Jour. Geol. Soc. Japan, Vol. 123, No. 6, p. 433–441, June 2017 doi: 10.5575/geosoc.2017.0004

Report

A Pleistocene rhinocerotid (Mammalia, Perissodactyla) from the Bisan-Seto area, western Japan

Naoto Handa[*] *and Yasushi Takechi*[**]

Received September 30, 2016
Accepted January 28, 2017

[*] Museum of Osaka University, 1-20 Machikaneyama-cho, Toyonaka, Osaka 560-0043, Japan
[**] Kurashiki Museum of Natural History, 2-6-1 Chuou, Kurashiki, Okayama 710-0046, Japan

Corresponding author: N. Handa, k1552325@kadai.jp

Abstract: We describe the characteristics of a Rhinocerotidae femur and tibia found within sea-floor sediments in the Bisan-Seto region, western Japan, a region for which the mammal fauna has been assigned the Middle Pleistocene age. Based on morphological and metrical comparisons between the studied specimens and those from Pleistocene rhinoceroses from Eurasia (*Stephanorhinus*, *Coelodonta*, and *Rhinoceros*), the studied specimens can be referred to as *Stephanorhinus* sp., although their more specific identification is not possible given a lack of further skeletal elements. Nevertheless, our study confirms the presence of *Stephanorhinus* during the Middle Pleistocene in Japan and supports similar finds elsewhere in western Japan (e.g., Isa in Yamaguchi Prefecture).

Keywords: Bisan-Seto area, Japan, Perissodactyla, Pleistocene, Rhinocerotidae

Introduction

The Quaternary sediments that are distributed on the seabed of the Seto Inland Sea in western Japan (Fig. 1) have yielded abundant land mammal fossils (Kurashiki Museum of Natural History, 1988). In particular, fossils have been discovered in the Bisan-Seto area of the Seto Inland Sea, which is situated between Okayama and Kagawa prefectures (Fig. 1). The mammal fossils that were collected by Mr. Keiichi Yamamoto are known as the "Yamamoto collection" (Kurashiki Museum of Natural History, 1988). Of these, a radius fragment and a tibia of rhinocerotid were tentatively described as Rhinocerotidae gen. et sp. indet. by Taruno (1988). A femur of rhinocerotid was also reported as Rhinocerotidae gen. et sp. indet. by Taruno (2000) without any descriptions or comparisons made.

In Japan, several rhinocerotid fossils have been described (Shikama, 1967; Shikama et al., 1967; Okazaki, 2007; Ogino et al., 2009; Handa, 2015; Handa and Pandolfi, 2016). However, the postcranial specimens of rhinocerotid from the Pleistocene have been poorly investigated. Therefore, the limb bone specimens from the Bisan-Seto area could provide knowledge of the postcranial specimens of the Pleistocene rhinocerotid in Japan. Of these, the radius is too fragmented to discuss its detailed morphology and taxonomic status. In contrast, the femur and tibia are almost completely preserved specimens (Fig. 2). Here, we re-describe the femur and tibia from the Bisan-Seto area.

In Japan, almost all of the Quaternary rhinocerotid fossils have been discovered from the Middle Pleistocene sediments, as is the cases with present specimens (Fig. 1). Shikama et al. (1967) reported *Dicerorhinus nipponicus* from the Middle Pleistocene in Isa, Yamaguchi Prefecture (Fig. 1a). Recently, this species was re-identified as *Stephanorhinus kirchbergensis* (Handa and Pandolfi, 2016). Handa and Pandolfi (2016) also noted that the tooth fragments of *Dicerorhinus* sp. from the Middle Pleistocene in Matsugae, Fukuoka Prefecture (Ogino et al., 2009), possibly belong to the same species. These results suggest the presence of *Stephanorhinus* in the Middle Pleistocene in Japan. The present study provides additional evidence to confirm this hypothesis.

Geological setting

The Plio-Pleistocene Mitoyo and Quaternary Bisanseto groups are distributed on the seabed of the Bisan-Seto area (Taruno and Yamamoto, 1988). The Bisanseto Group is divided into the Ozuchijima, Tsuchinotoseto, and Bannosu formations, in ascending order. Moreover, the Ozuchijima Formation is subdivided into the lower and upper parts (Taruno, 1988; Taruno and Yamamoto, 1988).

There are many small "sea basins" (basin A to Q: Taruno, 1988) in the Bisan-Seto area. The radius and tibia of rhinocerotid were collected from basins P and M, respectively (Taruno, 1988) (Fig. 1b). The Mitoyo Group and the Ozuchijima Formation are distributed in basin P and M (Taruno, 1988). The basins have yielded two species of the fossil Proboscidea, *Stegodon orientalis*

