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Note on the Occurrence of the Latest Pleistocene Mammals from Lake Nojiri (Part 1)

By

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Abstract

During the excavation of 1962-1965, numerous mammalian bones were unearthed from the bottom of Lake Nojiri at Tategahana, northern part of Nagano-ken, Central Japan. Fossil bones were embedded in the Latest Pleistocene lacustrine deposits of the middle part of the Nojiriko Formation of which the radiocarbon date is 21,600±900 yrs. B. P. and 31,100±2500 yrs. B. P. From the stratigraphical view point, the age of the fossil bones is estimated as twenty thousand years before.

In spite of the abundance of fossil bones, only two species of gregorious hervivores, Nauman's Elephant *Elephas naumanni* Makiyama and Yabe's Giant Deer *Shinomegaceroides yabei* Shikama, are identified. As the range of *E. naumanni* in Japan has been considered to be from the Middle to the Late Pleistocene, the present specimens represent the latest survivor.

In this paper, the description of *E. naumanni* of Lake Nojiri is given. In comparison with other specimens including type specimens the authors state that Lake Nojiri specimens are characterized in having eurycronine and hypsodont molars with thin enamel, and that *E. naumanni* of Lake Nojiri was an inhabitant of cool temperate or subarctic environment. Near the fossil locality the Late Paleolithic site of Sugikubo is located, and at the fossil locality some tips of the stone implements were discovered in association with fossil bones. But the definite relation between the mammalian remains and the Paleolithic site has not yet been confirmed.

Introduction

Associating with the recent advancement of the Quaternary stratigraphy, it became desirable to have the inspection for the Pleistocene mammalian faunae in Japan. Fortunately, the authors could have an opportunity to examine the materials obtained by the excavation of 1962–1965 at Lake Nojiri, Central Japan. In the present paper they wish to call further attention to those valuable materials which initiated the re-study on the Pleistocene mammalian faunae in Japan. Some remarks described below deal with the introduction into stratigraphical, paleontological and paleoecological studies on the specimens of Lake Nojiri.

As for mammalian fossils of Lake Nojiri, the first has been recorded in the report of Tomizawa (1956) in which he described the occurrence of a molar tooth of *Elephas* as *Palaeoloxodon namadicus naumanni* (Makiyama). This specimen had been found in Feburuary 1948 by Mr. M. Kato who was the manager of Hotel Komatsuya. After then, however, it has been known that occurrences of fossil bones from the bottom of the lake had been already noticed and obtained by some inhibitants of this place. According to Messrs. T. IKEDA and S. MARUYAMA, occurrences of some fossil bones, though those were already lost due to ill-preservation, had been collected at north-west coast of Lake Nojiri, between Biwajima and Tategahana. Furthermore, there is another interesting and important problem that the archaeological site Sugikubo where the stone implements supposed to belong to the Late Palaeolithic culture had been unearthed, is situated very near, about 600 m. north, to the fossil locality at Tategahana (SERIZAWA & AZŌ, 1953).

The need for research in the relation between fossil bones and Palaeolithic site led Dr. S. IJIRI to initiate TOYONO RESEARCH GROUP (TOYONO DAN KEN) into a excavation project at that area in 1960. Subsequently, in every early spring of 1962–1965 the excavation of the bottom of Lake Nojiri had been carried out under the guidance of Prof. Dr. M. SUZUKI of Shinshu University. The senior author was fortunate in being able to participate in this project during 1962–1965. The jumior author engaged in joint-work with the senior author in preparation, measuring and description of those excavated materials. All over the time of the excavation, the collaboration with geologists, paleontologists, archeologists and anthropologists had been performed, receiving the assistance of many students and the people who had come ready to join the excavation from many places in Japan.

The excavation of 1962–1965 resulted in uncovering a large area of fossil bones which were referable to *Elephas naumanni* and *Sinomegaceroides yabei* and in the discovery, in association with fossil bones, of some obsidian tips suggesting the presence of the Palaeolithic culture in the bone horizon. The pieces of the fossil bones were numbered up to 276, but most of them were very friable and preserved in unfavourable condition to deal with. Therefore, in the present paper, the stratigraphical remarks and the description on part of the specimens of *Elephas naumanni* are given preliminarily.

The authors wish to express their sincere thanks for all people who engaged in and gave effective support to the excavation of 1962–1965 at the bottom of Lake Nojiri. They were most fortunate in receiving valuable guidance of Dr. S. IJIRI and Prof. M. SUZUKI in the field and the laboratory. To the members of PROBOSCIDEAN RESEARCH GROUP and TOYONO RESEARCH GROUP, the authors would like to express their thanks for helpful cooperation and critical suggestion during this work. Dr. Y. SAITO and Mrs. Y. ŌSHIMA (formerly MORI) have contributed to offer many available data in stratigraphy and pollen analysis. Mr. T. FUJITA made excellent technical assistance in this work. The authors are most grateful to them for their help. Thanks are given to the members of Department of Geology, Shinshu University for their very helpful advice and help. The research was supported in part by a grant from the Ministry of Education.

Stratigraphical Remarks

Lake Nojiri is 654 m high above the sea level and located in so-called northern volcanic highland area of Central Japan. Surrounding the lake, there are many volcanoes of Pleistocene and Holocene, such as Mt. Madarao (1381.8 m), Mt. Iizuna (1917.4 m), Mt Kurohime (2053.4 m), Mt. Myōko (2445.9 m) and so on, standing high and stretching their skirts. It is then natural to presume that the geology of this area is composed of various pyroclastic sediments and volcanic rocks.

Fossiliferous locality of Tategahana is situated at the north-west lake-side of Lake Nojiri and belongs to Shinano-machi, Kamiminochi-Gun, Nagano-Ken (in lat. 36°50′ N and long. 138°14′56″ E) (Fig. 1). Around the lake, one may easily notice that there are two suits of sediments, one is subaerial volcanic and

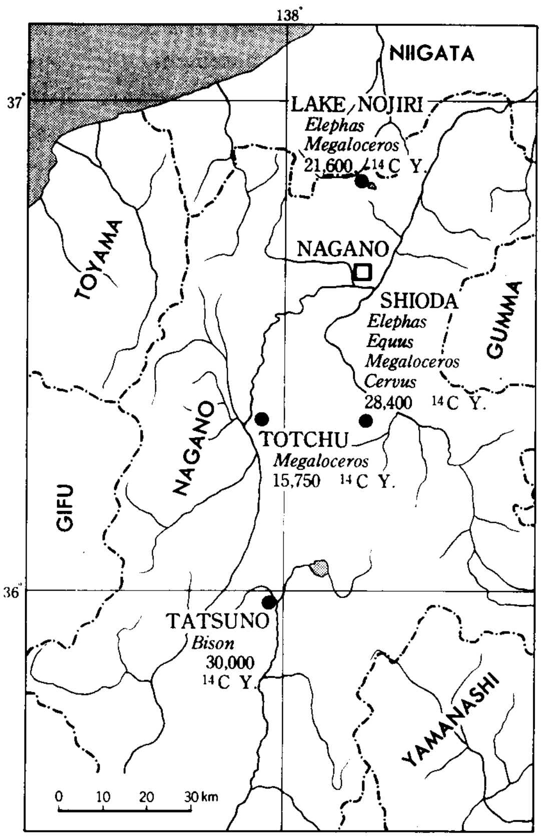

Fig. 1. Locality map of the site of the Late Pleistocene mammalian fauna in northern part of Central Japan.

the other is lacustrine. As to the subaerial volcanic sediments, they are classed stratigraphically into two units, the Younger Loam and the Older Loam. And furthermore, the former is subdivided into three subunits, the Younger Loam I, II and III ascendingly (TOYONO RESEARCH GROUP & SAITO, 1964). Recently HAYATSU (1972) carried out the sutdy on the volcanostratigraphy of the neighbouring area of this land, and he has re-defined those volcanic sediment units like as the Upper Loam, the upper Middle Loam, the lower Middle Loam and the Lower Loam. According to him, those loam units are superposed upon one another unconformably. Although the correlation between those two classifications is still uncertain, roughly to speak, the fossil horizon may correspond to the Younger Loam II of the former or the upper Middle Loam of the latter.

