

## Fossil *Rhinoceros* from the T'ouk'oushan Group in Taiwan

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### I. Introduction and Acknowledgements

This paper presents the result of the paleontological studies of the fossil rhinocerids collected from the Early Pleistocene T'ouk'oushan Group in Taiwan. Geological notes on the occurrence of the fossil rhinocerid and the detailed record of the excavation at Ch'ailliao, Chochen village, Tainan Prefecture are also given in this paper.

Most of the rhinocerid specimens treated in this paper belong to the National Taiwan University, the Taiwan Prefectural Museum and the Tainan Prefectural Fossil Museum. The National Taiwan University Collection was mostly collected from the T'ouk'oushan Group distributed in the area covering the western foothill of the backbone range in the Hsinchu, Taichung and Tainan Prefectures. The rhinocerid fossils in the University Collection have first studied by the late Professor Ichiro Hayasaka, the founder of the Department of Geology of that university. The specimens belonging to the Taiwan Provincial Museum Collection include an individual rhinocerid skeleton and teeth. These specimens were excavated from the Ch'iting Formation of the T'ouk'oushan Group exposed along the river side of the Ch'ailliao in 1972 by the members of the Taiwan Provincial Museum and the National Taiwan University, some amateur fossil collectors living in Tainan in collaboration with the late Professor Tokio Shikama and the senior writer. The rhinocerid specimens belonging to the Tainan Prefectural Fossil Museum Collection were collected from the river floor of the Ch'ailliao-hsi by three fossil collectors living in Tainan Prefecture such as Messrs C.

M. Chen, C. W. P'an and B. M. Yeh. In this paper, furthermore, the molar of the rhinocerid specimens collected from the environs of the Chochen district by Mr. M. S. Su was also described.

The paleontological and biostratigraphical studies on the fossil Proboscidea and the Cervidae from the T'ouk'oushan Group were already published by Shikama *et al.* (1975) and Otsuka and Shikama (1978), respectively. The rhinocerid Bed in Ch'ailliao was recently studied by Liew (1978) from the palynological point of view.

More than 70 specimens including skull, jaws, isolated molars and other incomplete bones treated in this paper represent a single rhinocerid individual. Through the detailed examination of them, it was concluded that they should be regarded as a new subspecies of the genus *Rhinoceros*. This subspecies is referred to *Rhinoceros sinensis* Owen commonly known in the *Stegodon-Ailuropoda* Fauna of the early Middle Pleistocene age in South China (Kahlke, 1961; Colbert and Hooijer, 1953) but it is discriminated from the latter by its small size as an adult specimen and it is named *Rhinoceros sinensis hayasakai* subsp. nov.

Here the writers expresses their deep gratitude to the staffs of the Ministry of Education, the Economic and Foreign Affairs of the Chinese Government for their kind help during the course of this study. He is also indebted to the Interchange Association for the financial support. The writers wish to express their deep appreciation to the following gentlemen in Taiwan for their kind help and collaboration: Mr. Shih-Chun Young, the director of the

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Taiwan Provincial Museum, Mr. Yen Liu, the former director of the Museum, the late Mr. Lian-Cheng Chin, Mr. Kin-Yang Lai of the Museum, Miss Wuan-Yun Chung and Mr. Min-Nin Cheng in Taipei, Mr. Chun-Muh Chen in Ch'ailliao, Chochen, Mr. Te-Lin Kuo and Mr. Chang-Wu P'an in Tainan. Sincere thanks are also due to Dr. Hiroshi Ozaki, Honorary Curator of the National Science Museum of Tokyo, Mr. Yukimitsu Tomida of the same Museum and Professor Shozo Hayasaka of the Kagoshima University for their valuable advices and encouragements. Last but not least, the writers are deeply indebted to the late Professor Tikio Shikama of the Yokohama National University, who kindly introduce the senior writer to the paleontological project on the vertebrate fossils in Taiwan and had been engaged as the project leader in the studies both in field and laboratory until last hour of his life on December 12th, 1978.

## II. Brief Remarks on the T'ouk'oushan Group

The T'ouk'oushan Group, which represents an important Plio-Pleistocene deposits in Taiwan, was first proposed by Lin (1935) for the sedimentary series of sandstone, shale and conglomerate distributed in the Fengyuan (=Toyohara) district, hillyland area east of Taichung City, under the name of the Tokazan (=T'ouk'oushan) Series. At present, this group is known to be distributed in the western foothills of the Taiwan Mountain Range ranging from the Taipei Prefecture to the Hengchun Peninsula. It is composed mainly of silt, sand and gravel and their alternations and the total thickness exceeds 1000 meters. This group unconformably overlies the Pliocene Cholan Formation of the Miaoli Group and is unconformably overlain the middle to late Pleistocene or the Holocene deposits.

The T'ouk'oushan Group is lithologically divided into two formations: the Tunghsiao (lower) and the Huayenshan (upper). The Tunghsiao Formation made up largely of sand, silt and their alternation shows a remarkable

lateral change in lithofacies. Furthermore, this formation is subdivided into three types of sedimentary facies, i.e. the Hsiangshan, the Tak'eng and the Yuchi (Lin, 1963). Among these facies, the Takeng and the Hsiangshan facies yield numerous fossils of marine mollusc, foraminifer and land vertebrate. The Huoyenshan (=Kaenzan) Formation distributed typically in the Nanto and the Taichung Prefectures, middle-west Taiwan is composed of thick terrestrial boulder conglomerate. The T'ouk'oushan Group has been studied by many authors from the paleontological and stratigraphical points of view (Saito, 1927; Hayasaka, 1929, 1930, 1934, 1942; Kaneko, 1941; Tokunaga, 1936; Lin, 1933, 1935; Shikama, 1937a, 1937b, 1972; Shikama et al., 1975; Huang, 1967, 1975, 1976; Otsuka and Shikama, 1978; Ueno, 1978; Liew, 1978).

The Chochen district is situated in the hilly land area about 20 km east of Tainan City. The T'ouk'oushan Group in this district is well exposed in the area along the river sides of the Ch'ailliao and the Yenshui Rivers and yields abundant vertebrate fossils called the "Chochen Fauna" (Shikama, 1937). The marine Tertiary and the Quaternary deposits in this district were divided by Torii (1937) into three formations, that is, the Muzha (=Mokusaku), the Gutingkeng (=Koteiko) and the Ch'iting (=Kicho) in ascending order. The Ch'iting Formation is correlated to the Tunghsiao Formation in the type section in Taiwan. On January, 1974, the late Professor T. Shikama, Mr. Y. Tomida and the senior writer visited the Chochen district and spent several days for their field-works in the area between east of Chochen and Wantan along the Ch'ailliao River. A preliminary note on the results of their field-works was already reported by Shikama et al. (1975) and Otsuka and Shikama (1978). The Ch'iting Formation exposed in the narrow area along the river sides of the Ch'ailliao and the Yenshui Rivers strikes N10°~35°W and dips 10° to 70°SW. This formation rests conformably upon the Gutingkeng Formation and lithologically divided into two members: the lower and the upper (Shikama et al., 1975). The lower Ch'iting Formation, estimated to

be 450 meters thick, is composed mainly of silty sand and grey clay and yields abundant marine molluscs and foraminifers. The Upper Ch'iting Formation, which attains to more than 1000 meters in maximum thickness, is made up largely of grey sand with bluish grey silt and yields numerous marine molluscs and vertebrate fossils.

According to Shikama et al. (1975 and Otsuka and Shikama (1978), the Ch'iting Formation exposed along the Ch'ailiao and the Yenshui River valleys is divided into 10 stratigraphic units (KL1 to KL4, KU1 to KU6) on the basis of its lithology. From this formation, the following three mammalian zones are discriminated.

*Stegodon sinensis* Zone\* . . . . . KU2-KU3  
*Elaphurus formosanus*-*Rhinoceros sinensis*  
*hayasakai* Zone . . . . . KU4  
*Mammuthus armeniacus taiwanicus* Zone  
 . . . . . KU5-KU6

Detailed descriptions on the geology and the vertebrate fauna of the T'ouk'oushan Group are given in another paper of the present publication (Otsuka, 1984).

### III. Record of the Fossil Rhinocerids from Taiwan

In the report of the mammalian remains of the T'ouk'oushan Group by Hayasaka (1942), he recorded teeth of the fossil rhinocerid collected from several provinces in the western Taiwan. He regarded these specimens as a new species of the genus *Rhinoceros* and showed seven pictures of them in three plates without paleontological description. Among the illustrated specimens, well-preserved upper and the lower tooth row (Hayasaka, 1942, Pl. V, figs. 1 and 2) said to be obtained from the "yellowish brown sand belonging to the Neizha (= Naisaku) Group" exposed in the neighbourhood of Neizha of Tahsi (= Taikeli), Hsinchu (= Sinchiku) Prefecture (nowadays Taoyuan Pref.). These specimens are now kept in the Department of Geology, National Taiwan University. At present, the Neizha Group is

regarded to be contemporaneous with the T'ouk'oushan Group in the Taichung Prefecture. Beside these specimens, isolated molars of the rhinocerid were also recorded by him from the other three prefectures: the Taichung, the Tainan and the Kaoshiung.

An isolated right upper first molar recorded from the Taichung Prefecture (Hayasaka, 1942, Pl. VI, Fig. 7) is mentioned to have been found from the "sandstone and shale in alternation with pebble bands" series called the Lower Tokazan (= T'ouk'oushan) Beds by Lin (1934). The Fengyuan (= Toyohara) district is the type locality of the "Tokazan Series" proposed by Lin (1934). According to Lin (1934), there are two mammalian localities in this district. The first locality is located about 5600 meters upper course of the Taiko (= T'akeng) River from the town of T'akeng, about 7 km northeast of Taichung City. Another one is about 800 meters up the river from the first locality. According to Lin (1933, 1934) and Hayasaka (1942), molars of *Stegodon orientalis* Owen, *Stegodon insignis* Falc. & Caut. and *Cervus (Sika) taiouanus* Blyth were discovered from these fossil localities mentioned above. Among these proboscidea, however, *Stegodon orientalis* Owen by Hayasaka (1942, Pl. VI, fig. 10) was revised to be *Stegodon (Parastegodon) akashiensis (Takai)* which is known from the Japanese Early Pleistocene deposits (Shikama et al., 1975).

A right upper first molar of fossil rhinocerid was also recorded by Hayasaka (1942, Pl. VI, fig. 8) from the environs of the Ch'ailiao River, Chochen district without confirmation of the original bed of the specimen.

It has long been known that many bones and teeth of the fossil vertebrates are found from the river floor of the Ch'ailiao River most commonly after flood mixed with the gravels of the river floor. Therefore, the beds originally bearing these fossils are hardly decided on the available evidence. Although the most of the proboscidean and cervid fossils were collected from the river floor, some of

\* This zone was previously called "*Stegodon akashiensis* - *Stegodon sinensis* Zone" by Otsuka and Shikama (1978).

them were directly picked up from the debris after heavy rain falls or excavated from the beds belonging to the Upper Ch'iting Formation of the T'ouk'oushan Group (Shikama et al., 1975; Otsuka and Shikama, 1978). As will be mentioned in the succeeding chapter, many bones of an individual rhinocerotid were excavated from the mudstone bed exposed on the right bank of the Ch'ailliao River at Ch'ochü together with abundant brackish water molluscs and an antler of *Elaphurus formosanus* (Shikama) (Otsuka and Shikama, 1978). These bone fossils are considered to represent mature individual probably referable to "*Rhinoceros* sp." recorded by Hayasaka (1942) from the T'ouk'oushan Group in the Hsinchu Prefecture.

#### IV. On the Excavation of the Fossil Rhinocerotid in Ch'ailliao, Chochen District, Southwest Taiwan

##### 1. Discovery of Fossil Rhinocerotid

On September in 1971, Mr. Chan-Wu Pan who is a fossil collector living in Tainan City, visited Chochen district and met middle school boy who kept several fragments of teeth collected from the river floor of the Ch'ailliao River in Ch'ochü, Ch'ailliao. Soon after Mr. C. W. P'an visited the river side together with school boy and examined the fossil bed. He convinced that these fossil teeth might be washed out from the bluish grey mudstone bed exposed on the river side and confirmed that there are many more bones embedded in the bed. The information about this discovery was transmitted to Professor C. C. Lin of the National Taiwan University by Mr. C. W. Pan.

In 1971, the Taiwan Provincial Museum organized the excavation team to the bone bed in Ch'ailliao and the first excavation works held in December of the same year. The members of the excavation team were: the late Mr. L. C. Chin of the Taiwan Provincial Museum, Prof. C. C. Lin of the National Taiwan University and the other five gentlemen living in Tainan Prefecture: Mr. C. M. Chen in Ch'ailliao, Mr. T. L. Kuo, Mr. C. W. P'an, Mr. M. S. Su and Mr. T. F. Kuo in Tainan City.

By this excavation, many bones and teeth were excavated, but the other fragile bones were left in the bed until the second excavation by this team.

