THE PLEISTOCENE FOSSIL SUIDS FROM CHOCHEN, TAINAN, SOUTHWESTERN TAIWAN

GUQ-QIN Qi[1], CHUAN-KUN HO[2] and CHUN-HSIANG CHANG[3]

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China.
2. Department of Anthropology National Museum of Natural Science, Taichung, Taiwan 404, R.O.C. E-mail: ckho@mail.nmns.edu.tw.
3. Department of Geology, National Museum of Natural Science, Taichung, Taiwan 404, R.O.C. E-mail: cch@mail.nmns.edu.tw.

ABSTRACT - Fourteen isolated teeth of fossil suids described in this paper were originally collected from the Chiting Formation of the Tsailiao and Yanshui Rivers, Tainan Country, southwestern Taiwan. The teeth are assigned to *Sus houi* nov. sp., *Sus* cf. *Australis*, and *Potamochoerus* sp. taxonomically and are redated to the Chochen fauna of the early-middle Pleistocene chronologically.

KEY WORDS: Chiting Formation, Fossil suids, Chochen fauna

INTRODUCTION

Fourteen isolated teeth of fossil suids described in this paper were originally collected from the Chiting Formation, Chochen, Tainan County, Taiwan. The Chiting Formation, exposed in an area along the Tsailiao and Yanshui Rivers, is composed of sand and silt beds more than 2000 m thick. It is divided into lower and upper members. The relative age of the lower Chiting Formation is probably Pliocene. The upper Chiting Formation, allocated to the early-middle Pleistocene based on the rich mammalian fossils, has been further divided into six members (Tables 1-2). Most of the mammalian fossils were collected from the river beds of the Tsailiao and Yanshui Rivers after seasonal heavy floods, while others were unearthed *in situ*. The teeth of suid fossils in the present study have been tentatively assigned to three different taxa: *Sus houi* nov. sp., *Sus* cf. *australis,* and *Potamochoerus* sp. Such taxonomic reassignment may provide a new baseline for future redating of the Chochen fauna assemblage.

SYSTEMATIC DESCRIPTION

Artiodactyla Owen 1848
Suidae Gray 1821
Sus Linnaeu 1758
Sus houi nov. sp.
(Fig. 2, A-F)

Type: 1 right M3 (HZ-9; Specimen's Catalogue No.)

Hypodigm: 1 right M2 (HZ-11); 1 left M3

Bulletin of National Museum of Natural Science, No.12, PP. 33-40, 1999

Table 1
Section name, thickness, lithological characters, and mammalian zones of each member in the Upper Chiting Formation

Section name	Thickness(m)	Lithological Characters	Mammalian Zones
6.Niushishui	300	Brownish thick loose sandstone	*Mammuthus armeniacus taiwanicus* Zone
5.Sanchunghsi	230	Bluish gray blocky loose sandstone	*Elaphurus formosanus-Rhinoceros sinensis*
4.Kuoling	330	Thin sand and loose sandstone interbed	hayasakai Zone
3.Tishuitsi	290	Black greyish blocky loose sandstone	*Stegodon* (P.) *akashiensis-Stegodon sinensis* Zone
1.Kanglin	510	Blocky loose sandstone (Upper)	
		Sand and sandstone interbed (Lower)	

(after Otsuka 1978; Chung 1991)

Table 2.
Biostratigraphic range of Chochen faunal assemblages

Upper Chiting						Faunal Assemblages
1	2	3	4	5	6	
				.....	.....	*Mammuthus armeniacus taiwanicus*
		.....	.....	.....		*Elaphurus formosanus, Muntiacus* cf. *Bohlini, Muntiacus* sp.
			.....			*Rhinoceros sinensis* hayasakai
		.....	.....	.....		*Sus* sp., *Macaca* sp., *Panthera* sp., *Bubalus* sp.
		.....	.....	.....		*Cervus*(S.) *sintikuensis, Cervus*(S.) sp., *Cervus*(R.)
		.....	.....			*Stegodon sinesis*
		.....				*Stegodon*(P.) *akashiensis*

(Modified after Otsuka, 1978)

(HZ-14); 1 right M3 (HZ-10); 1 left m1 (HZ-13); 1 right m2 (HZ-12).

