FOSSIL DEER ASSEMBLAGE FROM SEA BOTTOM OF BISAN-SETO AREA WITH SPECIAL REFERENCE TO THEIR STRATIGRAPHIC POSITIONS (PLEISTOCENE DEER FAUNA IN SETO INLAND SEA, ----PART III)

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FOSSIL DEER ASSEMBLAGE FROM SEA BOTTOM OF BISAN-SETO AREA WITH SPECIAL REFERENCE TO THEIR STRATIGRAPHIC POSITIONS (PLEISTOCENE DEER FAUNA IN SETO INLAND SEA, ----PART Ⅲ)

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Abstract

This paper presents the results of paleontological and geological studies of fossil deer fauna collected from the sea bottom of the Bisan-seto area, in the eastern part of the Seto Inland Sea, West Japan. The fossil deer assemblages in this area are associated with abundant mammals of forest- to grassland habitats such as Naumann's elephant *(Palaeoloxodon naumanni)* and also with a few *Stegodon,* wild ox, rhino and water buffalo specimens. As a result of the present study, nine species fossil deer belonging to the family Cervidae were distinguished, among which six species are referred to the genus *Cervus* and others to the genus *Elaphurus* and *Sinomegaceros.*

Based on the mammalian assemblages and the exposed submarine beds, there is a good possibility that Naumann's elephant and most of the deer fossils collected from the submarine localities in the Bisan-seto area washed out from the upper member of the Pleistocene Ozuchijima Formation of Bando *et al.,* 1978. The mammalian assemblages in the Ozuchijima Formation as well as those in the Seto Inland Sea are correlative with those of the late Middle Pleistocene Byobugaura age (Mindel/Riss Interglacial–Riss glacial age).

Introduction

All of fossil deer specimens treated in this paper are from the Yamamoto Collection, named after Mr. Keiichi Yamamoto who, for a period of over a decade, collected these specimens dredged up by fishermen living in Shimotsui, Kurashiki City, Okayama Prefecture. The Yamamoto Collection was collected from more than twelve submarine localities located in the western part of the Bisan-seto, shallower than 80 meters in depth. The deer fossils in the collection total more than 900 specimens including antlers and various skeletal parts. As a result of the present study, eight species of fossil deer belonging to the family Cervidae were distinguished, among which six species are referred to the genus *Cervus* and other two to the genus *Elaphurus.* These species are also common in the Takao Collection which were collected from the sea bottom off the Shodoshima Island, the eastern large island of the Bisan-seto (Hasegawa, 1982 ; Otsuka and Shikama, 1977).

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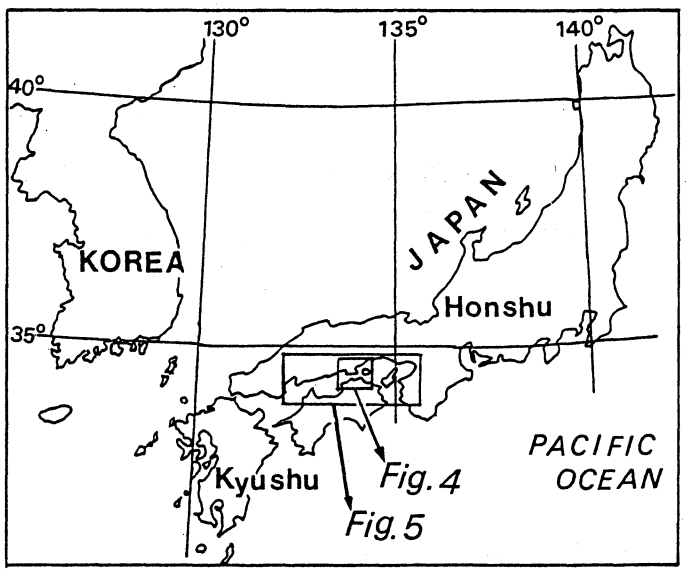

Fig. 1. Location of the Seto Inland Sea and the Bisan-seto in the Japanese islands.

The fossil deer from the Bisan-seto are sometimes accompanied by one or both of the proboscidea, *Stegodon orientalis* Owen and *Palaeoloxodon naumanni* Makiyama. In the Japanese Islands, in general, the former species is regard as one of representative of the early Middle Pleistocene vertebrate Fauna, indicating a close relationship with the Wanhsien vertebrate fauna (*Stegodon–Ailuropoda* Fauna) in South China, while the latter species is known from the late Middle- to the Late Pleistocene formations. Such being the case, the deer assemblages known from the sea bottom of the Bisan-seto area can be regarded as mixed assemblages which might be washed out from different horizons exposed on the sea bottom. Therefore, the sources of the bed originally containing the deer fossils are not confirmed by the available evidence. However, it is possible to presume the sources from the associated elephant fossils and the submarine geology where the fossil specimens were collected.

Remarks on the submarine topography and the geology of the Bisan-seto

1. Submarine topography

The Bisan-seto area exhibits typical submarine configuration represented by characteristic submarine terraces, sand bars, sand waves, caldron channels etc. and so on (Kuwashiro, 1959 ; Hoshino and Iwafuchi, 1963 ; Mogi, 1963, 1970 ; Honza *et al.*, 1970 ; Bando *et al.*, 1978). The Seto Inland Sea, in general, is roughly classified into two characteristic areas by topographical characters such as : 1) narrow strait having many small islands which might originate from drowned valleies and 2) sea areas characterized by so-called "Nada" which have no narrow straits and originate from sinking of the land area. The Bisan-seto area falls more closely within the former category.

The Bisan-seto is generally shallower than 50 meters and areas deeper than 100 meters

are recognized only in the southeastern part of the Koyo-jima where it attains 105 meters in depth. In general, the submarine topography in the eastern part is characterized by a submarine terrace stretching from west to east with depth ranging from 30 to 50 meters. On the other hand, the western area shows more complex submarine topography than in the east and many caldron channels have developed in the narrow straits among the many islands, called the Shiaku Islands.

Bando *et al.* (1975) recognized four submarine terraces in the Bisan-seto, the Terrace Ⅰ (0 to −6m), Terrace Ⅱ (−10m to −25m), Terrace Ⅲ (−25m to −40m) and Terrace Ⅳ (−40m to −50m) (Figure 4). Acoording to them, Terrace Ⅰ and Terrace Ⅱ represent accumulation terraces formed during the Holocene transgression. Terrace Ⅲ and Terrace Ⅳ are erosional flat planes on the Pleistocene formations, older than the lower member of the Holocene Bannosu Formation.

Another characteristic bottom configuration in the Bisan-seto area is the caldron channel. These developed in the narrowest parts between the islands, and attain more than 70 meters in depth. Regarding the origin of the caldron channels, Bando *et al.* (1978) had the following opinion : "their formation may have resulted from submarine erosion rather than being bestiges of subaerial valley bottoms produced during a period of lowered sea level. Judging from the fact that the −10 to −25 meters flat plane is incised, the caldrons may have been excavated after the Jomon regression".

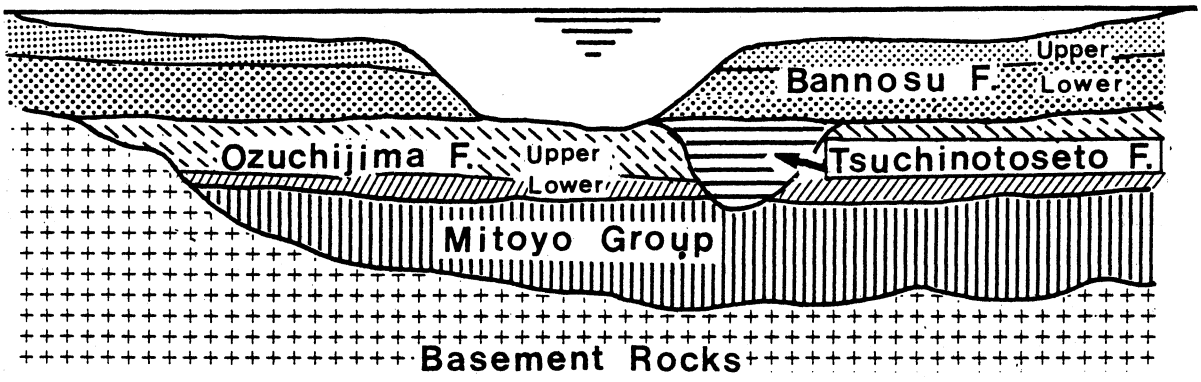

Fig. 2. Schematic geologic profile showing the geologic succession of the Pleistocene formations in the Bisan-seto (Bando *et al.*, 1978).

2. Geology

Hoshino and Iwafuchi (1963) studied the submarine geology of the eastern part of the Bisan-seto area and named the Samijima formation for the blue clay bed distributed around the small islands called Samishima and Koyo-jima. Using the electro-sonic profiler survey data in the Bisan-seto area, Honza *et al.* (1970) clarified the submarine stratigraphy in this area. Among four formations proposed by them, the Samishima Formation is said to be typical of the environs of the Bannosu-Samijima area off Sakaide City in Shikoku. After

their studies, however, this area was reclaimed from the sea and the Samijima Formation is no longer exposed there.

Bando *et al.* (1978) established the stratigraphy of the Bisan-seto area based on the lithologic character of bottom sediments analysed from numerous cores, and supplemented with echo sounding data (Fig. 1). Their standard succession was carried out from the environs of the Ozuchi-jima and the Kozuchi-jima off Osaki-bana. In their stratigraphy, three formations, the Bannosu, the Tsuchinotoseto and the Ozuchijima correspond to the Nakanose, the Ozuchi and the Samijima Formations of Honza *et al.* (1970), respectively. According to Bando *et al.* (1970), the geology of the Bisan-seto area is as follows :

1) Basement rocks. The basement rocks of the Bisan-seto area are mostly granitic rocks of the Cretaceous age. They are widely exposed on the land area of Honshu, Shikoku, small islands in the Bisan-seto and on the bottoms or walls of the caldron channels.

2) The Mitiyo Group. This name was used by Saito (1954) for the lacustrine deposits distributed in the northern area of Sanuki mountains of Shikoku. However, they are also known to be distributed in the southern area of Sanuki Plain where this group attains more than 100 meters thickness and is composed mainly of blue clay or siltstone and yields the so called "*Metasequoia* flora" characterized by such plants as *Metasequoia, Liquidamber* and *Nyssa* and fossil proboscidea such as *Parastegodon sugiyamai* (Tokunaga) (Furuichi *et al.*, 1977). From these fauna and flora, this group has been regarded as an Early Pleistocene deposit of older than one million years and correlated with the lower part of the Osaka Group in the Kinki district, west Japan (Bando *et al.*, 1978).

In the Bisan-seto area, this group is mainly exposed on the sea bottom of the central or western caldron channels, ranging from −60 to −80 meters in depth, where it covers the granitic rocks and shows almost flat stratification. This group consists mainly of alternations of greenish grey silty sand and silt. No marine sediments have been found within this group. About forty years ago, Matsumoto (1941) recorded a lower jaw of *Parastegodon shodoensis* from the sea bottom off Mitsuko-jima without comment on its bed of origin. Bando *et al.* (1978) regared the original bed of Matsumoto's specimens, as the Mitoyo Formation, judging from the known range of *Parastegodon* in the Japanese Pleistocene.

4) The Bisanseto Group. This was named and defined by Bando *et al.* (1978) to cover the Middle- to Late Pleistocene formations in the Bisan-seto area, younger than the age of extinction of the "*Metasequoia* flora of the Early Pleistocene in Japan. This group is subdivided into three formations, the Ozuchijima, the Tsuchinotoseto and the Bannosu, in ascending order.

The Ozuchijima Formation shows a more narrow distribution than the Mitoyo Group and is known only in the sea bottom of the Bisan-seto ranging from −60 to −80 meters in depth and rests unconformably on the eroded surface of the Mitoyo Group or on granitic rocks. This formation, 50 meters thick, consists of bluish grey coarse sand gravel and dark grey silty clay and intercalates two thin clay layers of marine origin. From the pollen assemblage, the lower part is inferred to have been deposited under a climate near to that of the present time while for the upper part it was cooler than the present. Bando *et al.* (1978)

regarded this transgression in the Ozichijima time as either the Mindel-Riss or the Riss-Würm Interglacial ages.