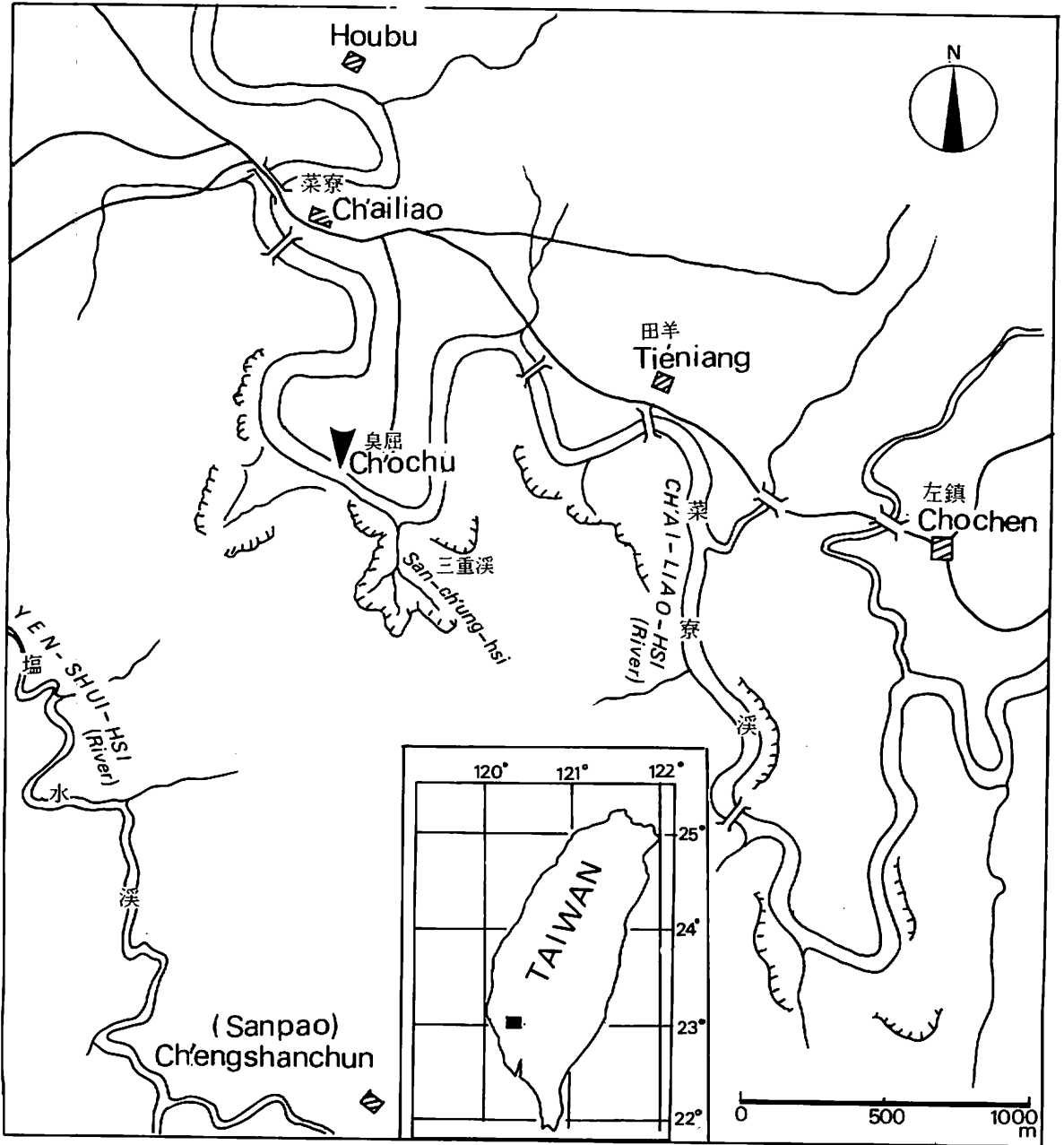
In 1972, two Japanese vertebrate paleontologists, Prof. T. Shikama of the Yokohama National University and the senior writer were invited to Taiwan by the Taiwan Provincial Museum with the financial support of Interchange Association in Japan and they participated in the second excavation held by the Chinese team in Chochen for a week.

##### 2. Excavation (Pl. 1, Pl. 2)

Ch'ochü is located on the right bank of the Ch'ailliao River (= Ch'ailliao-hsi) about 800 meters south of Ch'ailliao, Jungho village, Chochen district (Text-fig. 1). In this area, bluish grey mudstone bed belonging to the Ch'iting Formation is exposed on the right bank forming a cliff more than two meters high above the river floor and is covered with the river terrace deposits consisting of gravel and boulder of various sizes with a clinounconformity (Text-fig. 3).

The excavation works of fossil rhinocerotid were carried out taking the following steps.

- (1) Thick mudstone bed overlying the rhinocerotid-bearing bed was dug down to the level of the river floor within the extent of about 25 square meters.
- (2) To check the relative position of each isolated bones, the ropes were stretched horizontally with one meter interval (Text-fig. 2).
- (3) By making use of pick, shovel and bamboo spatula, the mudstone was carefully removed from the bone bed until the bones were exposed on the ground surface.
- (4) Through the careful observation, the mode of the occurrence of the bones was sketched in detail (Text-fig. 2).
- (5) Each bones was coated firmly with plaster to prevent from the damage by shock and then marked by a sample number. Finally, the specimens were packed up as small packages.



Text-fig. 1. Map showing the excavation site of the fossil *Rhinoceros* at Ch'ochü of Ch'ailiao, Chochen district, Tainan Prefecture.

- (6) Excavated specimens were transported to the Taiwan Provincial Museum in Taipei by truck.

### 3. The Works of Restoration at the Taiwan Provincial Museum

- (1) The number of packages with bone attached were collated with the numbers written in the map showing the distribution of the fossil rhinocerotid.
- (2) For the restoration of the bones to the original state, crushed, fragile pieces preserved in blocks were photographed to record their relative position.
- (3) Each bone was carefully picked up from the blocks. The fragile pieces were hardened by chemicals called "Binder".
- (4) Incomplete bones were restored by use of plaster.

Through the restoration works, 69 skeletons of mature individual of rhinocerotid and an antler of *Elaphurus formosanus* (Shikama) were discriminated. Items of the rhinocerotid remains are: femur 2, tibia 2, metatarsus 3, phalange 4, humerus 2, radius 2, metacarpus 3, corpus 2, pes 3, left jaw (incomplete) 1, right upper tooth row 1, rib (incomplete) 10, vertebra 1, and other fragmental bones 32.

As the excavated bones represent less than 40 percent of the whole skeleton of individual rhinocerotid lacking skull, most of vertebra, phalanges and pelvic bones, these bones were not mounted (Pl. 2, fig. 5). At present, these bones are displayed in the Tainan Fossil Museum in Ch'ailliao of Chochen.

### 4. Remarks on the Mode of Occurrence of the Fossil Rhinocerotid

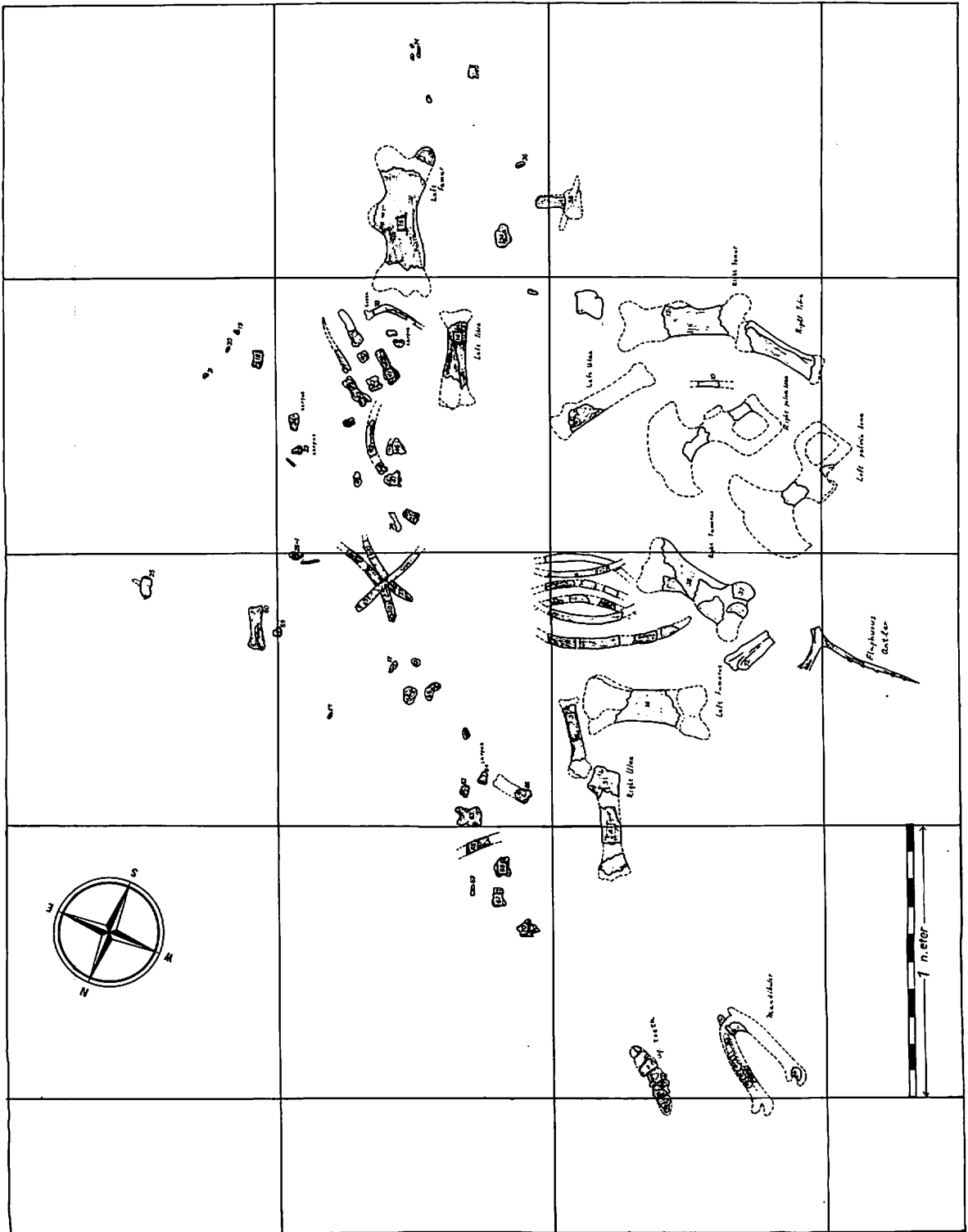
The fossil specimens representing about 40 percent of an individual rhinocerotid were scattering in a restricted area of about 25 square meters without showing the original position of each bone before dispersion of decayed body. Some of the long bones such as costae and limbs seemed to be arranged in the direc-

tions of NNW – SSE or NE – SW. Mode of occurrence of the isolated bones suggest an effect of water currents running in these directions which may have caused to accumulated the skeletons in this spot after the transportation from the place of death. Judging from the palaeogeographic map of the T'ouk'oushan Group drawn by Lin (1963), the rhinocerotid remains are judged to have been transported by the river from the place of death probably at the foot of the backbone range northwestward or southwestward to the coastal area. On the otherhand, there is a fossil tibia with some oyster (*Crassostrea gigas*) shells attached. This implies that the tibia has been kept scattered on the sea bottom like a beach gravel during the growth of oyster after adherence of the juvenile to the bone. This fact is very interesting for the paleoecological consideration. Furthermore, the rhinocerotid-bearing mudstone bed yields abundant molluscan fossils such as *Batillaria* and *Anadara*. This molluscan assemblage indicates that the rhinocerotid remains have been deposited in brackish water of inner bay environments.

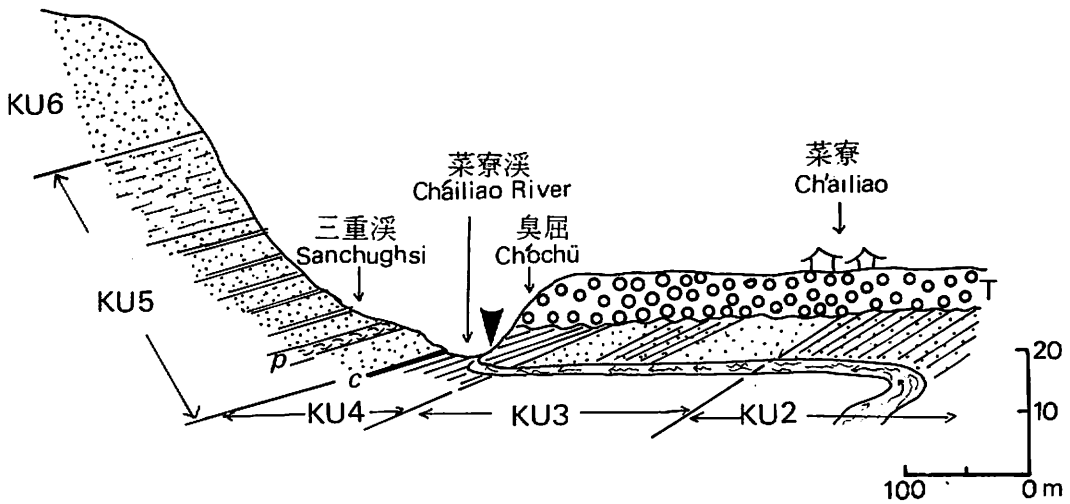
### V. On the Stratigraphic Position of the Rhinocerotid Bed in the Ch'iting Formation

In the Chochen area, the Ch'iting Formation has strikes of N10°~30°W trend and dips of 10°~50°W. It is composed mainly of silt, sandy silt and coarse-grained sand and yields abundant molluscan and vertebrate fossils from various horizons.

Near the Chengshan suspension bridge at Chochen in the Ch'ailliao River area, we can see the outcrop of the boundary between the Upper and the Lower Ch'iting Formation. It is also observed there that the lowest part of the Upper Ch'iting Formation consisting mainly of coarse-grained sand bed rests on the grey silt bed of the Lower Ch'iting Formation showing a gradual change in lithofacies between them. The Upper Ch'iting Formation is exposed in a narrow area along the lower stream of the Ch'ailliao River, where it is composed mainly of medium- to coarse-grained sand beds



Text-fig. 2. Mode of occurrence of fossil *Rhinoceros* at Ch'ochii of Ch'ailiao River, Choichen district.

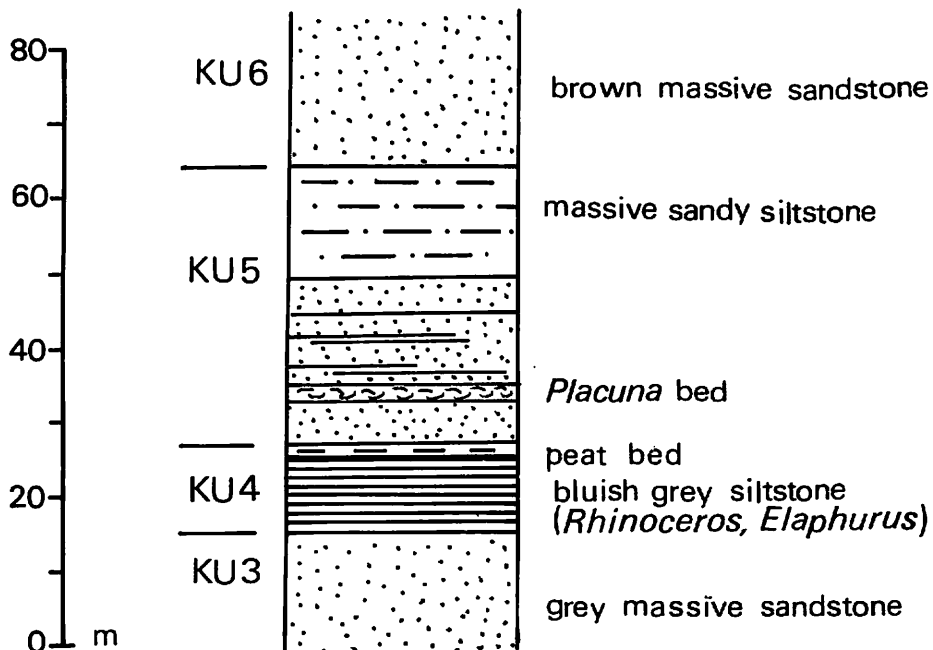


Text-fig. 3. Geologic profile of the Chiting Formation and the younger terrace deposits along the Ch'ailiao River between Sanchughsi and Ch'ailiao. Arrow indicates the excavation site of *Rhinoceros* at Ch'ochü. P: *Placuna* bed, C: lignite bed, T: terrace deposits

with intercalation of thin sandy silt beds and yields abundant molluscan fossils suggestive of inner-bay or shallow water habitat. As described by Shikama *et al.* (1975) and Otsuka and Shikama (1978), the Upper Ch'iting For-

mation in this area is divided into six lithologic units, KU1-KU6 in ascending order.