The view is taken here that the basement of this area may consist of the Older Loam characterized by the presence of abundant pumiceous and scoriaceous materials. The Older Loam is also intercalated in the Toyono Formation which has been considered to be the Early to Middle Pleistocene lacustrine deposits widely distributed to the south. Covering the basement, the younger lake sediments of the Nojiriko Formation extend to have a westward distribution beyond the present strandline of the lake. The Nojiriko Formation as newly defined is a series of medium to coarse sands whose lower and upper limits are the unconformity with the Older Loam and the base of the present lake sediments respectively. Within this formation, two disconformities separate the sediments into three parts. The lower part of it has a intercalation of the greyish purple coloured loam which is assumed to be equivalent with the Younger Loam I in heavy mineral composition. In the scoriaceous middle part, most of the fossil bones were contained. This horizon is assumed to be correlated with the Younger Loam II or the upper Middle Loam. The Paleolithic artifacts of Sugikubo were unearthed from the horizon of the Younger Loam III which seems to be equivalent to the upper part of the Nojiriko Formation.

The observation on the trench wall by the first time of the excavation provided the stratigraphyical succession of the fossil locality as below.

The present lake sediments		0–10 cm
	...............unconformity...............	
Bed 9	Brown medium sands	42 cm
Bed 8	Bluish grey medium sands with granules of andesite	6 cm
Bed 7	Coarse sands	7 cm
	...............disconformity...............	
Bed 6	Dark grey medium to coarse sands, fossiliferous	52 cm
	...............unconformity...............	
Bed 5	Greyish purple clayey loam	6 cm

Bed 4	Bluish grey volcanic gravels	14 cm
Bed 3	Brown volcanic gravels	3 cm
Bed 2	Green volcanic gravels	6 cm
	..............unconformity..............	
Bed 1	Volcanic ash deposits with abundant breccias and scorias, more than 150 cm	

In the stratigraphic column, it is without doubt that Bed 1 belongs to the Older Loam of the basement. Consequently, it may be tenable to denote that the sediments from Bed 2 to Bed 5 are designated to the lower part of the Nojiriko Formation. From Bed 6 to Bed 9 there are some disturbances of sedimentation, especially in Bed 9, but it is probable to say that those sediments belong to the middle part of the Nojiriko Formation.

The excavated area is large enough nearly to 3800 square meters, and scattering fossil bones have been digged out all over the area. Sometimes, fossil bones were occurred in association with many logs, some of which may be assignable to *Alnus*. The depth of the fossil bones from the surface is variable to have a range from 10 cm to 120 cm. As being well known, the facies and the thickness of lake sediments are usually variable from place to place. Neverthless, most of the fossil bones were found in the middle part of the Nojiriko Formation from the stratigraphical view point. Therefore, some fossil bones from the horizons upper than Bed 6 may be suggested to be the materials derived from the underlying sediments, judging from their fragmentary and broken occurence. Although the fossil bones in the middle part of the Nojiriko Formation had been well-preserved at the time of the excavation, some of them were desicated and broken to pieces after the transportation.

Just after the first excavation had finished, the radiocarbon dating was undertaken by wood timbers obtained from the sequence cited above. The values of them are 16,150$\pm$520 yrs. ($-$40 cm), 21,600$\pm$900 yrs. ($-$61 cm) and 31,100 $\pm$2,500 yrs. ($-$97 cm) (TOYONO RESEARCH GROUP & SAITO, 1964). Among them, the first value may represent that of the upper part of the Nojiriko Formation. It is also known that the Sekikawa Mud Flow, subaerial equivalent of the upper part of the Nojiriko Formation, has the radiocarbon date of 17,900$\pm$450 yrs., 19,300$\pm$200 yrs. and 19,600$\pm$600 yrs. Concerning the date of the middle part of the Nojiriko Formation, the value may be supplimented by the date of the upper Middle Loam of 24,550$\pm$700 yrs. (HAYATSU, 1972).

In conclusion, it can be noted without any objection that the fossiliferous horizon of the bottom sediments of Lake Nojiri is defined as the middle part of the Nojiriko Formation of the Latest Pleistocene. It is probable to say that the date of it is about twenty thousand years old. In addition, the paleoecological data which will be discussed below are present in profusion, and the objection which calls the fossiliferous horizon to be older than Late Pleistocene as formerly considered is valid on the grounds of inadequate understanding of the stratigraphy of this area. All data so far available agree there is no alternative to accepting the age for *E. naumanni* of Lake Nojiri. Therefore, Lake Nojiri bone horizon is referable to the youngest one among those of other localities of *E. naumanni* in Japan which have been ascertained so far.

Systematic Descriptions

Order PROBOSCIDEA ILLIGER, 1881
Family Elephantidae GRAY, 1821
Genus *Elephas* LINNAEUS, 1758
Elephas naumanni MAKIYAMA

1924 *Elephas namadicus naumanni* MAKIYAMA: MAKIYAMA, pp. 260–262, Pl. XI–XV, XVI Fig. 1.
1924 *Elephas namadicus namadi* POHLIG: MAKIYAMA, p. 264, Pl. XVI Fig. 2.
1938 *Elephas namadicus naumanni* MAKIYAMA: MAKIYAMA, pp. 41–54, Figs. 22, 24, 25, 26, 28, 29, 30.
1956 *Palaeoloxodon namadicus naumanni* (MAKIYAMA): TOMIZAWA, pp. 412–413, Fig. 4.

Remarks

In this paper the authors intend to compare Lake Nojiri specimens directly with the type specimens from the Sahamma Mud Formation, Sahamma, north-east of Hamamatsu City. The syntypes consist of five specimens, the mandible with the third molars *in situ* of both sides, two isolated upper third molars *sin. et dext.*, an isolated upper second molar *sin.* and an incisor probably *dext.* In 1924, MAKIYAMA had given full discription to those materials, and in that paper he had noted that those except the upper second molar might had been assigned to the same individual. All those specimens, except the second molar, have been kept in the Department of Geology and Mineralogy of Kyoto University.

The Sahamma Mud Formation or the Sahamma facies of the Hamamatsu Formation which yielded the type specimens forms the Mikatagahara upland assigned to the equivalent of the middle terraces along Pacific Coast, which is assumed to the sediments of the Last interglacial (K. KOBAYASHI, 1963). In 1938, MAKIYAMA reviewed the proboscidean fossils in Japan and denoted the species of *E. namadicus naumanni* to be synonimous with the following species: *E. namadicus namadi* of MAKIYAMA, 1924; *Parelephas protomammonteus* of MATSUMOTO; 1924; *Loxodonta* (*Palaeoloxodon*) *namadica yabei* of MATSUMOTO, 1929; *E.* (*Palaeoloxodon*) *namadicus setoensis* of MATSUMOTO, 1929; *E. indicus buski* of MATSUMOTO, 1929; *Euelephas trogontherii* of MAKIYAMA, 1924; *Palaeoloxodon yokohamanus* of TOKUNAGA, 1934. In this case the authors assent to his opinion, but they give the designation to *E. naumanni* MAKIYAMA as an independent species. So far as they have concerened, it seems that there is no cleancut distinction among some the specimens

Table 1. A list of the fossil bones of *Elephas naumanni* MAKIYAMA excavated from the bottom of Lake Nojiri.