The Tsuchinotoseto Formation is seen only in the walls of the caldron channels or the drowned valleys that developed on the eroded surface of the Ozuchijima Formation. It is estimated to be more than 75 meters thick and is mainly composed of dark greenish grey silty clay and sometimes yields foraminifer assemblages recording the inner bay environment. Usually, the upper surface of this formation is cut by the erosional flat planes called Terrace Ⅲ and Terrace Ⅳ. From the bed form and the configuration of the bed rock, Bando *et al.* (1978) regarded this formation as being sediments that filled an eroded valley formed at the time of maximum sea level lowering during the Würm glacial age. The Naumann's elephant might be washed out from this formation.

The Bannosu Formation, the uppermost marine sediments in this area, overlies Terrace Ⅳ on the Ozuchijima Formation. It is mainly composed of sand and gravels and is regarded as Holocene in age.

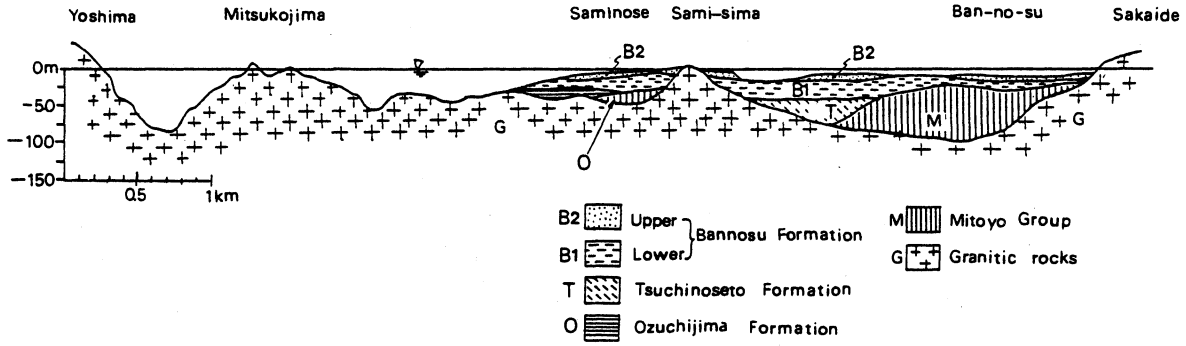

Fig. 3. North-south section across the Bisan-seto from Yoshima to northern coast of Sakaide City, Shikoku (Bando *et al.*, 1978)

The mammal-bearing beds in the Bisan-seto

As to the mammal-bearing beds in the Bisan-seto, I put together the several findings which I had obtained up to that time in a preliminary papers published for the last two years (Otsuka, 1987a, 1988). At present, the latest results reached can be expressed as follows.

The mammalian remains, collected from the sea bottom in twelve localities of the Bisan-seto area, comprise more than 900 specimens including teeth, antlers and various kinds of bones among which almost 90 percent of the specimens were dredged by fishing nets from the bottom of submarine valleys called caldron channels, and some others were collected from the surface of the submarine terraces. Usually, these caldron channels are developed around and near the narrowest part of the islands and incise deeply into terraces formed by the formations of the Bisan-seto Group. Therefore, it is no doubt that most of the mammalian remains dredged from the bottoms of the caldron channels were washed out from the Bisanseto Group. As a whole, the fossil deer assemblages dredged from the

Bisan-seto area are classified into types A and B based on associated proboscidean fossils. Type A is the mammalian assemblage accompanied by Naumann's elephant (*Palaeoloxodon naumanni*) and *Stegodon orientalis*. Type B is the mammalian assemblage accompanied by only Naumann's elephant. Usually, these two types are associated with the many species of cervids described in the present paper. However, there are also several submarine localities with *Stegodon* or Naumann's elephant accompanied by no mammalian fossils (Locs.C, H, I and N.)

1) Type A

The deer assemblage belonging to this category is known from five localities, J, L, M, O and P. Among these localities, Locs. L, M, O and P are caldron channels incised into the terraces from Ⅱ to Ⅳ. On the bottom or the walls of their channels, there are exposures of the Mitoyo and the Ozuchijima formations. In addition to these formations, the Bannosu or the Tsuchinotoseto Formations are exposed in Loc. M and Loc. Q, respectively. Therefore, the deer assemblages accompanied by the Naumann's elephant and *Stegodon* are inferred to be mixed assemblages which might be washed out from one of the formations mentioned above.

Location L, one of a typical locality yielding the deer assemblage belonging to this category, is located in the central part of a long caldron channel situated about 1 km south of Yo-shima. This channel is about 4.2km long and 70 meters in depth. The granitic rocks and Pleistocene formations older than the Tsuchinotoseto Formation are exposed on the channel bottom or walls. From this caldron channel, all the species of fossil deer except *Elaphurus* and *Sinomegaceros* were dredged, accompanied by the Naumann' elephant and *Stegodon*.

Location M, small caldron channel incised into the terrrasce Ⅲ, is situated in the area between Sei-shima ad Mitsuko-jima. This submarine locality is 66 meters in maximum depth and there are exposures of granitic rock and the Pleistocene formations except the Tsuchinotoseto formation. From this caldron channel, all the species of deer belonging to the subgenus *Sika* and *Nipponicervus* and Maya's "Su-pu-hsian" *(Elaphurus mayai)* were discovered.

Judging from the fact that most of the specimens of *Stegodon orientalis* were dredged from the caldron channels where the Mitoyo Group and the lower member of the Ozuchijima Formation are exposed, we may assume that their original bed of deposition is either of these two formations.

The type locality of *Stegodon (Parastegodon) shodoensis* (Matsumoto, 1941) is the caldron channel named Loc. L, about 500 meters north of Mitsuko-jima, where most of the Pleistocene formations except the Tsuchinotoseto Formation are exposed on its bottom or walls. Bando *et al.* (1978) regarded the Mitoyo Group as to the original bed of this type specimen judging from the known geologic range of this subgenus. We are quite in agreement with their view.

On the other hand, *Stegodon orientalis* in the Bisan-seto area was not accompanied by *Parastegodon,* and the submarine localities where only the upper member of the Ozuchijima

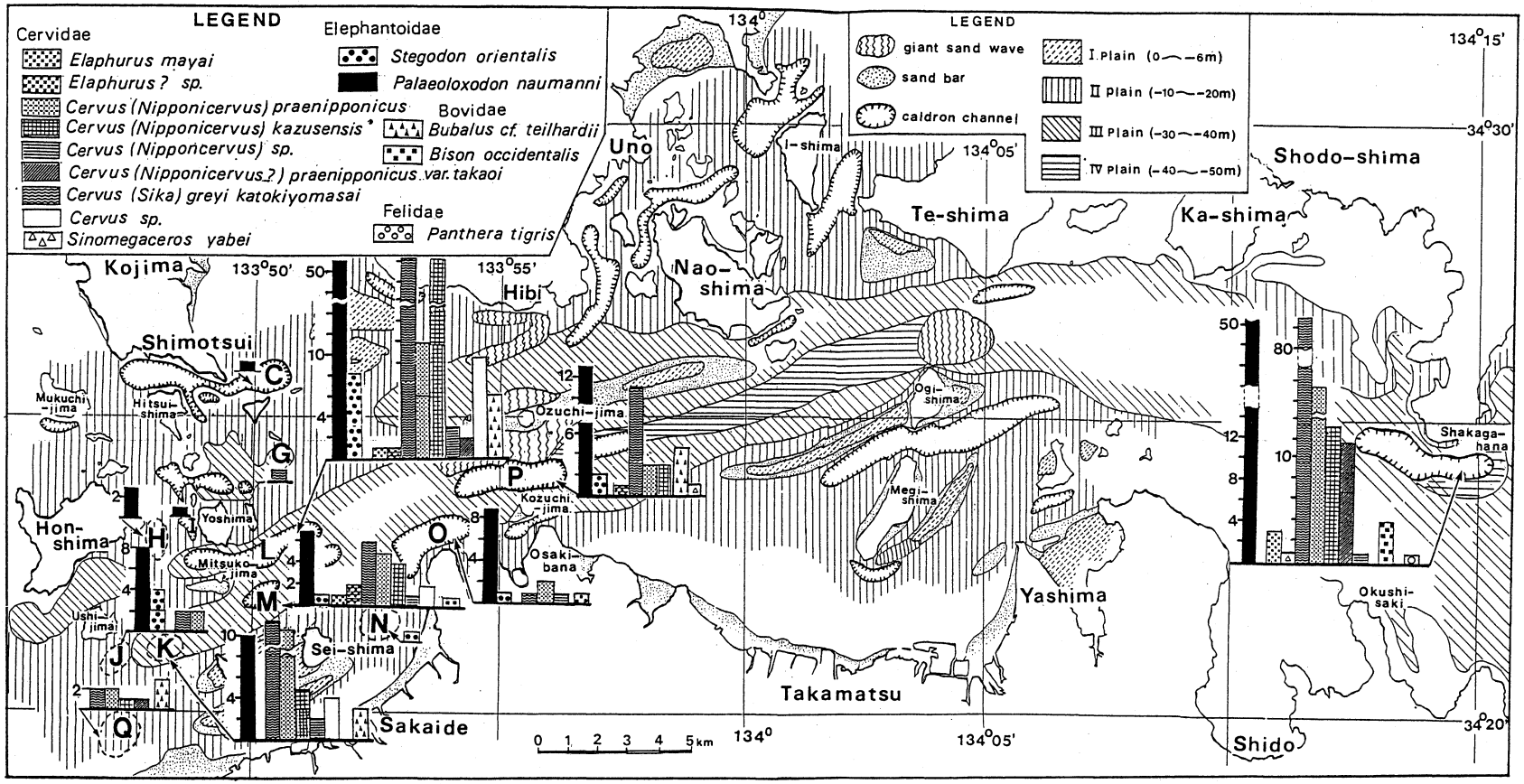

Fig. 4. Physiographic division of the Bisan-seto (Bando *et al.*, 1978). The numbers of mammalian specimens in the Yamamoto Collection collected from the Bisan-seto, and those of the Takao Collection collected from the sea bottom off Shakagahana, Shodoshima are also shown in this figure.

Species \ Locality	C	G	H	I	J	K	L	M	N	O	P	Q	off Shodo-shima
Cervidae													
Elaphurus mayai							1	1					3
Elaphurus? sp.							1	2			1		
Cervus (Nipponicervus) praenipponicus					2	15	11	9		1	5	1	38
Cervus (Nipponicervus) kazusensis						5	20	5			3	1	14
Cervus (Nipponcervus) sp.						2	5	1		1			1
Cervus (N.) praenipponicus var. takaoi							2						13
Cervus (Sika) greyi katokiyomasai		1			2	19	65	9			10	4	80
Cervus sp.						7	10	1				1	
Sinomegaceros yabei											1[1]		1
Bovidae													
Bubalus cf. teilhardii		1				3	6			1	5	2	?
Bison occidentalis							1[2]				1[3]		4
Rhinocerotidae													
Rhinoceros sp.								1					
Proboscidae													
Stegodon orientalis					2		8	1	1	1	2		
Palaeoloxodon naumanni	1		3	1	9	10	48	7		10	11		>50
Elephantidae gen. et sp. indet.		4	6	1	17	24	137	37		28	25	4	
Felidae													
Panthera tigris													1

Holocene	Bisanseto Group	Bannosu F.	●	●	●	●	unknown	●		●	●		●	●
Pleistocene Late		Tsuchinotoseto F.		●								●		●
Pleistocene Middle		Ozuchijima F. Upper		●		●		●	●	●	●	●	●	●
		Ozuchijima F. Lower				●			●	●	●	●	●	●?
Pleistocene Early		Mitoyo Group	●						●	●	●	●	unknown	●
Cretaceous		granitic rocks	●	●	●	●		●	●	●	●	●		●

1), 3): Maya Collection; 2) after Urakami (1932)

Table 1. The number of mammalian specimens collected from the thirteen submarine localities in Bisan-seto and the Pleistocene formations exposed in these localities (C-Q) (after Otsuka, 1987, 1988 ; partly revised).

