

PLEISTOCENE VERTEBRATE FAUNA FROM THE  
KUCHINOTSU GROUP OF WEST KYUSYU Part III.  
Proboscidean Fossils Part IV.Reptilian Fossils  
Part V.Concluding Remarks on the Vertebrate  
Fauna From the Kuchinotsu Group

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## PLEISTOCENE VERTEBRATE FAUNA FROM THE KUCHINOTSU GROUP OF WEST KYUSHU

**Part III. Proboscidean Fossils**

**Part IV. Reptilian Fossils**

**Part V. Concluding Remarks on the Vertebrate  
Fauna From the Kuchinotsu Group**

By

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### Abstract

This is a serial study on the early Pleistocene vertebrate fauna from the Kuchinotsu Group, west Kyushu.

As the previous two parts of this study, the writer gave a general account of the stratigraphy of the Kuchinotsu group with special reference to the vertebrate fossil beds and described a new species of *Cervus (Rusa)*, *Cervus (Axis)* and *Cervus (Deperetia)* (OTSUKA, 1966, 1967).

In the present two parts, two species of Proboscidea, two species of chelonia and one species of Crocodylia are described systematically. Furthermore, the final conclusions concerning the faunal character and the geological age of this group are discussed in the part V.

Through geological and paleontological line of evidence, it is clearly recognized that the vertebrate fauna of the Kuchinotsu group, which is characterized by the occurrence of abundant archetypal cervids and *Parastegodon* is closely related in faunal character and geological age to that of the Nihowan and Yushé in north China and that of the Akashi in Japan.

### Part III. Proboscidean Fossils

#### Systematic Descriptions [continued from Part II]

##### Order Proboscidea

##### Family Stegodontidae YOUNG-HOPWOOD, 1935

##### Subfamily Stegodontinae OSBORN, 1918

##### Genus *Parastegodon* MATSUMOTO, 1929

*Type-species.*- *Parastegodon aurorae* (MATSUMOTO), 1929

*Generic Diagnosis.*- See MATSUMOTO, 1929

*Parastegodon shodoensis* (Matsumoto), 1924

Pl. 4, Fig. 1.

*Compare.-*

1924. *Parastegodon shodoensis*, (MATSUMOTO), *Jour. Geol. Soc. Tokyo*, Vol. 31, No. 373~374, p. 3.  
 1938. *Stegodon shodoensis*, MAKIYAMA, *Mem. Coll. Sci., Kyoto Imp. Univ.*, ser. B, Vol. 14, No. 1,  
 p. 27-32, figs. 13-15.

*Material.-* GK. M 1189 (Pl. 4, Fig. 1), a lower left  $M_2$  with incomplete ramus collected from a gravel bed belonging to the basal part of the Ôya formation, lowest part of the Kuchinotsu group, at loc. KS 3900, Hayasaki of Kuchinotsu-machi, Minamitakaki-gun, Nagasaki Prefecture.

*Specific diagnosis.-* See MATSUMOTO, 1924.

*Description of the specimen.-* The tooth is wider behind than in front and slightly curved inward. It is about 145(+) mm along the grinding surface and about 81.7 (+) mm broad at the fifth ridge at base, where it is broadest. Molar bearing six ridges with a fore talon, of which the first to seventh are much damaged, so the detailed structure of each ridge except for the basal part is unknown. All the posterior ridges somewhat inclines forward, more particularly in the fourth, fifth and the sixth ridges. The frequency of the ridges in a length 100 mm count 5-5.5. Enamel walls of the second to the fourth ridges are moderately thick. All ridges taper acutely upward and much wider on outer side than on inner side. The valley are V-shape, moderately narrow and very shallow with thick cement, which is almost reaching grinding surface of the ridges. The enamel layer is 4.3-5.7 mm thick.

The first ridge is very closely fixed with fore talon. The third ridge curves forward making an oblique angle to the grinding margin. The fourth to sixth ridges rather straight and make almost reaching grinding margin.

The present specimen, when complete, probably had seven ridges and the anterior and the posterior talons. The lower jaw is about 120 mm broad just below

*Measurements in mm:*

	1	2	3	4	5	6	Fore talon
Maximum length at base	68.7	69.5	74.7	81.7	82.0	70(+)	60.5
Ditto along grinding surface	53.7	62(+)	65.6	65.5	64.6	—	—
Outer thickness at base	20.1	18.2	17.4	15.2	13(+)	—	—
Inner thickness at base	24.6	26.0	26.0	26.5	25(+)	—	19.2
Height at outer side	24.5	32(+)	34.0	32(+)	24(+)	—	26.2
Ditto at inner side	35(+)	42(+)	49(+)	44(+)	—	—	28(+)
Width of valley on grinding surface along median longitudinal line	8.7	10.0	11.6	11.8	14.3	—	—
Maximum thickness of lower jaw below the each ridges	—	86.6	94.3	120.0	—	—	—
Median width on grinding surface	—	15.0	11.3	10.9	9.9	10.3	—

the sixth ridge and about 92 mm high below the third ridge, where they are broadest and highest.

*Comparisons.*— The present specimen is more allied to *Parastegodon shodoensis* (MATSUMOTO) in much narrower valley between ridges, well developed cement and less plicated enamel wall and general size of the tooth.

The present specimen is also allied to *Par. kwantoensis* TOKUNAGA from the early Pleistocene of the Kanagawa Prefecture (TOKUNAGA, 1934) in less plicated enamel wall and clearly separated ridges, but the present specimen cannot be referred to *Par. kwantoensis* for the following reasons. Compared with the type specimen of *Par. kwantoensis*, the present specimen is characterized by higher and wider ridges, thicker enamel wall and more curved inner alveolar margin.

If we compared the present specimen with *Par. aurorae* (MATSUMOTO), the type species of *Parastegodon*, the former is characterized by somewhat longer posterior ridges, inner alveolar margin being more inwardly convex and less plicated enamel wall.

The present specimen is also distinguishable from *Par. akashiensis* TAKAI from the Akashi formation (TAKAI, 1936) for its wider valley between ridges and thin and less plicated enamel wall. *Par. sugiyamai* TOKUNAGA is also distinguishable in the same respect.

The present specimen cannot be referred to genus *Stegodon*, because it is characterized a narrow and V-shaped valley between ridges and higher and thicker ridge with rather thick cement.

To sum up the described specimen is probably ascribed to *Par. shodoensis*, because the difference from the holotype is rather slightly than from any other species.

#### Genus *Stegodon* FALCONER & CAUTLEY, 1847

*Type-species.*—*Elephas insignis* FALCONER & CAUTLEY, 1847

*Generic Diagnosis.*— See FALCONER, 1857

#### *Stegodon* (?) sp.

Pl. 4, Figs. 2-4; Text-fig. 1.

*Material.*— Some part of the posterior limb bones and a fragmental specimen of the tusk belonging to at least two individuals [GK. M 1050 (tusk), GK. M 1030 (right tibia), GK. M 1189 (left tibia), GK. M 1049 (right astragalus), GK. M 1061 (right costal)], collected from a dark blue mudstone bed (second bed) belonging to the upper part of the Kazusa formation, upper part of the Kuchinotsu group, at loc. KS 3920, Tsubami of Kazusa-machi, Minamitakaki-gun, Nagasaki Prefecture.

*Description of the specimens.*— Only one specimen of tusk (GK. M 1050, Pl. 1, Fig.

4) is preserved. It is moderate in size and has a constant thickness from the base tip. Enamel wall is rather thin and partly worn. The apical part is much worn and polished with numerous longitudinal striae and ring-shaped grooves.

Measurements in mm of GK.M 1050 as follows :

Length as preserved ..... 139 (+)  
 Diameter at the basal part as preserved ..... 27.2×26.0

Right tibia (GK.M 1030, Text-fig. 1) is preserved, but it is completely broken at the distal portion and cracked throughout. It is moderately large and about 359 mm long along the anterior border.

In the anterior view, the outer surface more steeply inclines than the inner at the proximal part. In the outer view, the anterior border is almost straight except near the distal part where the surface is slightly convex forward.

The posterior surface of the proximal part is rather deeply concave and the concavity becomes deep near the outer border; the middle part is moderately flat with slightly convex median longitudinal ridge. The tubercle on the inner-posterior corner of the posterior surface, which is sometimes developed in *Elephas* group, is not recognized.

In the inner view, there is a rather deep and wide, longitudinal furrow near the inner-posterior corner of the proximalis.

Measurements in mm of GK.M 1030 is as follows:

Diameter of the proximal end .....107.2× 92.8  
 Diameter at the distal end ..... 83.7×112.4  
 Maximum length along the anterior border..... 359.0  
 Maximum length along the posterior border ..... 364.8

Fragmental specimen of a left tibia (GK.M 1189) is somewhat larger than specimen GK.M 1035, so it is considered that this specimen belongs to another individual. The anterior border is almost straight with rugose surface and its lower-outer border is cut by a short and rather wide furrow. The posterior surface is much rugose and has many foraminas and striae, and its inner-outer border is much concaved. The inner border moderately distends and its surface is ornamented with small and irregular striae.

Measurements in mm of GK.M 1189 is as follows:

Side-to-side diameter of distal end.....110.1  
 Fore-and-aft diameter of distal end.....83.5

Astragalus. Right astragalus is preserved. Judging from the size, it seems that the present material probably belongs to the same individual as the GK.M 1189 (left tibia).

It is subquadrate and has a rounded anterior and lateral border. The facet for the articulation with the calcaneum is rather broad with median deep and broad

furrow which is about 17 mm in depth, 19 mm in width. The facet for the articulation with the carpus shows sector in outline with nearly straight lower, slightly curved upper borders. Measurements in mm are as follows.

Diameter of astragalus.....	94.4×81.8
Maximum thickness.....	59.5
Maximum width of furrow on the surface of the facet for the articulation with carpus .....	19.5

Cost. The right seventh or eighth costa is preserved, but its proximal portion is completely missing. The costa in proximal portion is subrectangular in outline, and width slightly convex outer and inner margins and concave anterior and posterior margins. In the inner view, the costa curves slightly forward in proximal part. Measurements in mm as follows.

Maximum length.....	610 (+)
Diameter at proximal end .....	22.3×30.4
Ditto at distal end .....	41.0×19.8

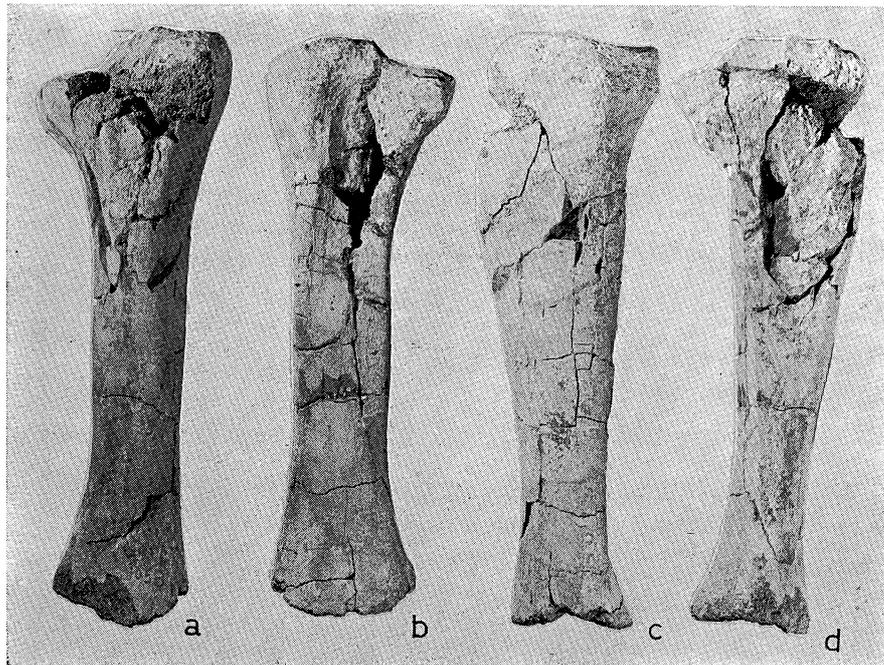


Fig. 1. The right tibia of *Stegodon* (?) sp.  
Anterior (a), posterior (b), inner (c) and outer (d) views, ×0.2

**Part IV. Reptilian Fossils**

## Abstract

In Part IV, the Chelonian and Crocodylian fossils from the Kuchinotsu group are described.

*Clemmys* sp. is described on the basis of fragmental specimens of the carapace and the plastrons belonging to at least two individuals. A new species of *Trionyx* is established on the basis of fragmental carapace and a few shoulder girdle probably belonging to one individual.