MOLARS	Upper third molars ($\underline{3}$ M $\underline{3}$)	5
	Upper second molars ($\underline{2}$ M $\underline{2}$)	2
	Lower third molars($\overline{3}$ M $\overline{3}$)	1
	Incisor (I)	1
	Isolated dental plates	many
SKULL	Fragment of parietal bone	1
	Fragment of malar bone	1
	Fragments of occipital bone	3
	Fragments of skull bones	5
	Fragments of mandibula	1
VERTEBRAE	Atlas	1
	Axis	1
	Cervical vertebrae	2
	Thorathic vertebrae (fragmentals)	3
	Lumbar? vertebrae (fragmental)	1
THORAX	Ribs (Partly fragmental)	43
FORE LIMB	Fragments of shoulder blade (Scapula)	4
	Humerus	2
	Isolated caput of Humerus	2
	Ulna	2
	Radius	1
	Carpal bones	3
	Metacarpal bones	1
HIND LIMB	Thigh bone (Femur)	3
	Isolated caput of thigh bone	4
	Shin bone (Tibia)	2
	Fibula (fragmental)	1
	Tarsal bones	2
	Total: More than	98

referred to *E. namadicus naumanni, E. naumanni, Palaeoloxodon namadicus naumanni, Palaeoloxodon naumanni, P. tokunagai, P. tokunagai junior.* As a result this species has a wide range of variation leaving out of consideration on age and area, and it is necessary to re-examine those specimens from paleontological as well as stratigraphical view points. Therefore, Lake Nojiri specimens which occurred from the definite horizon and are rich in number are worth to study.

The number of those materials excavated in Lake Nojiri attained about one hundred (Table 1), but most of them occured in friable and often even fragmentary state. Owing to such state of preservation the authors were obliged to deal with only a few mateials which were rather well preserved. For comparison with other species, some specimens of *E. naumanni* from the sea-bottom of the Seto Inland Sea (Setonaikai) and of living elephants such as *E. maximus* collected in Thailand and *Loxodonta africana* in East Africa, were also prepared.

Description

Upper third molar. There are five isolated molar teeth which are conveniently called by numbers from No. 1 to No. 5. In Table 2, measurements are shown to compare with those of other specimens. Among them, No. 1 specimen (Pl. 4, Figs. A, B) is a left molar which was collected by M. KATO in 1948. This specimen is dark grey in colour and has ragged surface of the enamel layer exposed as the result of severe weathering. Although there was originally a covering of cement, none of this remains now. Due to the damage of the tooth crown, some dental plates which occupied the mesial portion have been already lost. Accordingly, there are $+15\frac{1}{2}$ plates preserved of which the five distal ones are unworn and the mesial ten in early wear. The planks of the dental plate are arranged subparallel with one another, and the thickness of the plates is rather constant from top to base. All the plates are fused by the secondary dentine at their base throughout from mesial to distal, but in the distal part of the tooth crown behind the eighth, the base of plates leave each open cavities without any fillings. It indicates a half mature stage of this molar. In occulusal view, the well-worn dentinal discs of elongate elliptical form are surrounded by the coarsely folded thin enamel layer. There is no suggestion of the distinct loxodont sinus in the median axial zone. The complete plate is built from three cones of which the central is the broadest, and the crests are divided into minor digitations.

Table 2. Dimensions (mm.)

	Lake Nojiri specimens					Sahamma specimens (Syntypes)	
	(1)	(2)	(3)	(4)	(5)		
	l	l	r	l	l	r	l
N	$+15\frac{1}{2}$	$+19\frac{1}{2}$	$\frac{1}{2}17\frac{1}{2}$	+13+	$+16\frac{1}{2}$	$\frac{1}{2}17\frac{1}{2}$	$+16\frac{1}{2}$
U	11	11	10	11	12	11	11
L mm.	210	268	258	250	251	278	271
Lg mm.	172	159	170	221	168	211	198
H mm.	218	225	254	220	212	201	200
W mm.	95	91	91	89	90	84	86
E mm.	3.0	2.0	2.0–2.5	2.5	2.5	3	3
F	6–7	7	6–7	6–7	7	6–7	6–7
$\varphi°$	40	50	50	60	45	50	50
$\theta°$	70	60	60	50	60	60	60
K	2.3	2.5	2.7	2.5	2.4	2.5	2.3
Q %	6.4	6.9	5.9	5.0	7.1	5.2	5.6
W/L %	45	34	35	36	36	30	32
H/L%	104	84	98	88	84	72	74

l: left molar. r: right molar. N: number of dental plates. U: used dental plates. L: Length frequency of dental plates in 100 mm. φ: eruption angle. θ: occulusal angle. K: index of

A well-preserved right molar of No. 3 (Pl. 5, Figs. A, B) represents slightly younger stage than No. 1. The surface of the tooth crown is heavily covered by the cement of light brown in colour. The number of the dental plates is adequate to be indicated as ½ 17 ½ of which the mesial ten plates are already in wear. The basis of the plates from the first to the tenth are fused, and among them, the mesial three form the root-like projection, extending below the base. However, the distal plates behind the tenth are left freely without any basal conjugation. In occulusal view, the grinding surface is oval in outline, and each dentinal disc under wear forms elongate eliptical form with lateral tappering of the thickness. But the enamel figure is not lozenge in shape. The dental plate has the widest breadth in the basal part, but the breadth becomes narrower gradually near the top of the tooth crown. A dental plate consists of three portions divided longitudinally by the lateral fissures, of which the median portion is more swollen and broader than the other two lateral protions. The enamel plication is rather coarse and develops especially in the middle part of the plate. The loxodont sinus in the axial zone is recongnized feebly, protruding forwards and behind.

No. 2 (Pl. 6, Figs. A, B) is a left molar which exhibits nearly the same developmental stage as No. 1. Most of the cement is eroded out and some of ragged surface of the enamel layer is exposed. The mesial portion of the tooth is slightly damaged, but it is possible to denote the numbers of the dental plates as ½ 19 ½.

and indices of the 3 M 3.

Seto Inland specimens					*E. maximus*		
Shodoshima		Tomogashima			Thailand		
r	l	r	l	l	l	r	r
+14+	$+16\frac{1}{2}$	$\frac{1}{2}17\frac{1}{2}$	$\frac{1}{2}17\frac{1}{2}$	$\frac{1}{2}16+$	$\frac{1}{2}21\frac{1}{2}$	$+17\frac{1}{2}$	$+17\frac{1}{2}$
11	16	• 9	13	10	8	9	9
198	240	211	245	243	282	244	256
181	—	132	183	169	140	142	159
195	195	203	245	206	187	209	214
85	82	83	90	81	82	80	98
2	2	3.2	3.1	3.0	3.0	3.1	3.2
7	7	6–7	7	7	7–8	7–8	7
50	40	55	50	60	60	60	55
60	55	52	62	55	50	45	50
2.3	2.4	3.2	2.7	2.5	2.3	2.6	2.2
6.1	—	6.8	7.1	5.9	5.6	6.3	5.7
43	34	30	37	33	29	33	34
98	81	96	100	85	66	56	75

of crown. Lg: Length of grinding surface. W: maximal width. E: enamel thickness. F: hypsodonty, H/W. Q: index of functional density of plates, 100U/Lg

Among the plates, the mesial eleven ones are in wear, but the basal part of the plates from the tenth to the nineteenth is still escaped from the fusion. The appearence of the enamel figure is just as same as that of No. 1.

Both No. 4 and No. 5 seem to belong the left molar group and are in some way broken. Therefore, only the measurements are given in Table 2.

Compared with the well preserved specimens of Lake Nojiri to the type specimens, they are all very similar in size, form, proportions and other characteristics, but at first glance, it is clear that all of them are distinguishable from the upper third molars of *Elephas maximus* in having the lower value of the occulusal angle. The occulusal angle treated here is a morphological character conventionally named to an acute angle measured between the occuluding surface and the plane in parallel with the alignment of dental plates, and it seems to be available for the identification of Elephantidae in the uppermolar morphology of the same developmental stage. In this case, the value of *E. naumanni* ranges from 50° to 70°, while that of *E. maximus* is from 45° to 50°.