Locality and horizon: Chochen, Tainan County, Taiwan; Upper Chiting Formation; early-middle Pleistocene.

Diagnosis: A small species belonging to *Sus*. It is slightly larger than *Sus xiao* Zhu, and about the same size as *Chleuastohoerus stehlini*. There are 4 main cusps and a few secondary cusps with simple enamel folds on the occlusal surface of the molars. Both M2 and m2 are rectangular in shape. M3 is relatively long and has a slightly contracting talon which is composed of a larger cusp.

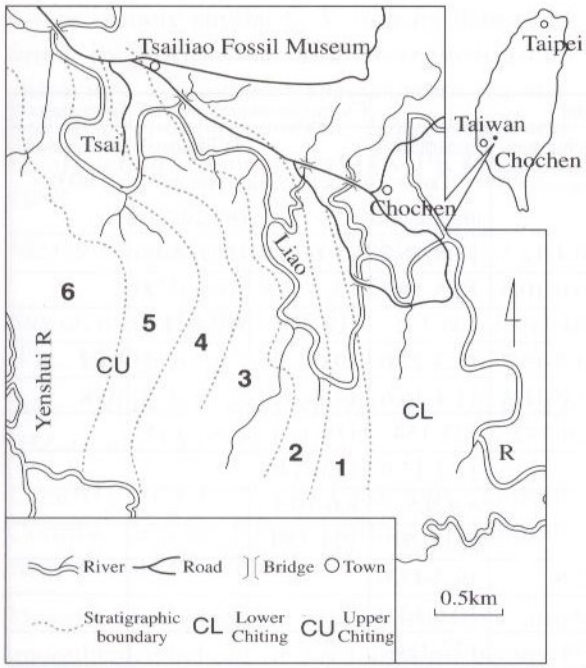
Etymology: The species name is dedicated to Mr. Hou Liren, a local fossil collector, who owned the specimens.

Description:

M2 (HZ-11; Fig. 2A) The tooth is worn. All the roots are damaged. The occlusal surface is rectangular in shape. There are 4 main cusps. Only 1 secondary cusp is apparent in the middle valley. There is a small cusp in the valley on the labial side. The anterior cingulum is wider than the posterior one.

M3 (HZ-9;10,14; Fig. 2 D,E,F) All specimens are worn. The outline of the occlusal surface is elongated triangular. The talons are slightly contracted. The roots of both HZ-9 and HZ-10 are damaged and are partly damaged in HZ-14.

Right M3 (HZ-9; Fig. 2F) is worn so much that the front 2 main cusps connect with the hypocone. The metacone forms an isolated



Text-figure 1
Fossil localities in Chochen, Tainan.

enamel circle. The talon consists of a cusp which is about the size of the main cusp. There is a larger secondary cusp between the metacone and talon. In addition to the accessory cusp of the middle valley, a small accessory cusp is present in the labial side valley.

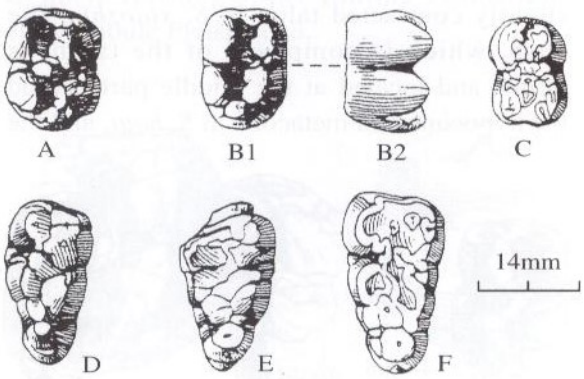
Right M3 (HZ-10; Fig. 2D) is slightly worn. The secondary cusp between the metacone and talon is larger than the talon cusp; left M3 (HZ-14; Fig. 2E) is quite worn. On the labial side are 2 main cusps and 1 talon forming 3 concave pits. As in HZ-9, the talon cusp is about the size of the main cusp.