Formation is exposed, has yielded only Naumann's elephant (Loc. K). As a result of these evidence, it can be stated that the original bed of derivation of *Stegodon orientalis* is the lower member of the Ozuchijima Formation.

2) Type B

Location K, one of the typical submarine locality yielding deer assemblages of this category, is situated in the area between Ushi-jima and Sami-jima off Sakaide City, Shikoku. This submarine locality is on the submarine terraces Ⅱ and Ⅲ, having a depth shallower than 40 meters, where the upper member of the Ozuchijima Formation and the lower member of the Bannosu Formation are exposed. To date, more than 90 specimens of mammalian fossils including seven kind of Cervidae, a few water buffalo and many molars of Naumann's elephant were collected from this locality, but no remains of *Stegodon* were found.

From these facts mentioned above, it is concluded that the mammalian assemblages

accompanied by Naumann's elephant have washed out from the upper member of the Ozuichijima Formation.

Deer assemblages from the Bisan-seto area

The deer assemblages from the Bisan-seto area are composed of eight species of Cervidae in the following frequencies :

Sinomegaceros (Sinomegaceroides) yabei Shikama* ..... 1(1**) specimen, 0.4%
Elaphurus mayai (Tokunaga and Takai) ..... 2 (2) specimens, 0.9%
Elaphurus ? sp. ..... 4 (4) specimens, 1.7%
Cervus (Sika) greyi katokiyomasai, new subsp. ..... 111 (54) specimens, 48.0%
Cervus (Nipponicervus) praenipponicus (Shikama) ..... 44 (28) specimens, 19.2%
Cervus (Nipponicervus) kazusensis Matsumoto ..... 34 (28) specimens, 14.8%
Cervus (Nipponicervus) praenipponicus var. *takaoi* Otsuka and Shikama ..... 2 (2) specimens, 0.9%
Cervus (Nipponicervus) sp. ..... 9 (5) specimens, 3.9%
Cervus sp. ..... 19 (11) specimens, 8.3%

Among eight species of the Cervidae from the Bisan-seto, three species, *praenipponicus, kazusensis* and *greyi katokiyomasai* occur with frequencies of more than 14%. *Elaphurus* are fewer than the others, but may be noteworthy because of their taxonomic character and geologic significance.

The deer assemblages from the Bisan-seto closely resemble those in the Takao Collection, collected from off Shakagahana on Shodoshima (Otsuka and Shikama, 1977) but somewhat differ from the latter in the absence of *Sinomegaceros yabei* (Table 2). Otsuka and Shikama (1977) stated as follows : "The Shodoshima deer assemblage called the *Sika–Nipponicervus* assemblage which comprises a complex consisting of such older elements of the Early to Middle Pleistocene faunae as *C. (N.) praenipponicus, C. (N.) kazusensis, C. (S.)* cf. *greyi* and of such younger elements of the Late Pleistocene as *C. (S.) paleoezoensis*. Among these species, the younger elements of *Sika* exceed the older ones of *Nipponicervus* in individual numbers". Therefore they regarded this assemblage as "a new deer fauna belonging to the Late Pleistocene vertebrate fauna of Japan. However, the present study revealed that several forms of antler of the genus *Cervus* from the Seto Inland Sea which have identified with different specific names, such as *katokiyomasai, natsumei,* cf. *greyi* and *paleoezoensis,* represent the antlers of different growth stages of a single subspecies of *Cervus greyi.* For the newly recognized *Sika*-deer in the Seto Inland Sea, the subspecific name *greyi katokiyomasai* was selected. This subspecies is closely allied to *Cervus greyi* from the Middle Pleistocene Choukoutien Fauna in North China, but somewhat smaller and more slender than the latter.

The deer assemblages in the Bisan-seto area, called the *Sika–Nipponicervus* assem-

* Maya Collection stored in National Museum of Japanese History.
** Number in parentheses means individual specimen.

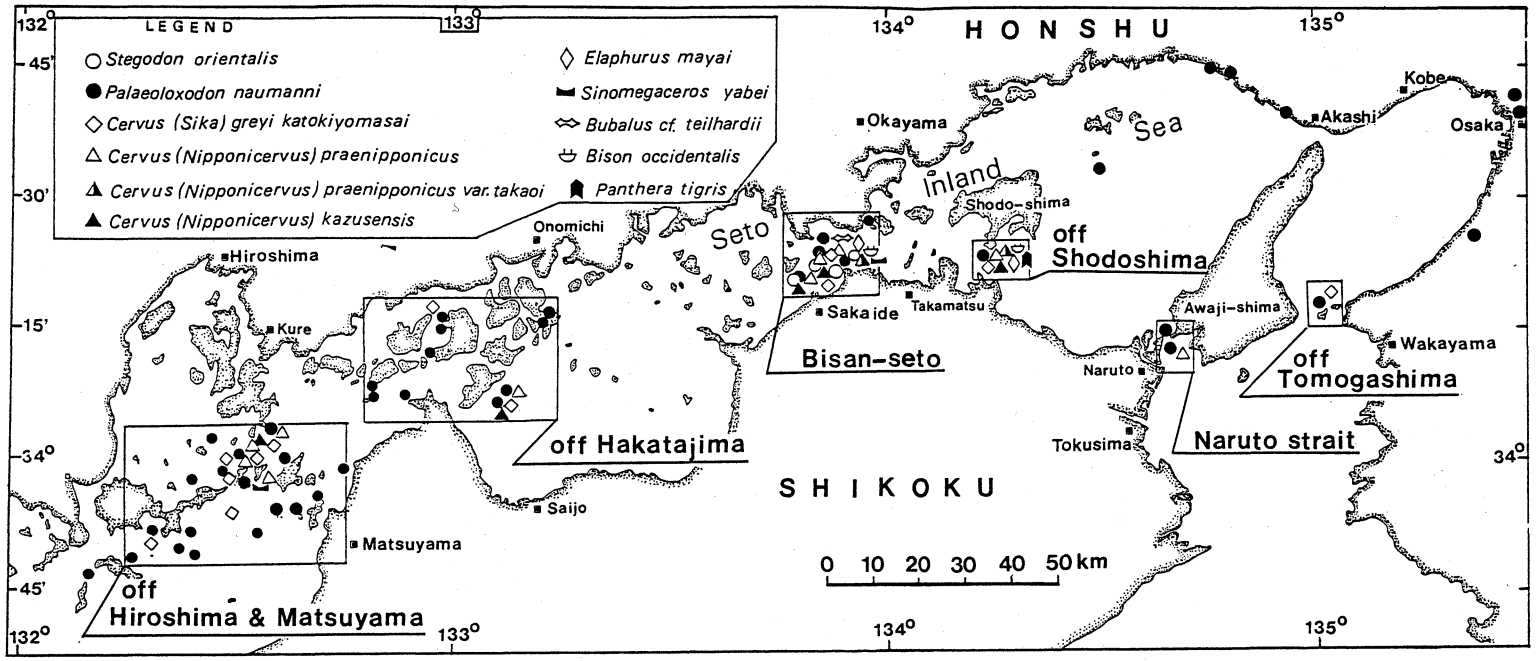

Fig. 5. Distribution of the Middle- and Late Pleistocene mammalian fossils in the Seto Inland Sea (after Otsuka, 1987 ; partly revised).

Localities / Mammalian fossils	off Hiroshima and Matsuyama	off Hakata-jima	Bisan-seto Yamamoto Coll.)	off Shodoshima (Takao Coll.)	Naruto strait	off Tomogashima (Doi Coll.)
Proboscidea						
Stegodon orientalis			○			
Palaeoloxodon naumanni	◎	◎	◎	◎	◎	◎
Cervidae						
Cervus (Sika) greyi katokiyomasai	○	◎	◎	●		●
C. (Nipponicervus) praenipponicus		◎	◎	◎	◎	
Cervus (Nipponicervus) kazusensis	●	●	◎	◎	○	●
C. (N.) praenipponicus var. takaoi		●	●	●		
Cervus sp.			●	●		
Sinomegaceros yabei	●			●		
Elaphurus mayai			●	●		
Bovidae						
Bison occidentalis			●	●	●	
Bubalus cf. teilhardii			●			
Felidae						
Panthera tigris				●		

◎ abundant ○ common ● rare

Table 2. The Middle- and Late Pleistocene mammalian assemblages in the Seto Inland Sea (Otsuka, 1987, partly revised).

blages, are comparable to, but differ from those in the Late Pleistocene "*Palaeoloxodon–Sinomegaceros* Complex in the Japanese Islands (Hasegawa, 1972) in the abundance of the subgenus *Sika,* indicating a close relationship with the Choukoutien Fauna in China, accompanied by such herbivorous mammals as *Elaphurus, Bubalus* and *Bison.* This *Sika–Nipponicervus* assemblage is also known for several areas of the Seto Inland Sea, ranging from off Hiroshima to the Osaka Bay area (Figure 5 and Table 2.) Therefore, it can be said that the deer assemblages in the Bisan-seto as well as those known in other areas in the Seto Inland Sea represent the typical forest- or grassland fauna of the middle- to late Middle Pleistocene of Japan.

Geological age of the deer assemblages in the Bisan-seto

As shown in Table 1, the deer assemblages accompanied by both Naumann's elephant and *Stegodon,* are more predominant than those accompanied only by Naumann's elephant. The frequent occurrence of the deer fossils is related to that of Naumann's elephant but shows no correspondence to the occurrence of *Stegodon.* Therefore, it is supposed that most of the deer fossils are washed out from the same bed as the Naumann's elephant. Furthermore, based on the mammalian assemblages and on the exposed submarine beds, there is a good possibility that Naumann's elephant and most of the deer fossils collected from the submarine localities in the Bisan-seto area washed out from the upper member of

the Ozuchijima Formation (the Samijima Formation of Honza *et al.*, 1970), but some percentage of *Cervus (Nipponicervus) kazusensis* might be derived from the lower member of the Ozuchijima Formation.

In the Japanese Islands, Naumann's elephant appeared in the Byobugaura age (late Middle Pleistocene) in west Japan and became distributed over the northern region. The upper limit of occurrence for this elephant is the last part of the Pleistocene (Hasegawa, 1972 ; Kamei and Otsuka, 1981).

As already mentioned, the lower member of the Ozuchijima Formation intercalates two silt beds of marine origin and the pollen assemblage of this member shows a temperate climate like that of the present Japanese islands while the upper member suggests a cool climate (Bando *et al.*, 1978). From this, it is inferred that the lower member was deposited during the first Pleistocene transgression in the Seto Inland Sea, which took place during the interglacial age, while the upper member might have been deposited during the transitional stage from the interglacial to the glacial age.

The mammalian assemblages from the Bisan-seto area are characterized by mammals of forest- to grassland habitats such as *Sika*-deer resembling elements of the Choukoutien Fauna *(Cervus greyi katokiyomasai),* large-scaled deer *(Elaphurus mayai),* wild buffalo *(Bison occidentalis)* and water buffalo *(Bubalus* cf. *teilhardii).* Assemblages of the Shimosueyoshi age (Riss/Würm Interglacial age) represented by Naumann's elephant and *Cervus (Nipponicervus) praenipponicus* give us the impression that the mammalian assemblages of the Shimosueyoshi age are relic of the *Sika–Nipponicervus* assemblages in the Ozuchijima Formation.

It is therefore concluded that the mammalian assemblages in the Ozuchijima Formation as well as those in the Seto Inland Sea are correlative with those of the late Middle Pleistocene Byobugaura age (Mindel/Riss Interglacial- Riss glacial age).

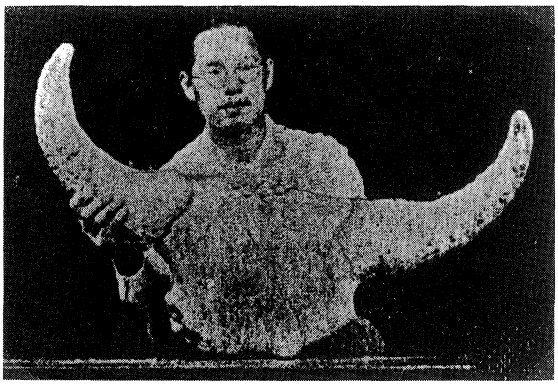

Fig. 6. "*Bison occidentalis occidentalis* Lucas" collected from sea bottom off Yo-shima (after Urakami, 1932).