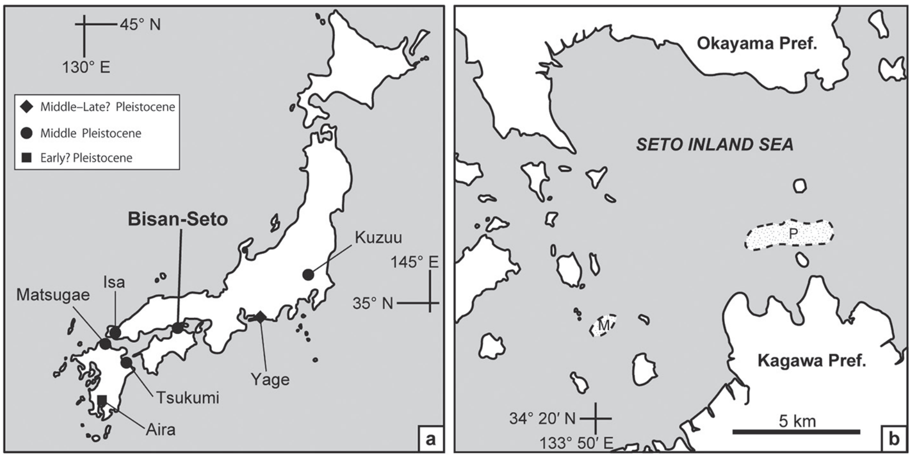

Fig. 1. a, Locations of the Pleistocene rhinocerotid in Japan (modified from Handa and Pandolfi, 2016); b, Map showing the localities of the rhinocerotid fossils in the Bisan-Seto area of the Seto Inland Sea (modified from Kurashiki Museum of Natural History, 1988). M: basin M; P: basin P.

Fig. 2. Rhinocerotid fossils from the Bisan-Seto area. a-d, left femur (YM-1048) in anterior (a), posterior (b), proximal (c) and distal (d) views; e-h, left tibia (YM-059) in anterior (e) posterior (f), proximal (g) and distal (h) views. Scale bars: 10 cm.

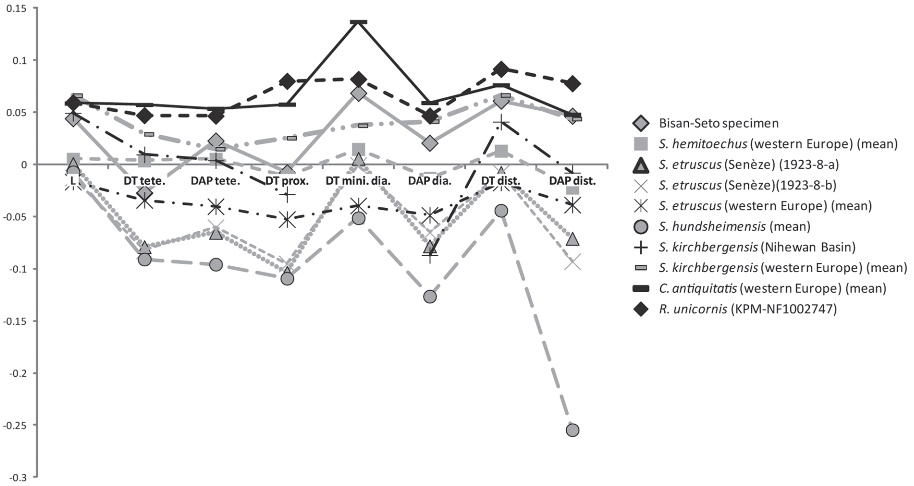

Fig. 3. The ratio diagram for the left femur (YM-1048) from the Bisan-Seto area and selected compared materials. Each value was calculated based on the methodology of Pandolfi and Tagliacozzo (2015). The standard values for ratio diagram were based on the data on the extant *Diceros bicornis* from Guérin (1980).

and *Palaeoloxodon naumanni* (Taruno, 1988). *Stegodon orientalis* was found in the Mitoyo Group or in the lower part of the Ozuchijima Formation. On the other hand, *P. naumanni* was discovered in the upper part of the Ozuchijima Formation. According to Kamei et al. (1988), occurrences of *S. orientalis* and *P. naumanni* in Japan are correlated with the middle Middle Pleistocene (QM4: Quaternary mammal zones in the Japanese Islands: Kamei et al., 1988) and the late Middle Pleistocene (QM5), respectively. Therefore, the age of the Mitoyo and Bisanseto groups in basins P and M would be the middle Middle Pleistocene to late Middle Pleistocene.

Although the femur was found on the Bisan-Seto seabed, the exact locality of the specimen is uncertain (Taruno, 2000). All of the sea basins in the Bisan-Seto area have yielded *S. orientalis* and/or *P. naumanni* (Taruno, 1988). Therefore, the femur is also probably derived from the sediments dating from the middle Middle Pleistocene to late Middle Pleistocene (Mitoyo or Bisanseto groups).

Material and methods

The specimens described here are stored in the Kurashiki Museum of Natural History, Kurashiki, Okayama Prefecture, in western Japan. The taxonomy used in the present study follows Heissig (1973, 1989). The metrical methodology uses the standard measurement method of the postcrania by Guérin (1980). The ratio diagram used in the present study follows Pandolfi and Tagliacozzo (2015): $A = \log_{10}(a/b) = \log_{10}(a) - \log_{10}(b)$; A = difference in log value; a = measurement of studied specimen; b = measurement of the standard specimen. This method is used for comparing the relative proportions between the studied specimen with the standard specimen. The differences in the relative proportions are evaluated based on the pattern of the line graph (Figs. 3, 4). The standard values for the ratio diagram are based on the data from the extant *Diceros bicornis* from Guérin (1980).