M1 (HZ-13; Fig. 2C) The posterior margin of the occlusal surface is wider than the anterior margin. The protoconid and paraconid are slightly visible, and the anterior cingulum is unclear because of wear. The metaconid and hypoconid connect with the posterior cingulum. In the posterior half of the tooth, the occlusal surface is a concave plane which inclines to the rear.

M2 (HZ-12; Fig. 2B) is unworn. The 4 main cusps are very clear. The front cingulum is depressed and beaded. The posterior one is strong forming a distinct heel. The 2 lingual cusps form a wall, and only on the buccal side is the transverse valley slightly open. The rest of the transverse valley is blocked by a higher crown when compared with *C. stehlni* and *S. xiaozhu.*

Comparison and discussion: During the Pliocene-Pleistocene, 2 small-sized suids were common in China. One was *Chleuastochoeru stehlini* from the *Hipparion* bed in North China. The other was *Sus xiaozhu* which lived in South China in the early-middle Pleistocene. The newly discovered species is similar to *C. stehlini* in size.

The following characters of the newly discovered species (*S. houi*) differ from those of *C. stehlihi*: (1) M2 of the new species is longer and narrower; (2) the cusp structure of the upper and lower molar is more complex in *S. houi* than in *C. stehlini*; (3) the main cusps are close together, thus the tooth valley is narrower in *S. houi*; (4) the cingulum of the upper molar only exists in the anterior and posterior ends in *S. houi*, but can extend to the



Text-figure 2
Teeth of *Sus houi* (occlusal and lingual views).
A. right M2 (HZ-11); B. right m2 (HZ-12);
C. left ml (HZ-13); D. left M3 (HZ-10);
D. right M3 (HZ-14); F. right M3 (HZ-9).

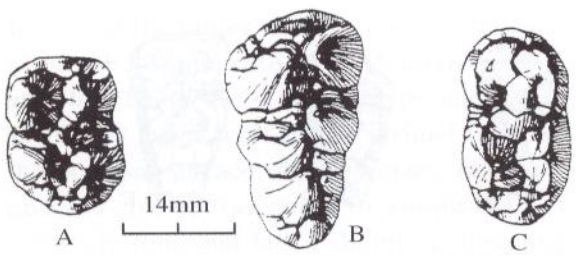
Table 3.
Measurements of the molars of *Sus houi* (in mm)

TEETH		Samples of this study			*Sus xiaozhu*				*Chleuastochoerus stehlini*		*Sus sangiranensis*
					Longgupo, Wushan (Huang *et al.*,1992)	Tungpaoshan (Wang *et al.*,1982)	Pichiashan (Han *et al.*,1928)	Gigantopithecus Cave (Han *et al.*,1987)	(Person, 1928)	IVPP fossil samples (RV.2800.1)*	(Koenigswald, 1933)
M2	L	18.0			14.0-16.0	12.4	10.4-12.3	13.8-16.8	15.1-18.8	15.1(L):16.0(R)	
	W	15.8			11.8-14.0	11.1	10.0-10.3	12.5-14.3	13.2-15.8	14.6(L):13.7(R)	
	L/Wx100	120				111	104-119	100-131	103-125	103 : 117	
M3	L	22.3	24.0	27.0		16.3 16.5	14.3-15.7	16.3-22.0	19.0-24.6	17.0(L):18.1(R)	16.3
	W	14.5	13.0	15.0		11.4 11.2	11.0-11.3	11.4-16.6	14.2-16.0	12.5(L):12.7(R)	10.8
	L/Wx100	153	184	180		142 147	126-142	127-154	119-159	136 : 142	
m1	L	15.5			13.8-18.5			11.2-13.6	12.0-14.8		
	W	11.0			11.0-11.8			8.4-9.5	8.6-10.5		
	L/Wx100	140						131-159	124-159		
m2	L	18.0			13.8-18.5	13.2	12.8	14.3-17.6			
	W	12.4			11.0-11.8	8.7	8.6	10.6-12.0			
	L/Wx100	145				151	148	132-156			