Systematic Description

Order Artiodactyla
Family Cervidae Gray, 1821
Genus *Sinomegaceros* Dietrich, 1933
Type-species. –*Euryceros pachyosteus* Young, 1932
Sinomegaceros (Sinomegaceroides) yabei (Shikama, 1938)
Pl. 1, fig. 5

Cervus (Sinomegaceros) yabei Shikama, 1938, *Jap. Jour. Geol. Geogr.*, vol. 16, nos. 1-2, p. 115-122; Shikama, 1941, *Jubl. Pub. Comm. Prof. Yabe's 60th Birthday,* vol. 2, p. 1157.

Cervus (Sinomagaceroides) yabei Shikama, 1949, *Sci. Rep. Tohoku Univ.*, 2nd ser., vol. 23, p. 107-111.

Megaceros sp., Naora, 1954, Old Stone Age in Japan, p. 132-134.

Euryceros sp., Naora, 1954, Ibid., p. 55-96, 197-200.

Sinomagaceros (Sinomegaceroides) yabei (Shikama), Shikama & Okafiji, 1958, *Sci. Rep. Yok. Nat. Univ.*, sec. 2,, no. 7, p. 78-83 ; Shikama & Tsugawa, 1962, *Bull. Nat. Sci. Mus. (Tokyo),* no. 50, p. 1-11, 6pls.

Magaceros (Sinomegaceros) ordosianus minor Kamei, 1958, *Jour. Fac. Lib. Art. Sci. Shinshu Univ.*, no. 8, p. 69-74.

Referred specimen. — A plaster cast of basal part of left antler with pedicle attached, which was donated by Dr. Nobuo Naora to the National Museum of Japanese History. The original specimen of this cast have belonged to the Maya Collection but it is said that it has destroyed by fire during World War Ⅱ.

Locality. — Sea bottom of the Kozuchi-jima, Bisan-seto of Seto Inland Sea.

Specific diagnosis. — Based upon the precise description of the megacerid specimens of this species by Shikama (1962), the specific dagnosis is given as follows :

Magacerid having medium-sized antler. Brow tine relatively large, flat and platy ; basal part extending forward and then extend upward and becoming much wider transversally. Palmation of brow tine very distinct. Main beam long, stout, running straight aftward. Crown flat, platy, relatively long, running in vertical direction to brow tine. Hind tine straight and extending inward, vertical to crown. Jaw large, low, not so pachyostosed as in *pachyosteus* Young.

Description of the antler specimen.- A left, incomplete antler lost distal part of brow tine and beam ; inner side of preserved parts are crumbled away.

The pedicle is stout and 66 mm long as preserved. The burr is thick and elongate oval in general outline. The brow tine extends forward. It is large, flat and becoming thinner distally ; basal part of the tine is measured 49.7mm in breadth. The main beam is stout, extending straight aftward, somewhat outward, making an angles of 110 degrees wit brow tine ; broken end of the beam is measured 55mm in fore-and-aft diameters. Measurements (in *mm*) are given as follows :

Burr
Fore-and-aft diameter ..... 87.5+
Side-to-side diameter ..... 66+
Brow tine
Fore-and-aft diameter above bifurcation 35.5
Side-to-side diameter above bifurcation ..... 49.7+
Beam
Fore-and-aft diameter just above bifurcation 70.9
Side-to-side diameter just above bifurcation ..... 49+

Comparison.- Megacerid antler described in this paper is almost same in size and mode of forking as the type specimen of *Sinomegaceros yabei* Shikama (Shikama, 1939) recorded from the Late Pleistocene Upper Kuzuü Formation (fissure deposits), west Japan, but it is somewhat larger than well-preserved antler specimen known from the Late Pleistocene Kamikuroiwa Formation of Gunma Prefecture, East Japan (Shikama and Tsugawa, 1962).

Genus *Elaphurus* Milne-Edwards, 1866
Type-species.- *Elaphurus davidianus* Milne-Edwards, 1866
Subgenus *Elaphurus* Otsuka, 1972
Elaphurus (Elaphurus) mayai (Tokunaga and Takai)
Pl. 1, figs. 1-4 ; Fig. 7

Capreolus (Capreolina) mayai Tokunaga and Takai, 1936, *Jour. Geol. Soc. Japan,* vol. 43, no. 515, pp. 642-645. _____, Nagasawa, 1965, *Bull. Tokyo Gakugei Univ.,* vol. 17, ser. 4, pp. 81-82.

Elaphurus menziesianus Sowerby, Otsuka and Shikama, 1977, *Bull. Nat. Sci. Mus.* (Geol.& Paleont.), vol. 3, no. 1, pp. 14-15.

Elaphurus mayai (Tokunaga & Takai), Otsuka, 1988, Kurashiki Mus. Nat. Hist., p. 63-93.

Specific diagnosis. — Elaphurine, providing a large antler. The beam is dichtomously forked at a comparatively large distance above the burr. The front or upper prong of the main beam fork streches straight upward without dividing; it is relatively flatted in fore-and-aft direction; noticeable, long tinelets are developed along its inner and the antero-outer borders. The posterior or the lower prong projects backward; noticeable tinelets are fitted along the distal end of its outer and inner surfaces.

Referred spcimens.-- 1. Left, shed antler (Reg. No. YM* 812) collected from Loc. L. 2. a right, shed antler (Reg. No. YM852) collected from Loc. M, west of Sei-shima.

Remarks on the genus *Elaphurus.* — The genus *Elaphurus* was divided into two subgenus, *Elaphuroides* and *Elaphurus* (s.s.) based upon the morphological characters of the antler (Otsuka, 1972). The subgenus *Elaphuroides* was established based on the antler of *Elaphurus shikamai* Otsuka as a subgenotype. To date, the following two species are recorded from the Japanese islands and the Chinese Continents.

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* Abbreviation for the Yamamoto Collection.

Elaphurus (Elaphuroides) bifurcatus Teilhard de Chardin ..... The Nihewan Formation, North China (EarlyPleistocene)

Elaphurus (Elaphuroides) shikamai Otsuka ..... The Osaka Group, West Japan (EarlyPleistocene)

The subgenus *Elaphurus* (s.s.) was established based on the living Pere David's deer *(Elaphurus davidianus).* To date, three fossil species belonging to this subgenus are known from the Middle- to late Pleistocene deposits of North China, Formosa and Northeast China. This subgenus is thought to be derived from the *Elaphuroides* group duiring the Early Pleistocene (Otsuka, 1972). Morphological features such as a straight, expanded anterior (or upper) prong with complicated or dichtomous branching at its upper half and a straight, prolonged posterior (or lower) beam with simple or complicated terminal forking clearly distinguish *Elaphurus* from *Elaphuroides.*

Elaphurus (Elaphurus) davidianus Milne-Edwards ..... Many locations in China (Late Pleistocene)

Elaphurus (Elaphurus) formosanus Otsuka and Shikama ..... The Chiting Formation of the Toukoushan Group, Taiwan (early Middle Pleistocene)

Elaphurus akashiensis Shikama ..... The Hirayama sand bed of the Minamitama Group ; the lower part of the Osaka Group, Japan (Early Pleistocene)

Elaphurus (Elaphurus) tamaensis Otsuka and Hasegawa ..... The Hirayama sand bed of the Minamitama Group

Elaphurus (Elaphurus) lantianensis Chi ..... Lantin, North China (Early Pleistocene)

Description of the specimens.- 1. Left, shed antler (Reg. No. YM812 ; Pl. 1, fig. 2 ; Fig. 7-2), is small in size and declines backward noticeably. Judging from the mode of forking, this antler is from an immature male belonging to the genus *Elaphurus.* The burr is thin and less rugose with a nearly circular outline. The posterior prong forked high at a point measuring 142mm above the burr. The beam below the main fork is suboval in section with a relatively convex inner surface and a slightly keeled anterior border. In anterior view, the beam below the main fork broadens upward forming a continuation between the posterior and the anterior prong. The front or upper prong is 80mm in preserved length. It projects antero-upward making an almost right angle with the posterior prong. The posterior prong, measuring 255mm along the curvature, projects antero-upward, forming a circular arc with a pointed apex. The surface of the antler is covered with many, small tubercles. They are more noticeable on the lateral surface of the posterior prong and the inner surface of the anterior prong.

2. A right, shed antler (Reg. No. YM852 ; Pl. 1 ; fig. 1 ; Fig. 7-1) is 420mm in preserved length. Most part of the posterior or lower prong and the distal part of the anterior prong are crumbled away. It is stout and tuberculated with many noticeable tinelets and tubercles ; remarkably wide and shallow furrows and longitudinal ridges are more noticeable on the inner and the frontal surface of the antler. In anterior view, the axis of the antler declines outward.

The beam below the main fork is stout and suboval in outline and most constricted near

the basal part. It is bifurcated into the anterior (or upper) and the posterior (or lower prong at a point very high above the burr, measuring 98mm height. The burr is rugose and nearly circular in outline, measuring 66.8mm (side-to-side) ×72.7mm (fore-and-aft) in diameters.

The anterior prong is stretched upward, somewhat forward from the beam without dichtomous forking into lateral prongs. It is subtriangular in basal section, suboval outline in distal section ; the postero-medial surface of the prong is keeled and squared ; the anterior surface is covered with two wide but shallow furrows and remarkable longitudinal ridges ; noticeable tinelets are arranged on the surface of the longitudinal ridges of the inner surface ; they are tiny in the lower part, then become longer and tabular in the upper part ; the maximum diameters of the tinelets are 15mm, 32mm, 34mm and 39mm in ascending order and the intervals between tinelets are 50mm, 378mm and 22mm in ascending order. Small tinelets are also recognized on the anterior- and outer border of the anterior prong. These tinelets seem to run off the anterior tine from the inner- to the posterior corner and then to the inner corner going obliquely across the shaft. The posterior prong, which is 100mm in preserved length, extends backward and somewhat upward, making an angle of 80 degrees with the anterior prong ; it is stout and the broken end measures 36mm (side-to-side) ×46.5mm (up-and-below) ; the outer surface is rather flat while the inner surface is rugose with noticeable longitudinal furrows and ridges.

3. Metatarsus (Reg. No. YM815, Pl. 1, fig. 3). A right metatarsus is in the collection. It is thick but smaller than those of *Sinomegaceroides yabei* recorded from the Late Pleistocene deposits in the Japanese islands. The vascular groove on the frontal-medial surface is more distinct and wider than in *S. yabei.* The minimum fore-and aft width of the shaft is at a point about 53mm back from the distal end. Measurements (in *mm*) are as follows :

Preserved length: 296.4 ; Diameter of proximal end: 40.5 (fore-and-aft) ×40.0 (side-to-side) ; Diameter of distal end: 32.4 (fore-and-aft) ×45.8 (side-to-side)

Comparisons and observations.-- Of the two antler specimens described here, the left, shed antler (Neotype, Reg. No. YM852) shows the general characteristic of the species. That is to say, the burr is almost circular in section ; strong, grooved and tuberculated fore tine is prolonged straight antero-upward and a thick posterior tine stretches posteriorly. From these characteristics, this specimen can be saidto be identical to the genus *Elaphurus.*

In 1936, Tokunaga and Takai described two antler specimens under the name of *Capreolus mayai* and established a new subgenus *Capreolina* based on *mayai.* These antler specimens were said to be collected from the sea bottom off Kozuchi island. At present, I think that "off Kozuchi-jima" means the caldron channel named Loc. P in this paper, where many fossil cervids including *Elaphurus* were collected. They stated that : "Upon comparing the present antlers with those of living Roe-deer, it was found that the present ones are intimately related to those of the *Hippocamelus* group, and should be included in the *Capreolus* group. ····· We regarded *Capreolina* as a subgenus of *Capreolus* and believe that phylogenetically, *Capreolina* stand between *Capreolus* and *Hippocamellus.* The morphological characters of antler specimens from the Bisan-seto described in this paper (YM852, YM

812) are almost identical with type specimens of "*Capreolus*" *mayai* (Pl.1, fig. 4 ; Fig. 7-3), particularly in the stout and grooved, tuberculated anterior prong with circular outline and the much lyrated posterior prong.