The fossil Crocodylia is described on the basis of the fragmental specimens of the teeth and a cervical vertebra.

1. **Systematic Description** [continued from Part III]

Order Chelonia MACRTHNEY

Family Emydidae GRAY

Genus *Clemmys* RITGEN, 1828*Type-species.*- *Testudo guttata* SCHNEIDER, 1792*Clemmys* sp.

Pl. 5, Figs. 1-4; Text-figs. 2 and 3

*Material.*- Fragments of carapace belonging to at least two individual [GK. M 1117 (hyoplastron), GK. M 1088 (xiphiplastron), GK. M 1179 (peripheral plate), GK. M 1178 (nuchal plate and nuchal scute)], collected from a dark bluish mudstone bed (second bed) belonging to the upper part of the Kazusa formation, upper part of the Kuchinotsu group, at loc. KS 3920, Tsubami of Kazusa-machi, Minamitakaki-gun, Nagasaki Prefecture.

*Description of the specimens.*- Xiphiplastron (GK. M 1088, Pl. 2, Fig. 1; Text-fig. 2) is represented by a single specimen; the inner view, the outer border much inclines outward, and the middle surface is concave and has a longitudinal deep striae which is divided into two striae near the posterior border; a short, longitudinal stria is also recognized on the surface of the outer border.

*Measurements in mm:*

Length along anterior border .....	48.0
Length along inner border .....	42.0
Length along posterior border .....	15.8
Length along outer border .....	50.7

The peripheral plate (GK. M 1179, Pl. 2, Fig. 4; Text-fig. 2) is represented by fragmental specimen which probably belongs to the posterior one (probably ninth) of left side; the upper face is moderately convex with a subacute outer border;

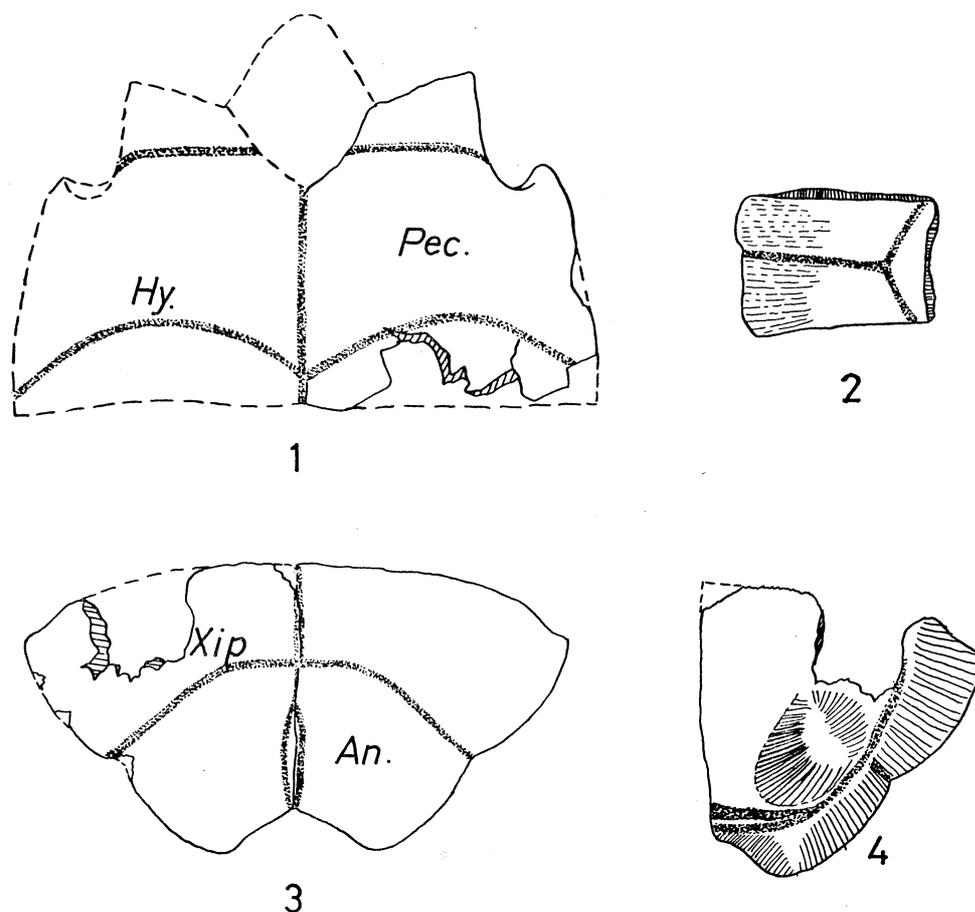


Fig. 2. Restored figures of the fragmental carapace of *Clemmys* sp.  
 1: outer view of hyoplastron, 2: outer view of ninth (?) plate of right side, 3: outer view of xiphiplastron, 4: inner view of xiphiplastron, Hy: hyoplastron, Pec: pectoral, Xip: xiphiplastron, An: anal,  $\times 0.7$ .

the anterior border is almost straight while the posterior border is slightly concaved forward; a longitudinal sulci is observed in the middle part of the upper surface, excepting the distinct Y-mark sulci. General size is larger than *C. yabei* and *C. japonica*.

*Measurements in mm:*

Length along inner border .....	20.5
Length along outer border .....	22.9
Width along anterior border .....	31.9
Width along posterior border.....	29.7
Maximum thickness .....	6.5

The nuchal scute (GK. M 1198, Pl. 5, Fig. 3; Text-fig. 3) is represented by a single specimen. It is trapezoid and has a weak convexity of the upper face. They are quite different from the triangular scute of *Clemmys yabei* from the upper Kuzuü formation, but more or less resemble that of *Clemmys japonica*; it is measured 8.8 mm long, 9.4 mm wide and 5.3 mm in maximum thickness. Late-

ral sulci of nuchal scute is opened forward at its anterior end. The nuchal plate is subrectangular and has a slightly concave anterior and posterior borders; it is measured 27.3 mm long and 26.2 mm wide. It closely resembles *C. japonica* in outline but is characterized by the deep longitudinal grooves and less opened sulci on its surface.

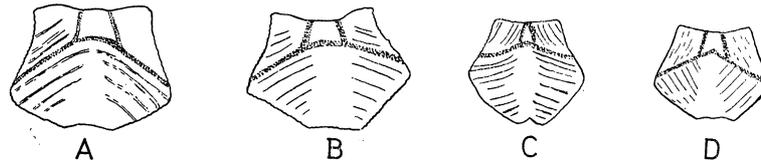


Fig. 3. Upper view of the nuchal bone. A: *Clemmys* sp. from the Kuchinotsu group, B: *Clemmys japonica*, C: *Clemmys yabei*, D: *Clemmys reevesi*,  $\times 0.5$ .

The hyoplastron (GK. M 1177, Pl. 5, Fig. 1; Text-fig. 2) is represented by a single specimen. The pectoral scute is quadrate in outline and has not parallel anterior and the posterior borders; the posterior border is much convex forward while the anterior border is almost straight. The pecto-abdominal sulcus runs posteriorly on the hyoplastron, about one-fourth the plastron. The humero-pectoral sulcus is almost straight and making a right angle with the median longitudinal sulcus. The feature of the pecto-abdominal and the humero-pectoral sulcus of the present specimen distinguish it from the *C. yabei* and *C. japonica*.

*Measurements in mm:*

Pectoral scute

Straight length along anterior border .....	56.8
Straight length along inner border.....	65.5
Straight length along posterior border.....	81(+)
Straight length along outer border .....	69.2

Hyoplastron

Straight length along anterior border .....	63.0
Straight length along posterior border.....	88.0
Straight length along inner border.....	67.0
Straight length along outer border .....	75.0
Maximum length of hyoplastron .....	98.8

The anal scute (GK. M 1088, Pl. 2, Fig. 5; Text-fig. 2) is represented by a single specimen. The outer border is slightly convex outward while the posterior border is slightly concave forward. The femoro-anal sulcus runs inwardly making an angle of almost right angle with a longitudinal median sulcus while it curves posteriorly on the xiphiplastron about one-third the full length of the plastron. The angle of the posterior-outer corner is more obtuse than that of *C. japonica* and *C. yabei*.

*Measurements in mm :*

Straight length along inner border.....	26.4
Straight length along outer border.....	27.0
Straight length along anterior border .....	37.0

*Comparisons*-. The present species resembles the living Japanese species *Clemmys japonica* TEM. & SCH. in the outline of shell, but it is difficult to identify it to *C. japonica* TEM. & SCH. in the following respects. Compared with *C. japonica* TEM. & SCH., the present species is characterized by the longer nuchal scute, less opened sulcus between the first vertebral scute and the first marginal, and almost straight humero-pectoral and sharply curved femoro-anal sulcus.

The present species is clearly distinguishable from *C. yabei* SHIKAMA, 1949 from the middle Pleistocene deposits of the upper Kuzuü formation by its trapezoid nuchal scute, more rectangular nuchal plate, less curved pecto-abdominal scute, and more convex anterior border of the anal scute.

*C. leprosa* SCHWEIG, now living in the Mediterranean region, is allied to but differs from the present species in having the long nuchal scute, different angle of the anal along the posterior border and different outline of the peripheral plate.

*C. reevesii* (GRAY) reported by BIEN (1934) from the middle Pleistocene deposits of the Chukoutien has the same kind of hyoplastron as the present species, but it differs in the form of the nuchal scute and anal.

## Family Trionychidae GRAY, 1825

Genus *Trionyx* GEOFFROY, 1809

Type-species.- *Trionyx triunguis* (FORSKAL), 1775

*Trionyx kazusensis* sp. nov.

Pl. 5, Fig. 6; Pl. 6, Figs. 1-5; Text-figs. 4-5.

*Material*.- Holotype: Four fragments of carapace probably belonging to one individual [GK.M 1180 (first costal), GK.M 1183 (third costal), GK.M 1181 (fourth costal) and GK.M 1182 (first neural)]: Paratype; a free portion of the rib (GK.M 1174), collected from a dark bluish mudstone beds (first to second beds), belonging to the upper part of the Kazusa formation, upper part of the Kuchinotsu group, at loc. KS 3920, Tsubami of Kazusa-machi, Minamitakaki-gun, Nagasaki Prefecture.

*Specific diagnosis*.- Large turtle belonging to the genus *Trionyx*. The shell of the carapace is thick and wide and has no preneural. The first neural is oblong, hexagonal and has a longest lateral, shortest posterior-lateral, somewhat convex anterior, and concave posterior borders. The anterior border is somewhat wider than posterior. The first costal has somewhat concave anterior, slightly

convex posterior and gently curved lateral borders. The long axis of the first costal is almost vertical to that of the first neural. The sculpture of the carapace consists of rather deep and wide pits and intervening reticular ridges narrower than pits themselves.