In this study, the specimens were morphologically compared with the following Pleistocene rhinocerotids from Eurasia: *Stephanorhinus kirchbergensis* from Taubach in Germany (Kahlke, 1977) and from Nihewan Basin in China (Tong et al., 2014); *S. hemitoechus* from Caune l'Alago in France (Lacombat, 2005) and from Neumark-Nord in Germany (van der Made, 2010); *S. etruscus* from Senèze in France (Lacombat, 2005) and from Valdarno supérieur, Italy (Mazza, 1988); *S. hundsheimensis* from Soleilhac in France (Lacombat, 2005); *Coelodonta antiquitatis* from Lodz in Poland (Borsuk-Bialynicka, 1973); *C. nihowanensis* from the Nihewan Basin in China (Tong and Wang, 2014); *Rhinoceros unicornis* (KPM-NF1002747).

The studied specimens were also metrically compared to the following taxa (Figs. 3, 4): *S. kirchbergensis* from Nihewan Basin in China (Tong et al., 2014) and western Europe (Guérin, 1980); *S. hemitoechus* from Neumark-Nord in Germany (van der Made, 2010), Lunel-Viel in France (Lacombat, 2005), and western Europe (Guérin, 1980); *S. etruscus* from Senèze in France (Lacombat, 2005) and from Valdarno supérieur, Italy (Lacombat, 2005), and from western Europe (Guérin, 1980); *S. hundsheimensis* from Pietrafitta in Italy (Lacombat, 2005) and from Soleilhac in France (Lacombat, 2005); *S.* aff. *hundsheimensis* from Ponte Molle in Italy (Pandolfi and Marra, 2015); *C. antiquitatis* from Lodz in Poland (Borsuk-Bialynicka, 1973) and from several areas in China (Tong and Wang, 2014) and western Europe (Guérin, 1980); *C. nihowanensis* from the Nihewan Ba-

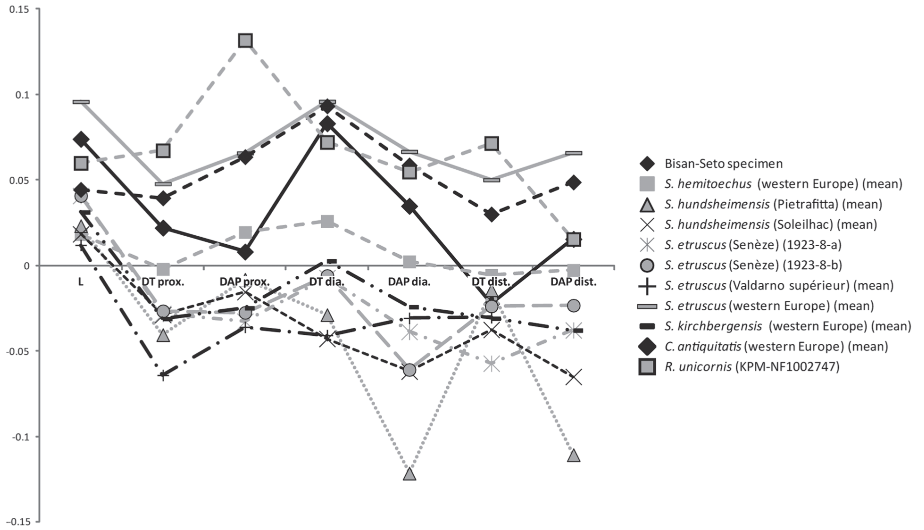

Fig. 4. Ratio diagram for the left tibia (YM-059) from Bisan-Seto and selected compared materials. Each value was calculated based on the methodology of Pandolfi and Tagliacozzo (2015). The standard values for the ratio diagram are based on the data on the extant *Diceros bicornis* from Guérin (1980).

sin in China (Tong and Wang, 2014); *R. unicornis* (KPM-NF1002747).

Although, several extinct species of *Dicerorhinus* (e.g., *D. kirchbergensis D. mercki*, *D. chukoutiensis*, *D. nipponicus*) have been found in Eurasia, They have been reassigned to *Stephanorhinus kirchbergensis* by several researchers (e.g., Handa and Pandolfi, 2016, and references therein). Other extinct species of *Dicerorhinus* from Europe have also been considered as several species of *Stephanorhinus* (e.g., Lacombat, 2005). Therefore, the extinct species of *Dicerorhinus* is considered as *Stephanorhinus* in this study.

The taxonomic status of *Rhinoceros* from Asia is still debated. Several species of *Rhinoceros* has been reported from Asia such as *Rhinoceros sinensis* and *R. sivalensis*. Recently, Antoine (2012) noted that these extinct species are included as synonyms for *R. unicornis*. On the contrary, Tong (2012) assigned *Rhinoceros sinensis* to two species of *Stephanorhinus*. Additionally, almost the postcranial skeleton of almost all extinct species of the genus *Rhinoceros* from Asia were poorly known. Thus, the detailed comparison with the studied materials and the specimens of the extinct taxa were difficult. Therefore, postcranial specimen of these extant species, *R. unicornis*, is used to comparison in this study.

