared with that of others. But it is probable to say that those differences in thickness of bones observed may depend upon the differences in the developmental stages of each individual.

As shown in the third column of Fig. 8, the angle between the shaft connecting

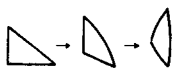
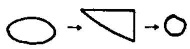
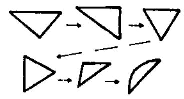
	E. naumanni	E. maximus	L. africana
GENERAL SHAPE : Generalized Form			
Thickness of Ramus	Thick	Thin	Thin
Angle between anterior margin of superior-inferior rami & ventral margin of posterior ramus	70° – 80°	90°	50°
Ratio of superior-posterior rami length to inferior ramus length	3 : 4	2 : 3	3 : 5
INFERIOR RAMUS : Shape of Extremity	gently flat antero-posteriorly	with a furrow running along the axis	expanded antero-posteriorly
Curvature	simple and slightly curved posteriorly	strongly curved near and to the branching	straight
Angle of Twisting	90°	10°	45°
Transition of Form of cross section from branching to extremity			
POSTERIOR RAMUS : Position of Ridge	in medial side along anterior and posterior margin	indistinct	in lateral side along anterior margin
Curvature	straight	bend posteriorly in the middle	slightly curved to posterior side
Generalized Cross section			
SUPERIOR RAMUS : Mode of Transition to Posterior Ramus	bend at branching	curved posteriorly	straight
Angulus of Posterior Ramus	present	absent	absent
Generalized Cross section			

Fig. 8. Comparative morphology of the stylohyoid bones of *Elephas naumanni*, *Elephas maximus* and *Loxodonta africana*.

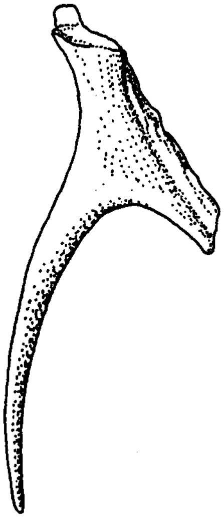


Fig. 9. The stylohyoid bone (left side) of *Elephas melitensis* (redrawn from ADAMS, 1874)

the inferior and superior rami and that of the posterior ramus is measured. The angle is larger in *E. naumanni* than in *L. africana* and smaller than in *E. maximus*. Apart from this, the angle of the divergence of the inferior ramus from the posterior ramus is large in *E. naumanni*, but it is much smaller in both *E. maximus* and *L. africana*. But the latter may also depend upon the differences of the developmental stages of those elephants.

Although the apical portion of the inferior ramus of the present material is slightly damaged, the ratio of the total length of the superior and posterior rami to that of the superior and inferior rami, shown in Fig. 8, is largest in *E. naumanni*. It is 3 : 4 in *E. naumanni*, but is 2 : 3 in *E. maximus* and 3 : 5 in *L. africana*. Accordingly, the posterior ramus in *E. naumanni* is well developed as compared with those of *E.maximus* and *L. africana*. It is also the same to say about the relation of relative ramus thickness in comparison among those elephants.

It is generally known that the styloglossus muscle arises from the distal extremity of the inferior ramus and extends to both sides of the tongue. The function of that muscle is to move the tongue side by side or withdraw it. Only in *L. africana*, the distal extremity of the inferior ramus is expanded fore-and-aft with well-marked tuberositas. In *E. maximus*, the inferior ramus is curved very strongly, especially near the branching, and bends to ventral side. The twisting angle of the inferior ramus is 90° in *E. naumanni*, but only 10° in *E. maximus*. Although in the case of *L. africana* it is about 45°, it is curious that the twisting movement is in the opposite direction to that of others.

The cross section of the inferior ramus varies in shape successively from the part near the branching to the distal extremity as figured in Fig. 8. The tuberositas of the inferior ramus is hardly seen in *E. naumanni*, but can be observed at the extremity in *L. africana*. In *E. maximus*, the tuberositas is seen in the sulcus near the extremity of the external side.

The ridge of the posterior ramus is present at the anterior-posterior border of internal side in *E. naumanni*. It is distinct at the anterior border of the external side in *L. africana*, but is obscure in *E. maximus*. The posterior ramus is straight in *E. naumanni*, but in *L. africana* it bends slightly backward. It turns behind at the middle of the ramus in *E. maximus*. The torsion is commonly observed but is very weak in those three. The cross section of the posterior ramus is different from each other, viz. bow form in *E. naumanni*, semi-circular in *L. africana* and eliptical in *E. maximus*. The tuberositas is seen on the surface of both the internal and the external sides and near the angulus of the posterior ramus in *E. naumanni*, but it covers all of the external side and the posterior half of the internal side in *E. maximus*. In *L. africana*, it can be observed in the distal part of the external side.