*Description of the specimens.*— The first neural is large, thick and somewhat depressed and has a rather regular outline. They are oblong hexagonal and has a longest lateral, shortest posterior-lateral, somewhat convex anterior and concave posterior borders. The anterior border is somewhat wider than the posterior. The sculpture of the first neural is ornamented with shallow and rather wide

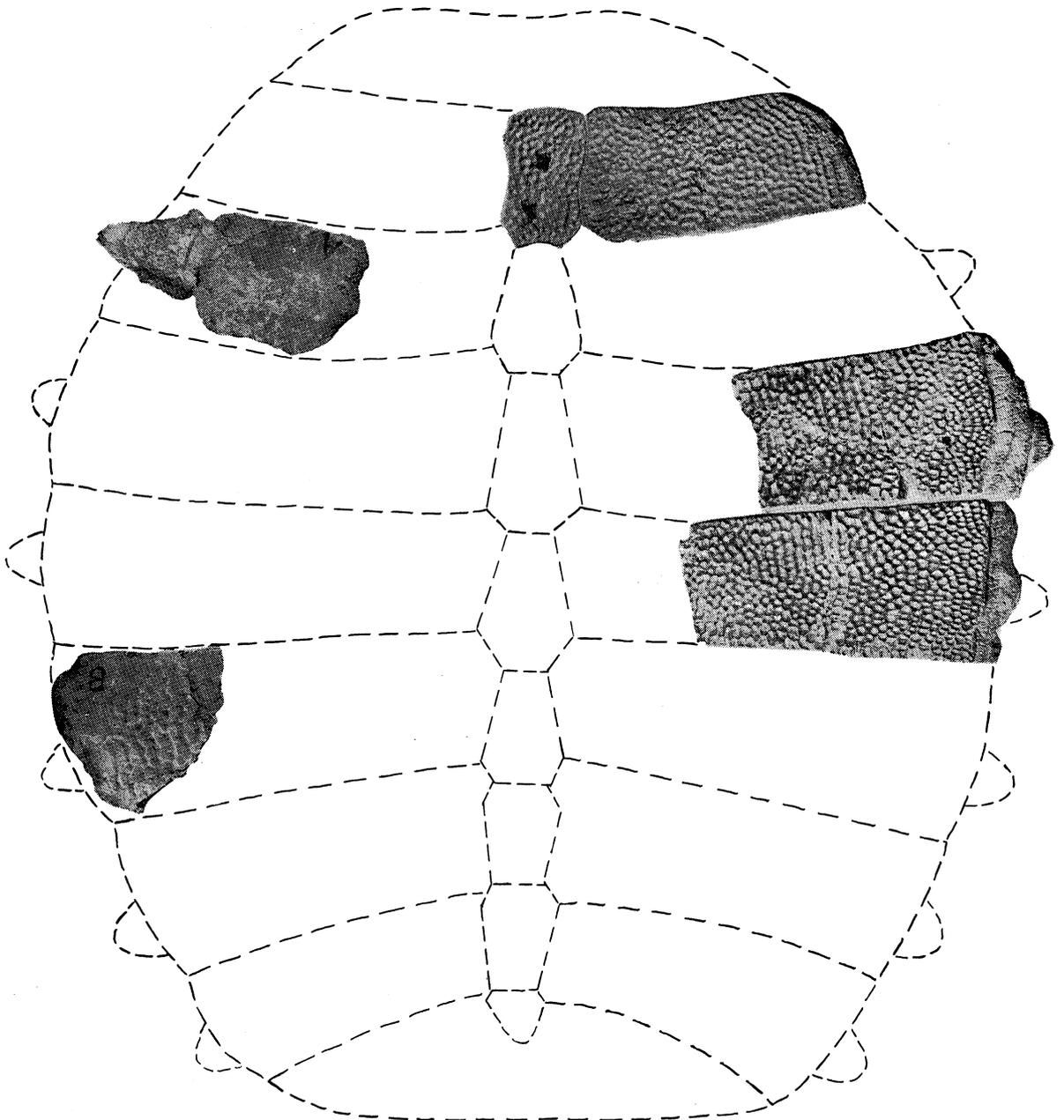


Fig. 4. Restored figure of the carapace of *Trionyx kazusensis* sp. nov. ( $\times 0.6$ ).

pits and intervening irregular ridges.

The width of the first costal is 54.6 mm near the neural and 53.0 mm near the margin and somewhat concave antero-inner, convex postero-inner, somewhat concave anterior, slightly convex posterior and gently curved lateral borders. The surface of the postero-inner and the antero-middle parts are moderately depressed. The long axis of the first costal is almost vertical to that of the first neural.

The third costal is broken away from the inner half. The width of the third costal is 67.5 mm near the margin, 49 mm near the costal part. The length of the costal at the central portion is 110 mm long. The thickness of the third costal is about 13.6 mm. Both anterior and the posterior borders are almost straight. The surface of the costal is slightly depressed near the central portion.

The width of the fourth costal is 69 mm near the margin, 49 (+) mm near the neural, 61 mm at the center. The thickness of the fourth costal is 13.2 mm. Both the anterior and the posterior borders are almost straight and has almost flat surface.

The sculpture of the carapace consists of rather deep and wide pits and intervening reticular ridges narrower than pits themselves. It becomes somewhat coarser toward outer border. The reticular ridges of the fore-and-aft direction are higher than that of side-to-side direction, so that the pits appear to be arranged more or less linearly in fore-and-aft direction. The free portion of the ribs is wide and thick and is measured 41.5 mm in width, 10.8 mm in thickness in a fragmental specimen (GK. M 1070).

*Measurements in mm :*

Costal

First	{	Maximum length at the anterior suture line .....	82.3
		Maximum length at the posterior suture line .....	119.2
		Width at the inner border near the neural .....	54.6
		Width at the outer border .....	52.6
		Thickness at the central part .....	9.2
Third	{	Length along anterior suture line .....	112.8(+)
		Length along the posterior suture line .....	110(+)
		Width along the outer border .....	67.5
		Thickness at the central part .....	16.0
Fourth	{	Length along the anterior suture line .....	141.3(+)
		Length along the posterior suture line .....	128(+)
		Width along the outer border .....	69.3
		Thickness at the central part .....	16.4
Fifth	{	Length along the anterior suture line .....	120(+)
		Width at the central part .....	16.4

Neural

First	{	Maximum length along the lateral border .....	59.2
		Maximum width along the posterior border .....	33.2
		Maximum width along the anterior border .....	33.7
		Thickness at the central part .....	9.2

The free portion of the ribs is measured as follows:

The free portion of the ribs is measured as follows:

No. of rib	Length along the outer border of carapace	width
III	ca. 24 mm	24.5 mm
IV (?)	ca. 14 mm	ca. 26 mm

Shoulder girdle. Preserved bony skeleton is a right shoulder girdle such as scapula and precoracoid process but the coracoid is completely missing (Pl. 5, Fig. 6; Text-fig. 5). The body of the scapula is 171.5 mm long, including the glenoid cavity is about 26 mm. The precoracoid process is 117.4 mm long. It expanded distally to a width of 34 mm. Both the scapula and the precoracoid are larger and more strongly constructed than the Recent Japanese species of *T. sinensis*.

Left pelvic girdle (GK.M 1074) preserved the distal part of the ilium except proximal part (Pl. 5, Fig. 5). The diameter of the ilium at the distal end is 21.2×13.4 mm. The minimum width of the ilium has a diameter of 16.3×7.0 mm.

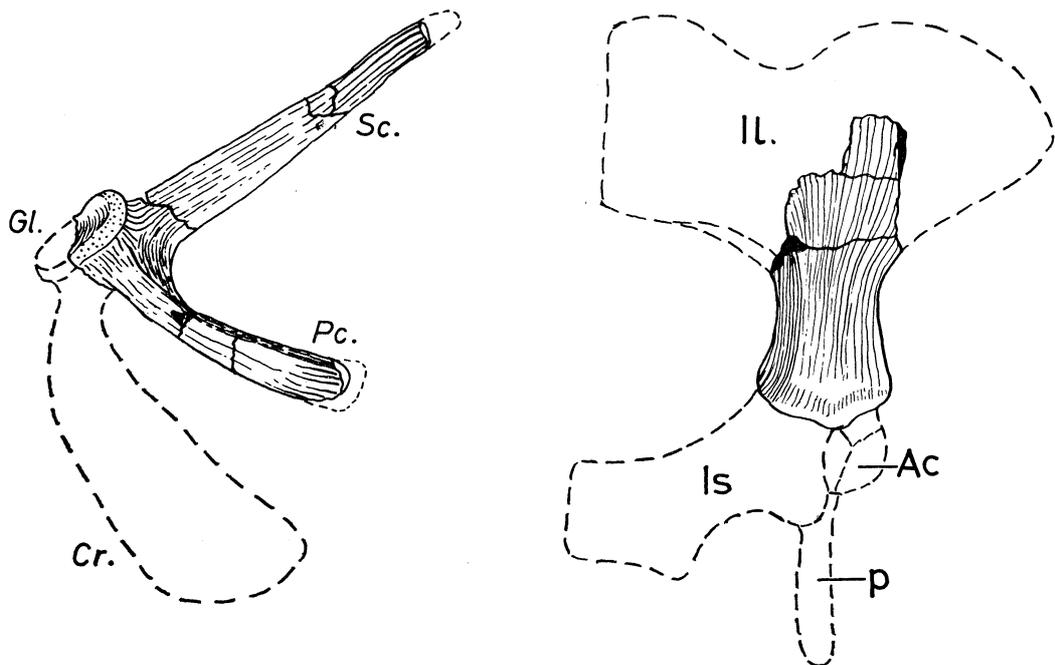


Fig. 5. Shoulder and pelvic girdle of *Trionyx kazusensis* sp. nov.  
Sc: scapula, Pc: precoracoid, Cr: coracoid, Il: ilium, Is: ischium, Gl: glenoid facet, Ac: acetabulum, P. pubis, ×0.2.

*Measurements in mm:*

Length of the scapula .....	171.5
Diameter of the scapula at distal end .....	19.0×13.2
Length of the precoracoid .....	117.4
Maximum width of the precoracoid at distal end .....	38(+)
Diameter of the glenoid cavity .....	26.5×27.6
Diameter of the scapula at proximal end .....	29.2×15.0
Diameter of precoracoid at proximal end .....	22.4×16.2

*Comparisons and observations.*— The present species apparently differs from the Recent Japanese species *Trionyx sinensis japonicus* TEM. & SCH. in its larger size and thicker carapace, more quadrate first neural and more regular pits in the sculpture of the costal.

The present species somewhat resembles *T. ubeensis* CHITANI from the Tertiary sandstone bed of the Ubé coal mine, Yamaguchi Prefecture (CHITANI, 1925). But the present species cannot be referred to *T. ubeensis* for the following reasons.

1) The long axis of the first costal of the present species makes a right angle to that of the first neural, while in *T. ubeensis*, they cross obliquely with each other. 2) The width of the first costal in the present species is wider near the nuchal plate than the lateral border while it is just reverse in *T. ubeensis*. 3) The costal of the present species, so far as preserved, is wider and thicker than that of *T. ubeensis*.

*Trionyx desmostyli* MATSUMOTO is the first record of this genus in Japan which was found from the Miocene (?) deposits of Hokkaido (MATSUMOTO, 1918). This species is represented by only a posterior half of the carapace, so it is very difficult to make the precise comparisons between the present species and *T. desmostyli*. But there are several differences between them. Compared with *T. desmostyli*, the present species is characterized by the wide and thick costal, wider and larger pits of the sculpture which is arranged more distinctly like a vesiculata in the direction of the antero-posteriorly.

The present species somewhat resembles *Amida gracilia* YEH from the Pliocene (?) formation of the Yushé Series in the southern part of Shansi, China, but is distinguishable from *A. gracilia* by its larger carapace, more rectangular first neural, a larger ratio of fore-and-aft to side-to-side diameter of the first neural, and by the different type of sculpture of the costal.

Fossil *Aspideretes* group from China is clearly distinguished from the present species by the presence of the preneural.

## Order Crocrodilia

Family, genus and species indet.

Pl. 7, Figs. 1-6; Pl. 8, Figs. 1-5; Text-figs. 6.

*Material.*- GK. M 1135-M 1147 (Pl. 7, Figs. 1-6; Pl. 8, Figs. 17), the lower or upper teeth; GK. K 1184, a third cervical vertebra, collected from a dark grey tuffaceous sand bed (fifth bed), belonging to the upper part of the Kazusa formation, upper part of the Kuchinotsu group, at loc. KS 3920, Tsubami of Kazusa-machi, Minamitakaki-gun, Nagasaki Prefecture.

*Description of the specimens.*- Teeth. Eight lower right (or upper left) and six lower left (or upper right) teeth, found separately, have been examined. These are much elongate-conical and moderately curved in outline. The crown bears on both sides very distinct, sharp-edged ridges which are extending from the apex to near the base. The inner surface defined laterally by these ridges is slightly concave while it is slightly convex on the outer surface. Besides these two prominent ridges, many fine ribs are recognized. The number of ribs is 22 on the average, 16 in minimum and 26 in maximum.

Generally the transverse section of the crown is nearly circular but in a few example it is slightly depressed laterally. The young, unused tooth is much compressed laterally at the apex and have distinct ridges on either side and many small ridges on the whole surface.

GK. M 1135 (Pl. 7, Fig. 1), a lower right or upper left tooth. This specimen is stoutest and pudgist among the specimens at hand. It gently curves inward. The basal part is missing and the apical part is much worn. The surface of the crown is rather smooth; no conspicuous striae are observed, but some weak striae of which intervals are about 0.8 mm on the average in the basal part are recognized. The transverse section of the crown is almost circular in the apical part. Several, weak, ring-like elevations are discernible in the upper half of the crown.

GK. M 1136 (Pl. 8, Fig. 7), a lower right or upper left tooth. This specimen is much polished and black in colour. The postero-lower and the basal parts are missing. The crown moderately curves inward and slightly backward, and has an acutely pointed apex; its transverse section is almost oval in outline in the basal part. The longitudinal striae, about 10 on either side, are observable on the surface of the crown, which are separated by intervals of about 1.5 mm in maximum and about 0.6 mm in minimum.