Abbreviations for the femur (Table 1 and Figure 3). — L, length; **DT tete**., transverse diameter of the femoral head; **DAP tete**., antero-posterior diameter of the femoral head; **DT prox**., transverse diameter of the proximal part; **DT mini. dia**., minimum transverse diameter of the shaft; **DAP dia**., antero-posterior diameter of the shaft; **DT dist**., transverse diameter of the distal part; **DAP dist**., antero-posterior diameter of the distal part; **H 3t**, height of the third trochanter; **DT 3t**, transverse diameter of the shaft with the third trochanter.

Abbreviations for the tibia (Table 2 and Figure 4). — L, length; **DT prox**., transverse diameter of the proximal part; **DAP prox**., antero-posterior diameter of the proximal part; **DT dia**., transverse diameter of the shaft; **DAP dia**., antero-posterior diameter of the shaft; **DT dist**., transverse diameter of the distal part; **DAP dist**., antero-posterior diameter of the distal part; **DT artic. dist**., transverse diameter of the distal articular part; **DAP artic. dist**., antero-posterior diameter of the distal articular part.

Other abbreviations. —**mini**., minimum value; **max**., maximum value; **KPM**, Kanagawa Prefectural Museum of Natural History, Odawara, Japan; **LV**, Lunel-Viel, Hérault, France; **MPUR**, Museo di Paleontologia, Sapienza, University of Rome, Italy; **YM**, mammal fossil from the Yamamoto Collection in the Kurashiki Museum of Natural History; **ZAPUJ**, Zoological Museum, Jagiellonian University, Poland.

Systematic description

Order Perissodactyla Owen, 1848
Family Rhinocerotidae Owen, 1845
Subfamily Rhinocerotinae Owen, 1845
Tribe Rhinocerotini Gray, 1821
Genus *Stephanorhinus* Kretzoi, 1942
Stephanorhinus sp.
Fig. 2

Rhinocerotidae gen. et sp. indet. Taruno, 1988, p. 57, plate 147, figs. 3–4; Taruno, 2000, p. 31, plate 15, figs. 1–3.

Material. —A left femur, YM-1048; a left tibia, YM-059.

Table 1. Measurements of the left femur (YM-1048) and compared specimens (in mm). *: These specimens have the same catalogue number. Thus these are conveniently divided into "-a" and "-b" in this study.

Taxa	Reference	Area		L	DT tete.	DAP tete.	DT prox.	DT mini. dia.	DAP dia.	DT dist.	DAP dist.	H 3t	DT 3t	Remarks
Stephanorhinus sp.	present study	Bisan-Seto area, Japan		505	86	92	>192	80	62	151	182	>79	>117	YM-1048
Stephanorhinus kirchbergensis	Tong et al. (2014)	Nihewan Basin, China		511	94	89	183	-	48	145	161	69	136	96-SGT2:2
Stephanorhinus kirchbergensis	Guèrin (1980)	western Europe	mean	531	98	91	207	74	65	153	181	83	147	originally described as *Rhinoceros mercki*
			mini.	502	90	85	193	70	61	138	162	67	142	
			max.	573	103	97	222	78	66	176	198	97	162	
Stephanorhinus hemitoechus	van der Made (2010)	Neumark-Nord, Germany		503	-	-	212	-	-	151	182	-	-	
Stephanorhinus hemitoechus	Lacombat (2005)	Lunel-Viel, France		445	80	-	-	66	46	127	-	-	-	LV IV 14298
Stephanorhinus hemitoechus	Guèrin (1980)	western Europe	mean	462	93	89	190	70	57	136	155	76	140	originally described as *Dicerorhinus hemitoechus*
			mini.	434	83	81	180	63	50	124	121	59	123	
			max.	503	101	94	211	79	65	149	172	90	163	
Stephanorhinus etruscus	Lacombat (2005)	Senèze, France		457	77	75	154	69	49	129	139	67	138	1923-8-a*
Stephanorhinus etruscus	Lacombat (2005)	Senèze, France		443	76	76	157	68	50	129	132	-	-	1923-8-b*
Stephanorhinus etruscus	Lacombat (2005)	Valdarno supèrieur, Italy	mean	446	-	72	159	58	-	122	139	62	122	
			mini.	442	-	66	150	50	-	115	119	52	109	
			max.	450	-	82	169	65	-	131	150	70	136	
Stephanorhinus etruscus	Guèrin (1980)	western Europe	mean	439	85	80	173	62	52	126	150	65	125	originally described as *Dicerorhinus etruscus brachycephalus*
			mini.	406	74	72	158	49	45	116	140	49	107	
			max.	472	95	88	186	72	62	141	163	77	124	
Stephanorhinus hundsheimensis	Lacombat (2005)	Pietrafitta, Italy	mean	449	75	70	152	60	44	119	91	141	448	
			mini.	439	74	68	-	49	42	116	89	-	439	
			max.	467	76	73	-	67	45	123	93	-	465	
Stephanorhinus aff. *hundsheimensis*	Pandolfi and Marra (2015)	Ponte Molle, Italy		-	77	70	169	-	-	-	-	64	127	MPUR 1523-2
Coelodonta antiquitatis	Borsuk-Bialynicka (1973)	Lodz, Poland		452	97	92	207	87 -		148			148	ZAPUJ No. 683
Coelodonta antiquitatis	Guèrin (1980)	western Europe	mean	522	105	99	223	93	67	157	183	86	159	
			mini.	467	94	87	195	65	54	139	159	74	121	
			max.	576	116	113	249	112	89	170	202	104	185	
Rhinoceros unicornis	present study	-		523	102	98	235	82	65	162	196	133	167	KPM-NF1002747

Table 2. Measurements of the left tibia (YM-059) and compared specimens (in mm). *: These specimens have the same specimen number. Thus, they are conveniently divided into "-a" and "-b" in this study.