The occulusal angle above mentioned is closely related to the eruption angle of AGUIRRE (1969). In the paper, he has defined that the eruption angle φ is measured as an angle between the occuluding surface and the base of the molar crown. Although the procedure to denote the base of the crown seems to hold some ambiguity in practice, he stated that the eruption angle is useful to track the phylogenical trend of Elephantidae. That is, the molar forms shift to those of more progressive polulation with the increase of that angle. The φ of *E. antiquus* has the range between 34° and 51°, and the values of the specimens refered to *E. naumanni* are also included in the extent of the former. Whilst, it must be noted that most of values of the latter concentrate in the domain of rather high value, more than 40°. Therefore, it is probable to say that the domain of *E. naumanni* coincides with the extent of the progressive form of *E. antiquus*.

Taken other morphological characteristics into consideration, the differences between the types and Lake Nojiri specimens are very slight, except the thickness of enamel. Therefore, in comparison with the intra-specific variation of *E. maximus*, all of *E. naumanni* given in Table 2 including Lake Nojiri, Sahamma-(the types), and Seto Inland Sea specimens, are inferred to be placed within the range of the individual variation.

In Fig. 2, the distribution of the width and the height of the upper last molar of *E. naumanni* is given. The width of the tooth crown has the range between 58 mm and 96 mm and the average of it is about 80–84 mm. Accordingly, the values of Lake Nojiri specimens, 89–95 mm., represent that those belong to the broad molar crown group. On the other hand, the height of the molar crown ranges from 185 mm to 230 mm and the average of it is 200–206 mm. The values of 212–254 mm of the present specimens indicates those of the high crown

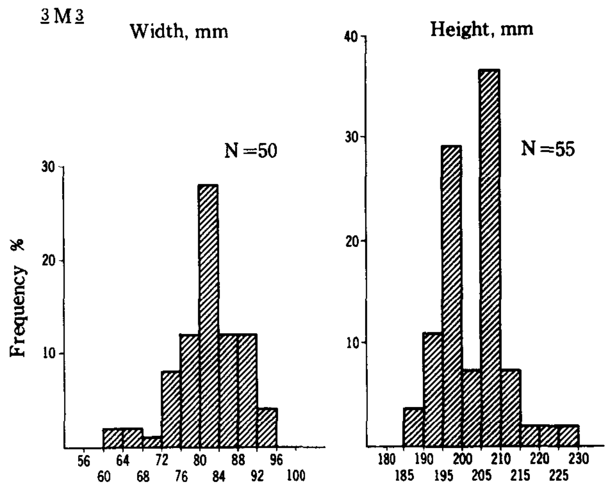

Fig. 2. Histogram showing percentage variation of width and height of th- 3 M 3 of *E. naumanni* in Japan. N means number of samples.

group. As the type specimens have the values coincident with average of the width and with that of the height, it may be concluded that Lake Nojiri specimens belong to eurycoronine and hypsodont group among the specimens refered to *E. naumanni*. Besides, the present specimens are characterized in having more number of plates and less thickness of enamel to compare with other materials.

Lower third molar. Only one specimen of the isolated right molar is preserved (Pl. 7, Figs. A, B). Owing to the weathering, ragged surface of the enamel is exposed, but the light brown cement material remains nearly all over the surface of the molar. The molar has a characteristic appearence of mesio-distal twisting as seen as usual in the lower last molar of *Elephas*. There are ½ 17+dental plates preserved of which the eight distal ones are unworn and the mesial nine in wear. The basis of the mesial ten plates are already united by the extention of the enamel layer, and have the well-developed root-like dentine projections. On the occuluding surface, the enamel figure appears rather smooth as a whole. The loxodont sinus is very feeble, but some significant notches made from the enamel is present especially in distal side of the plates. Measurements for the present and comparable specimens are given in Table 3.

In all the essential details, this molar tooth corresponds closely to the type specimens of *E. naumanni*. But the present specimen slightly differs from the latter in having less prominent loxodont sinus, more crenellate and thinner enamel, and broader and higher tooth crown. To compare with the other speci-

Table 3. Dimensions (mm.) and indices of the $\overline{3}$ M $\overline{3}$. Abbreviations are those used in Table 2.

	Lake Nojiri specimens specimen	Sahamma specimens (Holotype)		Seto Inland Sea (Shodoshima) specimen
	r	r	l	r
N	$\frac{1}{2}17+$	$\frac{1}{2}15+$	$\frac{1}{2}16+$	$\frac{1}{2}17\frac{1}{2}$
U	9	12	13	10
L mm.	252	250	277	221
Lg mm.	157	217	233	160
H mm.	182	134	146	168
W mm.	82	81	82	71
E mm.	2	2.5	2.5–3.0	72–2.5
F	5–5	5–6	5–6	6–7
W/L %	33	32	30	32
H/L %	72	—	—	76
K	2.22	—	—	2.37

mens as shown in Fig. 3, it becomes clear that Lake Nojiri specimens belong to eurycronine and hypsondont group as same as in the case of the upper molars.

As the type specimens are characterized in having somewhat emerged enamel figure of lozenge form, it is assumed that there are two types of the enamel figures, distinct and indistinct lozenge form. But, molars of those both types have been often obtained from the same locality. Therefore, those two types of enamel figure may be due to the sexual dimorphism.

Upper second molar. Two molars are collected from the just same locality of the bottom of the lake, and they are quite similar with each other in form and degree of wearing (Pl. 8, Figs. A, B, C). Therefore, it may be probable that those two specimens belong to the same individual. Both right and left molars are well preserved with the covering of light brown cement, and have the same numbers of plates as ½ 12 ½ of which only one plate is unworn. Two distal plates are isolated freely without any basal connection. The root-like projections are observed at the basal part of the mesial ones. The thickness of the lateral edge of a plate is moderately thin, and consequently, the margin of the dentinal disc tapers acutely to form a lozenge of enamel figure. Crenellation of the enamel layer is significantly developed at the axial zone and the loxodont sinus is rather distinct especially on the distal side of a plate. Measurements for the present and the comparable specimens are given in Table 4.

In comparison with other specimens, the values, the height and width of the crown, of the present specimens represent the average of *Elephas naumanni* in Japan (Fig. 4).

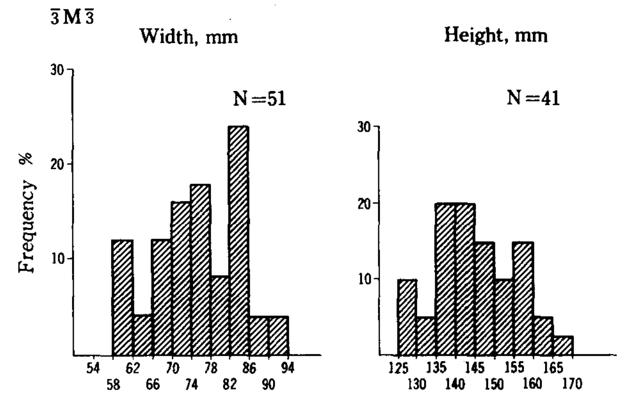

Fig. 3. Histogram showing percentage variation of width and height of the $\overline{3}$ M $\overline{3}$ of *E. naumanni* in Japan. N means number of samples.

Table 4. Dimensions (mm.) and indices of the $\overline{2}$ M $\overline{2}$. Abbreviations are those used in Table 2.