GK. M 1137 (Pl. 7, Fig. 3), a lower left or upper right tooth. This specimen is moderately stout and thick among the specimen at hand; it shows light brown surface; the outer surface of the apical and the basal parts are missing. The surface of the crown is rather smooth, but very weak striae are recognized; the basal part is somewhat depressed laterally; the long axis of the crown slightly inclines inward and backward. A ring-like pattern is also recognized in the basal part.

GK. M 1138 (P. 8, Fig. 6), a lower left or upper right tooth. This specimen is

relatively well preserved, but the basal part is missing. It is characterized by slender form for its diameter and acutely pointed apex. The longitudinal striae are rather well-developed, of which 9 are on the outer side and 10 on the inner. A ring-like pattern appears on the surface of the median part and also on the lower part and a few indistinct ones between them.

GK. M 1139 (Pl. 7, Fig. 2), a lower right or upper left tooth. The main part of the crown is rather well-preserved, but the apical and the basal part missing. The enamel wall is somewhat worn in its middle part. The size of this specimen is regarded as moderate among the specimens at hand. The crown curves moderately inward and backward. The nonserrated cutting edges on either side are pronounced above than below. The longitudinal striae, which are about 11 on the outer, 12-13 on the inner, are observable on the surface of the crown, which are separated by intervals of about 1.6 mm in maximum value. Several, weak, ring-like patterns are discernible in the middle part of the crown.

GK. M 1141 (Pl. 8, Fig. 3), a lower left or upper right tooth. The present specimen is much broken in the lower part and worn in the apical part. The crown is rather slender for its thickness and somewhat longer transversely. The present specimen is characterized by its smaller number of longitudinal striae which are about 7 on the inner side, 6 on the outer, which are separated by intervals of about 1.9 mm in maximum value. Several, weak, ring-like patterns are discernible in the upper half of the crown.

GK. M 1142 (Pl. 8, Fig. 1), a lower right or upper left tooth. The crown is rather small, slender and curves slightly inward; about 10 longitudinal striae are discernible on the whole surface of the crown, which are separated by intervals of about 0.8 mm in the average. A weak, ring-like pattern is recognized on the upper half of the crown.

GK. M 1143 (Pl. 7, Fig. 6), a lower left or upper right tooth. It is long, slender and moderately curved inward and with much pointed apex. About 13 longitudinal striae are discernible on the inner side of the crown. The transverse section of the crown is somewhat depressed laterally.

GK. M 1144 (Pl. 4, Fig. 4), a lower left or upper right tooth. The present specimen is very thick for its length and belongs to the small sized specimen group in my collection. This specimen is rather short, pudgy, conical and slightly curved inward.

GK. M 1145 (Pl. 7, Fig. 5), a lower right or upper left tooth. The present specimen belongs to the large sized specimen group in my collection. Tooth is rather long, slender and curved slightly inward and backward. There is a nonserrated cutting edge of slight prominence on either side. The longitudinal striae, which are about 13 on the inner side, are separated by interval of about 1.6 mm.

GK. M 1146 (Pl. 8, Fig. 4), a lower right (?) or upper left (?) tooth. The present specimen is very fragmental and its inner half and the basal part is completely broken away. The distinct, longitudinal striae are discernible on the crown.

GK. M 1147 (Pl. 8, Fig. 5), a lower left (?) or upper right (?) milk tooth. The present specimen is far smaller than the other specimens at hand and regarded as a milk tooth of the same individual. The crown is almost triangular in lateral view and much compressed laterally in the middle part and has very fine ridges on the whole surface.

GK. M 1185 (Pl. 8, Fig. 2), a lower right or upper left tooth. The curvature of this specimen is much stronger than the other specimens. The surface of the crown is rather smooth, but rather weak striae recognized, of which 11 are on the inner and 10 on the outer sides. The ring-like patterns are observable from the tip to the base of the crown.

*Measurements in mm:*

	Fore-and-aft diameter at basal part	Side-to-side diameter at basal part	Preserved length of tooth
GK. M 1135	11.6	12.0	25 (+)
GK. M 1136	10.2	11.7	26.3(+)
GK. M 1137	10.7	9.8	19.7(+)
GK. M 1138	9.2	9.2	27.8(+)
GK. M 1139	9.5	9.8	22.9(+)
GK. M 1140	10.1	8.9	26.2(+)
GK. M 1141	7.2	6.9	23.0(+)
GK. M 1142	6.8	7.1	19.7(+)
GK. M 1143	7.1	7.0	20.6(+)
GK. M 1144	8.2	7.6	14.2(+)
GK. M 1145	7.1	7.0	16.9(+)
GK. M 1146	—	—	18 (+)
GK. M 1147	3.2	4.4	7.2(+)
GK. M 1185	6.3	6.3	19.5(+)

Cervical vertebra. Third or fourth cervical vertebra (GK. M 1184, Text-fig. 6) is preserved, but it is much broken at the left postzygapophysis, left parapophysis, left diapophysis and the neural spine.

The centrum is about 59.7 mm long and is divided from the neural arch by a distinct suture.

In frontal view, the centrum has rather quadrate aspect and has rather squarish lateral corners. The anterior articular face of the centrum is about 35 mm broad, widest in the upper part and about 36.5 mm high. The posterior articular surface has a quadrate aspect and broaden from side to side with somewhat

squarish ventral border.

The vertebral foramen is rather oval in outline in frontal view but is broaden from above and below with deep, V-shaped, longitudinal furrow in the posterior view.

From the base of the prezygapophysis, the diapophysis moderately descends downward, backward and outward, but it extends backward less than, and outward equally to the parapophysis. The attachment for the head of the rib of this process is rather broad.

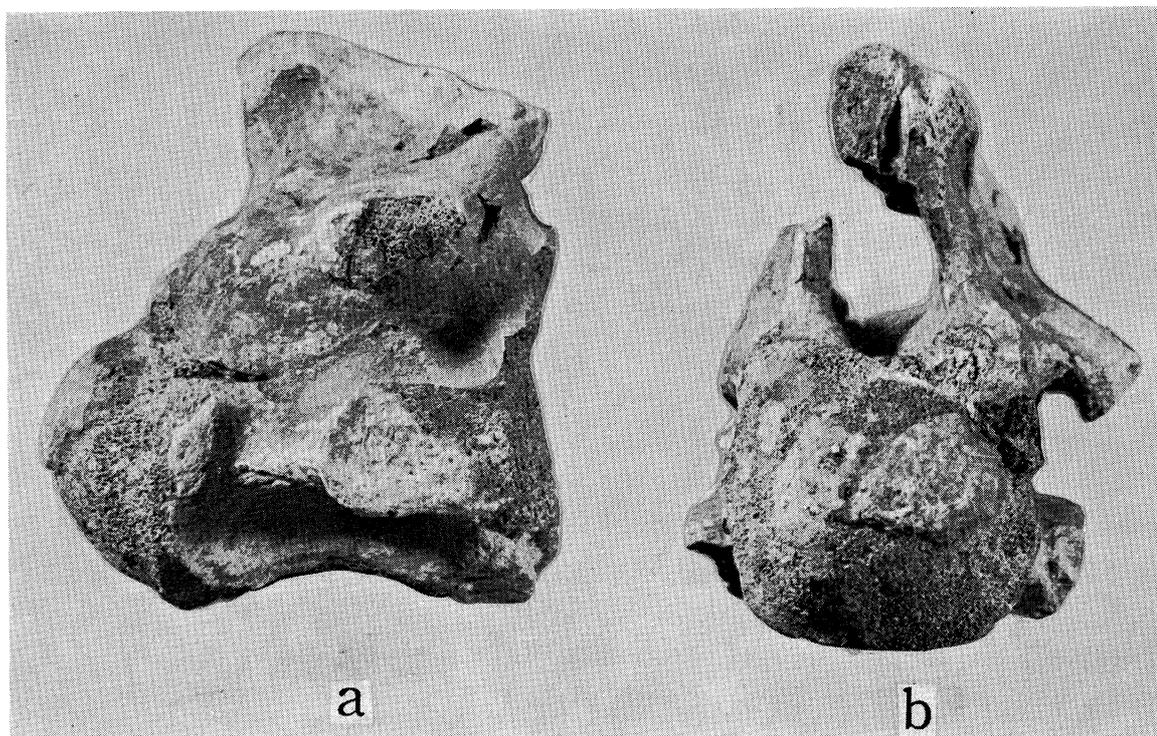


Fig. 6. The fourth or the fifth cervical vertebra of Crocodilia family, genus and species indet. Lateral (a) and posterior (b) views,  $\times 1$ .

The posterior zygapophysis is slightly preserved. The neural spine appear to be small and thick, but is broken off short at the height of about 69 mm from the ventral border of the centrum.

At the base of the centrum a median hypapophysial ridge runs along its entire length; behind the parapophysis the centrum is most constricted from side, measuring 27.5 mm.

The lateral surface of the centrum above the parapophysis is deeply convex. The surface of the neural arch is weakly convex and is limited above by slight angle connecting anterior and the posterior zygapophysis.

*Measurements in mm:*

Preserved length of the centrum.....	59.7(+)
Transverse length of the diapophysis in restored figures .....	58(+)

Transverse length between dia- and parapophysis .....	10.8
Minimum length between dia- and parapophysis .....	10.8
Diameter of the centrum at anterior end.....	35.0×36.0
Diameter of the centrum at posterior end .....	37.4×36.5

*Comparisons and observations.*— The species of crocodile known to live in the northeastern Asia is only of Alligatoridae, namely *Alligator sinensis* FAUVEL commonly called “Chinese Alligator”, of which distribution is restricted to the Yangze Valley area. On the other hand, all of the fossil species of crocodile hitherto discovered from the Tertiary and Quaternary formations in the said region are crocodylidae and a doubtful example of Gavialidae. Fossil species hitherto described are as follows:

*Tomistoma petrolica* YEH (YEH: 1958). Upper part of the Eocene deposits near Maoming Kwagtung, southwestern China.

“Gavialidae” or “Tomistmidae” genus and species indet. (TOKUNAGA: 1936). Early Pleistocene deposits near Syatin, Taiwan.

*Tomistoma machikanense* KAMEI & MATSUMOTO (KAMEI & MATSUMOTO: 1965). Early Pleistocene Ôsaka group, Japan.

The crocodylian fossils obtained from the fourth to fifth bed of the Tsubami bone beds (OTSUKA, 1966) were described on the basis of the fragmental specimens of teeth and a cervical vertebra. The teeth which constitute the main part of our collection, occur most abundantly in the lower part of the fifth bed, where the specimens are dispersed in all direction within twenty square meters. They are rather well preserved but the basal parts of them are completely missing in all specimens. The cervical vertebra is also excavated from the fifth bed. Since the time of excavation, the writer believes that these materials are originally of a single individual judging from the number of tooth and the state of preservation. It is very difficult, however, to know the definite position of genus rank or even of family rank to which the present specimens are referred, because of the absence of some important skeletal parts.

Judging from the fact that the fossil specimens hitherto described from Japan and adjacent region are of Crocodylidae, it may be assumed that the present specimens also represent the family Crocodylidae. But the final decision must be reserved until more materials are examined.

In Japan, the first discovery of fossil crocodile was made rather recently from the early Pleistocene Ôsaka group in the central Japan (KAMEI & MATSUMOTO, 1965) and the specimen was named as *Tomistoma machikanense* KAMEI & MATSUMOTO. The fossil crocodile from the Kuchinotsu is the second occurrence in Japan through the whole geological ages. Compared with *T. machikanense* KAMEI & MATSUMOTO, the teeth of the present specimens are characterized by the more curved and more striated surface of somewhat depressed crown. But a few example

such as the present tooth specimen GK.M 1139, show a little alliance to *T. machikanense* in its general outline.

#### Part V. Concluding Remarks on the Vertebrate Fauna From the Kuchinotsu Group

##### (1) Faunal assemblage

From the distribution area of the Kuchinotsu group, several molar specimen of Proboscidea have been reported by the previous authors under the following specific names.

*Archidiscodon planifrons* (FALCONER & CAUTLEY), [SHIKAMA, 1937]

*Parastegodon akashiensis* TAKAI, [TAKAI, 1937]

*Palaeoloxodon namadicus naumanni* MAKIYAMA, [INOUE & TAKAI, 1935]

*Stegodon orientalis* OWEN, [INOUE, 1952]

The first and the second specimens were reported to be collected from the "*Juglans cinerea* bed" of the Kuchinotsu group at Ôe, eastern part of the Kuchinotsu-machi (SHIKAMA, 1937; TAKAI, 1937). It is, however, difficult to allocate them at the stratigraphic horizons of my scheme of sequence.

The third specimen is the material collected from the sea bottom around this area by fishingnets, and the original bed of its derivation is hardly decided on the available evidence.