The rhinocerotid-bearing bluish grey mudstone bed (KU4) is exposed on the river side forming about two meters high cliff from



Text-fig. 4. Columnar section showing the upper Chiting Formation at Ch'ochü of Ch'ailiao. Stratigraphic horizon of fossil *Rhinoceros* and *Elaphurus* at Ch'ochü are shown in this section.



the river floor. This mudstone bed strikes in N10°W and dips about 10 degrees to the west. This bed is also exposed successively on the right river side about 30 meters up the Ch'ochü where the mudstone bed is about 20 meters in maximum thickness. The upper part of the Upper Ch'iting Formation (KU5, KU6) overlying the rhinocerotid-bearing mudstone bed is exposed on the opposite bank of Ch'ochü called Sanchunghsi forming a high cliff more than 50 meters from the river floor. At Sanchunghsi, the Upper Ch'iting Formation consists of coarse-grained sand bed with thin silt layers (10 m), coarse-grained sand (5 m), massive sandy silt (15 m) and reddish brown coarse-grained sand (+ 20 m) in ascending order (Text-fig. 3). From the massive sandy silt bed and reddish brown coarse-grained sand bed, several molars and jaws of *Mammuthus armeniacus taiwanicus* and isolated teeth of *Cervus (Sika) sintikuensis* were discovered (See Otsuka and Shikama, 1978). Furthermore, many bones and teeth of fossil deer such as *Muntiacus* and *Elaphurus* were picked up from the river floor between Ch'ochü and Sanchunghsi. As mentioned in the writer's another paper (Otsuka, 1984), these bones are regarded as derived fossils which might be washed out from the sand beds, probably KU4 and KU5 of the Upper Ch'iting Formation.

## VI. Systematic Description

Order Perissodactyla

Family Rhinocerotidae

Genus *Rhinoceros* Linnaeus, 1758

*Rhinoceros* Linnaeus, 1758, *Systema Naturae*, ed. 10, vol. 1, p. 56.

Generic type: *Rhinoceros unicornis* Linnaeus, 1758.

*Rhinoceros sinensis hayasakai* subsp. nov.

Pl. 4, figs. 1–2.; Pl. 5 figs. 1–2.;

Text-figs. 6–9.

*Rhinoceros sinensis* Owen, 1870, *Quart. Jour. Geol. Soc. London*, vol. 26, p. 424–426, Pl. 29, figs. 1–3.

*Rhinoceros sinensis* Koken, 1885, *Palaeont. Abhandl.*, vol. 3, p. 52.

*Rhinoceros sinensis*, Matthew and Granger, 1923, *Bull. Amer. Mus. Nat. Hist.*, vol. 102, p. 1–134, Pl. 20, figs. 1–3, Pl. 21, figs. 1–6.

*Rhinoceros sinensis*, Colbert and Hooijer, 1953, *Bull. Amer. Mus. Nat. Hist.*, vol. 102, art. 1, p. 1–130.

*Rhinoceros* sp., Hayasaka, 1942, *Taiwan Chigaku-kiji*, vol. 13, no. 4, p. 95–108, Pl. V, figs. 1 and 2, Pl. VI, figs. 8 and 9.

*Material examined.* — The specimens described in this paper belong to four main collections, namely the National Taiwan University Collection, the Taiwan Provincial Museum Collection, the Tainan Prefectural Fossil Museum Collection and some private collections. The specimens from the National Taiwan University include a pair of teeth row (Reg. No. DGNTU\*-FV11a and 11b) and a left jaw. These specimens were collected from the neighbourhood of Neizha of Tahsi, Taoyuan Prefecture and were illustrated by Hayasaka (1942, Pl. V, figs. 1 and 2). The specimens from the Tainan Provincial Fossil Museum were excavated from the mudstone bed (KU4) of the Ch'iting Formation exposed along the river side of the Ch'ailliao in 1972.

*Localities and horizons.* — The localities and horizons of the specimens examined are as follows:

Name of Collection	Specimen	Locality & Horizon
The National Taiwan University Collection Specimen Nos. 1 and 2 Specimen No. 3	a pair of upper teeth row a left lower teeth row	Localoty: Neizha of Tahsi, Taoyuan Prefecture Horizon: middle level of the T'unghsiao Formation, the T'ouk'oushan Group

\* Abbreviation for the Department of Geology, National Taiwan University.

Name of Collection	Specimen	Locality & Horizon
The Taiwan Provincial Museum Collection Specimen No. 4 Specimen No. 5 Specimen Nos. 6, 7 Specimen Nos. 8, 9 Specimen No. 10 Specimen Nos. 11, 12 Specimens Nos. 13, 14	a right upper teeth row a left lower teeth row a pair of humerus a pair of ulna a left radius a pair of femur a pair of tibia	Locality: Ch'ochü of Ch'ailliao, Chochen, Taiwan Prefecture Horizon: upper part of the Ch'iting Formation (KU4) of the T'ouk'oushan Group
The Tainan Prefectural Fossil Museum P'an's Collection Specimen No. 15 (PC-116) Specimen No. 16 (PC-117) Specimen No. 17 (PC-119) Specimen No. 18 (PC-121) Chen's Collection Specimen No. 19 (CM-001) Specimen No. 20 (CM-002) Yeh's Collection Specimen No. 21 (YB-001)	a left lower jaw with M1-M3 a left lower jaw with P4-M2 a left upper M1 a right lower M2 a left lower jaw with P4-M2 a right lower M1 a right lower jaw with M1-M2	Locality: river floor of the Ch'ailliao-hsi, Chochen, Tainan Prefecture Horizon: unknown (Probably derived from the Upper Ch'iting Formation)
The Su's Collection Specimen No. 22	a left upper M1	Locality: river floor of the Ch'ailliao-hsi

*Diagnosis.* — Medium-sized *Rhinoceros* having rather short limb bone; dentine formula is given as  $\frac{1 \cdot 0 \cdot 4 \cdot 3}{1 \cdot 0 \cdot 3 \cdot 3}$ ; the upper molar is medium in size, longer than wide transversely and usually lacks crista; the antichrochet is well developed in upper M3; the meta- and the protoloph are transversely set to the labial wall of the crown. The size of molar is plotted within the range of variation of *Rhinoceros sinensis* but upper M2 and M3 are narrower transversely than those of *sinensis*; the lower molar are somewhat shorter than *sinensis*.

*Description.* —

1. Upper jaw and upper cheek teeth

(1) Specimen No. 1 (right upper cheek teeth row; Pl. 4, fig. 1; Text-fig. 6) and Specimen 2 (left upper teeth row; Pl. 4, fig. 2) (National Taiwan University Collection).

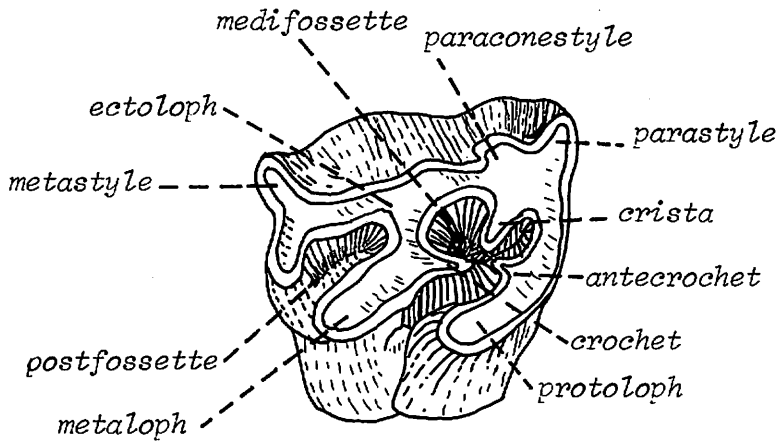
A fragmental right upper jaw carries teeth row of P3-M3 and left one that of P1-M2; when Hayasaka (1942) reported these speci-

mens, left M3 was attached to teeth row, but it is completely missing at present. The cheek teeth are large in size, much worn down and partly missing. The enamel wall is bluish grey colour while the dentine is brownish black. Right jaw is represented by maxillary portion just below the jugal arch. Left jaw is more or less worn and roots of each teeth are exposed. Measurements are as follows (in mm).

	Right	Left
Maximum length of jaw as preserved	224	220
Maximum width of jaw as preserved	106	98
Height of jugal arch	60	—

Upper Cheek teeth:

All cheek teeth are well preserved and dentine surface is distinctly depressed at a portion of the crochet. The antero-outer corner of the ectoloph is distinctly projected forward. The crista is almost absent and the

Text-fig. 5. Terminology of *Rhinoceros* molar.

crochet is generally weak except in the third molar. According to Hayasaka's figure (1942, Pl. V, fig. 2b), the left teeth row (P1-M2) is estimated to be 279 mm long along the occlusal surface. Along the outer alveolar margin, the left premolar series (P1-P4) is about 128 mm and the right molar series (M1-M3) is 141 mm long.

Left P1 is small sized, trigonal in crown view with gently curved margins; dentine surface is very flat and smooth. Enamel wall is very thin and the posterior wall of it is disappeared.

Left P2 is wider than long, quadrate in crown view, wider outwardly than the inwardly; the outer margin is slightly undulated and fore margin is gently curved; the antero-outer corner is a little broken. The occlusal surface is almost flat; the prefossette is strongly curved backward and become deeper outwardly; the postfossette is small and oval shaped; the metaloph is broad while the protoloph is narrow and expanded inwardly; the croket is weakly projected. The interior side of the crown is much crumbled away.

Left P3 is also wider than long, subquadrate in crown view, running oblique to the median longitudinal suture of the palate. When Hayasaka (1942) reported this jaw, the inner portion of P3 was well preserved, but nowadays it is distinctly broken. The dentine surface is depressed at curved portion of the postfossette;

the ectoloph is highest. The enamel walls of both anterior and the posterior margins are disappeared outwardly. The protoloph is much expanded inwardly; the prefossette is much curved, becomes very narrow at inner entrance; the metaloph runs straight to the outer wall; the postfossette is recognizable as an elongate oval-shaped one; the crochet is distinctly projected. Right P3 is much broken. The dentine surface is depressed and the ectoloph is partly eroded. The protoloph is broad and remarkably expanded. The enamel wall of the posterior margin is straight.

Left P4 is much wider than long and shows nearly rectangular outline in crown view. The dentine surface is much worn and depressed, therefore the proto- and the metalophs look broad. The pre- and medifossettes are much curved and worn; the postfossette is recognizable as a large, elongate-shaped hole, being 15 mm in diameter. The enamel wall of the metaloph facing the medifossette shows peculiar undulation allied to the crista (Text-fig. 6, 3b). The crochet is also recognized as a small but clear projection. Right P4 is also much worn and almost same as left one in general appearance. The dentine surface is much worn and depressed in central portion while the ectoloph is much elevated; the medifossette is deep and curved with closed entrance. The crochet is less prominent. The protoloph broadens inwardly; the metaloph is rather

narrow and runs straight to the inner; the inner wall of the meta- and the protoloph are much crumbled away.

Right M1 shows subrectangular outline in crown view, much wider than long. Both the anterior and the posterior margins are almost straight but the outer margin is slightly undulated. The antero-outer corner is eminently projected anteriorly. The dentine surface is depressed and much worn, therefore the postfossette is recognized as a small hole; the medifossette is shallow and narrow and their wall possess a faint crochet. In the antero-inner corner of the crown, there is a narrow and shallow fossa. The metaloph is smaller than the protoloph and runs straight to the inner; the protoloph broadens inwardly. In the posterior view, the occusal surface of the dentine is much depressed at middle. Left M1 also much worn, therefore the postfossette is recognized as an oval hole. The protoloph broadens inwardly and curved; the metaloph runs straight without distinct crochet.

Right M2 is subquadrate in crown view and much wider than long. The antero-outer corner of the crown eminently projects anteriorly. The protoloph remarkably broadens inwardly with a rather deep, wide fossa on its anterior margins. The metaloph is less wider than those of the protoloph and runs straight transversely. The postfossette is suboval in the crown view while the medifossette is remarkably curved with a large but blunt crochet. The occusal surface especially on its middle portion is much concaved while the ectoloph and the inner portion of the metaloph are prominently elevated. In the outer view, a tip portion of the anterior and the posterior outer lobes are acutely pointed. Left M2 is almost same as right one in general appearance and in size.

Right M3 is almost trigonal in the crown view, somewhat wider than long with gently curved outer margin. The medifossette is deep and narrow. The occusal surface of the dentine is deeply concaved while the protoloph and the anterior part of the ectoloph are highly elevated. The crochet is subtrigonal and distinctly projected forward; the metaloph is moderately large and runs straightly along the

outer margin. The protoloph is subquadrate, broadening inwardly and runs almost straight transversely. The parastyle is less prominent. In the outer view, a tip portion of the anterior outer lobe is acutely pointed. A large anti-crochet is recognized in left M3 but it is less prominent in right one.

(2) Specimen No. 4, a right upper teeth row in the Taiwan Provincial Museum Collection (P1. 5, fig. 2; Text-fig. 7).

The left upper cheek teeth (P1-M3) are in the Collection, however, they are much damaged by excavation. Pictures in Plate 5 and Text-fig. 7 are taken after restoration of each incomplete teeth. The third and the fourth molars are rather well restored but the others are uncertain. All the teeth are much worn down so the crown are barely preserved. That is to say, rhinocerotid from Chochü is regarded to be of senile stage, judging from the extreme grinding of the teeth.

P1 is subtriangular with gently curved outer and the posterior margins; the inner margin is slightly convexed inwardly with concaved middle portion. The crown is 29 mm long at the outer, 24.2 mm in width at the posterior borders. The enamel is measured 1.1 mm at the inner margin. Small, oval-shaped fossette is recognized on the postero-inner part of the occusal surface.