*Author's measurements

buccal side in *C. stehlini*; and (5) the main cusps on the lower molar separate at a position a certain distance from the tooth base in *S. houi*, but at the tooth base in *C. stehlini*.

The new species is larger than *S. xiaozhu* in size. Its upper molars are also longer and narrower than those of *S. xiaozhu*. M3 has a slightly contracted talon in *S. xiaozhu*. The cusp, which is composed of the talon, is larger, and located at the middle part behind the hypocone and metacone in *S. houi*, and the talon is strongly contracted. The cusp is smaller and located behind the hypocone is *S. xiaozhu*. The main cusps are relatively small and the secondary cusps are relatively large in *S. houi* in contrast to those of *S. xiaozhu*.



Text-figure 3
Teeth of *Sus* cf. *S. australis* (occlusal views).
A. right M2 (HZ-6); B. left M3 (HZ-1);
C. left m2 (HZ-8).

Other small-sized fossil suids have also been found in China such as *Sus* sp. A (Xu et al., 1974) which is sometimes referred to as *S. xiaozhu*, *Sus officinalis*, and *Sinohyus minimus* (Koengswald 1963), with only a m3 and a m1. Among our specimens, there was no m3, thus it was difficult to compare *S. houi* and *S. officinalis*. HZ-12 is an m2, similar to the m1 of *S. nimimus* in shape. However, the Chochen specimens are larger and the cusps are less swollen than those in *S. minimus*.

Some smaller species of *Sus* were discovered in Southeast and South Asia, such as *S. sangiranensis* from Indonesia (Koengswald, 1933), as well as *S. adolenscens*, *S. pelegrinus*, and *S. bakeri* from the Sivalik beds of the Indo-Pakistani sub-continent (Pilgrim, 1926: Colbert, 1935). *S. sangira-*

nensis is more similar to *S. xiaozhu* than to *S. houi* in both size and morphological characters. The other 3 species were reassigned to *Propotamochoerus, Hippohyus,* and *Hyotherium,* respectively, by Pickford in 1988.

Measurements: (in mm; see Table 3)

Sus cf. ***australis*** Han, 1987
(Fig. 3A-C)

Type: Isolated 1 right M2 (HZ-6), 1 left M3 (HZ-1) and 2 left m2.

Locality and horizon: Chochen, Tainan County, Taiwan; Upper Chiting Formation; early-middle Pleistocene.

Description: The teeth are all worn and undoubtedly belong to *Sus* based on occlusal morphology.

M2 (HZ-6; Fig. 3A) is rectangular. There are 4 main cusps and a secondary cusp located in the median valley. The anterior cingulum is wider than the posterior one. The central part rises upward and forms a small cingulum cusp. Several small cusps are apparent on the buccal side.

M3 (HZ-1; Fig. 3B) is longer and narrower than that of the common *Sus*. The anterior margin of the occlusal surface looks very oblique. The cusp, which is composed of the talon, is large, low, and located behind the hypocone. The posterior margin is covered by 1 large and 2 small accessory cusps.

M2 (HZ-7, 8; Fig. 3C) is also rectangular in shape. The cusp of the posterior cingulum is larger and at the same height or slightly lower than the metaconid and hypoconid.