As to the relation of the superior ramus to the posterior ramus, a conspicuous break is observed in *E. naumanni* near the point of bifurcation. The superior-posterior rami bend slightly backward in *E. maximus* and is straight in *L. africana*. The cross section of the superior ramus is represented by depressive shape in *L. africana*, internally convex shape in *E. naumanni* and externally convex shape in *E. maximus*. The tuberositas of the superior ramus is seen in the upper half of the external side of the ramus in *E. naumanni*. It is observed in the anterior half of the external side and in the posterior to the middle of the internal side in *E. maximus*. In *L. africana*, it is distributed in the anterior half of the external side and the posterior border.

A distinct feature of the angulus of the posterior ramus seen only in *E. naumanni* is worth to discuss. From this place, a strip of the digastric muscle (*Musculus digastrcus Venter posterior*) arises. The presence of a strong process, development of tuberositas around it and a stout posterior ramus, all of them suggest that the digastric muscle was much developed in *E. naumanni*. Accordingly, it seems that Naumann's elephant was vigorous in the motion of mouth-opening and swallowing. In addition to this, it must be mentioned that only in *E. naumanni* the tuberositas can be seen on the internal and ventral sides at the junction of the superior and posterior rami. The stylopharyngeus muscle which participates in the motion of the larynx attaches to this place. Moreover, the tuberositas in the transitional area of the anterior border from the inferior ramus to the superior ramus is commonly observed in all of three elephants. But the tuberositas is developed especially in *E. maximus* and is weakly observed in *L. africana*. It may be true that stylohyoideus muscle attaches to this place in *E. naumanni*, while in *L. africana* it is uncertain what kind of muscle, viz., stylopharyngeus muscle or stylohyoideus muscle, attaches to here.

The stylohyoid bone of *E. melitensis* (ADAMS, 1873) is similar to that of *E. naumanni* in having the same curvature in the inferior ramus and the same value in the ratio of the thickness to the length. On the other hand, the former has also some characteristics common to *L. africana*, namely, the same value of the bifurcation angle of the ramus, the absence of the angle of posterior ramus and the straight feature of the posterior and superior rami. According to the original description, "When we know that fig. 10 could not have belonged to a foetal individual, it will be conceded that its owner must have been a diminutive form of Elephant." (ADAMS, 1874, p.45)

Summary

The results of the observation given to fossil hyoid bone from Lake Nojiri are summarized as follows.

1) Both of two specimens (5NC9-13, 14) from Lake Nojiti are the stylohyoid bone of Proboscidea. Moreover, it is highly probable that they belong to a part of the hyoid bone of *E. naumanni* MAKIYAMA.

2) As the results of comparison among *E. naumanni*, *E. maximus*, *L. africana*, it becomes clear that there are some morphogical differences among them.

   i) It is characteristic that the stylohyoid bone of *E. naumanni* is distinct in having a distinct process (the angulus of the posterior ramus).

   ii) The distal extremity of the inferor ramus is depressed fore-and-aft in *L. africna*.

   iii) The degree of twisting in the inferior ramus is highest in *E. naumanni*.

As the materials used for comparison were limited in this case, it is untenable to discuss in this article about the problems of functional and phylogenetic meanings of them. Therefore, it is necessary to make re-examination on those materials when more numerous and more useful materials for comparison are obtained in future.