P2 is wider than long transversely, subquadrate in the crown view with slightly undulated outer, nearly straight posterior and slightly concaved anterior margins; the inner margin is convexed inwardly with concaved middle portion. The occusal surface is almost flat and the medi- and the postfossettes are recognized as four, small subcircular fossettes. Maximum height of the crown is measured 16.4 mm at the inner wall. The enamel is relatively thin, being 1.7 mm at the outer, 2.0 mm at the inner walls. The metaloph is wider than the protoloph.

P3 is broken into two pieces and the antero-outer and the postero-mesial portions are damaged. The crown is much wider than long, subrectangular in crown view; the anterior and the posterior margins are almost straight while the lateral margins are undulated. The molar

is 44.6 mm in length at the outer and 69 mm in width at the posterior margins.

P4 is represented by the inner and the antero-outer parts of the crown. The crown is much worn so the trace of the entrance of fossette remains on the middle portion of the inner border.

M1 shows subrectangular in crown view, much wider than long. Both the anterior and the posterior margins are nearly straight but the outer and the inner margins are undulated. The crown is much worn and lost the inner enamel wall and the fossette.

M2 is represented by the antero-outer part of the crown. Other parts are completely missing.

M3 is much damaged and retains two pieces of the outer and the postero-outer parts. The outer border of the crown is slightly undulated. The enamel wall at the posterior margin is measured 3.1 mm in average thickness.

(3) Specimen No. 18, a well-preserved upper left M1 (Reg. No. PC-119; the P'an's Collection; P1. 6, fig. 2). The molar is wider than long transversely, being 65.6 mm at the antero-transverse diameter and 50.1 mm in length at the labial side; the crown is rather hypsodonty, being 47 mm in height at the labial side. The parastyle is projected distinctly. The crochet is prominent; the cingulum is also recognized on the basal part of the buccal surface. A small, regular-shaped, enamel pro-

jection arise from the posterior enamel wall at the combined part of the ectoloph and the metaloph into the postfossette.

(4) Specimen No. 21, a well-preserved upper left M1 (the Su's Collection; P1. 6, fig. 3). About one-half of the crown worn down. It is provided rather distinct crochet and crista; the protocone fold is also recognized on the antero-buccal side of the protoloph. The size is 59.3 mm at the antero-transverse width and 46 mm long anteroposteriorly.

Measurements of the upper teeth of *R. sinensis hayasakai* and the other species are as follows (in mm):

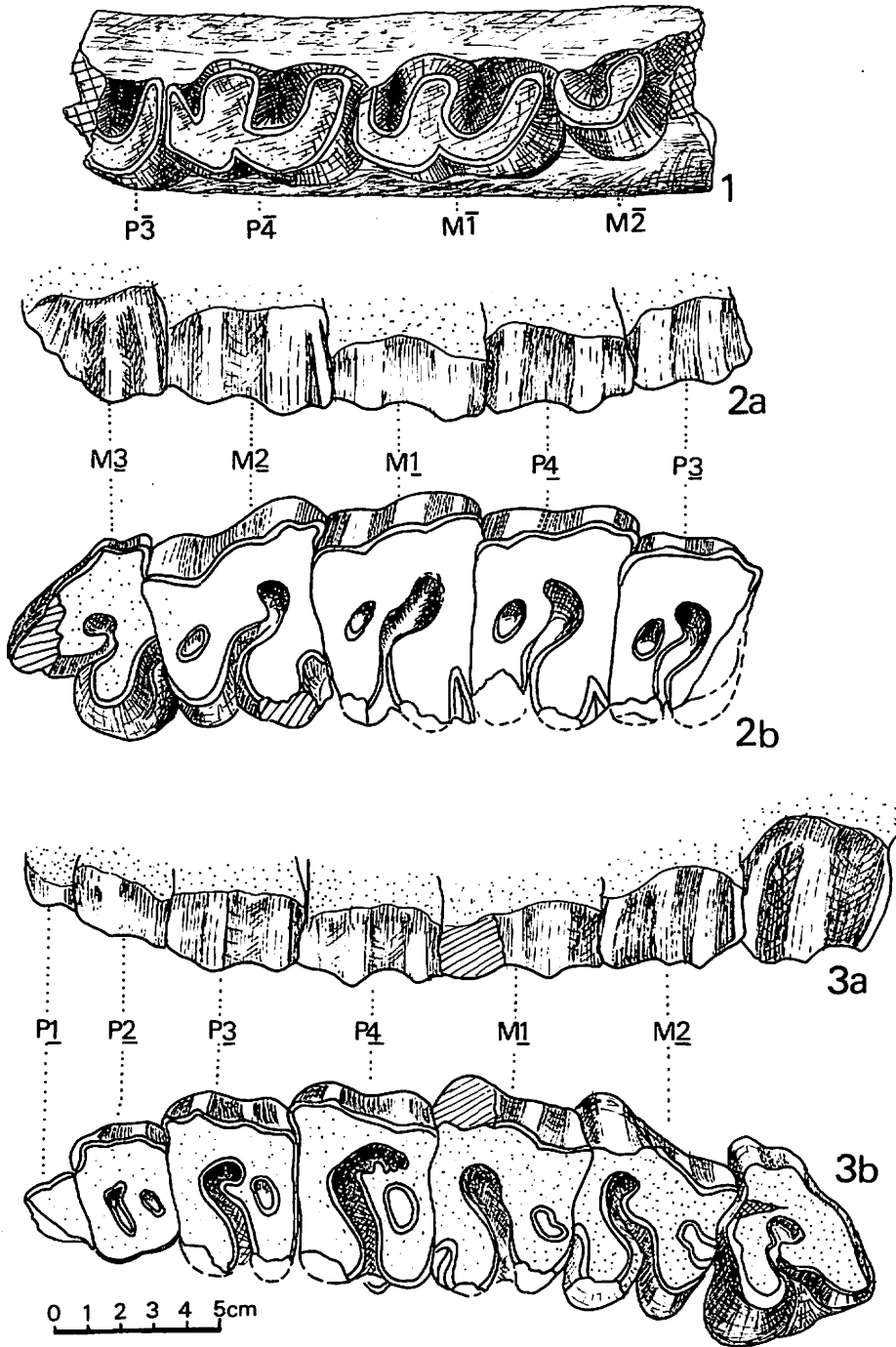
#### 2. Lower cheek teeth

Lower cheek teeth of *R. sinensis hayasakai* is characterized by the following points. (a) incisor tooth is present, (b) crown is rather broad transversely, subhypsodonty and scarcely cemented, (c) labial wall of the crown is rather convexed.

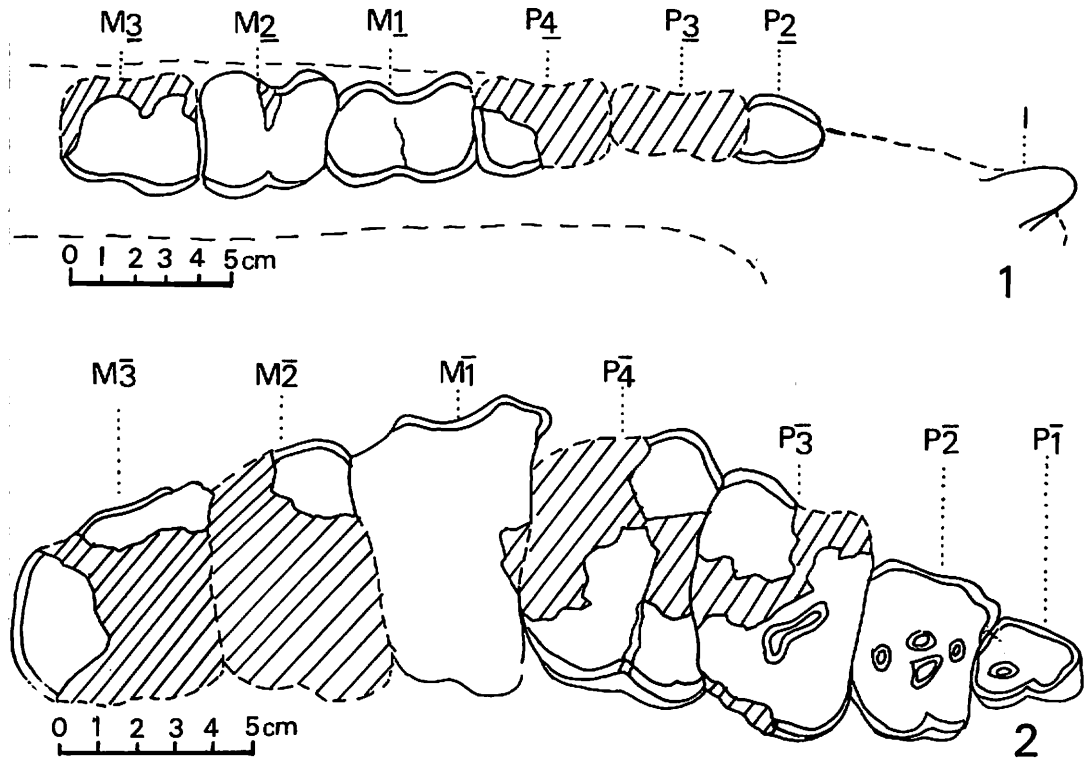
(1) Left lower jaw with cheek teeth (P3-M2) attached was recorded by Hayasaka (1942) in his Plate V, Fig. 1 as a new species of *Rhinoceros* (Text-fig. 6; Specimen No. 3). According to his description, this jaw was discovered from the T'ouk'oushan Group accompanied with pair of teeth (Specimens Nos. 1 and 2). Since then, this specimen has long been kept in the Department of Geology, National Taiwan University. At present, however, we cannot find out the specimen from the collection of that Department. As far as the picture of the jaw shown

	Upper		Lower
	P1-P4	M1-M3	M1-M3
<i>R. sinensis hayasakai</i>			
Specimen Nos. 1 & 2	128	141	—
Specimen No. 3	—	—	ca. 121
<i>R. mercki</i> (Choukoutien No. 9)*			P3-P4: 69 137
<i>R. tichorhinus</i> (Sjara-osso-gol)*			
Specimen No. 1		144	138
Specimen No. 2		—	150
Sjara-osso-gol		155	147

\* Teilhard de Chardin, 1936



Text-fig. 6. Views to illustrate the morphology of the lower and the upper teeth in *Rhinoceros sinensis hayasakai* subsp. nov. obtained from the neighbourhood of Neizha (= Naisaku) of Tahsi (= Taikei), Hsinchu Prefecture.  
 Fig. 1. The lower tooth row (P3-M2), illustrated based on the original picture by Hayasaka (1942, Plate V, fig. 1).  
 Fig. 2. and 3. Right (2) and left (3) upper tooth rows.  
 Lateral (a) and occlusal (b) views. In fig. 2, the last molar (M3) was illustrated based on the original figure shown by Hayasaka (1942, Pl. V, fig. 2b).



Text-fig. 7. View to illustrate the morphology of the lower (1) and the upper (2) teeth in *Rhinoceros sinensis hayasakai* subsp. nov., excavated from Ch'ochü of Ch'ailliao River, Chochen district.

Table 1. Measurements of the upper cheek teeth (in mm):

Position	No. of Specimen	Length of crown		Antero-transverse width of crown	Height of crown	
		inner	outer		inner	outer
P1	Specimen No. 1 (right)	—	—	—	—	—
	Specimen No. 2 (left)	—	ca. 17	ca. 27	8.0	10+
	Specimen No. 4	29.6	24.2	24.2	9.0	8.1
P2	Specimen No. 1	—	—	—	—	—
	Specimen No. 2	ca. 27	ca. 29	ca. 43	15.0	20+
	Specimen No. 4	25.3	28.6	45.4	16.4	13.8
P3	Specimen No. 1	—	39.8	57.9	—	24+
	Specimen No. 2	ca. 36	ca. 42	ca. 57	15.0	24+
	Specimen No. 4	27.6	45.5	ca. 69	8.9	7.8
P4	Specimen No. 1	39.2	44.5	68.6	16+	24.5
	Specimen No. 2	ca. 41	ca. 44	ca. 65	ca. 21	22+
	Specimen No. 4	45.0	ca. 43	ca. 72	12.1	12.3
M1	Specimen No. 1	37.6	ca. 43	68.8	14+	20+
	Specimen No. 2	ca. 40	43.5	ca. 69	ca. 21	22+
	Specimen No. 4	34.8	42.7	68.5	—	9.9
M2	Specimen No. 1	45.4	46.6	68.2	17.2	32+
	Specimen No. 2	ca. 46	ca. 44	ca. 69	ca. 18	29+
	Specimen No. 4	—	ca. 34	ca. 66	—	8.2
M3	Specimen No. 1	59.2	ca. 58	61.2	22+	34.5+
	Specimen No. 2	—	—	—	—	—
	Specimen No. 4	—	ca. 61	ca. 58	—	9.6

by Hayasaka (1942) in concerned, the lower cheek teeth is characterized by subhypsodont and scarcely cemented crown with convexed labial wall.

(2) Specimen No. 5, left lower cheek teeth in the Taiwan Provincial Museum Collection (Pl. 5, fig. 1; Text-fig. 7).

Left lower cheek teeth and the incisor are preserved, however, P4 and M3 are very incomplete in preservation and P3 is crumbled away completely. All the teeth are much worn down so the crowns retain little enamel wall.

Incisor tooth (I) shows dark brown and polished. It is 30.8 mm in height and 17.4 mm in width. P2 shows subrectangular outline with slightly convexed lateral and concaved posterior margins. The enamel wall is measured 1.2 mm in thickness. P4 retains the postero-inner portion of the crown. M1 is rectangular outline with concaved lateral walls. By extreme abrasion, the crown retains no inner fossette. M3 shows subquadrate outline. It is much worn down so the postero-outer enamel wall lost completely. Total length of the molar series (M1-M3) is estimated to be 121 mm along the mesial line. Measurements of the lower teeth are shown in Table 2 (in mm):

**Table 2. Measurements of the lower teeth (Specimen No. 5) (in mm).**

	I	P1	P2	P3	P4	M1	M2	M3
Maximum length as preserved	30.8	—	26.6 (L) 20.3 (R)	—	—	44.5	35.9	40.5
Maximum width as preserved	17.4	—	21.9 (L) 20.9 (R)	—	—	39.0	33.1	21.7

(3) Specimen Nos. 15 and 16, two left lower jaws belonging to the P'an's Collection in the Tainan Prefectural Fossil Museum.