Otsuka and Shikama (1977) described three fragmental specimens of antler in the Takao Collection collected from the sea bottom off Shodoshima. These specimens are characterized by a tuberculated prong with many strong tinelets and are allied to roe-deer at the first glance. They tentatively referred these antler specimens to *Elaphurus menziesianus* (Sowerby) recorded from the Archaeological site of Anyang, North China. However, these tuberculated antler specimens seem identical to the frontal and a posterior prongs of *Elaphurus mayai* (Fig. 7-4 and 5).

In general, the fore tine of *Elaphurus* is divided into two laterals prongs at a

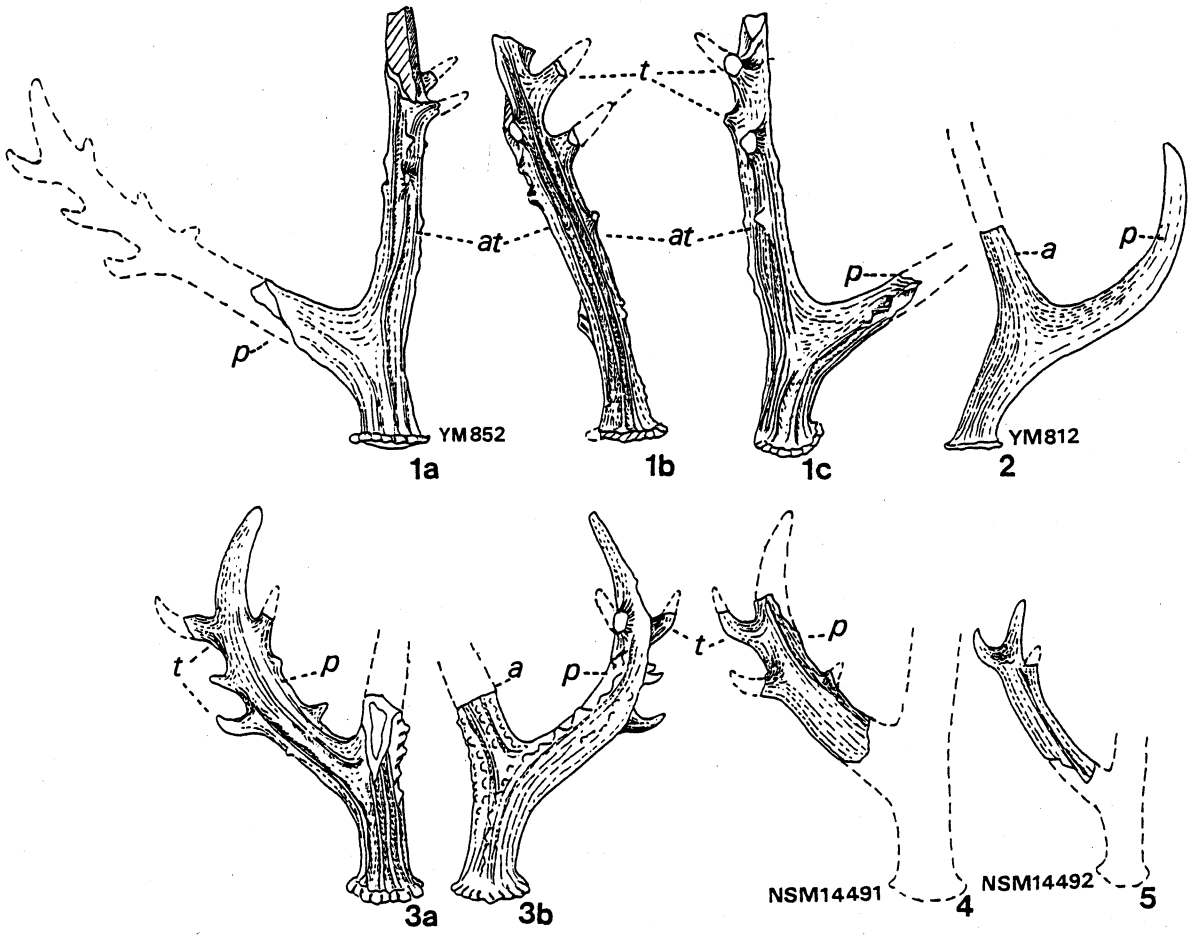

Fig. 7. Antler of the Maya's Su-pu-hsian (Maya-Sifuzou) —*Elaphurus mayai* (Tokunaga & Takai) —from the Seto Inland Sea. 1-2 : Yamamoto Collection ; 4 and 5 : Takao Collection (after Otsuka & Shikama, 1977), 3a and 3b : type specimin of *Capreolus* (*Capreolina*) *mayai* Tokunaga & Takai in the Maya Collection which was destroyed by fire during World War Ⅱ (after Tokunaga & Takai, 1936).
Outer (a), inner (b) and frontal (c) views, ×0.12. Anterior prong (at), posterior prong (p) and tinelet (t).

comparatively long distance above the burr (Otsuka, 1977). However, those of *Elaphurus mayai* show no indication of forking into lateral prongs corresponding to "Prong Ⅱ and Ⅲ" of Teilhard and Young (1936). Thus, the *Elaphurus* collected from the Bisan-seto of the Seto Inland Sea seem to deviate from the generic definition of the anterior prong of the genus *Elaphurus*. At present, they can be regarded as an extinct species which has deviated from the main phyletic line of the genus *Elaphurus*.

Elaphurus (?) **sp.**

Elaphurus (?) sp., Otsuka, 1988, Kurashiki Mus. Nat. Hist., p. 63-93.

Referred specimens.- Five postcranial skeletons including scapula, humerus, femur and tibia are in the collection. These bones are imcomplete and much crumbled.

Scapula. A right scapula is 173mm long as preserved. The glenoid cavity is completely crumbled away ; the neck is relatively long for cervid and its minimum width is measured 41.2mm.

Humerus. A right humerus is 167mm in preserved length ; both extremities are completely crumbled away ; the shaft near the distal part is 54.4mm side-to-side minimum diameter.

Femur. A right femur, represented by its proximal half, is 191 mm long as preserved ; the head of the proximal end is 26mm in fore-and-aft diameter.

Tibia. A left tibia is 263 mm as preserved ; proximal and distal extremities are completely crumbled away ; the shaft is stout for cervid and is measured 29.6 mm in smallest side-to-side diameter.

Observation.- The bones mentioned above differ from *Sika* and *Nipponicervus* in large size and in some characters and these remains a possibility that these bones may represent those of the genus *Elaphurus* known from the Seto Inlands Sea.

Genus *Cervus* Linnaeus, 1785
Subgenus *Sika* Sclatter, 1870

Type-species - *Cervus nippon* Temminck, 1873

Cervus (Sika) greyi katokiyomasai Shikama & Hasagawa, 1965, Pl. 2, Figs. 1-7 ; Pl. 3, figs. 1-6.

cfr. *Pseudaxis greyi* Zdansky, Zdansky, 1925, *Pal. Sinica.* ser. C, vol. 2, fasc. 3, p. 65-72, Taf. XIII, figs. 2-12.

Cervus (Pseudaxisis) greyi Zdansky, Teildard de chardin & Pei, 1941, *Ibid.*, N.S.ser. C, no 11, p. 76-80, pl. Ⅱ, pl. Ⅱ, fig. 3.

Pseudaxisis greyi var., Young, 1923, *Ibid.*, ser. C, Vol. Ⅷ, fasc. 2, p. 21-37.

Cervus cf. *greyi* Zdansky var. *etva* Teilhard de Chardin, Teilhard de Chardin, 1936, *Ibid.*, ser. C, Vol. Ⅶ, fasc. 4,, p. 39-42.

Cervus (Sika) cf. *greyi* (Zdansky), Otsuka & Shikama, 1976, *Bull. Nat. Sci. Mus.*, ser. C, Geol. & Paleont., vol. 12, no. 3, p. 1-40. _____ ; Otsuka, 1977, *Rep. Fac. Sci. Kagoshima Univ.*, (Earth Sci. & Biol)., p. 47-48.

Cervus (Rucervus ?) katokiyomasai Shikama & Hasegawa, 1965, *Sci. Rep. Yokohama Natn.*

Univ., ser. 2, no. 12, p. 45-47 _____ ; Otsuka, 1977, *Rep. Fac. Sci. Kagoshima Univ.*, no. 10, p. 41-52.

Cervus (Sika) natsumei Matsumoto, Otsuka & Shikama, 1977, *Bull. Natn. Sci. Mus.*, ser. C (Geol.& Paleont.),vol. 3, no. 1, p. 17-19, pl. 1, figs. 4-7.

Cervus (Sika) paleoezoensis Otsuka & Shikama, 1977, *Ibid.*, vol. 3, no. 1, p. 19-24, pl. 2, figs. 1-12.

Cervus (Sika) greyi katokiyomasai Shikama & Hasegawa, Otsuka, 1988, Kurashiki Mus. Nat Hist., p. 63-93.

Type specimen. — Right, shed immature antler stored in the Department of Geology, Kumamoto University. A plaster cast of the type specimen is kept in the National Science Museum, Tokyo (NSMReg. No. 6586) and in the Institute of Earth Sciences, Kagoshima University (Reg. No. ESK6052).

Referred specimens. — one hundred ten antler specimens including eighteen non-shed antlers are known ; They occupy about 48 % of total number of individual cervid specimens in the Yamamoto Collection.

Subspecific diagnosis. — *Sika*-deer with a medium- to large, triple-forked antler, showing great morphological variation in life. The beam of the antler in the adult stage is strongly lyrated backward, making an angle of 100 degrees with the long first tine. The general form somewhat resembles the subgenus *Rucervus*, but those of the young stage shows almost the same form as seen in many species of the subgenus *Sika*.

Remarks. — Abundant antler specimens of *Sika* from the sea bottom of the Seto Inland Sea show great morphological variety and some of the characteristic antler specimens or specimen groups have been regarded as an independent species (Shikama& Hasegawa, 1965 ; Otsuka & Shikama, 1977 ; Otsuka, 1977). Recently, however, I examined numerous antler specimens of the *Sika*-deer collected from the Bisan-seto, using statistical analyses, and concluded that the various antler forms represent different growth stages of a single species which shows a close relationship with *Cervus (Sika) greyi* Zdansky from the Middle Pleistocene Choukoutien Fauna in North China. For this newly recognized *Sika*-deer from the Seto Inland Sea, the subspecific name *Cervus (Sika) greyi katokiyomasai* (Shikama & Hasegawa) was given (Otsuka, 1987).

Description of some selected antler specimens.—

In the preceding study (Otsuka,1987), the approximate ages of most antler specimens were roughly estimated based on "the Pedicle Index", size of antler and mode of forking.

1. Young antler specimen (estimated to be about three to five years of age)

A left, shed antler of a young male (Reg. No. YM309 ; Pl. 2, fig. 4) was collected from Loc. K. It is 260mm in preserved length from the burr to the broken end of the beam above the second fork. The burr is thin, less rugose, oval-shaped in section, and measuring 36× 38mm across. The first tine forked at a low position above the burr, making an angle of 75 degrees with the beam. The beam above the first fork is lyrated slightly backward. The distance between the first and the second forks is short, measuring 200mm along the lateral border.

A right shed antler of a young male (Reg. No. YM469 ; Pl. 2, fig. 2) was collected from Loc. P between Ozuchi-jima and Kozuchi-jima. It is 250mm in preserved length from the burr to the tip of the second tine. The burr is almost circular and thin, measuring 35.8mm in fore-and-aft diameter. The first tine is 97mm long and is forked at a point 32 mm above the burr, making an angle of 75 degrees with the beam. The interval between the first and the second fork is short, measuring 164mm along the inner border. The surface of the antler is almost smooth, except the basal part. The general shape and mode of forking of this antler resembles that of young antler (Reg. No. NSM14438) in the Takao Collection.