Comparison and discussion: S. lydekkeri and *S. scrofa* are 2 common medium-sized middle-late Pleistocene *Sus* in China. It is possible that some of the described specimens have been included in the taxa of *S. scrofa* or even *Sus* sp. (Person, 1928; Han, 1975; Han, 1982). Since the early 1970s, Han (1974, 1987) has assigned several new species to *Sus* (*S. bijiashanensis, S. australis, S. liuchengensis,* and *S. peii*) based on the rich materials unearthed from Pleistocene cave deposits in South China. The specimens described in this paper are closer to *S. australis* than to any of the other mentioned species in terms of size and morphological characters. They all share long and narrow molars, low and conical cusps, and simple folds on the occlusal surface of the upper and lower molars.

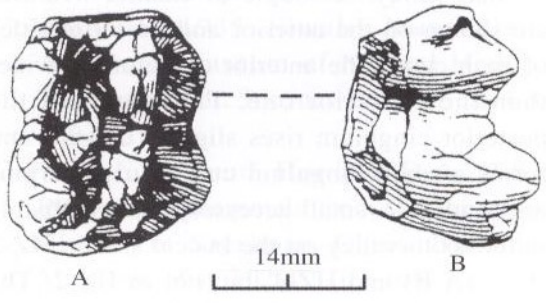
Koenigswald (1933) described a few medium-sized *Sus* fossils unearthed from Pleistocene beds in Indonesia: *S. brachygnathus, S. macrognathus,* and *S. stremmi.* They differ from the Chochen specimens on morphological grounds. *S. comes* and *S. hysudricus* from the Sivalik beds of India are closer to the Chochen specimens in size but have both been denounced as *Sus* by Pickford (1988).

Measurements: (in mm; see Table 4)

Potamochoerus sp.
(Fig. 4A-B)

Type: Isolated 2 left M2 (HZ-3.4) and 2 right M2 (HZ-2.5).

Locality and horizon: Chochen, Tainan County, Taiwan; Upper Chiting Formation; early-middle Pleistocene.



Text-figure 4
Potamochoerusus sp. left M2 (HZ-3).
A. occlusal view;
B. lingual view.

Table 4.
Measurements of the molars of *Sus* cf. *australis* (in mm)

TEETH		Samples of this study	*S. australis*		*S. scrofa*			*Sus* sp.	
			Gigantopithecus Cave (Han *et al.*, 1987)	Yanching Kou (Colbert *et al.*, 1953)	*Gigantopithecus* Cave (Han *et al.*, 1987)	Yanching Kou (Colbert *et al.*, 1953)	Paote (Person, 1933)	Pichiashan (Han *et al.*,1975)	Tahsinghai heitung (Han *et al.*,1987)
M2	L	23.2	23.2	20.3-26.5	21.0	16.0-23.0	23.8 : 22.2	23.2 : 25.0	
	W	16.2	20.5				21.0 : 19.7	21.3 : 21.0	
	L/Wx100	143	113						
M3	L	34.0	30.0-35.3	33.5-44.5	35.8	29.4-34.4	37.5 : 35.3	32.2-38.5	31.0-39.0
	W	19.2	18.8-23.5				23.7 : 21.6	21.0-24.5	20.0-22.3
	L/Wx100	177	150-178						
m2	L	26.5 :23.0	22.0	20.3-25.6	23.0	18.5-19.3		24.0 : 23.4	
	W	15.5 : 16.5	16.5					16.5 : 14.7	
	L/Wx100	160 : 139	133						

Table 5.
Measurements of the upper molars of *Potamochoerus* sp. (in mm)

TEETH		Samples of this study					*P. hyotherioides* (Person, 1928)	*P. nodosarius* (Han, 1987)	*P. chinhsienensis* (Li, 1963)
		HZ-2	HZ-2	HZ-2	HZ-2	(Range)			
M2	L	26.0	24.0	23.5	25.5	23.5-26.0	24.5	21.8	27.5
	W	20.1	20.0	19.6	21.9	19.6-21.9	21.6 ; 22.2	17.2	21.5
	L/Wx100	127	120	120	116	116-127	113 ; 110	127	127