Specimen No. 15 (Reg. No. PC-116; Pl. 6, fig. 6), a left, incomplete lower jaw is represented by a part of the horizontal ramus with three molars attached. The ramus is about 87 mm in height, 51 mm in width below M1, 111 mm in height below M3 and 204 mm in preserved length. These molars are much worn down and their buccal sides are crumbled away completely. The molars are moderately long,

being 40.5 mm, 44.2 mm and 50 mm in length in M1, M2 and M3, respectively. Enamel wall is 2 mm in average. The roots of M1 and M2 are exposed on the labial surface of the ramus.

Specimen No. 16 (Reg. No. PC-117; Pl. 6, fig. 5) is represented by left, incomplete lower jaw with molars from P4 to M2 attached. The ramus is about 280 mm in preserved length, 89.4 mm and 102 mm in height at the behind of P4 and M2, respectively. The crown of P4 and M3 are crumbled away completely. M1 is 40.9 mm in length and 34.3 mm in the antero-transverse width; the buccal surface of the meta- and the entoconids are nearly flat. M2 is much worn down; the para- and the entoconids are connected with each others. It is 42.5 mm long, 37 mm in the postero-transverse width and 21.7 mm in preserved height.

(4) Specimen No. 21, a right incomplete jaw with M1 and M2 attached (Reg. No. YB-001, the Yeh's Collection; Pl. 6, fig. 8). M1 is much worn and the anterior half of the crown is broken away completely. M3 is crumbled away completely. M2 is 54.2 mm long and 35.7 mm in the antero-transverse width; enamel wall is 1.9 mm in thickness in average. The horizontal ramus is 164 in pre-

served length but its ventral half is broken away.

(5) Specimen No. 19, a left incomplete ramus with cheek teeth (P4-M2) attached (Reg. No. CM-001; the Chen's Collection; Pl. 6, Fig. 7). P3 is crumbled away. M2 is preserved only the anterior root of the tooth. P4 is much worn down and the postero-labial enamel wall barely remained. It must have been at least 38 mm in length, judging from the well-preserved roots. M1 is also much worn down and about one third of the labial enamel wall barely



Table 3. Measurements of the lower teeth (in mm)

		P4	M1	M2	M3
Specimen No. 15 (PC-116)	length	—	ca. 40.5	44.2	49.6
	width	—	—	—	—
Specimen No. 16 (PC-117)	length	—	49.9	42.5	—
	width	—	34.3	40	—
Specimen No. 17 (PC-121)	length	—	—	49.2	—
	width	—	—	32.3	—
Specimen No. 18 (CM-001)	length	ca. 38	40.1	—	—
	width	—	—	—	—
Specimen No. 19 (CM-002)	length	—	—	43.9	—
	width	—	—	32.3	—
Specimen No. 20 (YB-001)	length	—	—	54.2	—
	width	—	—	35.7	—

remained. It is about 40 mm in estimated length.

(6) Specimen No. 18, a well-preserved, isolated lower M2 (Reg. No. PC-121; the P'an's Collection; Pl. 6, fig. 4). It is 49.2 mm in length, 32.3 mm in the postero-transverse width, 46 mm in the antero-transverse width and 46 mm in height at the antero-outer surface of the crown. The outer wall is moderately convexed with small accessory column on its basal part.

(7) Specimen No. 20, an isolated right M1 (Reg. No. CM-002; the Chen's Collection; Pl. 6, fig. 1). It is moderate in size for *Rhinoceros*, being 43.9 mm in length, 31.3 mm in the postero-transverse width and 37.5 mm in the postero-labial surface of the crown. The labial wall is rather convexed and lacks cingulum.

3. Humerus, Specimen Nos. 6 and 7, the Taiwan Provincial Museum Collection (Text-fig. 8; 1, 2). A pair of incomplete humerus is preserved. A right humerus (Specimen No. 6, Text-fig. 7; 2a, 2b) is represented by a central portion of shaft and small pieces of the proximal tuberosities. The shaft is 262 mm in preserved length and is constricted at the middle portion. A left humerus (Specimen No. 7; Text-fig. 7; 1a, 1b) is represented by a central portion of shaft; the distal and the proximal parts are crumbled away completely. A shaft is 218 mm in preserved length and 61.3 mm in side-to-side diameter at the middle portion and it is twisted clockwise with somewhat concaved postero-outer surface. Length of humerus is estimated to be 390 mm, if restored. Measurements of humerus are shown in Table 4 (in mm):

Table 4.

	<i>R. sinensis hayasakai</i>		<i>R. cf. tichorhinus*</i> (from Nihowan)
	Right	Left	
Estimated length (a-a')	ca. 390	ca. 390	440
Preserved length of shaft (e-e')	262	218	
Estimated proximal width (b-b')	ca. 27		
Estimated distal width (c-c')	ca. 171		
Minimum width of shaft at middle (d-d')	62	63	

\* Teilhard de Chardin &amp; J. Piveteau (1930)

4. Ulna, Specimen Nos. 7 and 8, the Taiwan Provincial Museum Collection (Text-fig. 8; 4, 5). A pair of incomplete ulna is preserved. A right ulna is represented by a part of the olecranon and the proximal part of the shaft. A left one is represented by a head part of the olecranon, proximal-, middle- and the distal part of a shaft. Measurements are as follows (in mm):

**Table 5.**

Fore-and-aft width of olecranon (b-b')	82.2
Width of shaft near the process anconaeus (d-d')	77.1
Estimated length (a-a')	ca. 330

5. Radius, Specimen No. 9, Taiwan Provincial Museum Collection (Text-fig. 8; 3a, 3b).

An incomplete left radius is represented by the postero-outer part near the proximal end, the proximal portion of shaft. Length of radius is estimated to be 325 mm, if restored. This value is smaller than *R. cf. tichorhinus* from Nihowan and *R. tichorhinus* from Choukoutien Loc. 9. Measurements are shown in Table 6 (in mm):

6. Femur, Specimen Nos. 11 and 12, the Taiwan Provincial Museum Collection (Text-fig. 9; 1, 2). A pair of incomplete femur is preserved. A right femur represented by a central part of shaft and some other pieces, is large, tabular and broad laterally and slightly bent backward with distal and proximal expansions.

**Table 7.**

	<i>R. sinensis hayasakai</i>		<i>R. cf. tichorhinus*</i> (Nihowan)
	Right	Left	
Estimated length (a-a')	ca. 430		505
Preserved length of shaft (b-b')	268	187	
Minimum width of shaft near distalis (d-d')	68.6	68	
Minimum width of shaft near proximalist (e-e')	99		
Ide-to-side width of head at proximalis (f-f')	49.5		
Fore-and-aft width of head near distalis (m-m')	27.5		

\* Teilhard de Chardin &amp; J. Piveteau (1930)

**Table 6.**

	<i>R. sinensis hayasakai*</i>	<i>R. cf. tichorhinus**</i>
Estimated length (a-a')	ca. 325	375, 403
Estimated width at the proximal end (b-b')	73	
Width of shaft near the proximal part (e-e')	39	
Width of shaft near the distal part (g-g')	47.2	
Width of shaft near the distal part (h-h')	54.8	

\* Teilhard de Chardin (1936)

\*\* Teilhard de Chardin &amp; Piveteau (1930)

The shaft below the tronchanter tertius is constricted, being 68.6 mm in minimum diameter. Length of right femur is estimated to be 430 mm, if restored. A left femur is represented by a lower half of the shaft; the other part are crumbled away completely. It is about 187 mm in preserved length. Measurements are shown in Table 7 (in mm):

7. Tibia, Specimen No. 13, the Taiwan Provincial Museum Collection (Text-fig. 9; 3, 4). A pair of incomplete tibia is preserved, however, their proximal and the distal portions are missing. A right tibia is represented by a shaft, being 263 mm in preserved length. The shaft broaden in fore-and-aft direction and slightly twisted clockwise with angulated frontal border. A left tibia is 165 mm in preserved length. Original length of tibia is

Table 8.

	<i>R. sinensis hayasakai</i>		<i>R. cf. tichorhinus*</i> (Nihowan)
	Right	Left	
Estimated length (a-a')	ca. 310	ca. 310	420, 415
Side-to-side width of shaft near proximal part (f-f')	68.6	65.8	
Side-to-side width of shaft in middle portion (g-g')	57.7	57.6	
Fore-and-aft thickness of shaft near distal part (d-d')	83.2	83.0	
Preserved length of shaft (b-b')	263	165	

\* Teilhard de Chardin & J. Piveteau (1930)

estimated to be 310 mm, if restored. Measurements are shown in Table 8 (in mm):

*Comparisons.* — The Taiwanese rhinocerotid named *Rhinoceros sinensis hayasakai* subsp. nov. is closely allied to *Rhinoceros sinensis sinensis* Owen from the Middle Pleistocene deposits in Szechuan of China (Owen, 1870; Colbert and Hooijer, 1953) in having the following characters. 1. Regarding the upper molars of *R. sinensis hayasakai*, the outer surface of the crown is almost flat and the anterior part of it is slightly convexed outwardly forming a weak paracone style. The metastyle is not clear in M1 or entirely absent in M2 and M3. These dental characters suggest that *R. sinensis hayasakai* has close alliance to *R. sinensis sinensis* or the Javanese rhinocerotid (*R. sondaicus*) than to the Indian rhinocerotid (*R. unicornis*). 2. On the anterior wall of the protocone of *R. sinensis hayasakai*, there is a protocone fold. According to Colbert and Hooijer (1953), most of the upper molars of *R. sinensis sinensis* has sharply defined protocone fold on the anterior surface of the protocone which is typical for *R. unicornis* (Hooijer, 1946) but not shown in the upper molars of *R. sondaicus*. *R. sinensis hayasakai* has a weak protocone fold on the anterior wall of the premolars (P3, P4) as well as of the succeeding molars. As far as these characters are concerned, *R. sinensis hayasakai* is closely related to *R. sinensis sinensis*. 3. In *R. sinensis hayasakai*, the outer surface of the posterior moiety of the ectoloph is remarkably concaved behind and more inclined inwardly as in *R. sondaicus*

and resembles those of *R. sinensis sinensis*. 4. The inner portion of the portoloph has greater backward extension in *R. sinensis hayasakai* as in *R. sinensis sinensis* than in *R. sondaicus*. 5. Usually, *R. sinensis hayasakai* lacks distinct crista in the upper molar. In this point, *R. sinensis hayasakai* resembles *R. sondaicus* or *R. sinensis sinensis*. In *R. sondaicus*, the crista is rarely recognized on the upper milk molar and absent in the upper molars (Colbert and Hooijer, 1953). In *R. sinensis sinensis*, there are several irregularly shaped, small enamel projections arise from the ectoloph into the medisinus but there is no well-defined crista.

The Taiwanese rhinocerotid (*R. sinensis hayasakai*) is safely distinguished from *R. tichorhinus* (= *Coelodonta antiquitatus*) from Loc. 9 of Choukoutien of North China (Teilhard de Chardin, 1936) by transversely wider molar (Text-figs. 10–12) with less prominent folding of the outer wall, absence of crista and more remarkable development of the meta- and the protocones which are transversely set to the outer wall of the crown. That is to say, the molars of *R. tichorhinus* from Choukoutien are comparatively longer than wide transversely and show subrectangular outline prolonging in fore-and-aft direction with prominently developed crochet, crista and meta- and the protocones which are obliquely set to the outer wall of the crown. The Late Pleistocene species of *R. tichorhinus* from Europe and Asia are also distinguished from *R. sinensis hayasakai* in same respects.

The Taiwanese rhinoceros (*R. sinensis*

*hayasakai*) is safely discriminated from *R. (Dicerorhinus) mercki* Jager from the Middle Pleistocene deposits from Choukoutien No. 9 (Teilhard de Chardin, 1936) by transversely wide, less hypsodont molars without remarkable paracone fold, vestigial crista, the anterior cingulum and by shorter lower molars with flat wall of the crown. *R. sinensis hayasakai* is also discriminated from the European species of *R. (D.) mercki* in the same respects.

*R. sinensis hayasakai* resembles *R. kendingindicus* from the Djetis Fauna in Java (Hooijer, 1946) in size and general appearance of the molars but it is discriminated from the latter by longer and wider molar with crista.

*Dicerorhinus nipponicus* Shikama (1967), reported by Shikama *et. al.* (1967) from the limestone quarry of the Akiyoshi district, West Japan accompanied with the "Choukoutien Fauna" such as *Panthera youngi* and *Stegodon orientalis*, is discriminated from *R. sinensis hayasakai* by different outline of the molar with remarkable crochet and crista.

*R. cf. sinensis* Owen described by Teilhard de Chardin and Piveteau (1930) as one of the "Nihowan fauna" based on the upper cheek teeth. As to this species from Nihowan, Teilhard de Chardin (1936) regarded it as a species closely allied to *R. mercki* from Choukoutien but a little more primitive than the latter. Certainly, *Rhinoceros* from Nihowan seems to be much closer to *mercki* from Choukoutien and Europe and to *R. sinensis hayasakai* in size than any other species ever reported. Although *R. sinensis hayasakai* seems to be allied to *Rhinoceros* from Nihowan in size and existence of the incisor, it is discriminated from the latter by absence of the crista in the premolars and transversely wide molars (Text-figs. 10–12).