A right, shed antler of a young male (Reg. No. YM566 ; Pl. 2, fig. 1) was collected from Loc. L. It is about 240mm in preserved length from the burr to the second fork. The first tine is forked at a point just above the burr, making an angle of 85 degrees with the beam. The beam between the first and the second forks is less lyrated and short, measuring 195mm along the lateral border.

A left, shed antler of a young male (Reg. No. YM714 ; Pl. 2, fig. 3) was collected from Loc. L. It is 265mm from the burr to the tip of the third (hind) tine above the second fork. The first tine, which is forked at a point close to the burr, projects antero-upward, making a nearly right angle with the beam. The beam between the first and the second forks is rather short, measuring 175mm along the lateral border.

A right, shed antler (Reg. No. YM810 ; Pl. 2, fig. 8) was collected from Loc. L. It is represented by the main part of the second fork, measuring 275 mm in preserved length. The first tine is forked at a position 30.5 mm above the beam between the first and the second forks is weakly lyrated, measuring 192 mm along the curvature. The second tine projects antero-upward, making angle of 75 degrees with the hind tine.

2. Maturemale (Five to seven years of age)

A right, shed antler (Reg. No. YM725 ; pl. 2, fig. 5) was collected from Loc. L. It is 310mm from the burr to the second fork. The first tine is rather long, measuring 190mm in preserved length. It directs antero-upwards from the base, making an angle of 85 degrees with the beam. The beam above the first fork stretches upward from the base with a slight inclination in the lower two thirds and then it curves gently forward. The length of the beam between the first and the second forks is 250mm along the outer border. The second tine rises from the frontal surface of the second fork making an angle of 65 degrees with the hind tine.

A left, shed antler (Reg. No. YM665 ; Pl. 2, fig. 6) was dredged from Loc. L. The basal part of the antler is well preserved but a portion above the second fork is completely broken away. The first tine is strongly projected forward, and somewhat upward, making an angle of 100 degrees with the beam. It is rather long, 150mm in preserved lenght, but would be about 170mm, if restored. The beam between the first and the second forks is rather short for this species, measuring 260 mm along the lateral surface.

Another shed antler (Reg. No. YM698 ; Pl. 2, fig. 7) resembles specimen YM725 (Pl.2, fig. 5) in size and mode of forking. This antler has a strong first tine and a moderately lyrated beam with an distance between the first and the second forks of 280mm along the

beam.

3. Mature male (seven to nine years of age)

Left, shed antler (Reg. No. YM405 ; Pl. 3, fig. 3) was collected from Loc. Q, located about 3km south of Ushi-jima. It is 418mm in preserved length from the burr to the broken end of the beam above the second fork. The burr is rather thin and subcircular in outline. The first tine, which is broken off near the base, is forked at a low position about 37mm above the burr making an angle of 100 degrees with the beam. The beam is moderately lyrated backward in the lower four fifths of its length, then it curves gently forward near the second fork. The distance between the first and the second forks is long, measuring 380mm along the lateral curvature. This value is the largest among all antler specimens of this species in the collection. The second tine arising from the frontal surface of the beam stretches antero-upward, making angle of 65 degrees with the hind tine.

4. Aged mature (nine to ten years of age)

A left, shed antler (Reg. No. YM664 ; Pl. 3, fig. 2) was dredged up from Loc. L. It is 355mm in preserved length from the burr to the broken end of the beam just below the second fork. The first tine which is forked at a point 43mm above the burr, projects forward, making a very obtuse angle of more than 100 degrees with the beam. It is 155mm in preserved length and is much depressed laterally, showing a tabular section. A small, obtuse snag is observed on the upper surface of the first tine. The beam above the first fork is long, measuring 300mm in preserved length and it would be about 340mm long if restored.

A left, shed antler (Reg. No. YM616, Pl. 3, fig. 4) was dredged up from Loc. L. This is the largest antler specimen of this species in the collection. The first tine is projected strongly forward at a rather low position above the burr, making an angle of almost 100 degrees with the beam. The beam above the first fork is almost straight, measuring 343mm long. The second (or frontal) tine arises from the anterior surface of the beam.

A right antler with the pedicle attached (Reg. No. YM599 ; Pl. 3, fig. 1) was collected from Loc. L. The pedicle is 27mm long and 32mm wide. The antler is of large size for this subgenus and measures 475mm from the burr to the tip of the second tine. The burr shows an oval outline of 45.5×51.4mm. The first tine which stretches strongly forward, forks at a point about 31mm above the burr, making an angle of 97 degrees with the beam. The interval between the first and the second forks is long, measuring 305mm along the lateral surface. In frontal view, the opposed antlers would decline outward, making an angle of 70 degrees from each other, if restored. The space enclosed by the opposed antlers is V-shaped.

5. Aged male (older than ten years of age)

A right, shed antler (Reg. No. YM470 ; Pl. 3, fig. 6) was collected from Loc. P between Ozuchi-jima and Kozuchi-jima. It is thick but small in size, measuring 360mm in preserved length. The burr is rather thick and rugose. The first tine, which was crumbled away from the base. is forked at a low point above the burr. The beam stretches directly upward with a slight inclination. The distance between the first and the second forks is short, measuring 233 mm along the lateral surface. The second tine is 108mm long and projects antero-upward, making an angle of 70 degrees with the beam. The mode of forkig of this

specimen resembles the specimens of Type B in the Takao Collection.

A left, shed antler (Reg. No. YM614 ; Pl. 3, fig. 5) is collected from Loc. J, north of Ushi-jima. It is 340mm in preserved length. The beam above the second fork is short, only slightly lyrated, and measure 220mm long along the curvature. This specimen resembles the paratype of "*Cervus paleoezoensis*" in the Takao Collection (Reg. No. NSM14443-2) in forking mode and size.

Comparisons and observations.- As discussed elsewhere (Otsuka,1987), the type- and referred antler specimens of fossil sika-deer from the Seto Inland Sea such as cf. *greyi, natsumei, paleoezoensis* and *katokiyomasai* (Shikama& Hasegawa, 1965 ; Otsuka & Shikama, 1977) represent different growth stages of a single species. For this newly identified species, *Cervus greyi katokiyomasai* Shikama and Hasegawa was selected as a valid scientific name.

"*Cervus (Sika) natsumei* Matsumoto of Otsuka & Shikama (1977) with a small antler was judged to represent a juvenile male younger than three years of age. The medium-sized antler described under the name of "*Cervus (Sika) paleoezoensis*" includes antler of various growth stages older than three years old. The holotype of "*Cervus (Sika) paleoezoensis*" (Reg. No. NSM14476) characterized by "a long first tine and wide angles of the first forking was regarded as the antler of a mature male ranging from five to seven years of age, while its parapye (Reg. No. NSM14443-2) was considered to be the dwarf antler of an aged male, older than ten years of age.

Cervus (Sika) cf. *greyi* Zdansky in the Takao Collection was differentiated from *Cervus (Sika) paleoezoensis* by "a short fore-tine and wide angles of the first forking and was barely distinguishable from *Cervus (Sika) greyi* Zdansky from the Choukoutien Fauna in North China by "wider angles and lower position of the first forking (Otsuka & Shikama, 1977). According to the statistical analysis of antler specimens of *Sika* from the Bisan-seto (Otsuka, 1987),"*Cervus* cf. *greyi*" seems to represent antler of a mature male ranging from four to seven years of age.

Among the antler specimens described in this paper, those estimated to be from three to seven years of age and older than eleven years are mostly referred to "*C. (S.) paleoezoensis*" and those from seven to ten years of age to "*C. (S.)* cf. *greyi*".

Cervus (Sika) greyi katokiyomasai is closely allied to *Cervus (Sika) greyi* Zdansky from the Choukoutien Fauna by its wider angles of first forking but is slender and smaller than the latter. As discussed by Otsuka (1987), the former subspecies might be derived from the latter and flourished in the Japanese islands during the late Middle Pleistocene (the Byobugaura age in Japan, the Mindel/Riss Interglacial age to Riss Glacial age).

Cervus (Sika) greyi katokiyomasai is also allied to *Cervus harbinensis* excavated from the latest Pleistocene fuluvial deposits at Ku-hsian-tung near Harbin, North China, accompanied with abundant mammalian remains (Tokunaga and Naora, 1939) by its long first tine and short beam but is distinguished from the latter by much lyrated beam in the adult stage.

Cervus (Sika) greyi katokiyomasai is also similar to *Cervus (Sika) nippon yesoensis* in having

a long first tine and long beam, but it is distinguished from the latter by a slender antler with wide angle of the first forking

The present subspecies is clearly distinguished from living sika-deer such as *C. (S.) nippon nippon* and *C. (S.) pulchellus* by the large distance between the first and the second forks and the large angle of the first forking.

From these facts, it is concluded that *Cervus (Sika) greyi katokiyomasai* might be originally dervied from *Cervus (Sika) greyi* in China and has fluorished in the Japanese Islands at the during Middle Pleistocene (the Byobugaura age ; the Mindel/Riss Interglacial age — Riss Glacial age) accompanied by Naumann's elephant and Maya's Su-pu-hsian *(Elaphurus mayai).* Furthermore, it can be said that *Cervus (Sika) nippon yesoensis* may trace its origin back to *Cervus (Sika) greyi katokiyomasai* during the late Middle Pleistocene and *Cervus (Sika) nippon nippon and C. (S.) nippon centralis* might be derived from *C. (S.) nippon yesoensis* after the Jomon Period of the Early Holocene.

Subgenus *Nipponicervus* Krezoi, 1941

Type-species — *Cervus praenipponicus* Shikama, 1936

Cervus (Nipponicervus) praenipponicus Shikama

Pl. 4, figs. 1-5.

Cervus (cfr. *Anoglochis*) *praenipponicus* Shikama, 1963, *Jour. Geol. Soc. Japan.* no. 482, p. 251-254, p. 9

Cervus (Depéretia) praenipponicus Shikama, 1941, *Jub. Comm. Prof. Yabe's 60th Birthday.* vol. 2, p. 1142-1147 ; Shikama, 1949, *Sci. Rep. Tohoku Univ.,* 2nd. ser. vol. 23, p. 84-99, Pls. Ⅶ-ⅩⅥ.

Cervus (Depéretia) naorai Shikama, 1936, *Proc. Imp. Acad. Tokyo,* vol. 17, no. 8, p. 251-254.

Cervus (Nipponicervus) praenipponicus Shikama, Otsuka and Shikama, 1977, *Bull. Natn. Sci. Mus.,* Ser. C (Geol. & Paleont.), vol. 3, no. 1, p. 28-31, _____ Otsuka, 1977, Rep. Fac. Sci. Kagoshima Univ., no. 10, p. 41-52 ; _____ Otsuka, Kurashiki Mus. Nat. Hist., p. 63-93.

Subgeneric diagnosis.- See Shikama (1947) and Otsuka and Shikama (1977).

Referred specimens.- Forty four antler specimens including twenty nine shed antlers are in the collection ; twelve specimens are left antlers and twenty eight are right antlers. They occupy about 19.2% of the total number of dividual specimens in the Yamamoto Collection.

Descriptions of some selected antler specimens.-- A left, shed, small antler (Reg. No. YM497-2 ; Pl. 4, fig. 1), was collected from Loc. P off Kozuchi-jima. The upper part of the beam above the forking was completely broken off. The first tine, which is slender and 80.7mm long, is forked at a position about 58mm above the burr, making an angle of 70 degrees with the beam.

An incomplete, left, shed antler (Reg. No. YM299 ; Pl. 4, fig. 2) was collected from Loc. K. It is of large size for this species, of 322mm in preserved length ; the upper part of the beam above the forking was broken away from the middle portion. The burr is rather thin

with a nearly circular outline, measuring 40×43mm in diameter. The beam below the first fork broadens upward in lateral view. The first tine is 142mm long and is forked at a position about 62mm above the burr.