	Lake Nojiri specimen		Makinogahara specimen	Seto Inland Sea (Tomogashima) specimen
	r	l	l	r
N	$\frac{1}{2}12\frac{1}{2}$	$\frac{1}{2}12\frac{1}{2}$	$\frac{1}{2}12\frac{1}{2}$	$\frac{1}{2}12\frac{1}{2}$
U	11	11	7	11
L mm.	203	199	211	193
Lg mm.	192	188	191	189
H mm.	168	174	188	175
W mm.	75	76	75	73
E mm.	1.5–2.0	1.5–2.0	2.0	3.0
F	6	6	7	6.5
$\varphi°$	55	55	60	60
$\theta°$	70	69	50	55
K	2.2	2.3	2.5	2.3
Q	6.8	5.8	3.7	5.8
W/L %	37	38	36	38
H/L %	83	86	89	91

Incisor. Friable and curved right tusk is preserved, missing the root portion (Pl. 9, Fig. A). The straight length from apical to distal ends is measured as 1272 mm, and therefore, the estimated total length may be about 1500 mm. The length along the curvature is 1360 mm. The cross section near the apex is circular, but it becomes rather elliptical to go nearer to the distal portion. The diameters are 49 mm × 49 mm near the apical portion, 91 mm × 80 mm behind 500 mm

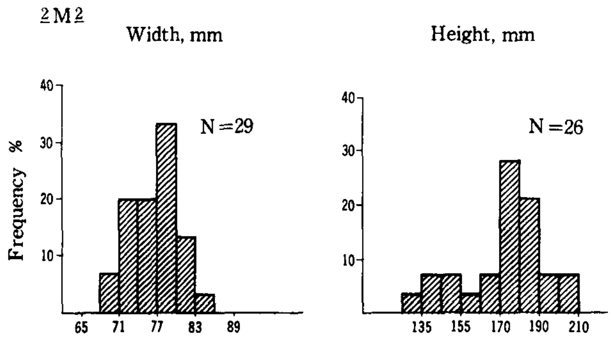

Fig. 4. Histogram showing percentage variation of width and height of the 2 M 2 of *E. naumanni* in Japan. N means the numbers of the sample.

from the former point and 119 mm × 97 mm at the distal portion. The tusk is twisted outside-ventrally at first, and mesio-dorsally in the next.

Vertebrae. There are one atlas, one axis and two cervical vertebrae moderately preserved. Measurements of them and those of the compared materials are given in Table 5. Compared with the materials of other species, Nojiri Lake specimens are characterized to be larger as a whole. The atlas (Pl. 10, Fig. A) is damaged to some extent at the external portions on each side, but it has transverse processes which bent slightly upwards like as those of *Loxodonta africana*. Contrast to them, the processes of *Elephas maximus* usually project nearly to horizontal direc-

Table 5. Dimensions (mm.) and comparison of the vertebrae

Atlas:	Lake Nojiri specimen	*L. africana** (E. Africa)	*E. maximus** (Thailand)	*E. antiquus*** (Upnor)
Extreme width of articulating surface for condyles of skull.........	225	205	223	295
Extreme height of vertebra.........	199	199	152	285
Extreme width of articulating surface for axis..................	224	184	143	265
Axis:				
Width of anterior surface.........	209	182	147	275
Extreme height of vertebra.........	200	174	137	370

Vertebrae:	Lake Nojiri specemen (1)	(2)	*E. maximus* Cervical VI
Width of anterior surface............	—	191±	136
Extreme height of corpus............	142	138	104

* Both *L. africana* and *E. maximus* have the second molars sufficiently masticated.
** The measurements of *E. antiquus* are after ANDREWS and COOPER (1928)

tion. Both tuberculum dorsale and t. ventrale descend by a gradual slope to the base, and such feature differs from *L. africana* and *E. maximus* which have eminent tuberculums. Foramen looks like the shape of the figure 8 of which the upper and the lower cavities are rather equal in size. Accordingly, it differs from those of reversed delta form of *L. africana, E. maximus* and *E. meridionalis.*

The *axis* (Pl. 10, Fig. B) has a slender but massive neural arch comparable to that of *E. antiquus* of Upnor (ANDFEWS & COOPER, 1928). It has been known that this feature is different from that of *E. meridionalis.* There are some other slight differences to compare with the axis of *L. africana* and *E. maximus* by the status of facies articularis cranialis, foramen, fossa vertebrae and dens.

Two cervical vertebrae are damaged severely and the neural spines are lost. Therefore, the angle at which the spines are placed is unknown. However, larger size of the present specimens is quite different from those of others.

Humerus. There is a damaged left Humerus of which shaft from just below tuberculum majus to above trochlea preserved (Pl. 11 Fig. A). The shaft preserved is measured as 560 mm. in length, and the total length is estimated as 750 mm. The bone is massive and stout, but is less twisted than that of *E. maximus.* The facies of tuberositas deltoidea is flat and broad. Measurements are as follows:

Length preserved	..........560 mm.
Total length (estimated)	..........750 mm.
Greatest width at distal end	..........216 mm.
Least diameter of the shaft	..........81 mm.
Mesio-distal thickness at the middle of the shaft	130 mm.

Radius. There is a friable but well preserved right radius (Pl. 11 Fig. B). It has no peculiarity in form, but is distinguishable in having larger size and stout feature. As it has been known that *E. naumanni* from Churui has also large and stout radius in proportions (KAMEI et al. 1971), such state of bone may be one of characteristics of this species. Measurements are given as follows:

	The present specimen	*E. maximus* (Thailand)	*E. antiquus* (Upnor)*
Length	752 mm.	610 mm.	990 mm.
Width of the middle	60 mm.	88 mm.	175 mm.
Width of upper articulation	142 mm.	102 mm.	190 mm.
Greatest width at distal end	60 mm.	32 mm.	—

* after ANDREWS & COOPER (1928)

Ulna. A broken left ulna is preserved with only a portion from the lower olecranon to the middle of the shaft, of 575 mm. in length. It is stout and massive. Estimate total length may be approximately 700 mm. and the least diameter of the shaft is 84 mm. Except massive and rough surface of inner side of the upper shaft, there are no peculiarity to describe.

Femur. The shaft of a right femur excluding both proximal and distal portions is preserved (Pl. 11, Fig. C). Preserved length is 775 mm., and estimate total length my be approximately 930 mm. Least diameter of the shaft at the middle portion before back is 141 mm and that from side to side is 99 mm. Depressed form of the shaft is the most characteristic. Apart from this, there are four isolated caput femoris. The diameters of them are measured as 140 mm, 144 mm, 146 mm and 156 mm, respectively.

Discussion

In Japan, *Elephas naumanni* appeared in the Middle Pleistocene and was widespread as a modest member of the well-known Late Pleistocene fauna. If the specimens dealt here belong to the last surviving one, this species persisted to the end of that period. As was said in the foregoing description, the molars of Lake Nojiri specimens have been generally classified as eurycronine and hypsodont form. However, the values measured are inferred to be continuous to those of the type specimens. Obviously the present specimens may be included within the variation of *E. naumanni*.

For a long time, there has been a discussion concerning the mutual relationship among *E. naumanni*, *E. namadicus* and *E. antiquus*. For comparison, morphological factors of the upper third molar of those and allied species are shown below (Table 6), following to the data of DIETRICH (1951), FRADE (1955) and DUBROVA (1960). In the table, bare figures represent the average and the figures in perenthsis shows the maximal values.

As seen in the table, it seems that *E. naumanni* is closely related with *E. antiquus*, *E. mnaidriensis*, *E. turkmenicus* and *E. namadicus*, however, it is obscure in practice to refer the materials given to any definite species to be based upon

Table 6. Comparison of dimension and indices of the $\underline{3}$ M $\underline{3}$.

	N	L mm.	W mm.	H mm.	F	E mm.	K	W/L %	H/L %
E. naumanni	17(19)	250(280)	85(95)	205(230)	6–7	2–3	2.4	34	82
E. *namadicus*	15(19)	240	94(106)	203(213)	5–6	3–4	2.2	39–44	84–88
E. antiquus	16(19)	254(280)	81(90)	165(190)	5	3–4	2–2.1	32	65–68
E. germanicus	16(20)	261(340)	70(98)	110(240)	6	2–2.5	2.7–2.5	27–29	71–73
E. italicus	20	195	82	190	6	—	2.3	28	64
E. ausonius	19?	270	75–89	165–190	5–5.5	2–2.5	2.1–2.2	28–33	61–71
E. mnaidriensis	14(15)	325	85	238	5	2.5	2.8	26	73
E. turkmenicus	19	366	109	260	4.5	3.5	2.4	30	71

* Abbreviations are those used in Table 2.