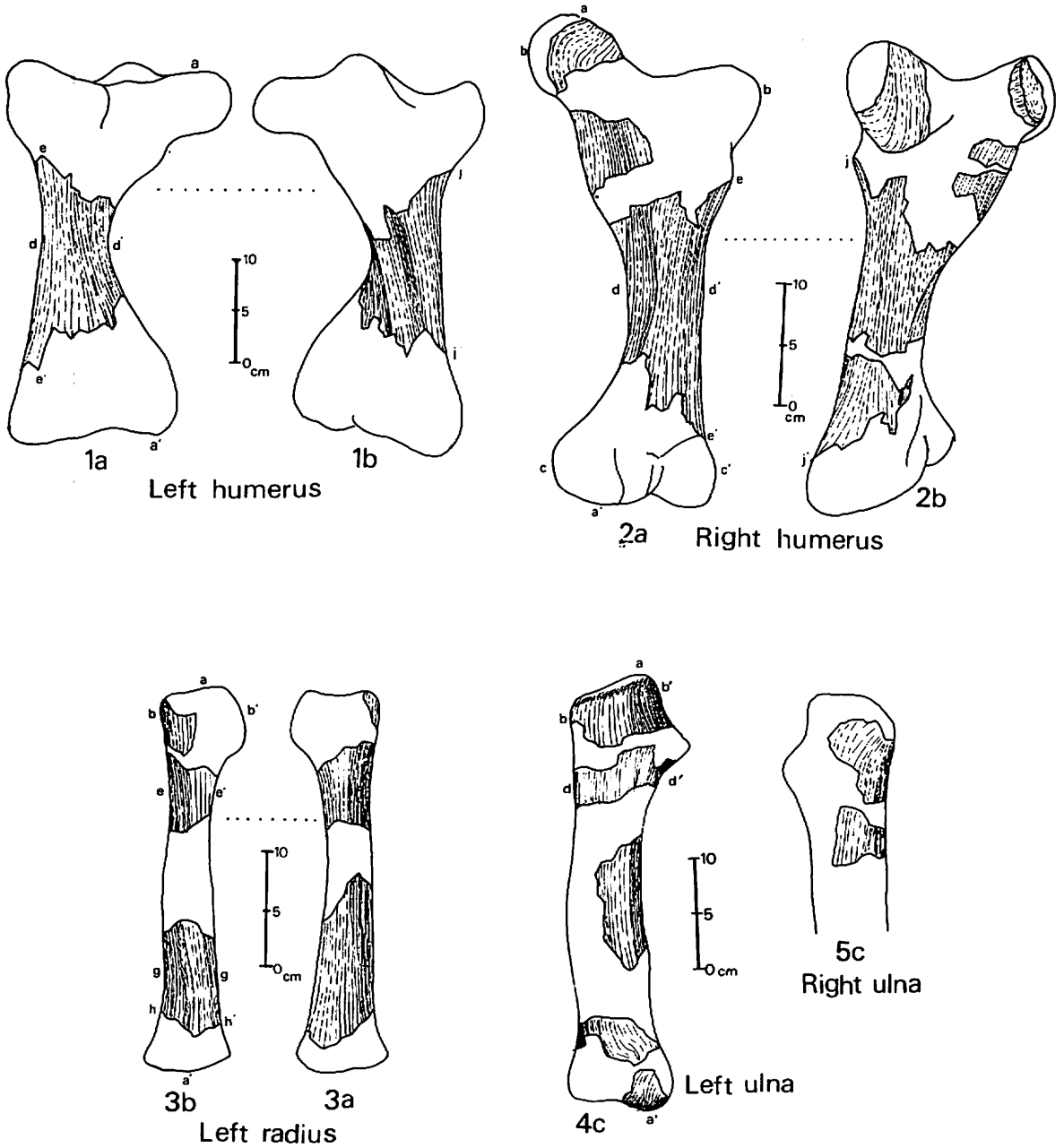
### VIII. Concluding Remarks on the Fossil Rhinocerotid from the T'ouk'oushan Group

*Rhinoceros sinensis hayasakai* subsp. nov. from the T'ouk'oushan Group in Taiwan is more closely related to *R. sinensis sinensis*

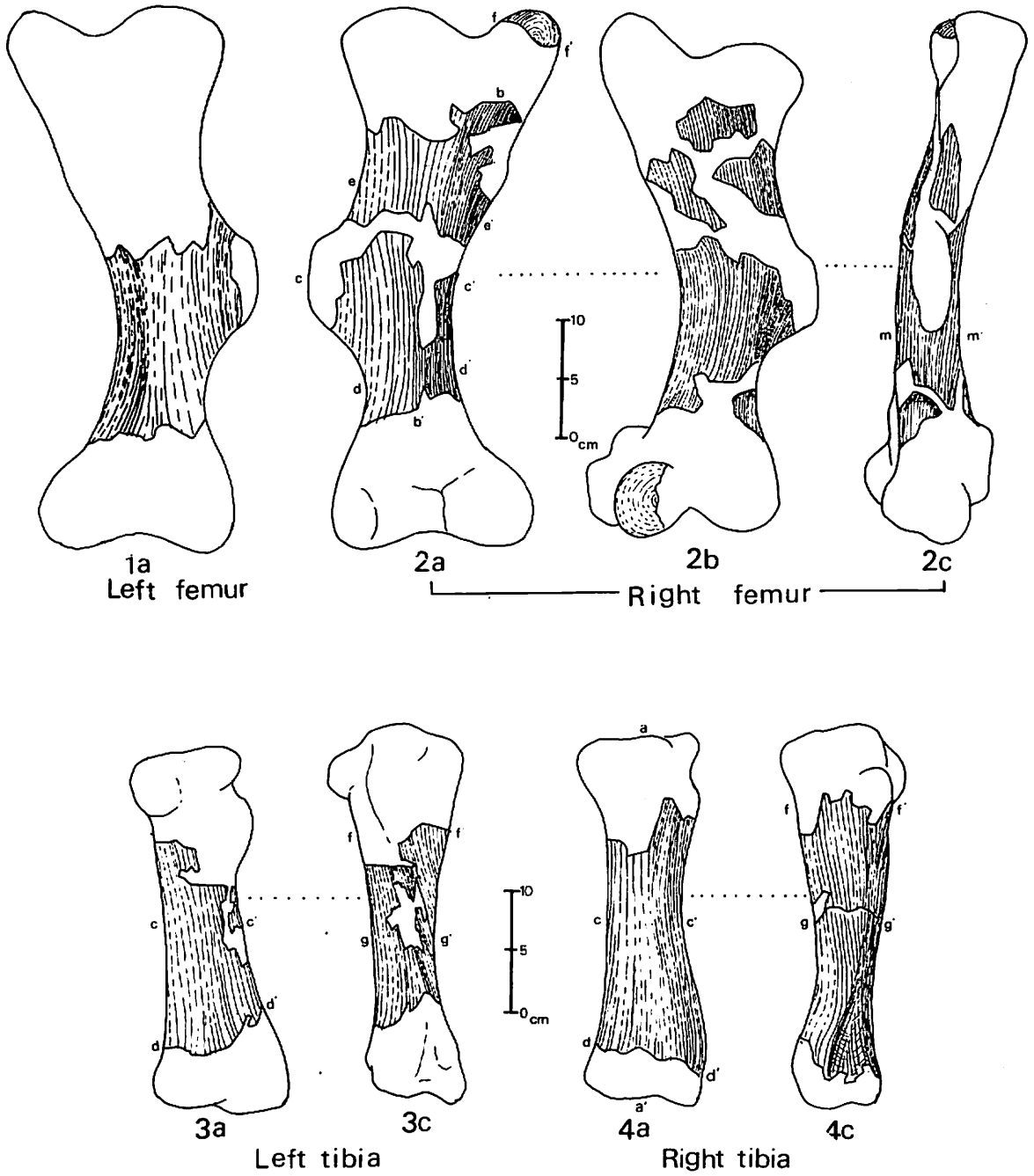
Owen known from the Middle Pleistocene Wanhsien Fauna in Szechuan, China than the other species known from Asia such as *R. sondaicus* and *R. kendingindicus* from Java, *R. mercki*, *R. tichorhinus* and *D. choukoutiensis* from Choukoutien in having transversely wide molar without distinct crista. Furthermore, the size of molar of *R. sinensis hayasakai* falls safely within the variation of those of *R. sinensis sinensis*, but the former is distinguished from the latter by transversely narrow molars (M2, M3).

In China, *R. sinensis sinensis* is known as a member of the Pleistocene *Stegodon-Ailuropoda* Fauna (Colbert & Hooijer, 1953; Kahlke, 1961) and is accompanied with *Stegodon orientalis*, *Bibos*, *Bubalus*, *Muntiacus*, *Hyaena* and *Panthera* etc. In Taiwan, the faunal assemblage characterized by the existence of *Stegodon orientalis* and *Rhinoceros sinensis hayasakai* is known from the T'ouk'oushan Group in the Taichung Prefecture, Central – West Taiwan (Hayasaka, 1942), while in the Chochen Fauna in the Tainan Prefecture, *Stegodon orientalis* has not been found so far. The Chochen Fauna, however, comprises numerous mammalian fossils indicating the faunal similarity to those of the Wanhsien Fauna such as *Rhinoceros sinensis hayasakai*, *Bibos*, *Bubalus*, *Panthera* and *Muntiacus*. On the other hand, *Elaphurus formosanus* in the Chochen Fauna suggests the faunal relationship with those of the Nihowan Fauna in North China and the Akashi Fauna in the Early Pleistocene Osaka Group, West Japan.

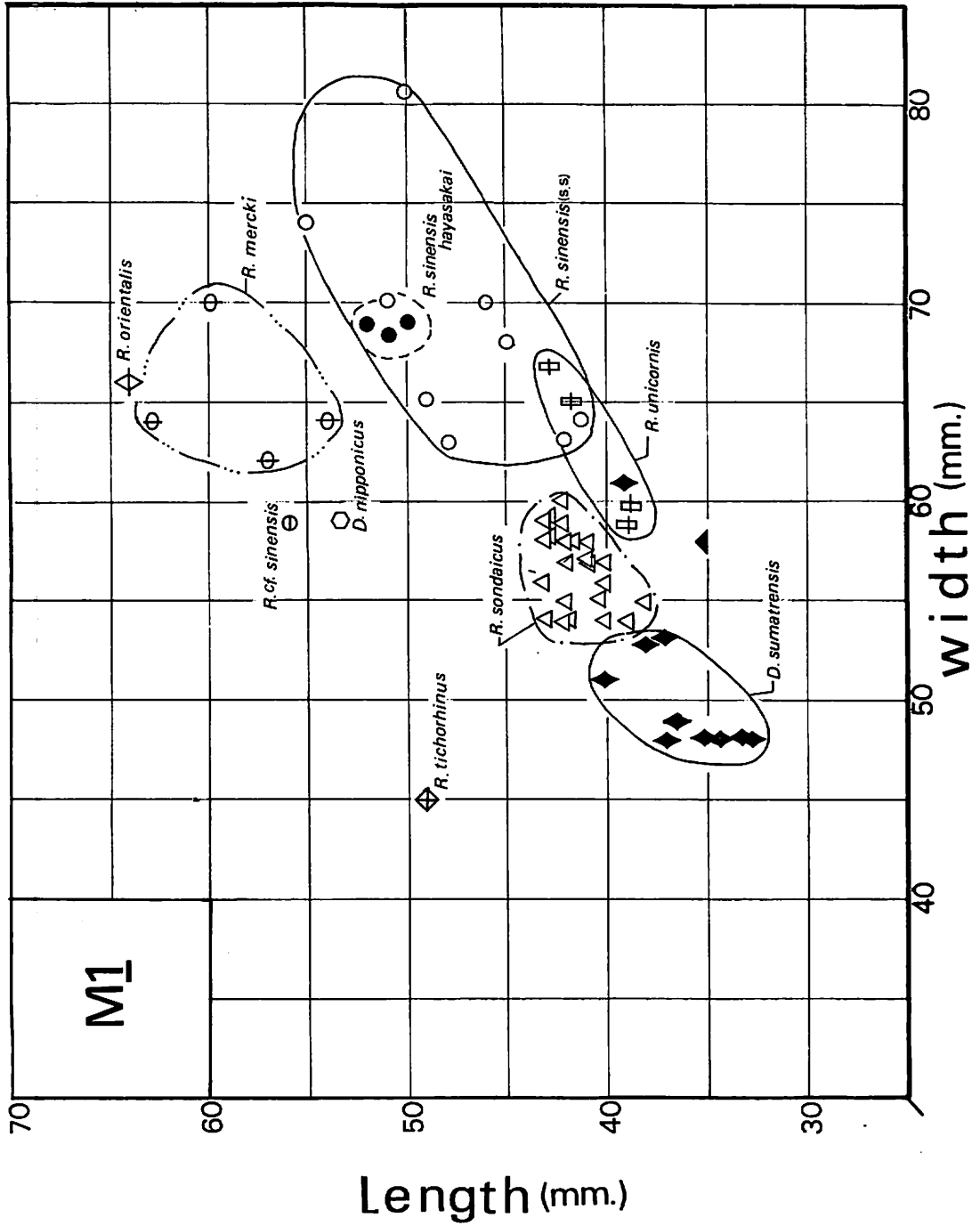
As mentioned by Otsuka and Shikama (1978) and Otsuka (1982). *Stegodon (Parastegodon) akashiensis* and *Stegodon sinensis* occurred from KU2 and KU3 in the Ch'iting Formation, while *Rhinoceros sinensis hayasakai* occurs from KU4 accompanied with *Elaphurus formosanus*. Therefore the writers suppose that the vertebrate fauna of the "Wanhsien type" was mixed with those of the "Nihowan type" in the age of the upper part of the Ch'iting Formation of the T'ouk'oushan Group in Taiwan.



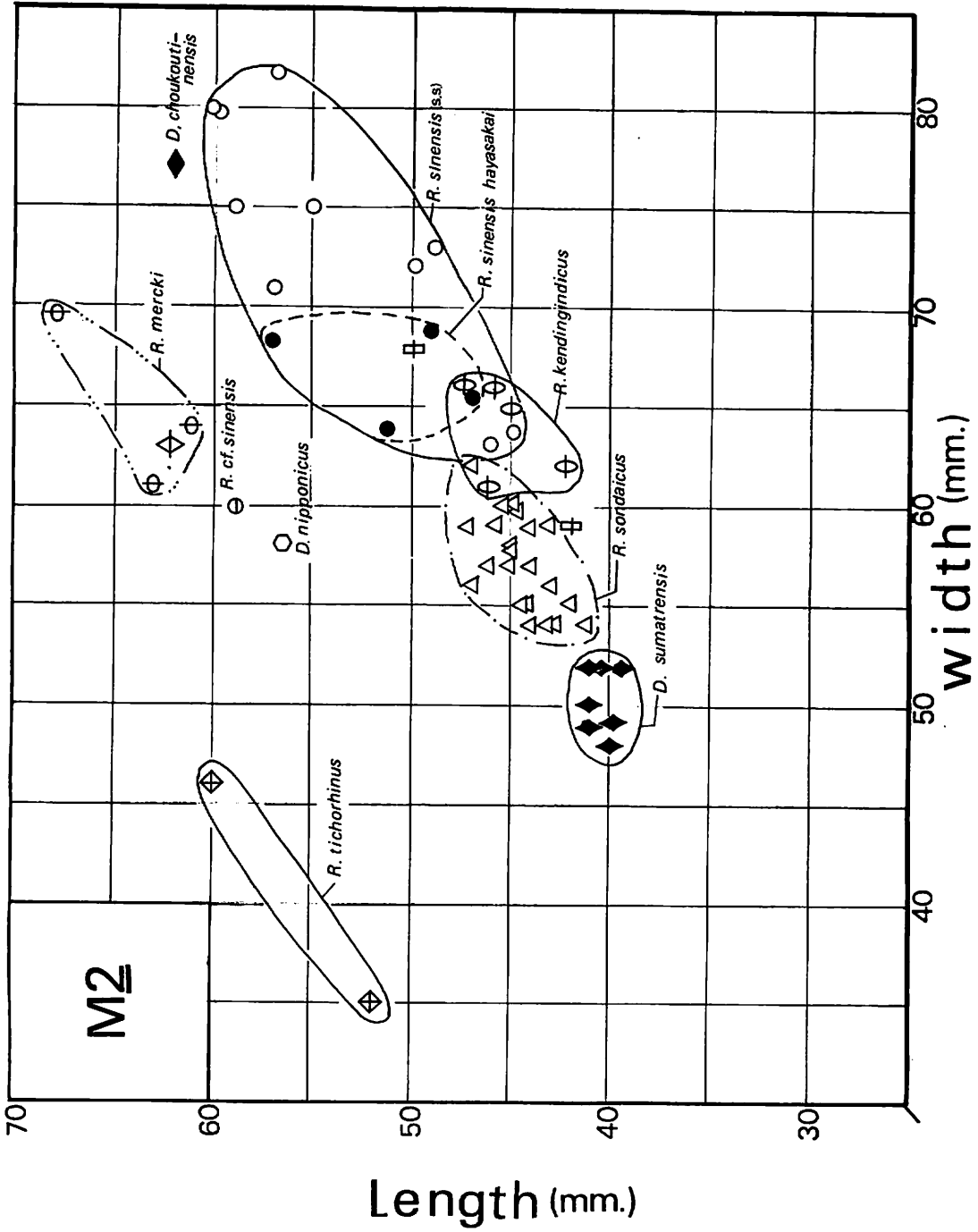
Text-fig. 8. Restored figures of paired humerus (1, 2), left radius (3) and paired ulna (4, 5). Anterior (a), posterior (b) and inner (c) views.