A right, shed antler (Reg. No. YM764 ; Pl. 4, fig. 3), was collected from Loc. L. It is long and slender, measuring 460mm in preserved length. The first tine was completely broken away from the base. The point of first forking is rather high for this species, measuring 74mm above the burr. The length of beam between the first and the second forks is long, measuring 310mm along the lateral surface. The second tine projects postero-inwardly, making an angle of 85 degrees with the beam.

A right, shed antler (Reg. No. YM109 ; Pl. 4, fig. 4) was collected from the Bisan-seto area but the exact locality is uncertain. It is 410mm in preserved length from the burr to the broken end of the beam above the second fork. The antler is much slender and shows nearly smooth surface. The burr is thin and has a nearly circular outline, measuring 38× 39mm across. The first tine, which was mostly broken away, is forked at a position 70mm above the burr, making an angle of 70 degrees with the beam. The distance between the first and the second forks is long, measuring 305mm along the leteral surface. A small second tine projects inward, making a 60 degree angle with the beam.

Comparisons. — When Otsuka and Shikama (1977) described the fossil deer assemblage from the sea bottom off Shodoshima island, they classified the antlers of *Cervus praenipponicus* Shikama into the following three types based on the height and angles of the first forking.

Type	Height	Degrees
A	44-55	67-75
B	55-65	65-80
C	65-75	65-80

They concluded that the differences in mode of forking of the basal part of the antler may represent different growth stages. That is, antler having relatively narrow angles and low forking points represents immature males, while antler having wide angles and high forking points represents mature males. As far as the Yamamoto Collection is concerned, the antlers of *Cervus praenipponicus* from the Bisan-seto area include all the types described in the Takao Collection, however, those of Type B are most abundant and make up 54% of total number for that species.

Cervus (Nipponicervus) kazusensis Matsumoto

Pl. 4, figs. 6-9

Cervus (cfr. *Sika*) *kazusensis* Matsumoto, 1926, *Sci. Rep. Tohoku Imp. Univ.*, 2nd. ser. vol. 10, no. 2, p. 58-60.

Cervus (Depéretia) kazusensis Matsumoto, Shikama, 1941, *Jubl. Pub. Comm. Prof. Yabe's 60th Birthday,* vol. 2, p. 1148-1149.

Cervus (Depéretia) urbanus Shikama, 1941, *Ibid.*, vol. 2, p. 1148.

Cervus (Depéretia) shimabarensis Otsuka, 1967, *Mem. Fac. Sci. Kyushu Univ.*, ser. D, vol. 28, no. 2, p. 360-310, pl. 9, fig. 1.

Cervus (Nipponicervus) kazusensis Matsumoto, Otsuka & Shikama, 1977, Bull. Nat. Sci. Mus., vol. 3, no. 1, p. 9-39, 6pls., _____ Otsuka, 1988, Kurashiki Mus. Nat. Hist., p. 63-93.

Referred specimens. — Thirty four specimens are known ; twenty four specimens are right antlers and ten are left antlers. Most of the specimens are represented by the basal part of the antler with nothing above the second fork. They make up 14.8% of total number of cervid specimens in the collection.

Descriptions of some selected antler specimens. — A left, shed antler (Reg. No. YM297 ; Pl. 4, fig. 6) was collected from Loc. K. It is slender and less rugose, measuring 225mm in preserved length from the burr to the broken end of the beam. The first tine is 80.7mm in preserved length and is forked at a position 85mm above the burr, making a 70 degree angle with the beam.

A right, shed antler (Reg. No. YM112 ; Pl. 4, fig. 7) was collected from the Bisan-seto area, but the exact locality is uncertain. It is slender with a smooth surface and is 280mm in preserved length from the burr to the broken end of the beam. A small first tine forks at a position 82mm above the burr. The beam below the first fork broadens upward.

A right, shed antler (Reg. No. YM310 ; Pl. 4, fig. 8) was collected from Loc. K. It is 275mm in preserved length. The main part of the first tine and the upper half of the beam above the forking are not preserved. The burr is rather thin and nearly subcircular, measuring 42× 45mm in diameter. The first tine is forked at a point very high above the burr (at about 95mm) making a 75 degree anlge with the beam.

A basal part of a left antler with the pedicle attached (Reg. No. YM712 ; Pl. 4, fig. 9) was collected from Loc. L. This slender antler, supported on a rather short pedicle, is 373mm in preserved length. The burr is rather thin, moderately rugose, measuring 52mm across. The first tine, which is forked at a point 82mm above the burr, making 75 degrees with the beam. It is long and projects strongly antero-upward. The surface of the antler is covered with many longitudinal grooves and furrows.

Comparisons. — The described antler specimens are characterized by antler having a high point of first fork. They are refered to those of *Cervus (Nipponicervus) kazusensis* (Matsumoto) recorded from many areas in Japan. In the Takao Collection, the subgenus *Nipponicervus* including *praenipponicus* and *kazusensis* occupy about 30% of total number of cervid specimens, among which *kazusensis* is less in number and makes 30% of the total number of *Nipponicervus*. Furthermore, *C. kazusensis* was distinguished from *C. praenipponicus* by the higher position of the first forking. In the Takao Collection, antlers of *kazusensis* were divided into two types, namely A and B, based on the height and angles of the first fork.

Type	Height (mm)	Angle
A	75-90	60-90
B	90-100	60-75

Among thirty four antler specimens of *C. kazusensis* in the Yamamoto Collection, most belong to Type B. All the species of Early Pleistocene *Nipponicervus* recorded from the Japanese Islands such as *shimabarensis* (Otsuka,1967) and *trassaerti* (Shikama, 1941) were regarded as a synonymous with *kazusensis* (Otsuka and Shikama, 1977) and these species fall under Type A. Because of this, it can be stated that *Cervus kazusensis* from the Bisan-seto area is mostly represented by the Middle Pleistocene form.

Cervus (Nipponicervus) praenipponicus var. *takaoi*
Otsuka and Shikama
Pl. 4, fig. 10

Rusa sp., Naora, 1970, *Sci. Rep. Inst. Min. Ind. Fac. Sci. Eng. Waseda Univ.*, no. 26,, p. 55-61, fig. 3

Cervus (Nipponicervus ?) takaoi Otsuka and Shikama, 1977, *Bull. Natn. Sci. Mus.*, ser. C (Geol.), vol. 3, no. 1, p. 33-36, Pl. 1, fig. 2 ; _____ Otsuka, 1977, *Rep. Fac. Sci. Kagoshima Univ.* (Earth Sci. & Biol.), no. 10, p. 51-52.

Cervus (Nipponicervus) praenipponicus Shikama var. *takaoi* Shikama & Otsuka, Otsuka, 1988, Kurashiki Mus. Nat. Hist, p. 63-93.

Subspecific diagnosis. — See Otsuka and Shikama, 1977.

Description of selected antler specimen. — A left antler with pedicle attached (Reg. No. YM110 ; Pl. 4, fig. 10) was collected from Loc. L. It is 487mm in preserved length from the burr to the point of the second forking. The pedicle is short, measuring 17.2mm in length and 42mm in side-to-side diameter. The burr is rather thin and their outline is broad side-to-side. The first tine is completely crumbled away from the base. The beam between the first and the second forks is weakly lyrated and measures 305 mm along the lateral surface. The second tine arises from the frontal surface of the beam and projects forward.

Comparisons.- *Cervus (Nipponicervus ?) takaoi Otsuka* and Shikama was first described by Otsuka and Shikama (1977) based on six antler specimens collected from the sea bottom off Shodoshima (Takao Collection). The type specimen was represented by a left, shed antler (NSM14436). Otsuka and Shikama (1977) pointed out that *C. takaoi* is closely allied to *C. (Nipponicervus) praenipponicus* Shikama in forking mode of antler, although, it is clearly distinguishable from the latter by somewhat lower position of the first forking and the terminal, small tine (second tine) projecting forward. Furthermore, they added the following remarks : "there still remains a possibility that this new species may become an extreme variation of *praenipponicus*.". In the Yamamoto Collection, two incomplete antler specimens belonging to *C. takaoi* are discriminated and these antlers hold somewhat lower

position of the first forking than those of *C. praenipponicus*. In the Yamamoto Collection, however, *C. takaoi* occur with frequencies of less than 2.3% of total number of antler specimens of the subgebus *Nipponicervus,* so that, in this study, *takaoi* are regarded as of variation of *C. praenipponicus*.

Cervus (Nipponicervus) sp.

Fig. 7

Cervus (Nipponicervsu) sp., Otsuka, 1988, Kurashiki Mus. Nat. Hist., p. 63-93.

Referred specimens.- Eleven, incomplete antler specimens belonging to the subgenus *Nipponicervus* are in the collection ; four specimens are right antlers and seven are right antlers. These specimens are incomplete in preservation and preserve no main part of beam below the second fork.

Description of selected antler specimens.- A distal portion of right antler (Reg. No. YM200 ; Fig. 8-a) was collected from Loc. K. Beam below the terminal (second) fork is 25mm as preserved ; its surface is smooth and shows tabular otline in section. The second (inner) tine of the terminal fork is rather long (144mm), slender, projecting inward or somewhat backward, making an angle of 75 degrees with the outer tine. Outer tine of the terminal fork is slender, 210mm long, and forming continuation of the beam.

A distal portion of left antler (Reg. No. YM292 ; Fig. 8-b) collected from Loc. K. It is 156mm long as preserved ; beam is much depressed with rough surface ; the second (inner) tine is 75mm long as preserved, projecting inward. Long outer tine projects upper-outward forming gentle curvature.

Observation.- These antler specimens shows characters of terminal forking of the subgenus *Nipponicervus*. In general, inner short tine of terminal fork projects inward, making an angle of 65 to 75 degrees with the outer tine.

Cervus sp.

Cervus sp., Otsuka, 1988, Kurashiki Mus. Nat. Hist., p. 63-93.

Twenty nine, incomplete specimens including antler, skull, lower jaw, vertebra, scapula, humerus, metacarpus, metatarsus, femur and tibia are in the collection. However, it is difficult to know the definite position of species rank to which the present specimens are referred, because of the absence of the osteological knowledge of the species known from the Seto Inland Sea.

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Fig. 8. Distal portion of antlers of *Cervus* (*Nipponicervus*) sp. A right antler (a) and a left antler (b), ×0.24.

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Explanation of Plates

Plate 1

Figs. 1-4. *Elaphurus mayai* (Tokunaga and Takai)
Shed antlers (1-2,4) and a right metatarsal bone (3). 1 (Reg. No. YM852), 2 (Reg. No. YM812), 3 (Reg. No. YM815), 4 (after Tokunaga & Takai, 1936). Right antler (1,4) and left antler (2). Inner (1a), outer (1b,2) and frontal (1c,3,4) views, ×0.3.

Fig. 5. *Sinomegaceros (Sinomegaceroides) yabei* (Shikama)
A plaster model of a basal part of right antler in the Maya Collection which is kept in the National Museum of Japanese History, Sakura. It is said that the original specimen has destroyed by fire during World War Ⅱ. Locality : sea bottom off northeast Kozuchi-jima in Bisan-seto, Seto Inland Sea. ×0.3.

Plate 2

Figs. 1-8. *Cervus (Sika) greyi katokiyomasai* Shikama Hasegawa
All the specimens are shed antler. 1 (Reg. No. YM566), 2 (Reg. No. 469), 3 (Reg. No. YM714), 4 (Reg. No. YM309), 5 (Reg. No. YM725), 6 (Reg. No. YM665), 7 (Reg. No. YM698) and 8 (Reg. No. YM810) ; rigth antlers (1,2 and 8) and left antlers (3-7) ; Outer (1,2,5-8) and inner (3,4) views, ×0.3.

Plate 3

Figs. 1-6. *Cervus (Sika) greyi katokiyomasai* Shikama and Hasegawa
All the specimens are shed antler. 1 (Reg. No. YM599), 2 (Reg. No. YM664), 3 (Reg. No. YM405), 4 (Reg.

No. YM616), 5(Reg. No. YM614), 6(Reg. No. YM470). Right antler (1,2 and 6), left antler (3-5). Inner(2,3) and outer(1,4-6) views, ×0.3.