Description and discussion: Type specimens are larger than those of the 2 above-described species. The teeth are all unworn. The main cusps on the occlusal surface are conical in shape, and a secondary cusp is present in the median valley. A couple of enamel wrinkles are shown on the anterior and posterior sides of each cusp. The anterior cingulum is wider than the posterior one. The center of the posterior cingulum rises slightly upward and forms a small cingulum cusp. Cusp margins are beaded. A small accessory cusp is visible in the tooth valley on the buccal side in HZ-3 (Fig. 4A-B) and HZ-4, but not in HZ-2. The cusp extends posteriorly and forms a portion of the cingulum. The tooth valley on the lingual side is V-shaped in profile and has several very small cusps on the anterior and posterior margins at the valley basin.

HZ-5 shows different occlusal patterns: the hypocone is damaged; the metacone is positioned posteriorly; the buccal cusp at the basin of the tooth valley is relatively large and does not extend posteriorly or form a cingulum. Four aforementioned M2 are equal to *S. lydekkeri, Dicryphochoerus ultima,* and some species of *Potamochoerus* in size. However, it is extremely hard to assign them to the former 2 genera morphologically. They should be assigned to *Potamochoerus* instead. In comparison with M2 of *Sus lydekkeri*, M2 of *Potamochoerus* has more complex enamel wrinkles, more accessory cusps, steeper cusps, and a relatively narrow tooth valley. In comparison with M2 of *Dicryphochoerus ultima,* the M2 of *Potamochoerus* is squarer in

shape with simple enamel wrinkles and an anterior cingulum cusp. The Chochen specimens are closer to *P. hyotherioides* both in size and morphological characters.

DISCUSSION

The Chochen fauna assemblage has been studied since the early 1930s. Both Japanese and Taiwanese scholars have made systematic geological surveys in the Chochen since the 1970s, and have designated the stratigraphic beds to the Upper Chiting Formation. After studying a large collection of Proboscidea and Cervidae fossils collected from the Chochen, most scholars have estimated the date of Chochen fauna assemblage as middle-upper Villafranchian, which is early-middle Pleistocene (Shikama et al., 1975; Otsuka et al., 1978). Since the 1980s, additional research conducted by Japanese and Taiwanese scholars has indicated that the relative date of this fauna is upper-post Villafranchian which is equivalent to the mammal age of the Gongwangling to Zhoukoudian Loc. 1 faunal sequence in northern China.

This study confirms the estimated date of Chochen fauna based on additional index species *Muntiacus* cf. *bohlini, Elaphurus formosanus, Rhinoceros s. hayasakai,* and *Mammuthus a. taiwanicus.* Of all three forms described in this paper, *S.* cf. *australis* is the index fossil of the early Pleistocene of South China. It is our suggestion that *Potamochoerus* sp. be assigned species status based on similarities with *hyotheriodes.* Sizewise, we propose that *Sus houi* be considered as a new species. The major differences between *Sus houi* and *S. xiaozhu* and *Chleuastochoerus stehlini* make it impossible to associate the same date with *S. scrofa* due to the latter's simple enamel wrinkles and cusp morphology. Thus, the present study of three fossil suids may provide new insight on the dating of the Chochen fauna assemblage.

In comparison to the faunal assemblages with corresponding time periods in North and South China, the Chochen fauna is characterized as follows: (1) Some are identical at the species level and others are similar subspecies; (2) Chochen fauna consists of the same species discovered in South and North China, even in the same time span of Japan and Europe; (3) The primitive *Mammuthus* co-existed with *Stegodon,* while lacking the common forms of *Euclacdoceros boulei* and *Megaloceros* pachyosteus in North China and *Elaphurus formosanus* (an intermediate form between *E. bifurcatus* and modern *E. davidianus*), and prevailing forms like *Cervus (S.) sintikuensis* (a small Sika). No *Proboscihipparion sinensis* or any species of *Equus* have been found in this fauna. We believe that paleoecological settings in Chochen during the early-middle Pleistocene may have differed from those of North and South mainland China due to Taiwan's unique paleogeographic location.