Text-fig. 9. Restored figures of paired femur (1, 2) and tibia (3, 4). Anterior (a), posterior (b) and outer (c) views.

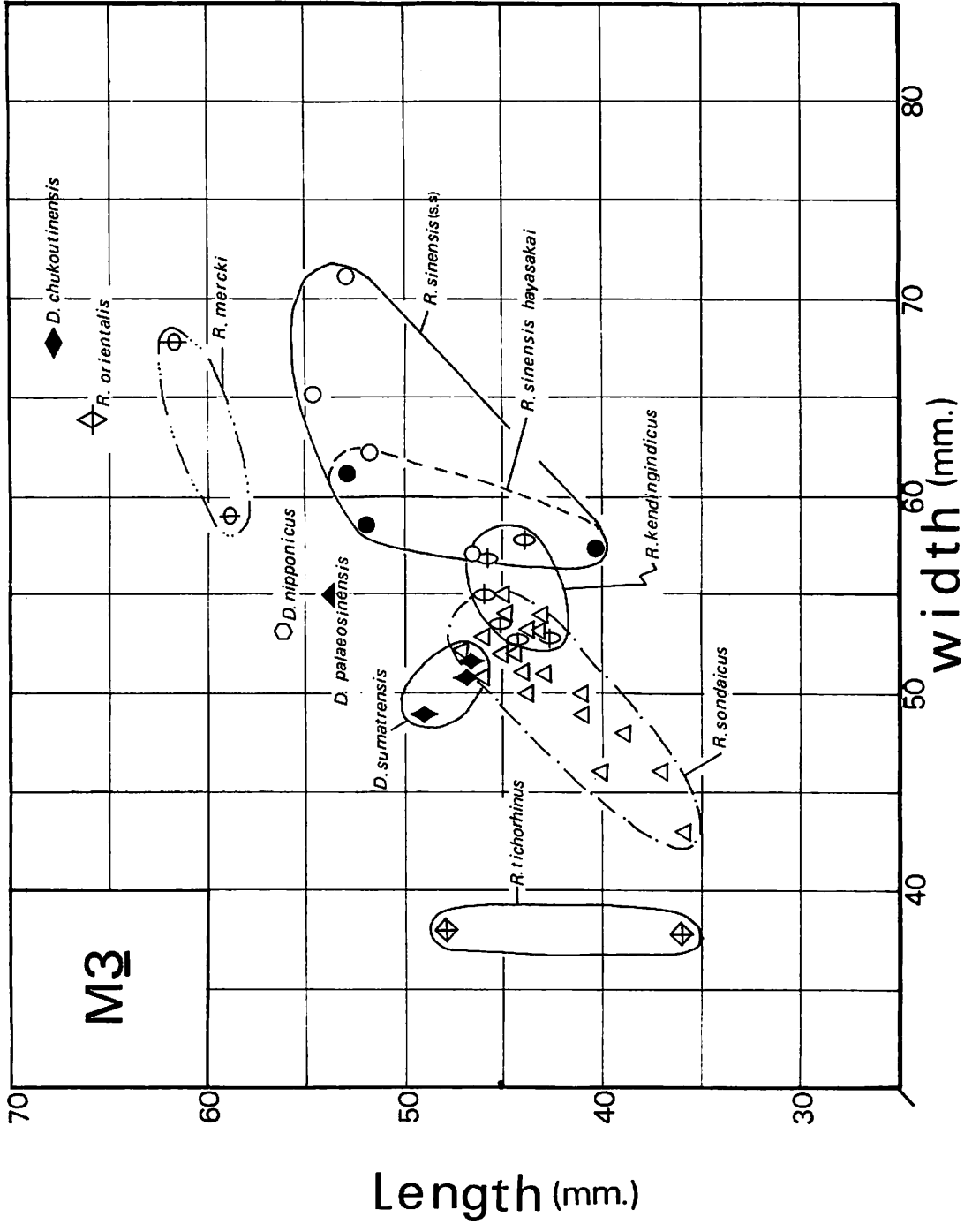


Text-fig. 10. Graph showing the relationship between the length and width of upper first molar (M1) of *Rhinoceros*.

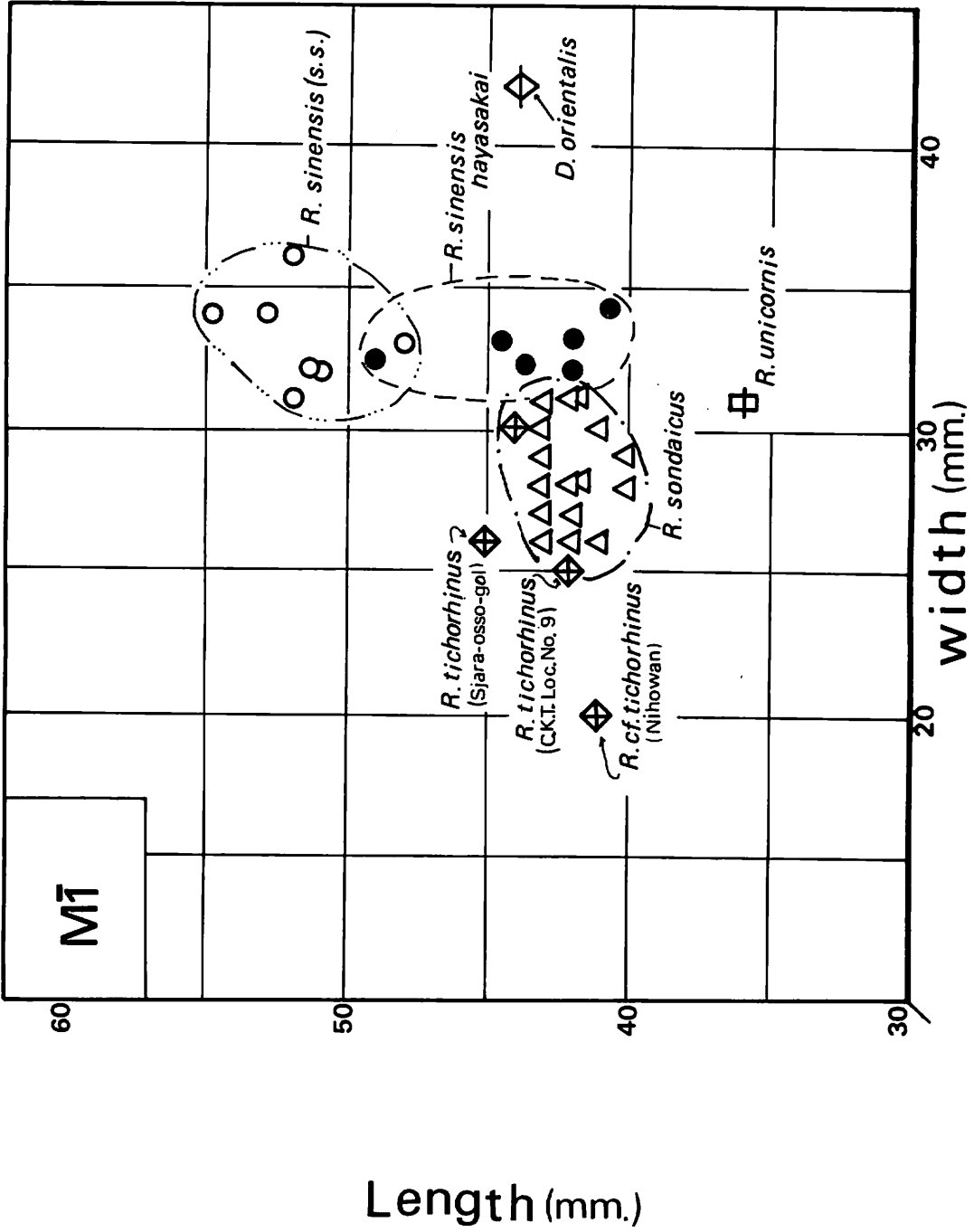


Text-fig. 11. Graph showing the relationship between the length and width of upper second molars (M2) of *Rhinoceros*.

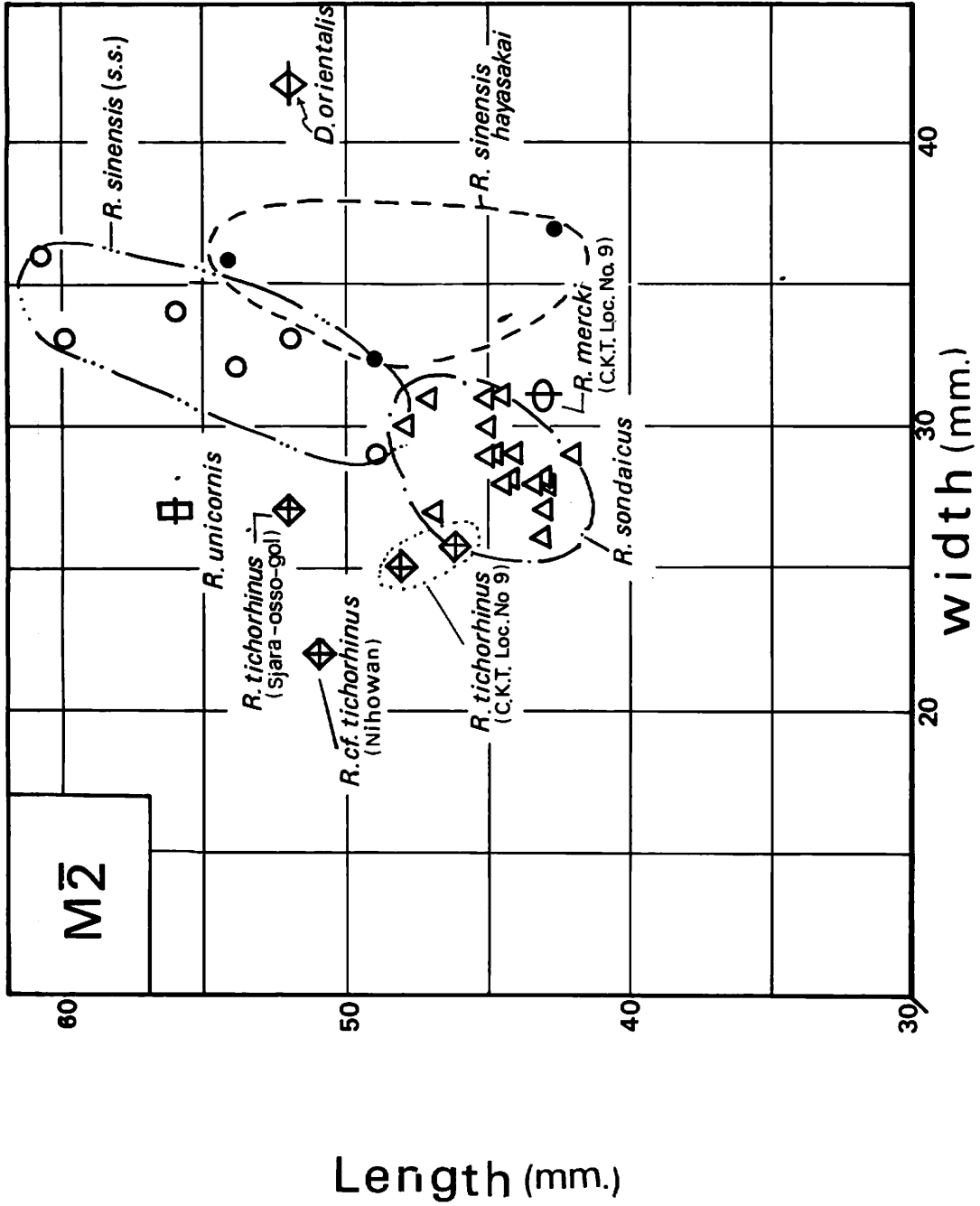




Text-fig. 12. Graph showing the relationship between the length and width of upper third molar (M3) of *Rhinoceros*.



Text-fig. 13. Graph showing the relationship between the length and the width of the lower first molar (M1) of *Rhinoceros*.



Text-fig. 14. Graph showing the relationship between the length and the width of the lower second molar (M2) of *Rhinoceros*.