Plate 4

Figs. 1-5. *Cervus (Nipponicervus) praenipponicus* Shikama
1(Reg. No. YM497-2), 2(Reg. No. YM299), 3(Reg. No. YM764), 4(Reg. No. YM109), 5(Reg. No. YM117). Left antlers(1,2) and right antlers(3-5). Inner views, ×0.3.

Figs. 6-9. *Cervus (Nipponicervus) kazusensis* Matsumoto
6(Reg. No. YM297), 7(Reg. No. YM112), 8(Reg. No. YM310), 9(Reg. No. YM712). Left antler (6,9) and right (7,8). Inner(9) and outer(6-8) views, ×0.3.

Fig. 10. *Cervus (Nipponicervus) paraenipponicus* Shikama var. *takaoi* Otsuka and Shikama
A left antler with a pedicle attached (Reg. No. YM110). Inner view, ×0.3.

摘　要

備讃瀬戸の海底に於ける鹿類化石群集—とくにその産出層準に関連して
（瀬戸内海に於ける第四紀鹿類化石群—その3）：
瀬戸内海東部の備讃瀬戸海域の海底から漁網によって引き揚げられた更新世の哺乳動物化石の収集標本から成る山本コレクションのうち，鹿類化石について記載した他，瀬戸内海全域の更新世哺乳動物化石群集と，それらの包含層について論じた。備讃瀬戸海域からは3属に属する8種類の鹿科化石が識別されたが，これらの大半は，海釜とよばれる海底の侵食された凹地から採集されたもので，その包含層は大槌島層上部と推定される。全体としてみると，同海域産の鹿類化石群集は，小豆島迦釈ケ鼻沖産のその群集（Otsuka & Shikama, 1977）と同じく，ナウマンゾウを伴った *Sika–Nipponicervus* 群集と呼べる。この群集には華北の周口店動物群の特長種であるグレイ班鹿（*Cervus greyi*）の亜種であるカトウキヨマサジカ（*Cervus greyi katokiyomasai*）とムカシジカ亜属（*Nipponicervus*）の2種（*praenipponicus, kazusensis*）が卓越し，これに低地ー森林棲のマヤシフゾウ（*Elaphurus mayai*），ヤベオオツノジカ（*Sinomegaceros yabei*），徳氏水牛（*Bubarus* cf. *teilhardii*），野牛（*Bison occidentalis*）さらに犀（*Rhinoceros* sp.）をともなっていることより，後期更新世の“*Palaeoloxodon–Sinomegaceroides Complex*”（Hasegawa, 1972）とは異なる。大槌島層上部に包含される哺乳動物群集の地質時代は中期更新世後半の屏風ケ浦期（ミンデル／リス間氷期～リス氷期）にあたるものと推定される。
（大塚裕之）

Formation Name

Bannnosu 番ノ州　Byoubugaura 屏風が浦　Mitoyo 三豊　Nakanose 中ノ瀬
Nihewan 泥河湾　Ozuchijima 大槌島　Samijima 沙弥島　Tsuchinotoseto 槌ノ戸瀬戸

Locality Name

Bisan-seto 備讃瀬戸　Choukoutien 周口店　Kozuchi-jima 小槌島　Kyo-jima 小与島
Kurashiki 倉敷　Mitsuko-jima 三つ子島　Osaki-bana 大崎鼻　Ozuchibana 大槌鼻
Sakaide 坂出　Sanuki 讃岐　Sei-shima 瀬居島　Seto Inland Sea 瀬戸内海
Shakagahana 釈迦ケ鼻　Shimotsui 下津井　Shodo-shima 小豆島　Ushi-jima 牛島

Person's Name

Bando Y. 坂東祐司　Doi, K. 土井歓照　Furuichi, M. 古市光信　Harunari, H. 春成秀爾
Hasegawa, Y. 長谷川善和　Hayasaka, S. 早坂祥三　Honza, E. 本座栄一
Hoshino, M. 星野通平　Hinoide, S. 樋出誠恂　Imamura, S. 今村外治
Iwafuchi, Y. 岩淵義郎　Kamei, T. 亀井節夫　Kuwasiro, I. 桑代 勲
Matsumoto, H. 松本彦七郎　Maya, U. 眞屋卯吉郎　Narushima, T. 成島 保
Otsuka, H. 大塚裕之　Shikama, T. 鹿間時夫　Takao, H. 高尾 寿　Taruno, H. 樽野博之
Takai, F. 高井冬二　Tokunaga, S. 徳永重康　Yamamoto, K. 山本慶一

Plate 1

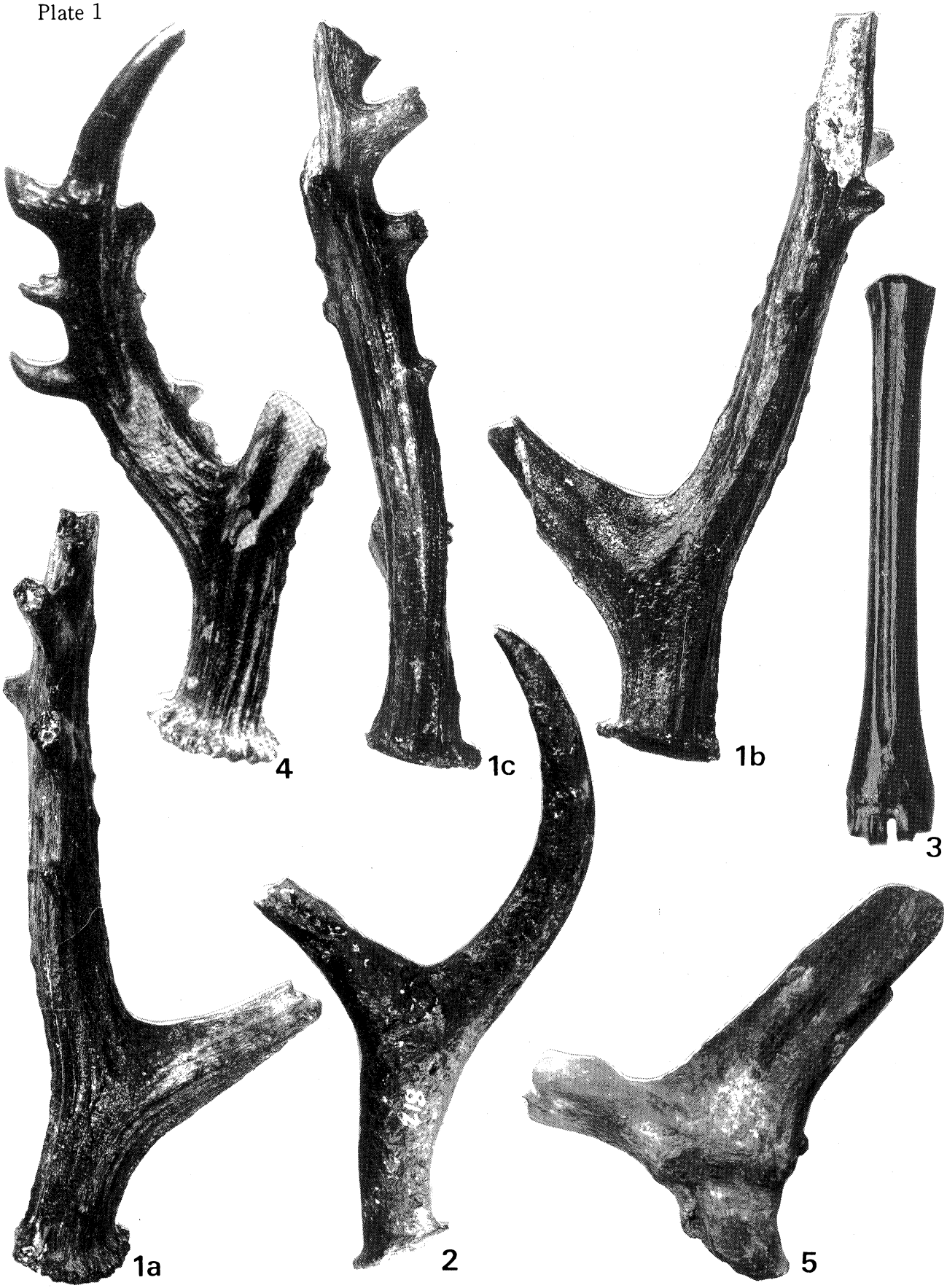

Plate 2

Plate 3

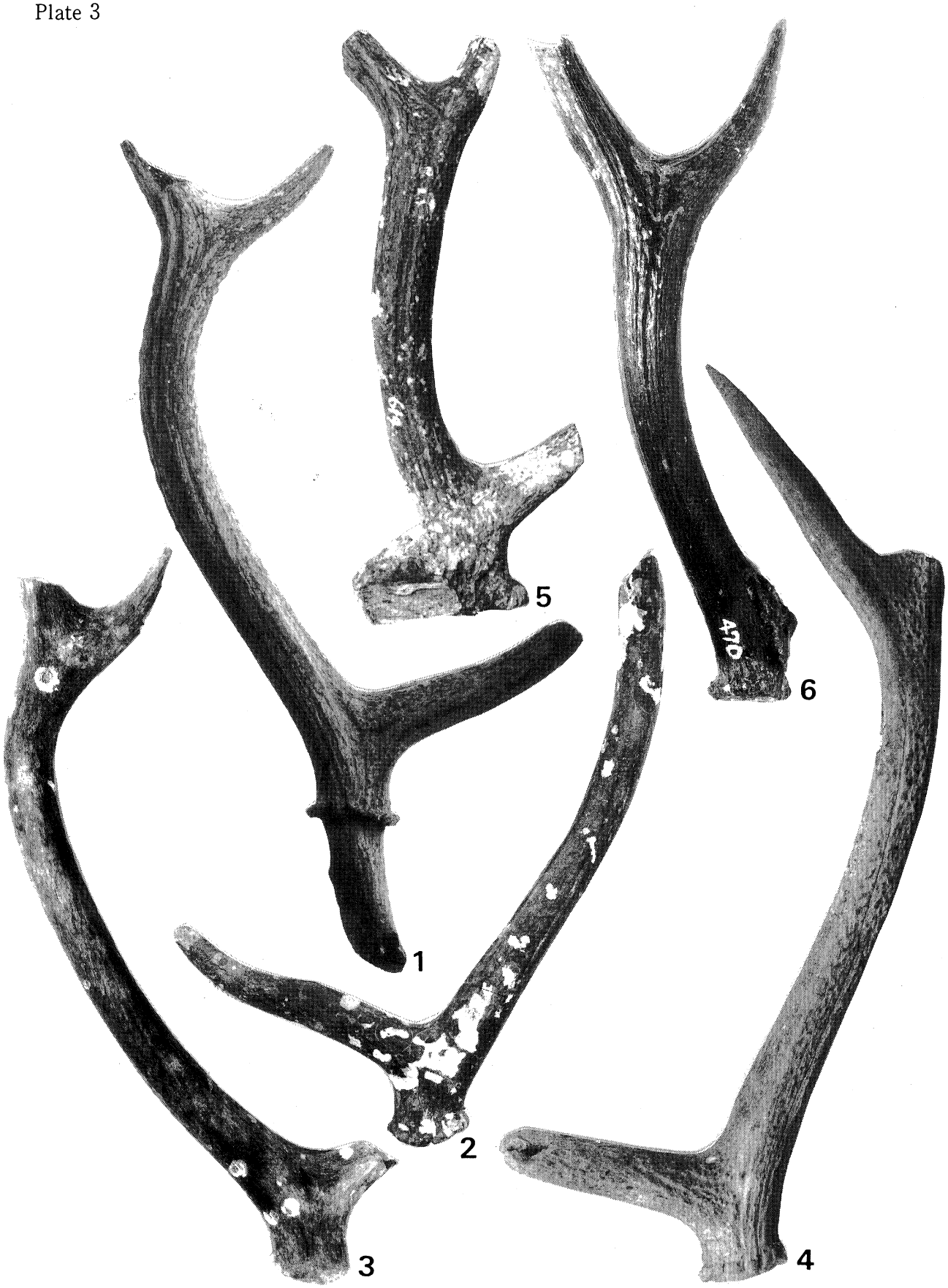

Plate 4