The specimen of which stratigraphic position and locality are exactly known is only the fourth. It was collected from the gravel bed just below the basalt layer of the lower Ôya formation, at Hayasaki of Kuchinotsu-machi (INOUE, 1952). It was identified to *Stegodon orientalis* OWEN and some geologists have discussed the geologic age and the faunal significance of the Kuchinotsu group on the basis of this molar tooth. I also discussed the geologic age of this group on the basis of this molar tooth in my previous report (OTSUKA, 1967). But as the result of examination of the specimen itself, I have arrived at the conclusion that the proboscidean molar tooth from the Hayasaki hitherto identified to *Stegodon orientalis* OWEN should be ascribed to genus *Parastegodon*, and that it is most closely allied to and possibly identical with *Parastegodon shodoensis* MATSUMOTO (see P. 2).

Recently, KAMEI (1964) has investigated the proboscidean fossils from the Kuchinotsu group and described two species: *Stegodon orientalis* Owen and "*Elephas* sp.". I would agree with his identification of *Stegodon orientalis*, but it is again difficult to determine the precise stratigraphic position of his specimens, since they were collected from the sea bottom of the Ariake bay on which the distribution area of the Kuchinotsu group is facing.

To discuss the exact age and the significance of the fauna of the Kuchinotsu group, we must at first select the specimens of which occurrences and the hori-

zons are exactly known.

I have identified the following vertebrate fossils from the Kuchinotsu group.

Kazusa formation	{	<i>Cervus (Axis) japonicus</i> OTSUKA <i>Cervus (Deperetia) shimabarensis</i> OTSUKA <i>Cervus (Rusa) kyushuensis</i> OTSUKA <i>Stegodon</i> (?) sp. <i>Trionyx kazusensis</i> OTSUKA <i>Clemmys</i> sp. Crocodilia family, genus and species indet.
Lower Ôya formation	{	<i>Parastegodon shodoensis</i> (MATSUMOTO)

The molar tooth of the so-called *Stegodon orientalis* OWEN is said to have been extracted from the younger gravel bed exposed at the cliff near Shiki Coal mine, northwestern part of the Amakusa shimo-shima. The gravel bed is correlated to the Kama gravel bed exposed typically on the sea cliff of the northwestern and western coast. The result of my pollen analysis on this bed shows close alliance to that of the Tatsuishi formation in the Shimabara Peninsula. Therefore it is reasonable to correlate them with each other.

## (2) Correlation

The Tsubami bone beds of the Kuchinotsu group, in which cervids form the main constituent, are regarded as providing one of the most remarkable mammalian faunas in the Japanese islands for their good preservation and the richness of the material, as are certain bone beds of the ossuary type in the Japanese Pleistocene, such as the early to late Pleistocene deposits of the Kuzuï formation of the central Japan and the middle to upper Pleistocene deposits in the Akiyoshi district of southwest Japan.

The cervid faunule of the Kuchinotsu group comprises *Cervus (Axis) japonicus* OTSUKA, *Cervus (Deperetia) shimabarensis* OTSUKA and *Cervus (Rusa) kyushuensis* OTSUKA. *Cervus (Rucervus) katokiyomasai* SHIKAMA and HASEGAWA, 1956, from the Ariake bay, is probably derived from the Kuchinotsu group.

Species of the Cervidae, like those of the Proboscidea, are important as indicators of geological ages, palaeogeographic land connection and also climate conditions during the Pleistocene in Japan. The fossil cervids have been studied by many previous authors and were summarized by SHIKAMA (1941), to whom I owe much.

The cervid faunas of the Japanese Pleistocene are divided into following three characteristic groups on the basis of the stratigraphic point of view and the associated proboscidean fossils (see Table 1). They are, 1) early Pleistocene cervid fauna associated with *Parastegodon* (Ôya and Kazusa formations of the Kuchinotsu group, Akashi formation of the Ôsaka group, Umegase formation), 2) early

Table 1. Geologic distribution of the fossil deer in the post-Nihowan of the Japanese Islands (SHIKAMA, 1941: partly revised by OTSUKA)

		Taiwan	Ryukyu	Kyushu	Honshu
Late Pleistocene	<i>Palaeoloxodon</i>		<i>Capreolus</i> sp. <i>Metacervulus astylodon</i>	<i>Cervus (Sika) nippon nippon</i>	<i>Sinomegaceros (Sinomegacerooides) yabei</i> <i>Moschus moschiferus</i> <i>Cervus (Deperetia) prae-nipponicus</i> <i>C. (D.) urbans</i> <i>C. (Sika) nippon nippon</i> <i>Capreolina mayai</i> <i>Alces</i> sp.
Late middle Pleistocene					<i>Cervus (Deperetia) prae-nipponicus</i>
Early middle Pleistocene	<i>Stegodon-Palaeoloxodon</i>	<i>Cervus (Sika) taiouanus</i> <i>C. (Deperetia) kokubuni</i> <i>C. (D.) syatinensis</i> <i>C. (Rusa) timoriensis</i> <i>Capreolus (?) formosanus</i>			<i>Cervus (Deperetia) prae-nipponicus</i> <i>C. (D.) naorai</i> <i>C. (D.) kazusensis</i> <i>C. (Cervus) cf. elephus</i> <i>C. (Sika) yesoensis</i>
Early Pleistocene	<i>Parastegodon</i>			<i>Cervus (Axis) japonicus</i> <i>C. (Rusa) kyushuensis</i> <i>C. (Deperetia) shimabarensis</i>	<i>Elapurus shikamai</i> <i>Elaphurus akashiensis</i> <i>Metaplatyceros sequoiae</i> <i>cervus (Deperetia) kazusensis</i>

middle Pleistocene cervid fauna associated with *Stegodon-Palaeoloxodon* (lower Kuzuü formation, Sanuki formation) (late middle Pleistocene may be included here), 3) late Pleistocene cervid fauna associated with *Palaeoloxodon namadicus naumanni* (upper Kuzuü formation).

Japanese vertebrate fauna characterized by the cervid and proboscidean fossils are known to occur mainly in the following formation: the Akashi formation and the Kobiwako group in the Kinki region, the Umegase, Sanuki and Kuzuü formation in the Kwanto region and the Ísa formation in the Akiyoshi province, Chugoku region. Among these cervid-bearing formations, the Akashi and the Umegase formations show a faunal resemblance to the Kuchinotsu group. The cervid fauna of the Akashi formation, referred to the lower part of of the Ôsaka group, characterized by the abundant archetypal cervids such as *Elaphurus shikamai* OTSUKA, *E. akashiensis* (SHIKAMA), *Metaplatyceros sequoiae* SHIKAMA accompanied with *Parastegodon akashiensis* TAKAI, *Par. aurorae* (MATSUMOTO), *Par. shodoensis* (MATSUMOTO) and *Par. sugiyamai* TOKUNAGA. In Bôsô Peninsula, the early Pleistocene Umegase formation bears such characteristic Cervidae as *Cervus (Deperetia)*

*kazusensis* (MATSUMOTO) accompanied with *Parelephus proximus* MATSUMOTO. These vertebrate assemblage has been called the "*Parastegodon* vertebrate fauna" (KAMEI, 1962 *et al.*) which is considered as a fauna typifying Japanese early Pleistocene. If place a great importance on the existence of the archetypal cervid, the Kuchinotsu group may be regarded as being contemporaneous with the Akashi and the Umegase formations. For the same reason, the Ôizumi and the Kuragari formations of the Agé group in the Ise Bay area, which bears *Parastegodon akashiensis*, can also correlated to the Kuchinotsu group.

In north China, very important cervid fauna has been reported from the Yushé basin, southern Shansi (TEILHARD de CHARDIN & M. TRASSAERT, 1937). According to TEILHARD de CHARDIN and TRASSAERT, the Plio-Pleistocene deposits called the Yushé series is biostratigraphically divided into three units, zone I (lower Pliocene, Pontian), zone II (mid. Pliocene) and zone III (Villafranchian~up. Pliocene). Each zone is characterized by a particular cervid fauna. The primitive deer such as a species *Cervocerus* characterized zone I, while the elements of what they called the Indo-Malayan group including the species of *Axis* and *Rusa* range from zone II to zone III (Villafranchian in a wide sence) and are accompanied with palaeartic group of *Eucladoceros* and *Dama*. The Nihowan formation of northern Shansi, which is correlated to zone III of Yushé, contains *Equus*, *Elaphurus* and *Rusa* among others.

In the Kuchinotsu vertebrate fauna, *Cervus* (*Deperetia*) *shimabarensis* OTSUKA is closely related to *C. (D.) trassaerti* SHIKAMA from zone III of the Yushé series. *Cervus* (*Rusa*) *kyushuensis* OTSUKA evidently differs from the Japanese species of *Deperetia* group and has several characters in common with *Cervus* (*Rusa*) *elegans* TEILHARD & PIVETEAU from zone III of the Yushé series. *Cervus* (*Axis*) *japonicus* OTSUKA does not seem to have an intimate relationship to the Chinese species of *Axis* from the Yushé series, but was probably derived from a common ancestor, *Cervocerus novorossiae* from north China, as I have discussed in the part II in this serial study.

*Elaphurus shikamai* OTSUKA from the Akashi formation is closely related to *Elaphurus bifurcatus* TEILHARD and PIVETEAU from the Nihowan of north China. As mentioned in my another paper (OTSUKA, 1968), the species of *Elaphurus* hitherto reported from the Akashi and the Umegase formations, which were mostly identified to *Elaphurus davidianus* MILNE-EDWARDS by the previous authors (WATASE, 1913, 1922; NAGASAWA, 1932; SHIKAMA, 1941), should be regarded as *E. shikamai* OTSUKA, although they are more or less fragmentary.

Although TEILHARD and TRASSAERT (1937) called the vertebrate fauna of the Yushé series the Indo-Malayan group, the early Pleistocene fauna of zone III has little affinity with the nearly contemporary Siva-Malayan fauna (KOENIGSWALD, 1940) of India and Java. Therefore it would be desirable to avoid the term Indo

Malayan group. I describe in this paper the fauna represented by the vertebrate fossils from zone III of the Yushé as well as by those of the Nihowan formation as the Nihoan fauna.

The fact that the species from the Kuchinotsu group and the Akashi formation are closely related to those of the Nihowan fauna indicates that the Kuchinotsu-Akashi cervid fauna of west Japan represent a faunal branch extending from the Nihowan fauna. Broadly speaking there may have been an intimate palaeobiogeographic connection between north China and west Japan. However, quite identical species has not yet been found between the two regions. In other words there may have been subprovincial difference. More evidences are necessary to explain in what way the fauna migrated and how they evolved during the migration.

Anyhow, the Kuchinotsu fauna is entirely different from the middle Pleistocene *Sinanthropus-Sinomegaceros* fauna of north China and much so from the Sino-Malayan fauna (TEILHARD de CHARDIN, 1953; KOENIGSWALD, 1939) of south China and Java.

*Parastegodon* bearing fauna, which is the representative of the Japanese early Pleistocene, has hitherto been considered as having affinities with vertebrate fauna of southwest Asia and interpreted to have migrated from that region (SHIKAMA, 1952). Previous authors said that the elements of the vertebrate fauna of north China, such as those of the Yushé and Nihowan vertebrate fauna, were scarcely found in the *Parastegodon* vertebrate fauna in Japan. As has already been mentioned, however, it is clearly recognized through the present study that some elements of the Yushé-Nihowan fauna actually exist in the *Parastegodon* bearing fauna in Japan.

Species of *Axis* and *Rusa* are one the characteristic groups of the Nihowan and the Kuchinotsu faunas. Someone may regard that they represent subtropical elements, because the living species of *Axis* and *Rusa* are mainly distributed in southeastern and southern Asia. This is, however, uncertain, since the Nihowan-Kuchinotsu species are extinct and since the Nihowan cervid fauna is generally distinct from the Siva-Malayan fauna. However *Archidiscodon planifrons* (FALCONER and CAUTLY), an important element of the Proboscidea, occurs commonly in the Pinjor (India), the Kali Glagah (Java) and zone II and III of the Yushé (north China).

*Deperetia*, another characteristic elements in the Kuchinotsu fauna, is rather characteristic of Japanese province (west to central Japan) and a species is known from north China and another from Taiwan.