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Explanation of plate 5

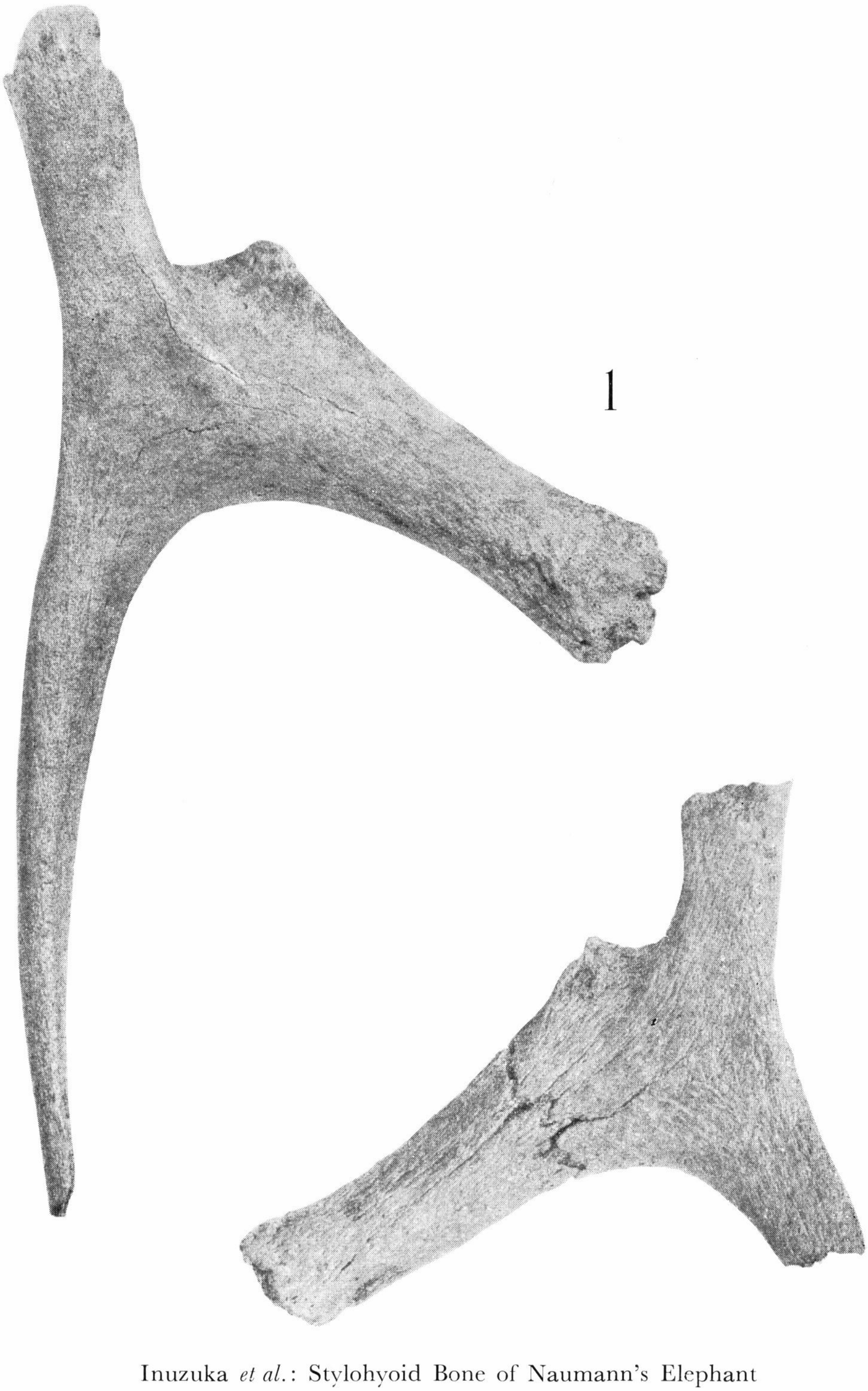
The Stylohyoid bones of *Elephas naumanni* MAKIYAMA (all natural size)
Fig. 1. Outer lateral view of the left side bone.
Fig. 2. Outer lateral view of the right side bone (partly broken).

Explanation of plate 6

The Stylohyoid bones of *Elephas naumanni* MAKIYAMA (all natural size)
Fig. 1. Inner lateral view of the left side bone.
Fig. 2. Inner lateral view of the right side bone (partly broken).

Explanation of plate 7

The Stylohyoid bones of *Elephas naumanni* MAKIYAMA (all natural size)
Fig. 1. Anterior view of the left side bone.
Fig. 2. Anterior view of the right side bone.
Fig. 3. Posterior view of the left side bone.
Fig. 4. Posterior view of the right side bone.
(Photo by T. FUJITA)