Taxa	Reference	Area		L	DT prox.	DAP prox.	DT dia.	DAP dia.	DT dist.	DAP dist.	DT artic. dist.	DAP artic. dist.	Remarks
Stephanorhinus sp.	present study	Bisan-Seto area, Japan		408	>128	>120	68	60	95	76	>70	61	YM-059
Stephanorhinus kirchbergensis	Guèrin (1980)	western Europe	mean	429	136	138	71	64	112	86	-	-	originally described as *Rhinoceros mercki*
			mini.	404	-	-	64	61	105	76	-	-	
			max.	457	-	-	80	70	128	92	-	-	
Stephanorhinus hemitoechus	Lacombat (2005)	Lunel-Viel, France	mean	355	-	-	55	52	97	66	71	-	
			mini.	-	-	-	53	50	96	62	68	-	
			max.	-	-	-	56	54	97	71	74	-	
Stephanorhinus hemitoechus	Guèrin (1980)	western Europe	mean	359	121	124	60	56	98	73	-	-	originally described as *Dicerorhinus hemitoechus*
			mini.	321	101	100	52	47	85	57	-	-	
			max.	400	138	130	70	63	114	87	-	-	
Stephanorhinus etruscus	Lacombat (2005)	Senèze, France		378	114	110	56	51	87	67	73	60	1923-8-a*
Stephanorhinus etruscus	Lacombat (2005)	Senèze, France		378	115	111	56	48	94	70	73	62	1923-8-b*
Stephanorhinus etruscus	Lacombat (2005)	Valdarno supèrieur, Italy	mean	354	105	56	51	51	60	-	-	-	
			mini.	336	87	41	46	46	57	-	-	-	
			max.	361	115	67	55	55	67	-	-	-	
Stephanorhinus etruscus	Guèrin (1980)	western Europe	mean	370	113	112	57	52	93	67	-	-	originally described as *Dicerorhinus etruscus brachycephalus*
			mini.	343	103	100	46	43	81	61	-	-	
			max.	395	124	126	68	66	104	73	-	-	
Stephanorhinus hundsheimensis	Lacombat (2005)	Pietrafitta, Italy	mean	363	111	116	53	42	96	57	78	36	
			mini.	-	-	-	50	35	88	-	67	-	
			max.	-	-	-	56	48	105	-	88	-	
Stephanorhinus hundsheimensis	Lacombat (2005)	Soleilhac, France	mean	359	114	114	51	48	91	63	68	54	
			mini.	358	109	113	51	46	91	61	65	52	
			max.	360	117	115	52	50	92	64	70	56	
Coelodonta antiquitatis	Guèrin (1980)	western Europe	mean	381	133	137	70	63	107	82	87	67	
			mini.	324	111	87	59	51	92	70	74	60	
			max.	433	163	158	83	77	127	98	97	79	
Coelodonta antiquitatis	Tong and Wang (2014)	Xiashagou, China		415-420	130	-	-	-	92-110	-	-	-	
Coelodonta antiquitatis	Tong and Wang (2014)	Chou-kou-tien, China		330-424	110-152	-	-	-	83-100	-	-	-	CKT Loc. 9
Coelodonta antiquitatis	Tong and Wang (2014)	Sjara-osso-gol, China		389-444	124-140	-	-	-	100-106	-	-	-	
Coelodonta antiquitatis	Tong and Wang (2014)	Northeast China		385	163	-	-	-	98	-	-	-	
Coelodonta antiquitatis	Tong and Wang (2014)	Europe		323.5-433	111-163	-	-	-	92-127	-	-	-	
Coelodonta antiquitatis	Borsuk-Bialynicka (1973)	Lodz, Poland		326	125	127	63	58	96	75	75	48	ZAPUJ No. 683-a*
Coelodonta antiquitatis	Borsuk-Bialynicka (1973)	Lodz, Poland		324	120	124	60	61	95	79	76	53	ZAPUJ No. 683-b*
Coelodonta nihowanensis	Tong and Wang (2014)	Shanshen-miaozui, China		395	124	-	-	-	96	-	-	-	
Rhinoceros unicornis	present study	-		395	142	160	67	63	117	76	-	-	KPM-NF1002747

Locality and horizon. —The Bisan-Seto area in the Seto Inland Sea, western Japan; the tibia was probably found in the Mitoyo Group or the Ozuchijima Formation. The femur was found in the Mitoyo or Bisanseto groups (detailed information of fossil-bearing stratum is uncertain); middle Middle Pleistocene to late Middle Pleistocene.

Measurements. —Shown in Tables 1 and 2.