The Kuchinotsu group was correlated to the Takioan substage (II) of the Ôita stage in east central Kyushu and to the Akashi formation of the Kwansai region (SHUTO, 1962). I was also led to the same conclusion, as I stated in my prelimi-

nary report concerning the geologic age of the Kuchinotsu group (OTSUKA, 1966). KAMEI (1962) correlated the proboscidean fauna of the Kuchinotsu group to the *Stegodon-Palaeoloxodon* fauna of the Kobiwako group and the Sanuki formation. KAMEI's idea concerning the age of the Kuchinotsu group was based on the proboscidean molar tooth such as *Stegodon orientalis* OWEN and *Palaeoloxodon namadicus naumanni* MAKIYAMA whose stratigraphical positions are uncertain. In the age of *Stegodon-Palaeoloxodon* fauna in Japan, the Nihowan type cervid fauna disappeared and was replaced by the modernized elements of deer such as *Cervus* (*Cervus*) cf. *elephus* LINNAEUS and *Cervus* (*Sika*) *yesoensis* HEUDE. This is quite consistent with the fact that the Nihowan cervid fauna was replaced by the new elements of Cervidae after the age of Yushé and Nihowan in north China. So far as the cervid fauna is concerned, the Kuchinotsu vertebrate fauna shows no sign of appearance of these new elements.

A word should be mentioned about *Stegodon*. I do not regard *Stegodon* (?) sp. from the Kazusa formation as a representative of the *Stegodon-Palaeoloxodon* fauna for the following reasons. As already mentioned, the *Stegodon-Palaeoloxodon* fauna in Japan is the middle Pleistocene in age. In north China, *Stegodon orientalis* is known to occur from the Plio-Pleistocene formations, that is, from the zone II and the lower subzone of the zone III of the Yushé series. Therefore, it is reasonable to consider that *Stegodon* has migrated from the north China to the western Japan at the age of land connection which had probably existed immediately before the Nihowan-Kuchinotsu age and they flourished in Japan at the middle Pleistocene. That is, *Stegodon* (?) sp. from the Kuchinotsu group may represent the earliest migrator of this group in the Japanese islands.

The Syatin fauna in Taiwan comprises such characteristic Cervidae as *Cervus* (*Sika*) *taiouanus* BLYTH, *C. (Deperetia) kokubuni* SHIKAMA and *C. (D.) syatinensis* SHIKAMA, *Capreolus* (?) *formosanus* SHIKAMA and *C. (Rusa) timoriensis* BLAINVILLE, accompanied with *Stegodon*, *Rhinoceros* and *Bibos* (SHIKAMA, 1937, 1941; HAYASAKA, 1930, 1933). The Syatin fauna is characterized by two mixed elements of cervids. One is represented by *Rusa*, which is the important southern elements, and the other by *Sika* and *Capreolus*, which are important northern elements. The fossiliferous bed in the Syatin is correlated to the Chukousan formation in Tainan and its geological age is considered to be the Villafranchian (LIN, 1936). But I think that the cervid fauna in the Syatin rather resembles the Japanese cervid fauna which is accompanied with *Stegodon-Palaeoloxodon*. If we give attention to the existence of *Rhinoceros* and *Stegodon* in the Syatin, this fauna seems to be related to the *Stegodon-Airuopoda* fauna in south China and probably be post-Nihowan.

Of the Kuchinotsu vertebrate fauna, *Cervus (Axis) japonicus* OTSUKA, which is sisterhood relation with *C. (A.) shansius*, is noticeable, because it is more closely related to and probably ancestral of *C. (A.) axis javanicus* KOENIGSWALD and *C. (A.)*

*lydekkeri* MARTIN from the Trinil of Java (see Part II of this serial study). The Trinil and the Djetis faunas in Java are correlated to the *Stegodon-Ailuropoda* fauna in south China, which, in turn, both belonging to the Sino-Malayan fauna, is probably of the same age as *Sinanthropus-Sinomegaceros* fauna of Chukoutien in north China. There is a general agreement that these are all of middle Pleistocene age (YOUNG and LIU, 1951; COLBERT and HOOIJER, 1953; KAHLKE, 1961). The above fact implies that the two middle Pleistocene species of *Axis* in Java may have originated from the early pleistocene species of *Axis* in Japan. The route of migration is, however, uncertain, because the data between Taiwan and Java are yet insufficient.

The plant remains of the Ôya formation is characterized by both the warm temperate and the temperate (s. s.) floral elements. The warm temperate elements are *Metasequoia japonica*, *Glyptostrobus pensilis*, *Camellia japonica*, *Cinnanomum camphora*, *Liquidambar formosana*, *Sapium sebiferum*, *Paliurus nipponicus* and *Quercus gilva*, while the elements indicating the temperate climate are *Fagus crenata*, *Acer palmatum*, *Buxus japonica* and *Zercova ungeri*. In this flora, *Metasequoia* and *Glyptostrobus* are important as the indicator of the warm and damp climate, while *Fagus crenata* and *Picea* are important for the indicator of a comparative cooler climate.

The pollen assemblage of the Ôya formation is characterized by the predominance of *Zercova* or *Ulmus-Fagus-Quercus-Pinus*, while *Metasequoia* and *Liquidambar* are found in a small ratio. Pollen grains indicating a cooler climate, such as *Picea*, *Tsuga*, Juglandaceae, *Betula* and *Acer*, are also found in a small ratio.

The plant remains of the Kitaarima formation are not sufficiently known. But the pollen assemblage of *Pinus*, *Fagus*, *Zercova* or *Ulmus* in this formation differs in its frequency of the occurrence from that of the Ôya formation. However, the pollen showing the cooler climate, such as *Picea*, *Tsuga* and *Larix* also occur in this formation in a small ratio. Thus no remarkable climatic change is recognized between the Ôya and the Kitaarima formations.

As mentioned above, the remains of *Metasequoia* are discernible at every examined horizon of the Ôya formation. On the other hand, the pollen of the Taxodiaceae including *Metasequoia* occur from the Ôya and the upper part of the Kitaarima formation. The remains of the exotic plants such as *Glyptostrobus* and *Liquidambar* occur from the Ôya formation and the pollen of *Liquidambar* from the Kitaarima formation.

In the Kinki region, the plant remains of the *Metasequoia* flora have been reported to occur only in the lower part of the Ôsaka group (Ôsaka Group Research Group, 1951; IKEBE, 1952; HUIJTA, 1954; ITHARA, 1961). Exactly, the *Metasequoia* flora disappears immediately below the horizon of the "Azuki tuff" of the Senriyama formation and it must be by a climatic change. The "Azuki tuff" is characterized by a cold climate flora and this horizon may be correlated to the Günz

glacial age. The result of pollen analysis (TAI, 1963) of the Ôsaka group shows that the horizon of the cold climate exists between Ma 4 and Ma 5 marine clay beds and the horizon of *Metasequoia* extinction is just below the Azuki tuff intercalated between Fr 4 to Ma 3 marine beds.

In the Kuchinotsu group, the upper most part of the Kitaarima formation is covered with thick volcanic products. Therefore, I do not recognize the exact horizon of the extinction of *Metasequoia* and the horizon which clearly shows the cold climate. However, if the floral change in the Kinki region in the early Pleistocene age can be adopted in Kyushu, the remains of *Metasequoia* in the Kuchinotsu group should be correlated to *Metasequoia* flora in the Kinki region. According to ITIHARA (1961), the mode of occurrence of the *Metasequoia* flora in the Ôraka group is classified into two types. The first type is recognized in the lower part of the Ôsaka group and clearly indicates a warm climate. *Metasequoia* flora of this type comprises *Metasequoia disticha*, *Sequoia*, *Glyptostrobus*, *Picea Koribai*, *Juglans cinerea*, *Liquidambar* and *Ginkgo*. The second type is recognized in the horizon a little lower than the Mal marine clay bed corresponding to the early First Glacial stage. In this type the plant remains of *Metasequoia disticha* and *Juglans cinerea* co-exist with *Pinus koraiensis*, *Menyanthus trifoliata* and *Chamaecyparis obtuze*. Therefore, the *Metasequoia* flora of the Ôya formation co-existing with *Liquidambar formosana*, *Ginkgo* and *Glyptostrobus* is more closely allied to the first type than to the second in the Ôsaka group. If the floral change in the Kinki region can be adopted in Kyushu, the flora of the Kuchinotsu group should be eventually correlated to the *Metasequoia* flora of the Ôsaka group.

Tubami bone beds of the Kazusa formation bears numerous characteristic plant remains such as *Metasequoia disticha* and *Sapium sebiferum* with cervid and proboscidean fossils and its upper part is covered with the first marine sediments of the Kitaarima formation characterized by such marine shells as *Volachlamys yagurai* and *Anadara subcrenata*. This stratigraphic relationship closely resemble the relation between the Byôbugaura and the Hayashizaki clay beds or the Maiko shell bed in the Akashi formation. The Byôbugaura clay bed bears Akashi vertebrate fauna including *Parastegodon* and the plant remains such as *Metasequoia*, *Sapium sebiferum* var., *Glyptostrobus*, *Juglans cinerea* and *Paliurus nipponicus*, and the Maiko shell bed is characterized by the shells of *Volachlamys yagurai* and *Chlamys harimensis* and has been correlated to the Mal marine clay in the type area (ITIHARA, 1961).

The faunal and floral resemblances of the vertebrate-bearing horizon in both regions are very interesting for the consideration of their contemporaneity. I believe that the sediments of the first marine transgression in the Kuchinotsu group, which is characterized by the first appearance of *Volachlamys yagurai*, may be correlative to the first marine sediments in Ôsaka and the Akashi area and the thick sediments of Kitaarima formation may be correlated to the marine

Table 2. Correlaton chart of the early- to middle Pleistocene mammal-bearing formations in Japan and adjacent regions.

	Kagoshima area	Sourth Shimabara and Amakusa area	Ôita area	Moji area	Ube area	Akashi area	Ôsaka area	Awaji area	Biwa Lake area	Ise bay area	Bôsô Peninsula
Late middle Pleistocene											
Early middle Pleistocene	Yoshida formation [Rh]	Tatsuishi formation & Kama gravel bed [So]	Ôita group Tsurusaki formation [So]	Matsugae formation [So, Pn, Rh, Su, Me]	Kusae silt formation [So]		Manjidani formation [Tom] Ibaragi foration		Katada formation [So, Ele(sh), C(C)e Bf]		Sanuki formation Nagahama gravel bed [Pn, So, C(D)p, C(D)k, C(S), Gr]
Early Pleistocene		Upper Ôya formation [C(D)s, Ax, C(R), Ch, So(?), Cro,] Lower Ôya formation [Pr(o)]	Himeshima formation [Pr(a)]			Akashi formation [Pr(a), Pr(s), Pr(o), C(D)p, El(s)]	Senriyama formation [Ele(Sh), Pr(s), So(?)]	Awaji formation [Pr(s)]	Iga formation [Pn(?)]	Ôizumi formation [Pr(a)] Kuragari formation [Pr(a)]	Umegase formation [Ple, "El(d)", C(D)k]

Ax : *Axis*  
 Ar : *Archidiscodon*  
 Bf : *Buffellus*  
 C(D)p : *Cervus (Deperetia) praenipponicus*  
 C(D)u : *Cervus (Deperetia) urbans*  
 C(D)k : *Cervus (Deperetia) kazusensis*  
 C(D)t : *Cervus (Deperetia) trassaerti*

C(D)s : *Cervus (Deperetia) shimabarensis*  
 C(C)e : *Cervus (Cervus) elephas*  
 C(R) : *Cervus (Rusa)*  
 C(S) : *Cervus (Sika)*  
 El(b) : *Elaphurus bifurcatus*

El(s) : *Elaphurus shikamai*  
 Eu : *Eucladoceros*  
 Ele(sh) : *Elephas sigenensis*  
 Eq : *Equus*  
 Gr : *Giraffa*  
 Met : *Metacervulus*

Me : *Meles*  
 Pr(a) : *Paras*  
 Pr(s) : *Paras*  
 Pr(o) : *Paras*  
 Pn : *Palae*  
 Pr(t) : "*Para*"

ns.