1

2

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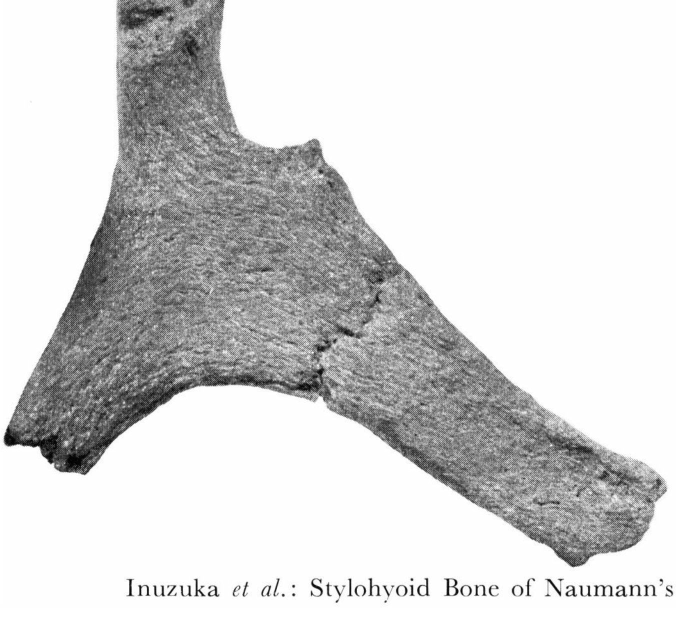
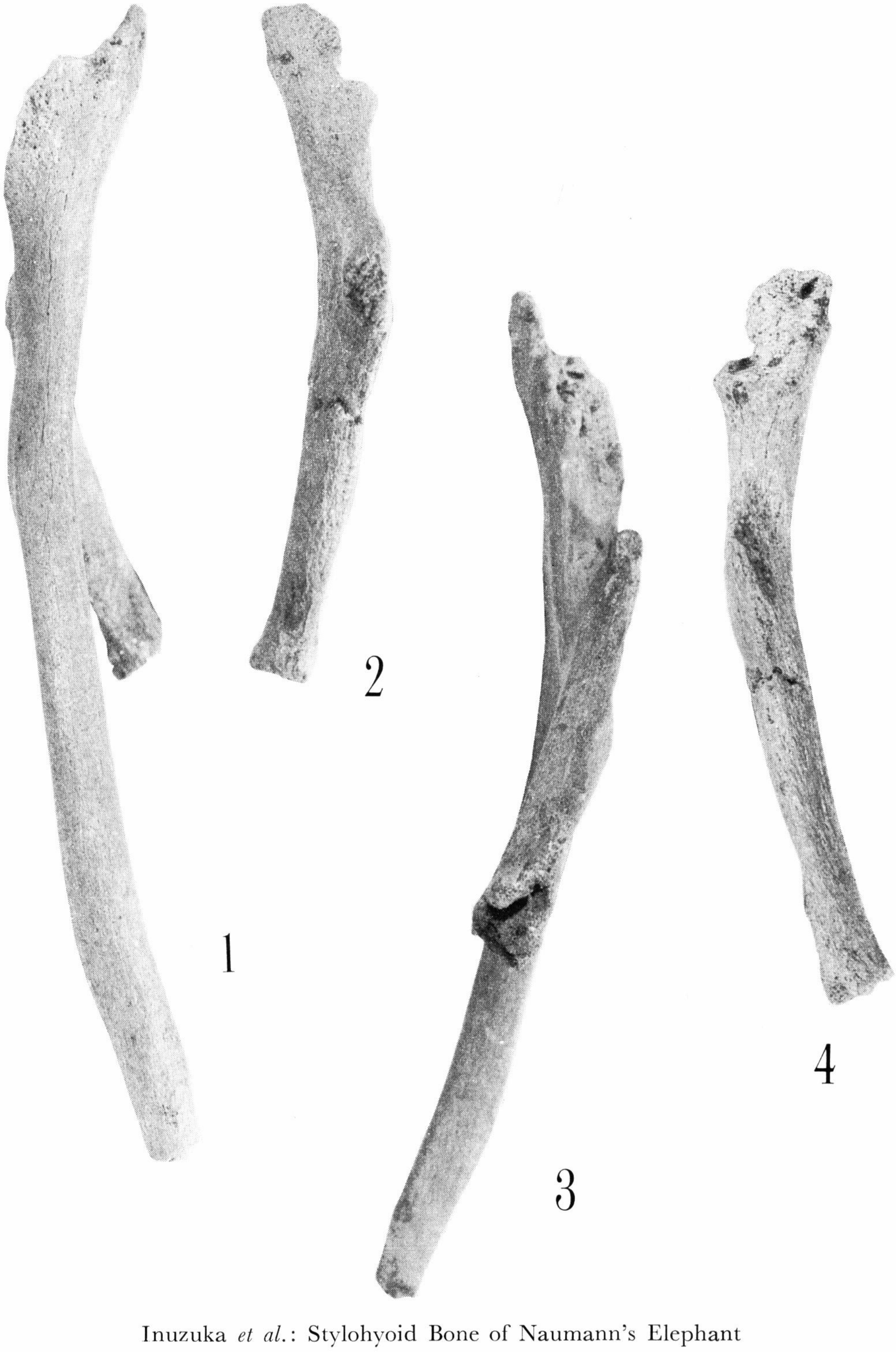
1



2

Inuzuka *et al.*: Stylohyoid Bone of Naumann's Elephant



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