Description. —The left femur (YM-1048) is well preserved (Fig. 2a–2d). The greater trochanter and the third trochanter are partially broken. The suture lines of the proximal and distal portions of the specimen are completely fused. The greater trochanter is lower than the femoral head in the anterior view. A lesser trochanter is weakly developed on the proximo-medial side of the femur. In the anterior view, the shaft of the femur is almost straight. The femoral head is hemisphere shaped. The surface of the epiphysis of the head is flattened. A low and wide fovea capitis of the head is present. A third trochanter has developed. In the posterior view, a trochanteric fossa is shallow. The intertrochanteric crest is weak. The relationships between the medial lip of the trochlea and the diaphysis are ramp. The proximal border of the patellar trochlea is curved. In distal view, the medial part of the trochlea is higher than lateral part of it, forming asymmetrical shape. The intercondylar fossa is deep and narrow. Both medial and lateral condyles are oval shaped in posterior view.

The left tibia (YM-059) is almost completely preserved (Fig. 2e–2h). The proximo-posterior surface is broken. The suture lines of the proximal and distal portions of the tibia are completely fused. The tibial tuberosity is well developed. A moderately deep ligamental groove is u-shaped in the anterior view. The cranial border of the tibial tuberosity is rounded in the proximal portion and tapering distally. This border runs down to the medial margin in the anterior view. The popliteal fossa is deep. In the proximal view, the outline of the proximal portion is nearly rectangular shaped (Fig. 2g). The lateral condyle is larger than the medial condyle. The medial intercondylar process is higher than the lateral intercondylar process. These are divided by the shallow central intercondylar eminence. The popliteal line is not developed on the surface of the shaft. There is a small foramen on the posterior surface of the shaft. In the distal view, the outline of the articular surface is rectangular shaped. The facet for the astragalus is moderately concave. The antero-distal groove of the tibia is absent. In the anterior view, the medial malleolus is relatively low. A shallow medio-distal gutter is present. The fibular facet is situated proximally. The distal part of the facet for the fibula is developed. The posterior apophysis is low and rounded.

Comparison

Comparison of femur. —The present specimen is similar to that of *Stephanorhinus hemitoechus* from Neumark-Nord in Germany (van der Made, 2010) in having a relatively hemispherical femoral head, and weakly developed lesser trochanter. However the shaft of the present specimen is more slender and the neck of the head is narrower than those of the specimen from Neumark-Nord.

The present specimen is also similar to that of *Stephanorhinus kirchbergensis* from Taubach in Germany (Kahlke, 1977) in having relatively hemispherical femoral head, a slender shaft, a weakly developed lesser trochanter, and the presence of the fovea capitis of the head. However, the patellar trochlea of the present specimen is wider and deeper than that of *S. kirchbergensis* from Taubach. The femur from Taubach has a more curved medial margin of the shaft than that of the present specimen. The intercondylar fossa of the present specimen is wider than that of the Taubach specimen.

The present specimen is similar to that of *S. kirchbergensis* from Nihewan Basin in China (Tong et al., 2014) in having a relatively hemispherical femoral head and a weakly developed lesser trochanter, although the shaft of the femur of the present specimen is more slender than that of the specimen from Nihewan Basin. In addition, the intercondylar fossa of the present specimen is wider than that of the Nihewan Basin specimen.

The present specimen is similar to that of *S. etruscus* from Valdarno supérieur, Italy (Mazza, 1988) in having the femoral head, being hemispherically shaped, and having a weak developed lesser trochanter, the fovea capitis, and a strongly projected patellar trochlea. In contrast, the present specimens differ from that of *S. etruscus* from Valdarno supérieur: a more slender shaft, a more mesially situated third trochanter, and a wider and shallower intercondylar fossa in the distal view.

The present specimen is different from those of *S. hundsheimensis* from Soleilhac in France and *S. hemitoechus* from Caune de l'Arago in France in having a more developed medial ridge of the patellar trochlea in the distal view (Lacombat, 2005).

The present specimen is different from that of *Coelodonta antiquiatis* from Poland (Borsuk-Bialynicka, 1973) in having a more slender shaft in the anterior view, a less developed lesser trochanter, a wider intercondylar fossa, and a wider patellar trochlea.

Compared with the femur of *Rhinoceros unicornis*

(KPM-NF1002747), the present specimen has a more slender shaft, a lower situated great trochanter than the head, a relatively smaller third trochanter, a shallow trochanteric fossa, a less developed intercondylar crest, wide intertrochanteric fossa in the distal view, and a rounded medial trochanter in the distal view.

Metrically, the dimensions of the present specimen are close to those of *S. hemitoechus* from Neumark-Nord, Germany (Table 1). The ratio diagram shows that the proportions of the present specimen are similar to those of *S. etruscus* from Senèze, France (Fig. 3).

Comparison of tibia. —The present specimen is similar to that of *S. etruscus* from Senèze in France (Lacombat, 2005) in having a slender shaft, a low and rounded posterior apophysis, and a low medial maleolus. However, it differs from the Senèze specimen in having a pentagonal shaped lateral condyle and a trapezoidal-shaped outline of the distal articular facet.

The present specimen is morphologically similar to that of *S. hemitoechus* from Caune l'Arago in France (Lacombat, 2005), although the posterior apophysis is more rounded and the medial malleolus is more projected.

The present specimen differs from that of *S. kirchbergensis* from Taubach in Germany (Kahlke, 1977) in having a more slender shaft, a more rounded posterior apophysis, a low medial malleolus and a wider lateral condyle in the proximal view.