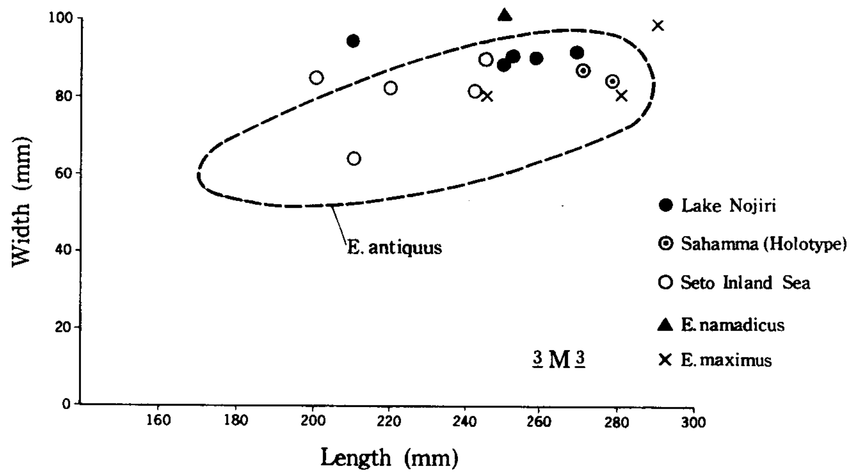

Fig. 5. Width-length diagram of the 3 N 3.

only those values without any consideration on the population variations. In order to compare with one another more directly, therefore, the present authors have attempt to refer the diagrams of AGUIRRE (1969) and have re-plotted the dimensions and indices of the Japanese specimens on them. As to the width-length diagram (Fig. 5), the distribution of the values of *E. naumanni* overlaps partly with the area of *E. antiquus*, but it seems that together with *E. namadicus*, the former forms a domain of rather broad molar groups. Among the specimens of *E. naumanni*, seemingly the longer molar type of Lake Nojiri and type specimens, and the shorter member of Seto Inland Sea may come from within the continuous variation.

It has been known that the nature of the enamel thickness has been generally used as a key character in tracking the evolutionary trend of *Elephas* in broad sense. As stated above, *E. naumanni* is characterized by the possession of rather broad and hysodont molars, and it is then necessary to examine the relations between the enamel thickness and the width or the height of the molar. In diagrams shown in Fig. 6, the top diagram indicates the relation between the width (W) and the enamel thickness (E), while the bottom diagram expresses K-E relation (K; the index of hypsodonty). In the former, solid line encloses the distribution range of *E. naumanni*, and it should be noted that the range lies within the area of *E. antiquus*. Moreover, the distribution range seems to extend over those of *E. namadicus* and *E. trogontherii*. On the other hand, the bottom diagram shows that the distribution range of *E. naumanni* overlaps to some extent on that of *E. antiquus* but occupies the high area beyond the limitation of the *antiquus* range. Here, it becomes clear that the hypsodonty is the most important characteristic in *E. naumanni* population.

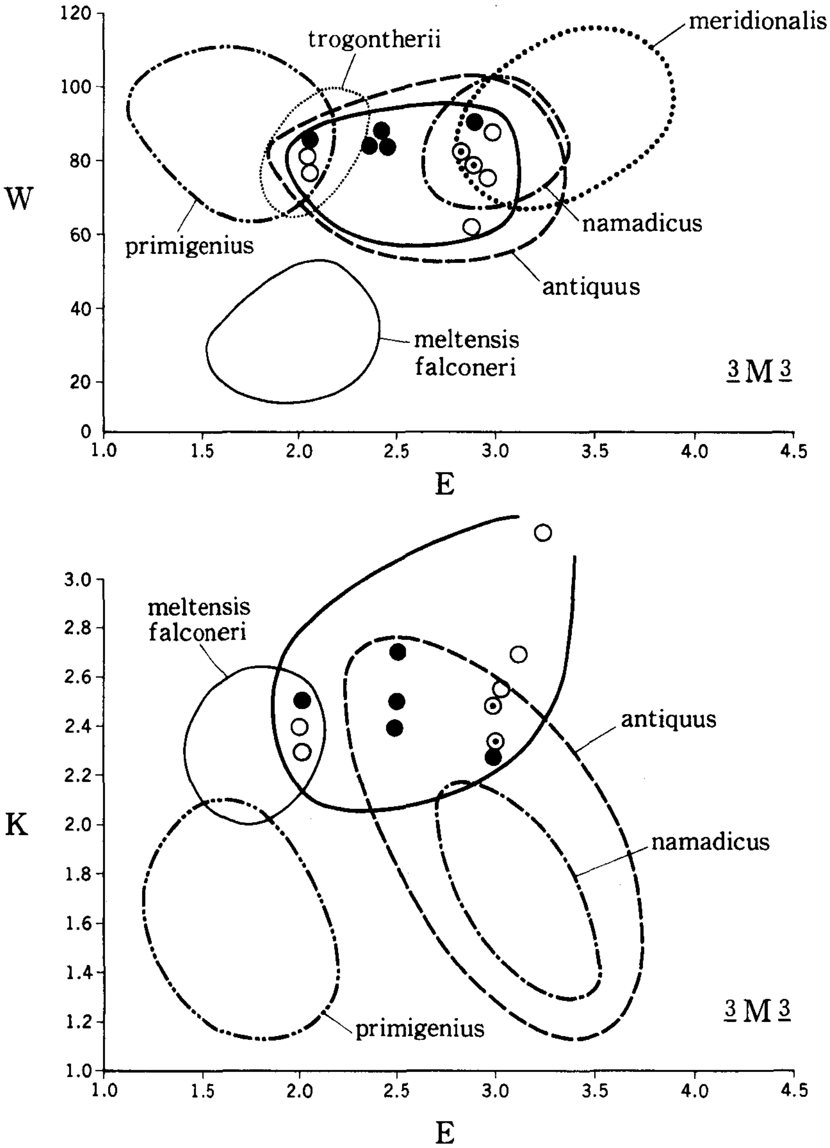

Fig. 6. Width-enamel thickness (top) and K-E (bottom) diagrams showing the variation of *E. naumanni*. Symbols are those used in Fig. 5.

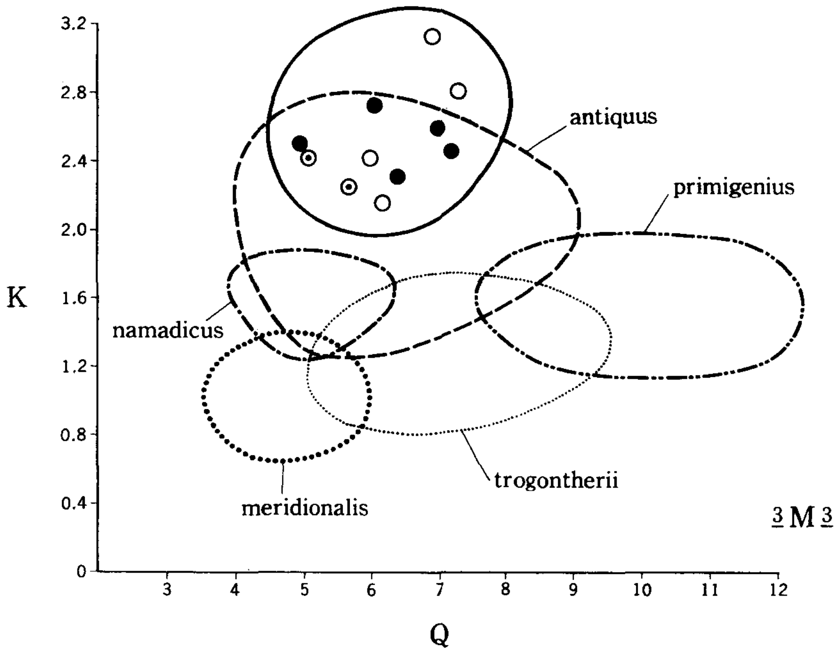

Fig. 7. K-Q diagram showing the distribution of *E. naumanni* and allied species. Symbols are those used in Fig. 5.