Area	Bôso Peninsula	Kuzuü area	Miura Peninsula	Outside Japan						
				North China (N. shansi)	North China (S. Shansi)	South China	Taiwan	Java	India	
			<i>Bydbugaura</i> formation [Pn, Pr(t)]	<i>Choukoutien</i> Loc. 1, 2, 7, 12, 9, 13  (containing <i>Sinanthropus-Sinomegaceros</i> fauna)						
	<i>Sanuki</i> formation <i>Nagahama</i> gravel bed  [Pn, So, C(D)p, C(D)k, C(S), Gr]	<i>Lower Kuzuü</i> formation [Pn, So, C(L)P, Su]				<i>Stegodon-Airulopoda</i> Fauna  Sino-Malayan fauna ↑	<i>Chukousan &amp; Syatin</i>  Sino-Malayan fauna ↑	<i>Trinil</i> (containing <i>Pitecanthropus</i> fauna)	<i>Narbada</i>  <i>Boulder conglomerate</i>	
<i>Umegase</i> formation [Ple, "El(d)", C(D)k]  Nihowan fauna ↑				<i>Nihowan</i> formation [containing El(b) Ru, Eq among others]	<i>Yushé</i> series [containing Ax, Ru, So, C(D)t, Eu, Met. Ar among others]	<i>Gigantopithecus</i> Fauna		Kali Glagah  Siva-Malayan fauna ↑	<i>Pinjor</i>	

Me : *Meles*  
Pr(a) : *Parastegodon akashiensis*  
Pr(s) : *Parastegodon sugiyamai*  
Pr(o) : *Parastegodon shodoensis*  
Pn : *Palaeoloxodon namadicus*  
Pr(t) : "*Paraelephas proximus*"

Rh : *Rhinoceros*  
So : *Stegodon orientalis*  
Su : *Sus*  
Cro : *Crocodylia*  
Tom : *Tomistoma machikanense*

sediments in the upper member of the Ôsaka group.

On the basis of the foregoing descriptions and considerations, the following remarks can be made as the conclusion.

1. In the Kuchinotsu group the vertebrate-bearing beds are recognized at a horizon in the lower Ôya formation and at several horizons in the uppermost part of the Kazusa formation.
2. The cervid fauna of the Kuchinotsu group is closely related to the Nihowan cervid fauna of north China. This suggests that a branch of the Nihowan vertebrate fauna may extend to west Japan.
3. *Cervus (Axis) japonicus* from the Kuchinotsu group is probably ancestral to *C. (A.) axis javanicus* and *C. (A.) lydekkeri* from the Trinil of Java. The route of migration from Japan to Java should be determined by further evidence.
4. The vertebrate fauna of the Kuchinotsu group is ascribed to the *Parastegodon* fauna in Japan.
5. By floral assemblage the Kuchinotsu group is correlated to the lower part of the Ôsaka group.
6. The age of the Kuchinotsu group is early Pleistocene.

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## Appendix :

## Revision of the Stratigraphic Classification of the Kuchinotsu Group

In the Part I of this serial studies, I described the general stratigraphy of the Kuchinotsu group and the stratigraphic position of the newly discovered Tsubami bone beds (OTSUKA, 1966d). At that time, I had an opinion that these bone beds should be referred to the upper part of the Kazusa formation occupying the middle part of the Kuchinotsu group, and since then this opinion has been maintained by me throughout the serial studies. However, as the results of succeeding field investigations carried out in parallel with the present study, it became necessary to revise my opinion concerning the subdivision of the Kuchinotsu group. From the sedimentological point of view, the main part of the Kazusa formation (OTSUKA, 1966 d), namely, from the lower member to the middle part of the upper member of this formation should be included stratigraphically into the upper member of the Ôya formation, which is characterized by sediments deposited under the fluvio-deltaic conditions. And the upper part of the upper member of the Kazusa formation, which is characterized by the abundant occurrence of marine shells such as *Volachlamys yagurai* and *Anadara (Scapharca) subcrenata*, is safely correlated to the lower part of the Kitaarima formation in the type area.

Accordingly, now I am convinced that the horizon of the Tsubami bone beds should to the uppermost part of the Ôya formation. The comparison of the revised stratigraphic classification of the Kuchinotsu group to the former one is shown in the following table.

		OTSUKA (1966) Tatsuishi Formation		OTSUKA (1969) Tatsuishi Formation	
↑ Kuchinotsu group		Minami-kushiyama formation	Kitaarima formation	Minami-kushiyama formation	Kitaarima formation
	Kazusa formation	upper member			
		middle member		upper member	
		lower member			
		Ôya formation	upper member		lower member
↓					
		Basement rock (Tertiary)		Basement rock (Tertiary)	

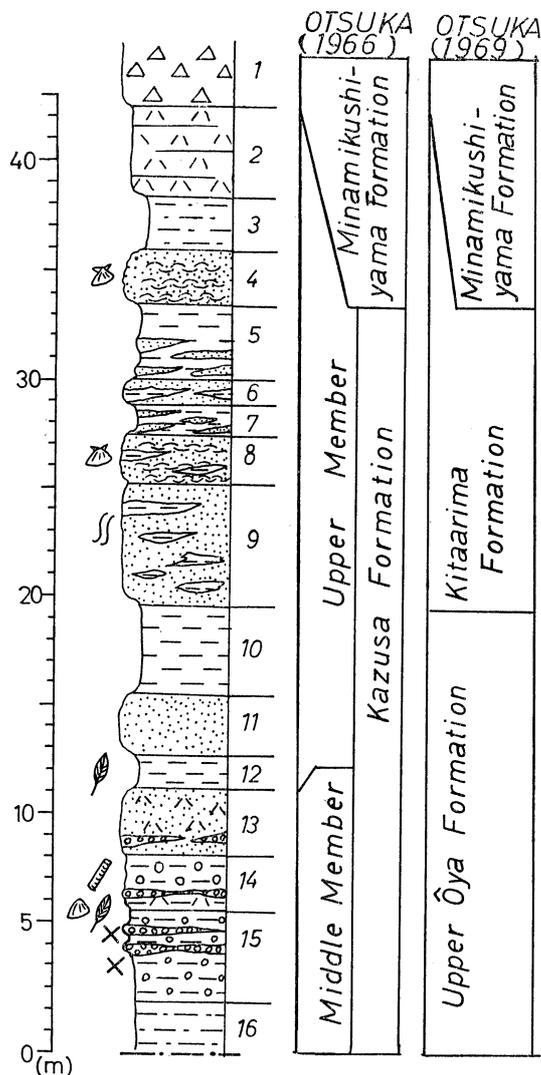
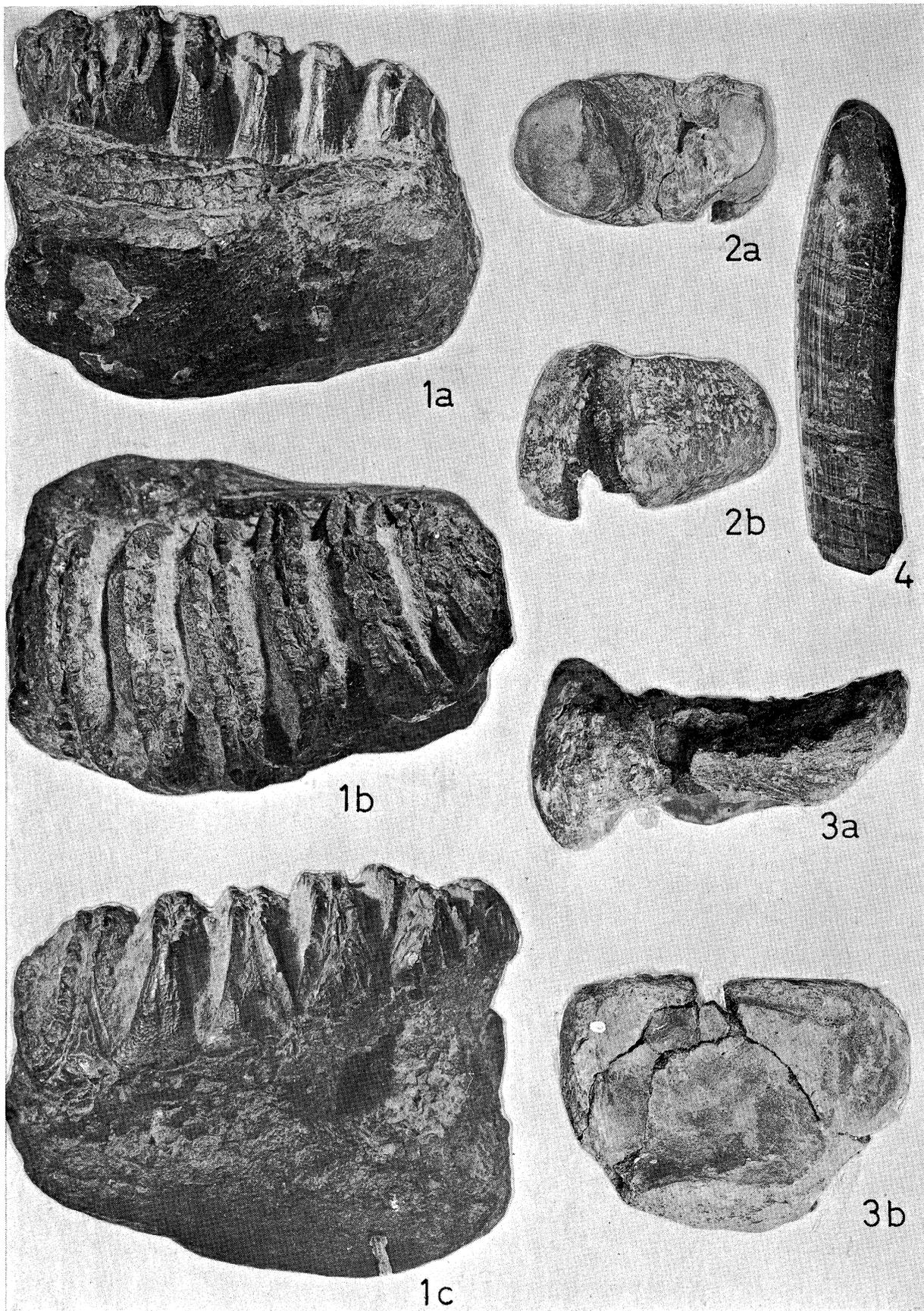


Fig. 7. Columnar section showing the stratigraphic sequence of the Ôya and Kitaarima formations on the coast of Tsubami, Kazusamachi (Revised by Otsuka, 1966*d*). 1. tuff breccia and volcanic agglomerate (Minami-kushiyama formation), 2. white tuff, light brown silt, 4, 8. medium- to coarse-grained sand containing many marine shells, 5, 7. light brown silt including patches of fine-grained sand, 6. fine-grained sand, 9. fine- to medium-grained sand including patches of silt, 9. medium- to coarse-grained sand including many sand pipes (Kitaarima formation), 10, 12. light blue massive mud including many plant remains, 11. coarse grained sand, 13. light brown tuffaceous sand, 14. light blue mud containing numerous vertebrates, brackish-water shells and plant remains (Ôya formation).