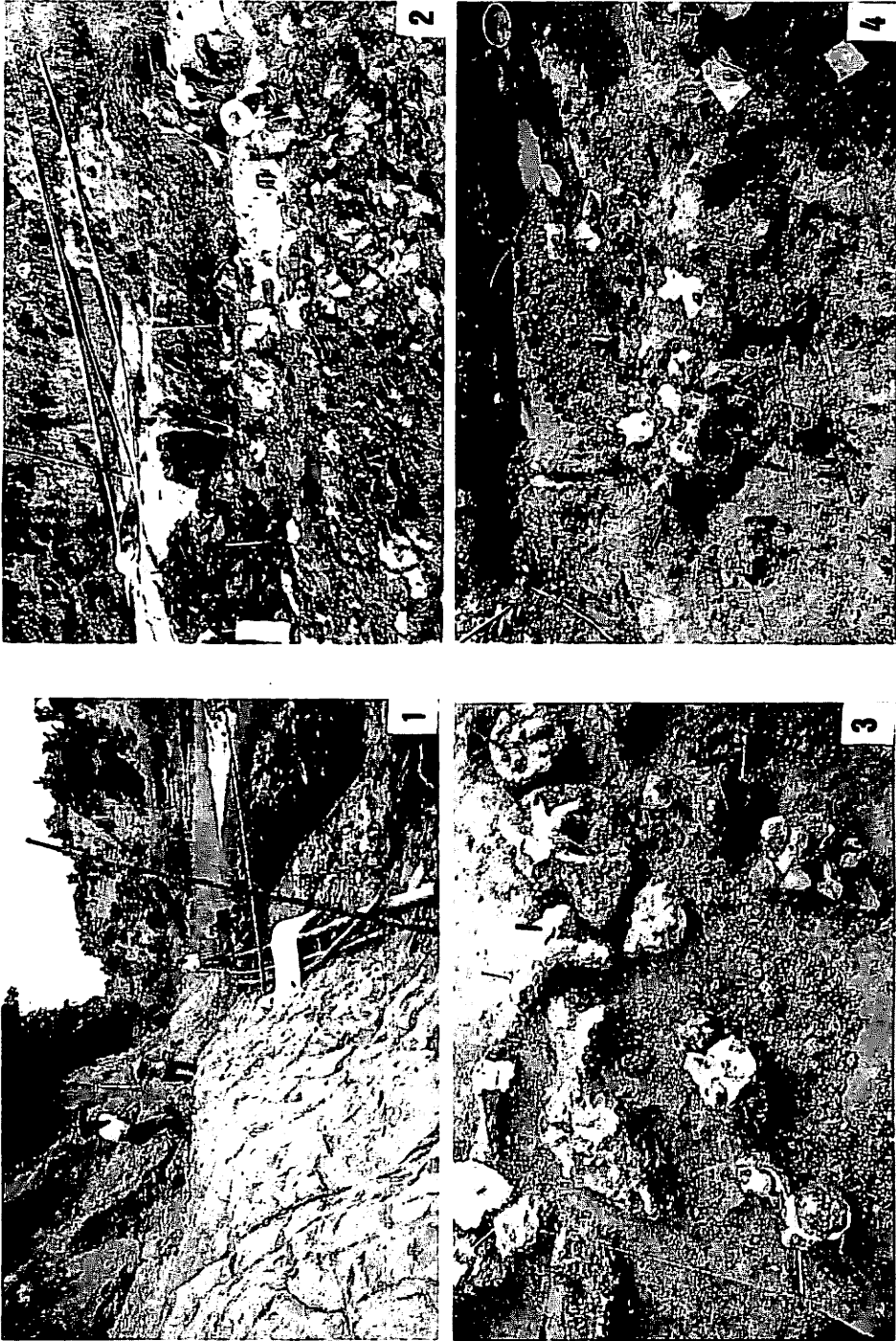


Plate 1

- Fig. 1. Beginning of the excavation of the fossil *Rhinoceros* at Ch'ochü of Ch'alliao River. River terrace deposits (upper) covers the bluish grey mudstone bed (KU 4) of the Chiting Formation.
- Fig. 2. The mudstone bed cut down to the level of bone bed.
- Fig. 3. The mudstone bed was removed out until each bones were exposed on the ground and the bones with mudstone attached were separated into many blocks to make easy to picked up.
- Fig. 4. Exposed fossil *Rhinoceros* on the ground.



- Fig. 1. Exposed fossil *Rhinoceros*.  
 Fig. 2. Blocks with bone attached were coated firmly with plaster to prevent a damage.  
 Fig. 3. The stuffs of the excavation.  
 Fig. 4. Excavaged antler of Taiwanese "Su-pu-shan" (*Elaphurus formosanus*).  
 Fig. 5. Restored rhinoceros bones were arranged tentatively on the floor of the Taiwan Provincial Museum in Taipei.



Figs. 1-6. Restoration works of rhinocid skeletons in Taiwan Provincial Museum in Taipei.

Fig. 1. Restoration work of lower jaw by late Prof. T. Shikama of Yokohama National University.

Fig. 2. For the restoration of the bones to the original state, crushed fragile pieces in blocks were photographed to keep the relationships of the each pieces on record.

Fig. 3-6. Restoration works of bones by late Prof. T. Shikama, the senior writer (Otsuka) and the university students of geology course of the National Taiwan University.

Plate 4



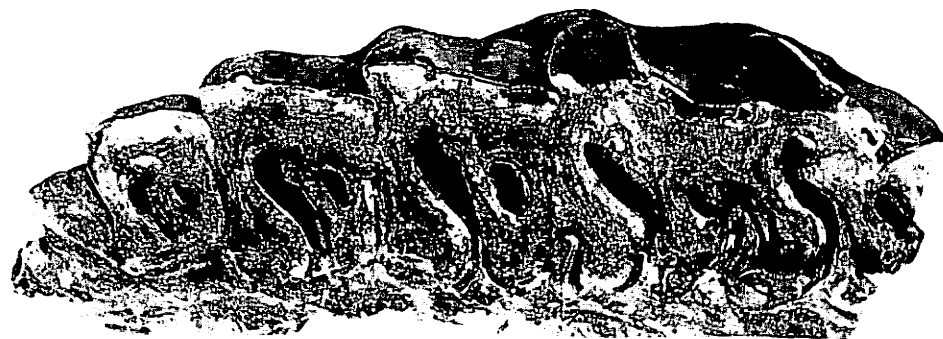
1a



1b



2a



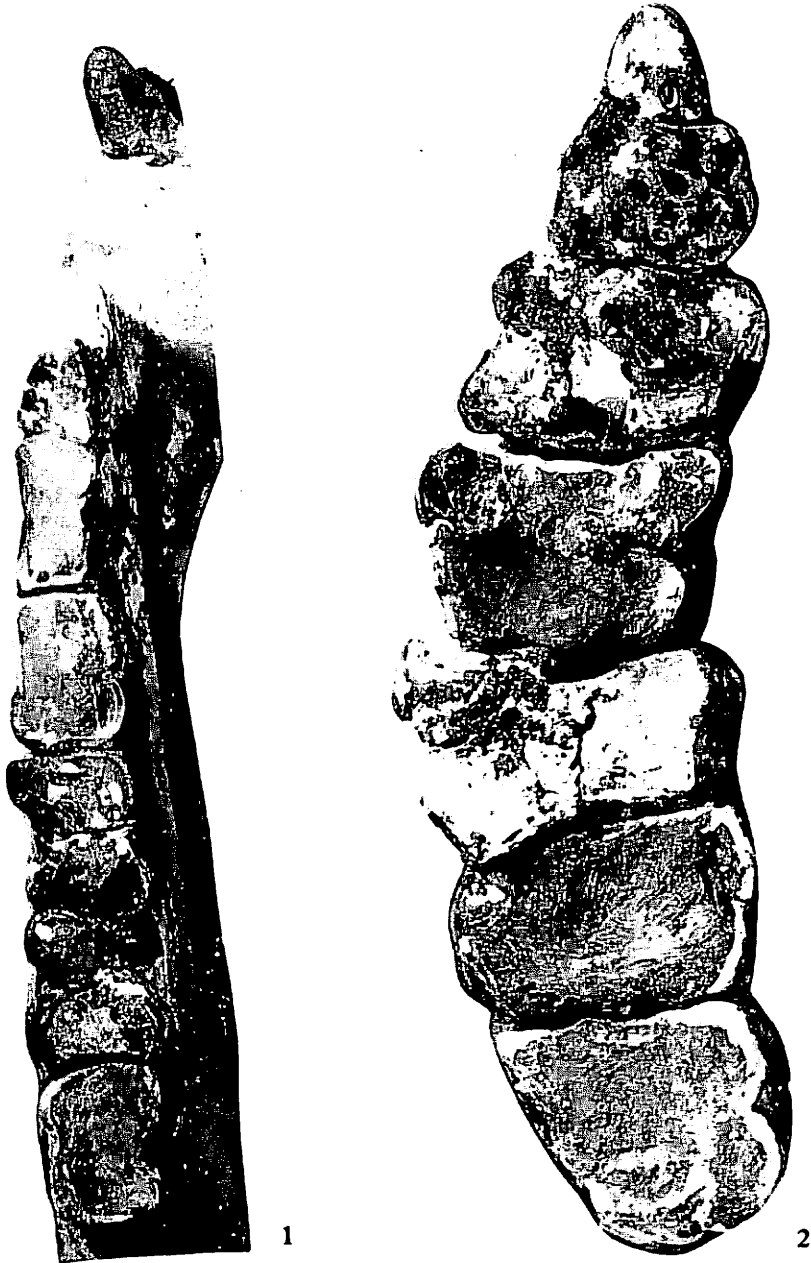
2b

Fig. 1 and 2. *Rhinoceros sinensis hayasakai* subsp. nov.

Fig. 1. A right upper cheek teeth (P3-M3) (Specimen No. 1). Outer (a) and occusal (b) views, x 0.6.

Fig. 2. A left upper cheek teeth (P1-M2) (Specimen No. 2). Outer (a) and occusal (b) views, x 0.6.

Both teeth row have been shown in Hayasaka's paper (Hayasaka, 1942, Plate V, figs. 2a and 2b). Last molar of the left teeth (fig. 2) is now missing.

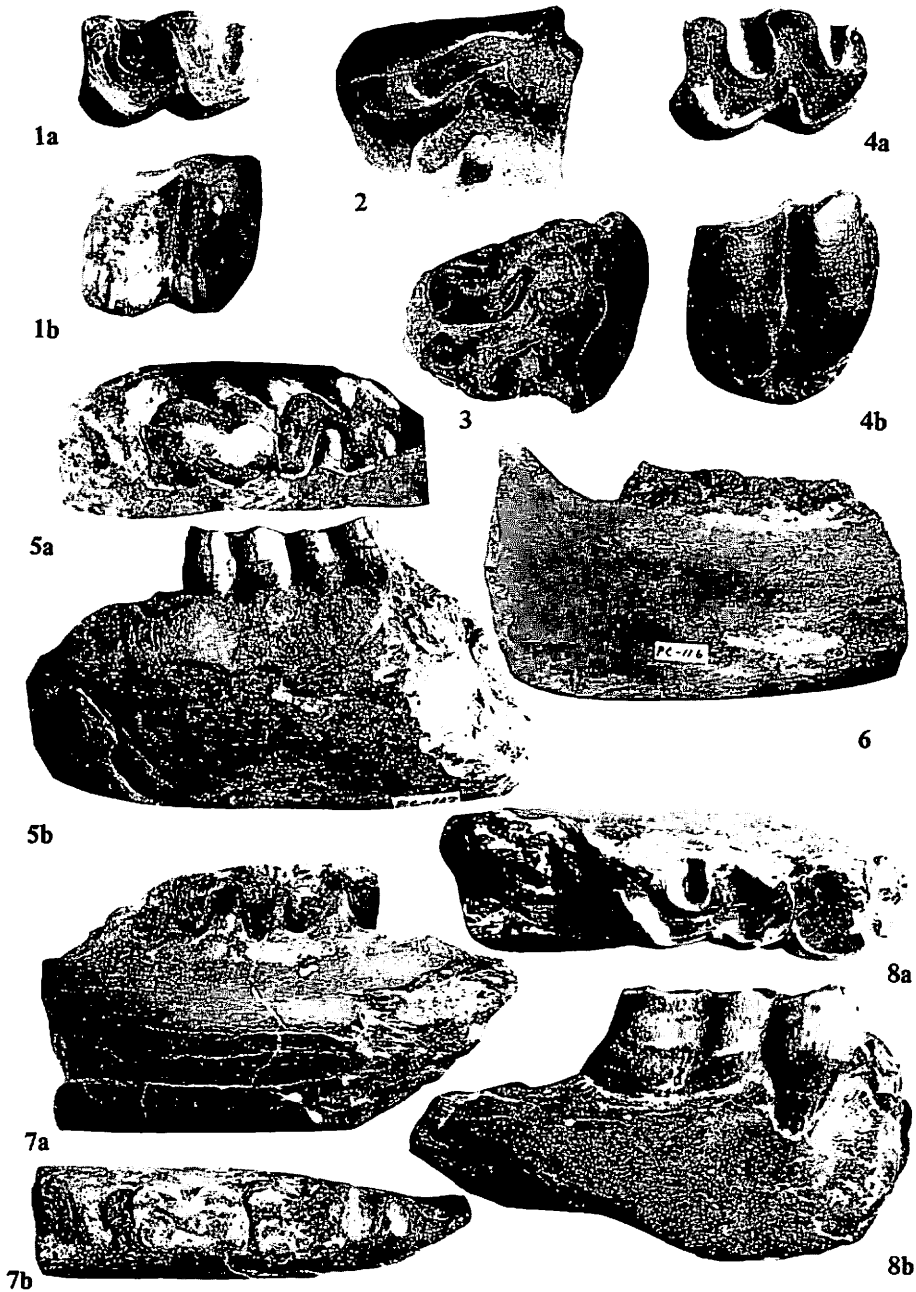


Figs. 1 and 2. *Rhinoceros sinensis hayasakai* subsp. nov.

Fig. 1. A left lower jaw with cheek and incisor teeth attached (Specimen No. 5). Occlusal view, x 0.5.

Fig. 2. A right upper cheek teeth (P1-M3) (Specimen No. 4). Occlusal view, x 0.6.





Figs. 1-8. *Rhinoceros sinensis hayasakai* subsp. nov.

Fig. 1. A right lower M1 (Specimen No. 20; CM-002). Occusal (a) and outer (b) views, x 0.6.

Fig. 2. A left upper M1 (Specimen No. 1; PC-119). Occusal view, x 0.6.

Fig. 3. A left upper M1 (Specimen No. 22, the Su's Collection). Occusal view, x 0.6.

Fig. 4. A right lower M2 (Specimen No. 18; P-121). Occusal (a) and outer (b) views, x 0.6.

Fig. 5. A left lower jaw with P4-M2 attached (Specimen No. 16; PC-117). Occusal (a) and outer (b) views, x 0.5.

Fig. 6. A left lower jaw with M1-M3 attached (Specimen No. 15; PC-116). Inner view, x 0.3.

Fig. 7. A left lower jaw with P4-M2 attached (Specimen No. 19; CM-001). Inner (a) and occusal (b) views, x 0.5.

Fig. 8. A right lower jaw with M1 and M2 attached (Specimen No. 21; YB-001). Occusal (a) and outer views, x 0.5.

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