The present specimen also differs from that of *S. hundsheimensis* from Soleilhac in France (Lacombat, 2005) in having a more rounded and lower posterior apophysis, a less projected medial malleolus, a more anteriorly projected tibial tuberosity, a more laterally elongated lateral condyle, and a wider lateral facet for the astragalus.

The present specimen obviously differs from that of *Coelodonta nihowanensis* from Shanshenmiaozui, in the Nihewan Basin in China (Tong and Wang, 2014), in having a more slender shaft, a less developed tibial tuberosity, a narrower ligamental groove, a laterally elongated lateral condyle, a less rounded medial margin of the medial condyle and a rounded medial mallelus.

The tibia of *C. antiquitatis* is characterized by a large and robust shaft, a deep ligamental groove, a developed tibial tuberosity, an oval-shaped lateral condyle, and a less developed medial maleolus (Borsuk-Bialyncka, 1973). In contrast, the present specimen has a more slender shaft, a shallow ligamental groove, a less developed tibial tuberosity than that of *C. antiquitatis*, a laterally elongated lateral condyle, and a projected medial malleolus. Therefore, the present specimen is distinguished from the tibia of *C. antiquitatis*.

The present specimen clearly differs from that of *R. unicornis* (KPM-NF1002747) in having a slender shaft, a shallow popliteal fossa, a nearly quadrate shaped outline of the proximal portion, a rectangular shaped lateral condyle, a more developed medial intercondylar process, a relatively wide central intercondylar eminence, a sharp cranial border, a weak popliteal line, and a developed medial malleolus in the distal view.

The dimensions of the present specimen are close to the minimum value of *S. kirchbersensis* from western Europe (Table 2). The proportions of the present specimen in the ratio diagram are relatively similar to those of *S. etruscus* from Senèze in France and *S. kirchbersensis* from western Europe (Fig. 4).

Remarks. —The present femur and tibia in this study are morphologically distinguished from those of *Coelodonta* and *Rhinoceros*. In contrast, the present specimens are morphologically and metrically comparable to several species of *Stephanorhinus*. However, the detailed specific identification is difficult because other elements that are usually used to identify the species, such as teeth and the skull, have not been recovered, and the differences in the morphological characteristics of the femur and tibia to distinguish various species have not been fully recognized yet. Therefore, the present specimens of the femur and tibia are identified as *Stephanorhinus* sp. in this study. Both the femur and tibia would be from relatively mature individuals because the suture lines of the proximal and distal portions are completely fused.

Acknowledgements

The first author wishes to thank Mitsuharu Oshima and Hiroko Hirotani (Kanagawa Prefectural Museum of Natural History, Odawara, Japan) for providing access to comparative materials. The authors also would like to thank the editor, Shin-ichi Sano, and the reviewer, Hao-Wen Tong, who made constructive suggestions for improving the original article. This study was partially supported by funding from the Nagano Society for the Promotion of Science, Japan (awarded to Naoto Handa in 2015).

References

Antoine P.-O., 2012, Pleistocene and Holocene rhinocerotids (Mammalia, Perissodactyla) from the Indochinese Peninsula. *C. R. Palevol,* **11**, 159–168.

Borsuk-Bialynicka, M., 1973, Studies on the pleistocene rhinoceros *Coelodonta antiquitatis* (Blumenbach). *Palaeont. Pol.,* **29**, 1–148.

Gray, J. E., 1821, On the natural arrangement of vertebrate animals. *London Medical Repository, Monthly Journal and Review,* **15**, 296–310.

Guérin, C., 1980, *Les rhinocéros (Mammalia, Perissodactyla) du Miocene Terminal au Pléistocène Supérieur en Europe Occidentale, Comparaison Avec Les Espèces Actuelles*. Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon, **79**, 1185p.

Handa, N., 2015, A Pleistocene rhinocerotid (Mammalia, Perissodactyla) from Yage, Shizuoka Prefecuture, central Japan. *Paleont. Res.,* **19**, 139–142.

Handa, N. and Pandolfi, L., 2016, Reassessment of the Middle Pleistocene Japanese rhinoceroses (Mammalia, Rhinocerotidae) and paleobiogeographic implications. *Paleont. Res.,* **20**, 247–260.

Heissig, K., 1973, Die Unterfamilien und Tribus der rezenten und fossilen Rhinocerotidae (Mammalia). *Säugetierkundl. Mitt.,* **21**, 25–30.

Heissig, K., 1989, The Rhinocerotidae. *In* Prothero, D. R. and Schoch, R. M., eds., *The Evolution of Perissodactyls*. Oxford Monogr. Geol. Geophys., **15**, Oxford Univ. Press, New York, 399–417.

Kahlke, H. D., 1977, Die Rhinocerotidenreste aus den Travertinen von Taubach. *Quart Ärpaläontol.,* **2**, 305–359.

Kamei, T., Kawamura, Y. and Taruno, H., 1988, Mammalian stratigraphy of the Late Neogene and Quaternary in the Japanese Islands. *Mem. Geol. Soc. Japan,* **30**, 181–204.*

Kretzoi, M., 1942, Bemerkungen zur System der Nachmiozänen Nashorn-Gattungen. *Földtani Közlöny,* **72**, 309–318.