**Plates 4-8**

Explanation of Plate 4

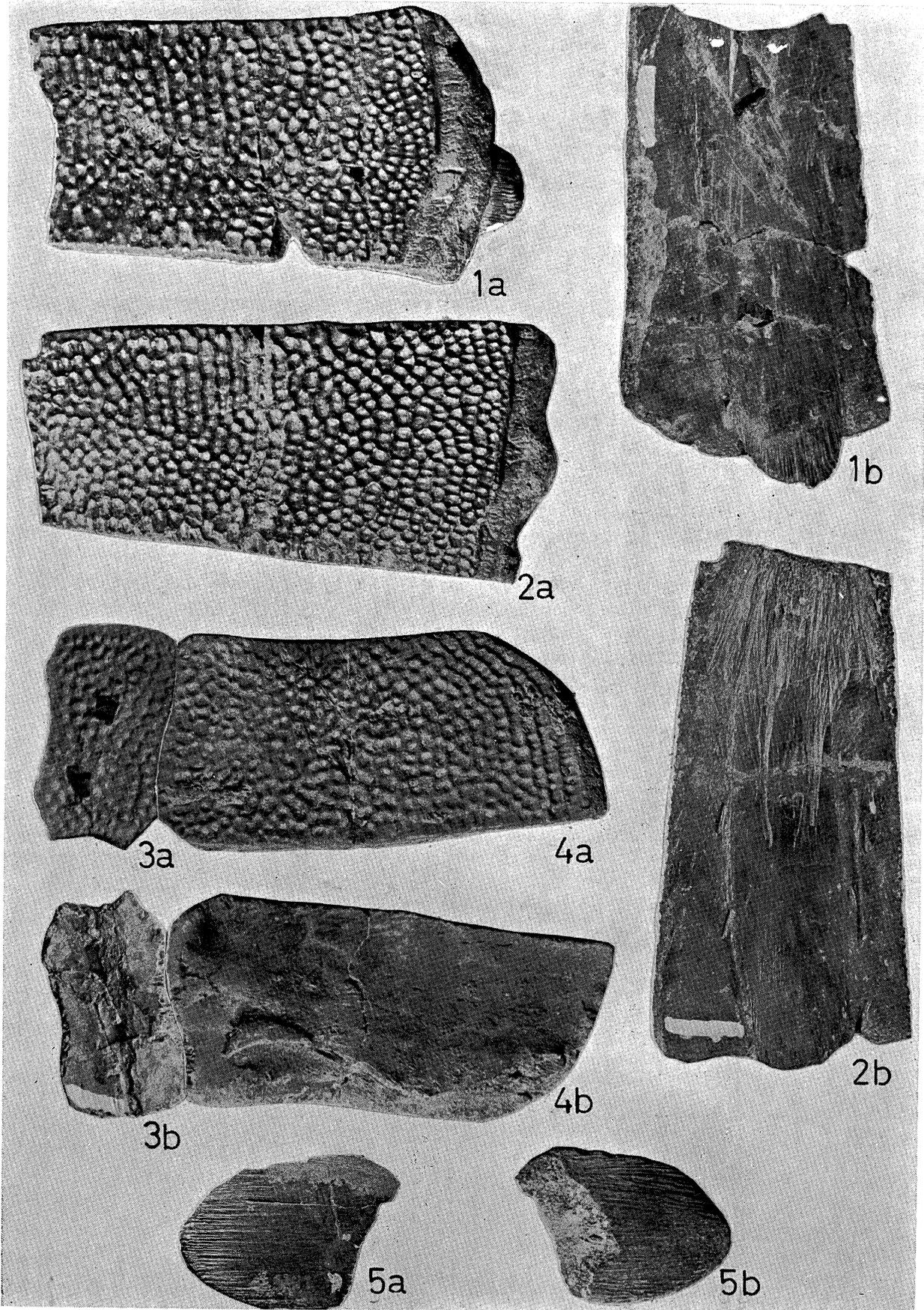
- Fig. 1. *Parastegodon shodoensis* (Matsumoto).....Page 54-55.  
GK. M1053, a left lower molar. Outer (a), crown (b) and inner (c) views,  
×0.3.
- Figs. 2-4. *Stegodon* (?) sp. ....Page 55-57.
2. GK. M1049, a right astragalus. Inner (a) and Outer (b) views, ×0.3.
  3. GK. M1189, a left tibia. Posterior (a) and lower (b) views, ×0.3.
  4. GK. M1050, a lateral view of tusk, ×0.3.



H. OTSUKA: Pleistocene Vertebrate Fauna from the Kuchinotsu Group

Explanation of Plate 6

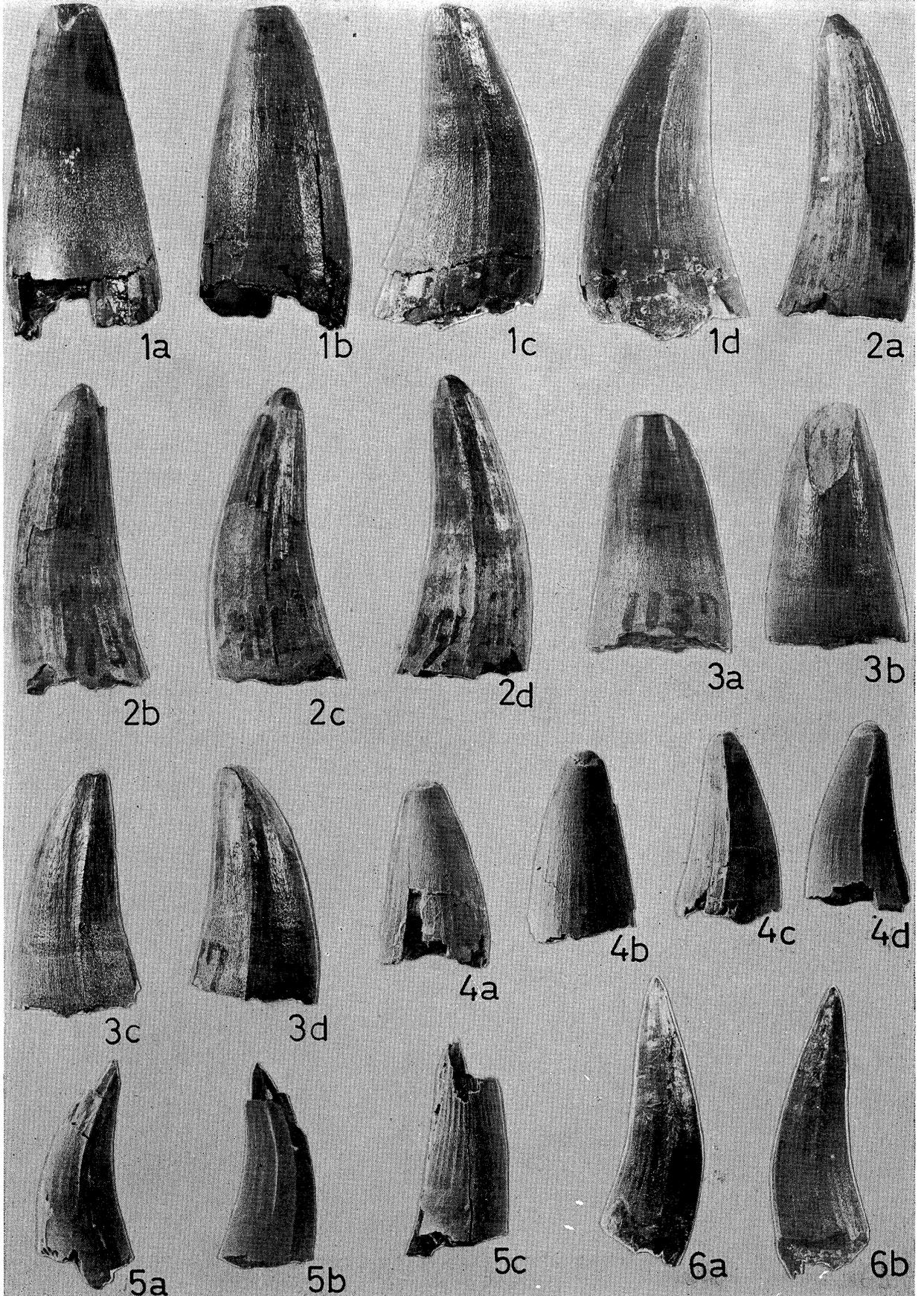
- Figs. 1-5. *Trionyx katusensis* sp. nov. .... Page 61-65.
1. GK. M1183, a fragmental specimen of second costal. Outer (a) and inner face,  $\times 0.6$ .
  2. GK. M1181, a fragmental specimen of third costal. Outer (a) and inner (b) faces,  $\times 0.6$ .
  3. GK. M1182, a first neural. Outer (a) and inner (b) faces,  $\times 0.6$ .
  4. GK. M1180, a first costal. Outer. (a) and inner (b) views,  $\times 0.6$ .
  5. GK. M1170, a fragmental specimen of free portion of rib. Outer (a) and inner (b) views,  $\times 0.6$ .



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Explanation of Plate 7

- Figs. 1-6. Crocodylidae fam. gen. and sp. indet.....Page 65-71.
1. GK. M1135, a lower right or upper left tooth. Inner (a), outer (b), posterior (c) and anterior (d) views,  $\times 2$ .
  2. G K. M1139, a lower right or upper left tooth. Outer (a), inner (b), anterior (c) and posterior (d) views,  $\times 2$ .
  3. GK. M1137, a lower left or upper right tooth. Inner (a), outer (b), posterior (c) and anterior (d) views,  $\times 2$ .
  4. GK. M1144, a lower right or upper left tooth. Inner (a), outer (b), posterior (c) and anterior (d) views,  $\times 2$ .
  5. GK. M1145, a lower right or upper left tooth. Anterior (a), posterior (b) and inner (c) views,  $\times 2$ .
  6. GK. M1143, a lower right or upper left tooth. Anterior (a) and posterior (b) views,  $\times 2$ .

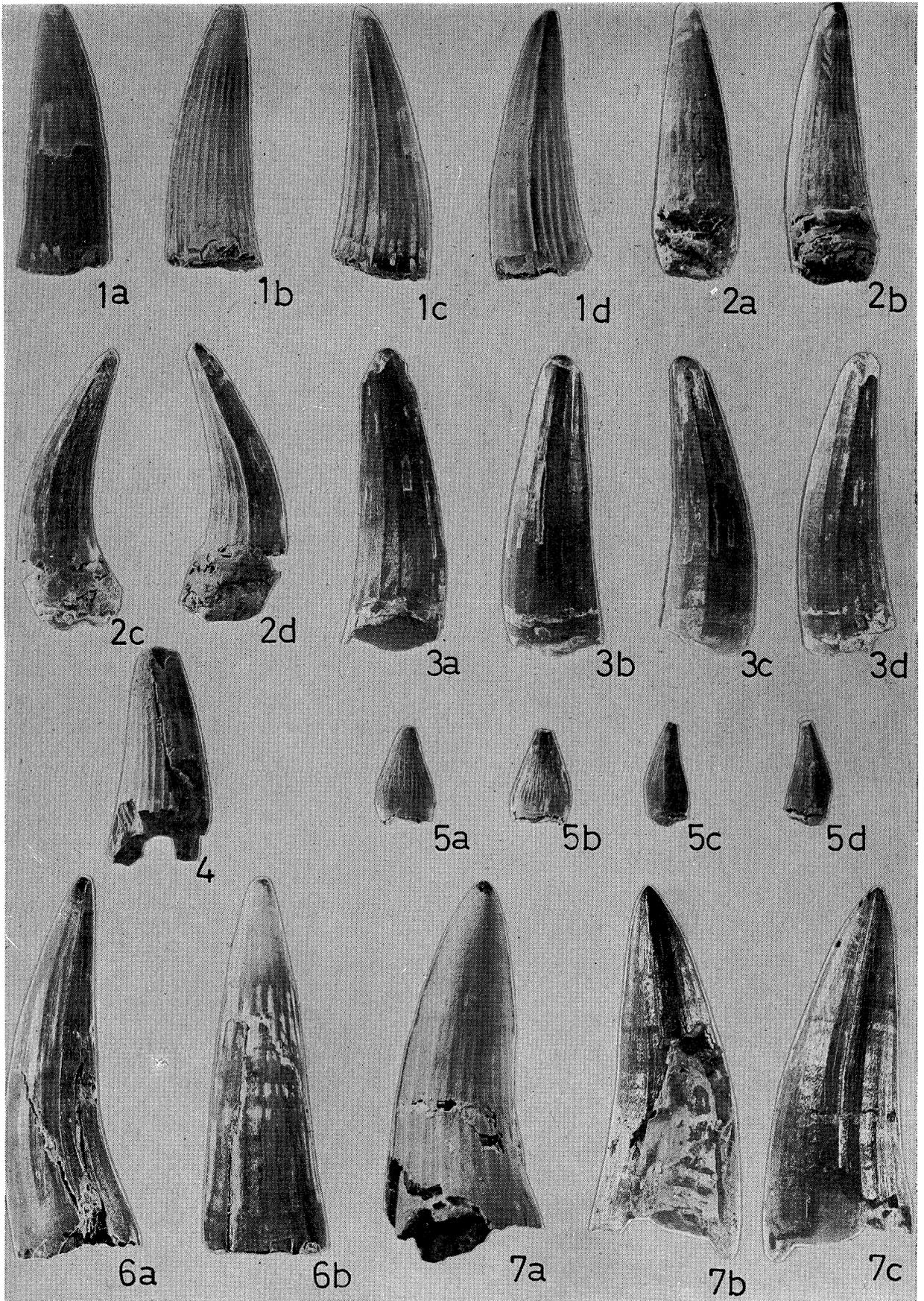


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Explanation of Plate 8

Figs. 1-5. Crocodylidae fam. gen. and sp. indet. .... Page 65-71.

1. GK. M1142, a lower right or upper left tooth. Posterior (a), anterior (b), inner (c) and outer (d) views,  $\times 2$ .
2. GK. M1185, a lower right or upper left tooth. Outer (a), inner (b), anterior (c) and posterior (d) view,  $\times 2$ .
3. GK. M1141, a lower left or upper right tooth. Inner (a), outer (b), anterior (c) and posterior (d) views,  $\times 2$ .
4. GK. M1146, a lower left (?) or upper right (?) tooth. Inner view,  $\times 2$ .
5. GK. M1147, a lower left (?) or upper right (?) tooth. Outer (a), inner (b) posterior (c) and anterior views,  $\times 2$ .
6. GK. M1138, a lower left or upper right tooth. Posterior (a) and outer (b) views,  $\times 2$ .
7. GK. M1136, a lower right or upper left tooth. Inner (a), posterior (b) and anterior views,  $\times 2$ .



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