Fig. 7 shows the K-Q diagram in which Q is the index of the functional density of the plates. In that diagram, there can be obtained the understandings that the molar population of *E. naumanni* is independent from that of the *trogontherii-primigenius* lineage as formerly thought. Furthermore, as to the specific separation between *E. naumanni* and *E. namadicus*, it is justified in view of the fact that those two molar populations are separable with each other. Obviously the emendation of the specific definition of those two species is not sufficient to describe only from those evidences, and it is necessary for the recongnition of *E. naumanni* as the independent species to be supported not only by other morphological characteristics as well as by ecological and biogeographical evidences.

It is concluded that the *naumanni* specimens from Lake Nojiri is a progressive form, very close to the Sahamma specimens (syntypes) in size and in details of enamel pattern. However, as the present specimens are distinct in having more hypsodont and broader molar and thinner enamel, it would be assignable that Lake Nojiri form tends to be even more progressive. Under the circumstances, therefore, the present materials will be left in *naumanni* as a later variant, without separate specific or subspecific designation.

Paleoecology

Returning to the age problem concerning Lake Nojiri fauna, it is worth mentioning that an age of 21,600±900 yrs., measured by the radiocabon dating, is possible to suggest. Both the stratigraphy of the lake sediments and the palynological data do not contradict with such a suggestion. In paticular, the pollen assemblage is very characteristic. According to the data by Y. MORI, the pollen assemblage from the fossil horizon is characterized by the dominance of *Picea, Tsuga* and the subordinate pollen grains of *Abies, Larix, Pinus, Juglans, Betula, Corylus, Fagus* etc. (KAGAKU NO JIKKEN, 1963). The dominance of coniferous trees of that time, despite the presence of a parkland vegetation with scattered arboreal tree growth, can only be explained by a dry, cold climate; and hence the presence of subarctic to cool-temperate vegetation.

According to NIIGATA POLLEN GROUP (1971), the samples obtained from the Asoda Peat Bed, about 20 km. north of Lake Nojiri contain such pollen as is characteristic of the subalpine forest vegetation composed chiefly of *Abies* and *Pinus* and subdominant *Tsuga, Picea, Betula, Alnus, Quercus etc.* associations. As the elevation of the locality is 120 m., the amount of depression of the subalpine coniferous forest zone of that time is pressumed as 1,900 m.; namely, about 9.5°C lower than the present in annual mean. The date of the Asoda Peat Bed is from 20,2000±800 C^{14} yrs. B.P. to 17,900±450 C^{14} yrs. B.P., and then, the data mentioned above may suggest the nature of the paleoenvironment of Lake Nojiri mammalian fauna.

From the stratigraphical view point, the authors estimate the date of the mammalian horizon of Lake Nojiri to be about twenty thousand years before, as previously stated. It may correspond to the midway of the last glaciation in Japan; the time when alpine glaciers imparted the maximal extention in the high mountains of Central Japan (SHIMIZU, 1972).

Due to the recent geological exploration, floristic evidences from the sediments of the last glacial phase have been obtained from some localities near Lake Nojiri. In the neighbourhood of Tatsuno (see Fig. 1), the Ono Peat Bed (35,700 ±1,400 C^{14} yrs. B.P.) yielded *Picea bicolor, P. jezoensis, Pinus koraiensis, Taxus cuspidata, Abies veitchi*. On the other hand, some coniferous tree remains like as *Pinus koraiensis, Tsuga diversifolia, Abies veitchi, Picea jezoensis* were reported from Totchu conifer bed (15,750±390 C^{14} yrs. B.P.) at Totchu (KOBAYASHI, 1965). It can be concluded that the areas around Lake Nojiri through the time of the last glaciation, had been covered by the forests mainly consisting of coniferous trees.

For a long time it has generally been suggested that *E. naumanni* was an imigrant from "southern continent" and was an inhabitant of warm-temperate or tropical biotope. However, it becomes clear that the evidences stated above contradict such a suggestion. Moreover, the evidence obtained by the excavation provided the fact that the elephant was contemporaneous with *Megaloceros* (*Shinomegaceroides*) *yabei* SHIKAMA. Outside Lake Nojiri, *Megaloceros* has been reported from the Totchu conifer bed (*Megaloceros ordosianus minor* closely related with *Shinomegaceroides yabei*) (KAMEI, 1958) and from the lacustrine deposits of Shioda (28,400±1,800 C^{14} yrs. B.P.) (SHIOKAWA RESEARCH GROUP & IIJIMA, 1964). In addition to *Megaloceros*, the Shioda fauna is composed of *E. naumanni*, *Equus hemionus*, *Cervus yagianus*. Besides them, it should be noted that *Bison* sp. was found from the volcanic ash sediments of the Latest Pleistocene (more than 3,000 C^{14} yrs.) at Tatsuno (SHIMIZU *et al.* 1966).

The faunal assemblage of *E. naumanni* with *Megaloceros*, *Equus*, *Bison*, *Cervus* etc. is rather common in the Latest Pleistocene deposits of Central and Northeast Japan (SUZUKI & KAMEI, 1969). Moreover, it is very important that *Alces* has to be added in that faunal list (ONODERA, 1970). Therefore, it is interesting that *E. naumanni* was contemporaneous with subarctic fauna in Japan at the time of the Latest Pleistocene. As a result, the restoration of the paleoenvironment as follows may be possible. The middle-latitude coniferous forest might be rather sparse and provide much herbaceous vegetation for such gregorious herbivores. There can be no doubt that *E. naumanni* of Lake Nojiri was the last survivor of the Latest Pleistocene, under somewhat cold climate, and was an inhabitant of cool-temperate of subarctic biotope.

In connection with this, it should be noted that there were nothing of other mammalian bones from the bottom of Lake Nojiri, exculing those of *E. naumanni* and *Shinomeyaceroides yabei*. That is, there are known only two species of large and gregorious mammals, in spite of the abundance of fossil bones. Furthermore, all of them belong to the bones of mature animals and none of the immature was discovered. The ecological analysis of the herds of elephant or deer can not help to solve this problem, and there are many varied interpretations from paleoecological and geological views. The difinite understandings will be left in future study.

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Supplement

After the manuscript of this paper was accepted, the authors could have an opportunity of reading the paper on the Naumann's elephant written by Y. HASEGAWA of National Science Museum (The NAUMANN's Elephant, *Palaeoloxodon naumanni* (MAKIYAMA) from the Late Pleistocene off Shakagahana, Shodoshima Is. in Seto Inland Sea, Japan. *Bull. Nat. Sci. Museum.*, **15**, 3, pp.513–591. pls. 22 Sept. 22, 1972). In this excellent paper, he described the result of study on the materials obtained from the sea bottom, off Shodoshima Island in Seto Inland Sea and he also adopted the specific name *Palaeoloxodon naumanni* (MAKIYAMA) for the Naumann's elephant. The present authors agree with his opinion in the treatment of the Naumann's elephant as an independent species separated from *E. namadicus* FALC. et CAUT., but they think that it is rather better to give the specific name *E. naumanni* MAKIYAMA to that elephant. Because it seems that there still remain some problems in regard to taxonomical state of *Palaeoloxodon*. Usually

Palaeoloxodon is treated as a genus in Loxodontinae, but it is doubtful whether or not the present species belongs to Loxodontinae. Therefore, in this paper the authors used the generic name *Elephas* in a wide sense and regarded *Palaeoloxodon* as a group name of *Elephas* (s. l.).

Explanation of plates

Plate 4.

Elephas naumanni MAKIYAMA
(All half natural size)

Fig. A. Buccal view of the upper left the third molar (No. 1).
Fig. B. Occulusal view of *ibid.*

Plate 5.

Elephas naumanni MAKIYAMA
(All half natural size)

Fig. A. Palatal view of the upper right third molar (No. 3).
Fig. B. Occulusal view of *ibid.*

Plate 6.

Elephas naumanni MAKIYAMA
(All half natural size)

Fig. A. Buccal view of the upper third molar (No. 2).
Fig. B. Occulusal view of *ibid.*

Plate 7.

Elephas naumanni MAKIYAMA
(All half natural size)

Fig. A. Occulusal view of the lower right third molar.
Fig. B. Lingual view of *ibid.*

Plate 8.