Kurashiki Museum of Natural History ed., 1988, *Vertebrate Fossils from the Sea Bottom of Bisan-Seto, West Japan*. Report of Researches on the Yamamoto Collection I, Kurashiki Museum of Natural History, 109p. 168pls.**

Lacombat, F., 2005, Les Rhinocéros fossiles des sites prehistoriques de l'Europe Mediterranéenne et du Massif Central–Paléontologie et implications biochronologiques. *British Archeol. Rep.,* **1419**, 1–175.

van der Made, J., 2010. The rhinos from the middle Pleistocene of Neumark-Nord (Saxony-Anhalt). *Veröff. Land. Denkmalpfi Archäol.,* **62**, 433–527.

Mazza, P., 1988, The Tuscan Early Pleistocene rhinoceros *Dicerorhinus etruscus. Palaeont. Ital.,* **75**, 1–87.

Ogino, S., Otsuka, H. and Harunari, H., 2009, The Pleistocene Matsugae fauna, northern Kyushu, West Japan. *Paleont. Res.,* **13**, 367–384.

Okazaki, Y., 2007, Several fossils of Pleistocene rhinocerotid from the "Matsugae Cave", Kitakyushu City, Japan. *In* Commemorative Association of Prof. Kamei Tadao's 80th Birthday, eds., *Jubilee Publication in Commemoration of Prof. Kamei Tadao's 80th Birthday*, Commemorative Association of Prof. Kamei Tadao's 80th Birthday, Tokyo, 135–140.*

Owen, R., 1845, *Odontography; or, a Treatise on the Comparative Anatomy of the Teeth, their Physiological Relations, Mode of Development, and Microscopic Structure, in the Vertebrate Animals*. H. Baillière, London, 655p.

Owen, R., 1848, *On the Archetype and Homologies of the Vertebrate Skeleton*. J. Van Voorst, London, 1560p.

Pandolfi, L. and Marra, F., 2015, Rhinocerotidae (Mammalia, Perissodactyla) from the chrono-stratigraphically constrained Pleistocene deposits of the urban area of Rome (Central Italy). *Geobios,* **48**, 147–167.

Pandolfi, L. and Tagliacozzo, A., 2015, *Stephanorhinus hemitoechus* (Mammalia, Rhinocerotidae) from the late Pleistocene of Valle Radice (Sora, Central Italy) and re-evaluation of the morphometric variability of the species in Europe. *Geobios,* **48**, 169–191.

Shikama, T., 1967, Note on the occurrence of fossil rhinoceros from Kagoshima Prefecture, southern Japan. *In* Committee for the Commemoration of Prof. Ichiro Hayasaka's 76th Birthday, ed., *Contributions to Celebrate Prof. Ichiro Hayasaka's 76th Birthday*, Hashimotokakubundo, Kanazawa, 117–119.

Shikama, T., Hasegawa, Y. and Okafuji, G., 1967, On a rhinocerotid skull from Isa (Yamaguchi Prefecture, Japan). *Bull. Nat. Sci. Mus. (Tokyo),* **10**, 455–462.

Taruno, H., 1988, Vertebrate fossils from the Bisan Seto, part 1, Proboscidea etc. *In* Kurashiki Museum of Natural History, ed., *Vertebrate Fossils from the Sea Bottom of Bisan-Seto, West Japan*. Report of Researches on the Yamamoto Collection I, Kurashiki Museum of Natural History, 11–61. plt. 1–148.**

Taruno, H., 2000, Proboscidea etc. *In* Kurashiki Museum of Natural History, ed., *Vertebrate fossils from Bisan-Seto Sea, preserved in the Kurashiki Museum of Natural History –Research report of Yamamoto Collection (Part II)–*, Catalogue of the materials in the Kurashiki Museum of Natural History No. 9, Kurashiki Museum of Natural History, 1–31. plt. 1–15.**

Taruno, H. and Yamamoto, K., 1988, The submarine topography and geology of the Bisan-Seto. *In* Kurashiki Museum of Natural History, ed., *Vertebrate Fossils from the Sea Bottom of Bisan-Seto, West Japan*. Report of Researches on the Yamamoto Collection I, Kurashiki Museum of Natural History, 7–10.**

Tong, H.-W., 2012, Evolution of the non-Coelodonta dicerorhine lineage in China. *C. R. Palevol.,* **11**, 555–562.

Tong, H.-W. and Wang, X.-M., 2014, Juvenile skulls and other postcranial bones of Coelodonta nihowanensis from Shanshenmiaozui, Nihewan Basin, China. *Jour. Vert. Paleont.,* **34**, 710–724.

Tong, H.-W., Wang, F., Zheng, M. and Chen, X., 2014, New fossils of *Stephanorhinus kirchbergensis* and *Elasmotherium peii* from the Nihewan Basin. *Acta Anthropol. Sin.,* **33**, 369–388. ***

*: in Japanese with an English abstract
**: in Japanese
***: in Chinese

用語対比

Aira	姶良
Bannosu Formation	番ノ巣層
Bisan-Seto area	備讃瀬戸地域
Bisanseto Group	備讃瀬戸層群
Isa	伊佐
Kuzuu	葛生
Matsugae	松ヶ枝
Mitoyo Group	三豊層群
Ozuchijima Formation	大槌島層
Tsuchinotoseto Formation	槌ノ戸瀬戸層
Tsukumi	津久見
Yage	谷下