REFERENCES

Chung, K. C., 1991. Geomorphological and Preliminary Geological survey of Hsinhwa Hill, Tainan Country. Tainan Provincial Cultural Center ed. Special Publication on Fossils Unearthed from Tsailiao River, Chochen, Tainan Province, Pp.40-58.

Colbert E.H.,1935. Siwalik Mammals in American Museum of Natural History. Trans. Am Phil. Soc. new ser. Vol. 26, I-X, 300-401.

Colbert E.H., and Hooijer D.A.,1953. Pleistocene mammals from the limestone fissures of Szechuan, China. Bull. Am Mus. Nat. Hist. 102(1): 102-105.

Koenigswald G.H.R. Von,1933. Beitrag zur Kenntrnis der fossilen Wirbeltiere Javas. Tail I. Dienst Mijnb. Nederlandsch-Indie,Wetensch. Meded., No.23, 31-54.

Koenigswald G.H.R. Von,1963. Fossil pygmy Suidae from Java and China. Koninkl. Nederl. Akademie van Wetenschappen-Amsterdam from Proceedings, Series B, 66 (4): 192-197.

Otsuka H. and Shikama T.,1978. Fossil Cervidae from the Tou-kou-shan Group in Taiwan. Reports Faculty Sci. Kagashima Univ. (11): 27-59.

Otsuka H., and Lin C.C.,1984. Fossil *Rhinoceros* from the Toukoushan Group in Taiwan. J. Taiwan Mus. 37(1): 1-36.

Otsuka H.,1984. Stratigraphic position of the Chochen vertebrate fauna of the Toukoushan Group in the environs of the Chochen district, Southwest Taiwan. With special references to its geologic age. J. Taiwan Mus. 37(1): 37-56.

Pickford, M.,1988. Revision of the Miocene Suidae of the Indian Subcontinent. Munchner Geowisseschaftliche Abhandlungen Reihe A Geol. Palaontol. 12: 21-83.

Person, H. S.,1928. Chinese fossil Suidae. Paleontol. Sin. Ser. C.5(5): 11-67.

Pilgrim, G.E.,1926. The fossil Suidae of India. Mem. Geol. Surv. Indica Palaeontal. Indica 8(4): 1-68.

Shikama T., Otsuka H., and Tomida Y.,1975 Fossil Proboscidea from Taiwan. Science Reports Yokohama National Univ. Sec.2. No.221-62.

Young, C.C.,1932. On the Artiodactyla from the Sinanthropos Site at Choukoutien. Paleontol. Sin. Ser. C. 7(3): 5-13.

Zdansky, O.,1928. Die Saugetiere der Quartafaund Von Choukoutien. Paleontol. Sin. Ser. C. 5(4): 91-128.

Manuscript received May 15, 1999
Revised manuscript accepted December 8, 1999

台南左鎮更新世豬類化石

祁國琴　何傳坤　張鈞翔

摘要

台南新化丘陵發現了相當豐富的第四紀左鎮哺乳動物群。這批化石大多是從左鎮菜寮溪河床中採集而來。本文所描述的十顆豬類牙齒是台南侯立仁先生所收藏的。經牙齒化石型態及大小對比之後，可鑑定爲三種：*Sus houi* nov. sp.(侯氏豬)，*Sus* cf. *S. australis*(南方豬)及*Potamochoerus* sp.(河豬)。其中*Sus houi*是一種體型比*Sus xiazhu*(小豬)稍大，與*Chleuastochoerus Stehlini*(斯氏弓頜豬)相近的小型豬類。歸入*Sus* cf. *australis* 及*Potamochoerus* sp.的化石標本，分別與華南早更新世的*Sus australis*和華北三趾馬層中的*P. hyotherioides*(似豬獸河豬)相近。因此，根據以上三種豬類化石的發現和研究，進一步地確定左鎮動物群的年代屬於早至中更新世。

關鍵詞：崎頂組、豬斜化石、左鎮動物群