Elephas naumanni MAKIYAMA
(All half natural size)

Fig. A. Palatal view of the upper right second molar.
Fig. B. Occulusal view of *ibid.*
Fig. C. Distal view showing a form of last dental plate.

Plate 9

Elephas naumanni MAKIYAMA
(One-fifth natural size)

Fig. A. External side of the right tusk.

Plate 10.

Elephas naumanni MAKIYAMA
(All two-fifth natural size)

Fig. A. Cranial side of the Atlas.
Fig. B. Cranial side of the Axis.

Plate 11.

Elephas naumanni MAKIYAMA
(All one-fifth natural size)

Fig. A. A broken shaft of left humerus, cranial side.
Fig. B. A left redius, cranial side.
Fig. C. A broken shaft of left femur, cranial side.

A

B

Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake

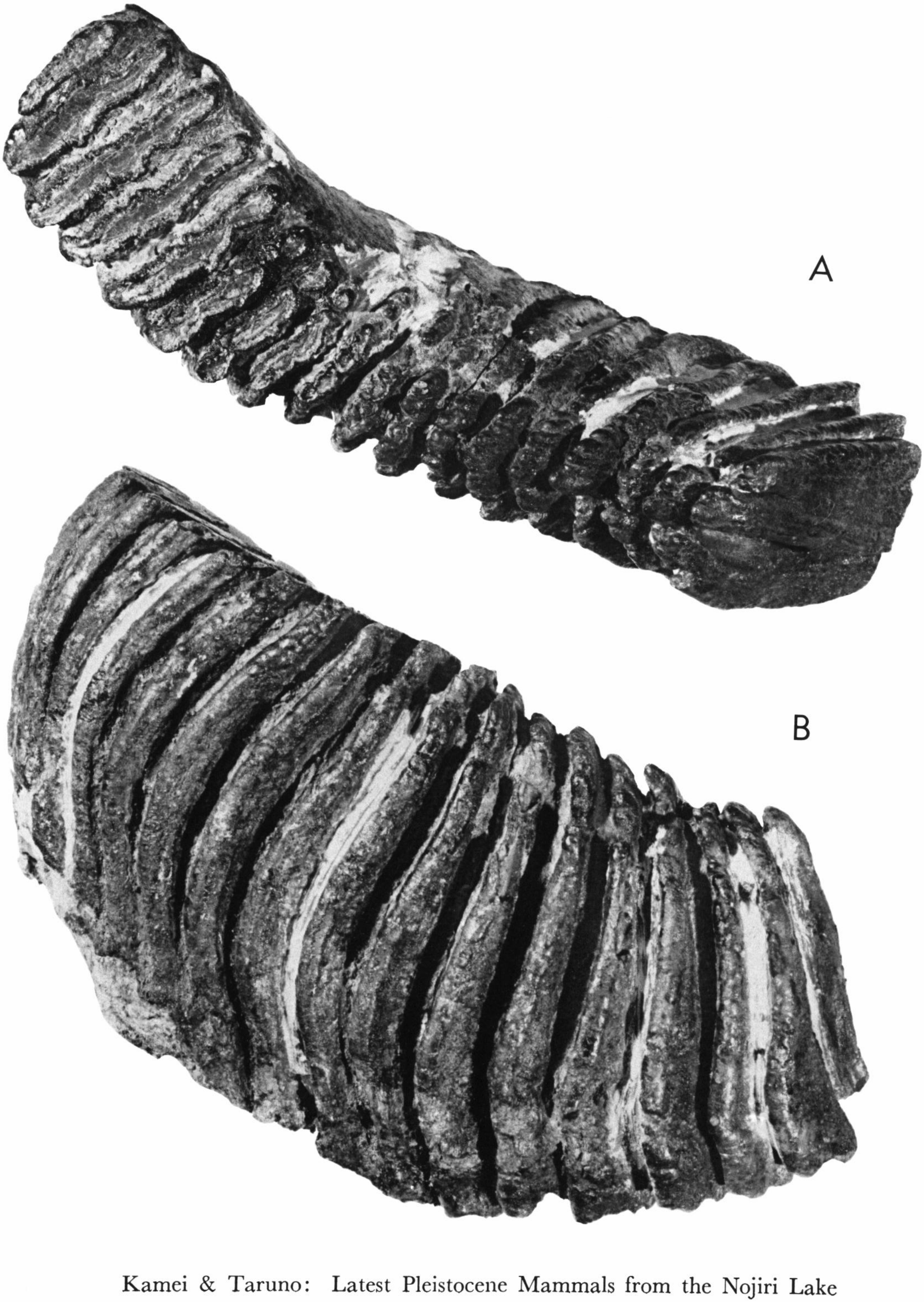
A

B

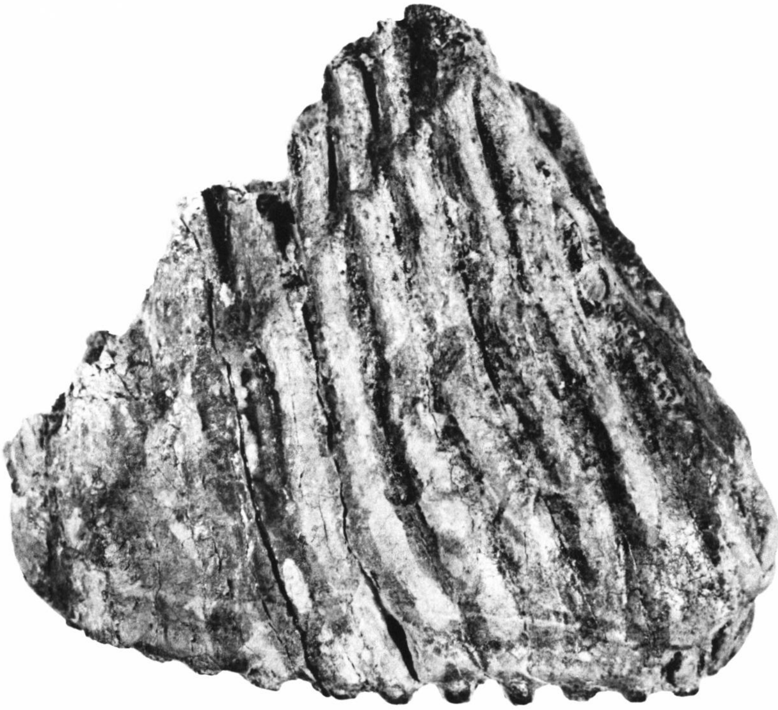
A

B

Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake



Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake



A

B

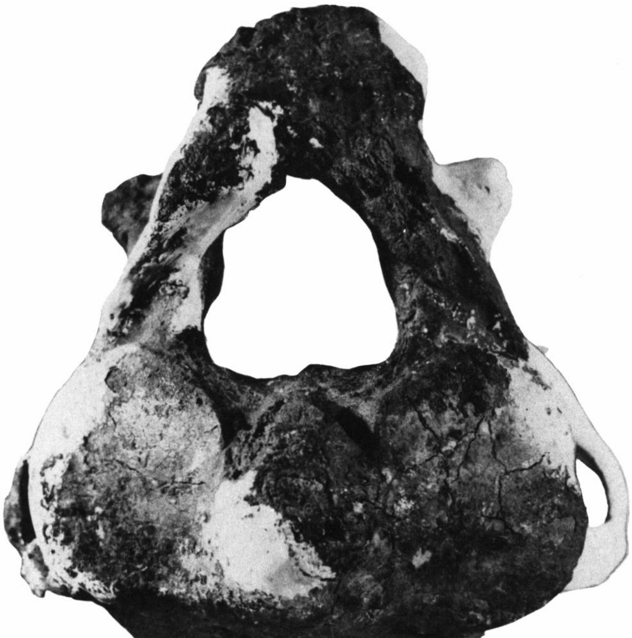
C

Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake

A

Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake

A



B

Kamei & Taruno: Latest Pleistocene Mammals from the Nojiri Lake