THE TAXONOMIC STATUS OF THE MIOCENE HORSE GENUS *SINOHIPPUS*

by ANN FORSTEN

ABSTRACT. The large Asiatic anchitheriine, *Sinohippus zitteli*, is discussed and compared with some other Old and New World anchitheriines.

THE taxonomic history of *Sinohippus zitteli* has been a thorny one. Schlosser (1903, pp. 76–78; Taf. III. 6, 8–12) originally described *Anchitherium zitteli* on isolated teeth, probably from the 'Pontian' Red Clays of Shansi, China. Osborn (1918, p. 203) referred *A. zitteli* to the New World genus *Hypohippus* Leidy. Following Osborn, Schlosser (1924, p. 68; Taf. V. 10) referred material from Olan Chorea, Mongolia, to *H. zitteli*. Zdansky (1935, pp. 17–20; Taf. I. 4, II. 1) described additional material from Loc. 31, Shansi, but did not assign it to genus or species. Finally, Zhai (1962) erected a new genus, *Sinohippus*, for this large Asiatic anchitheriine.

DESCRIPTION

Skull and teeth

Osborn (1918, p. 203) did not give particular reasons for referring *zitteli* to *Hypohippus*, but listed eleven characters thought to characterize the genus *Hypohippus*, including *zitteli*. Of these some do characterize *zitteli*, at least with amendments, while others do not.

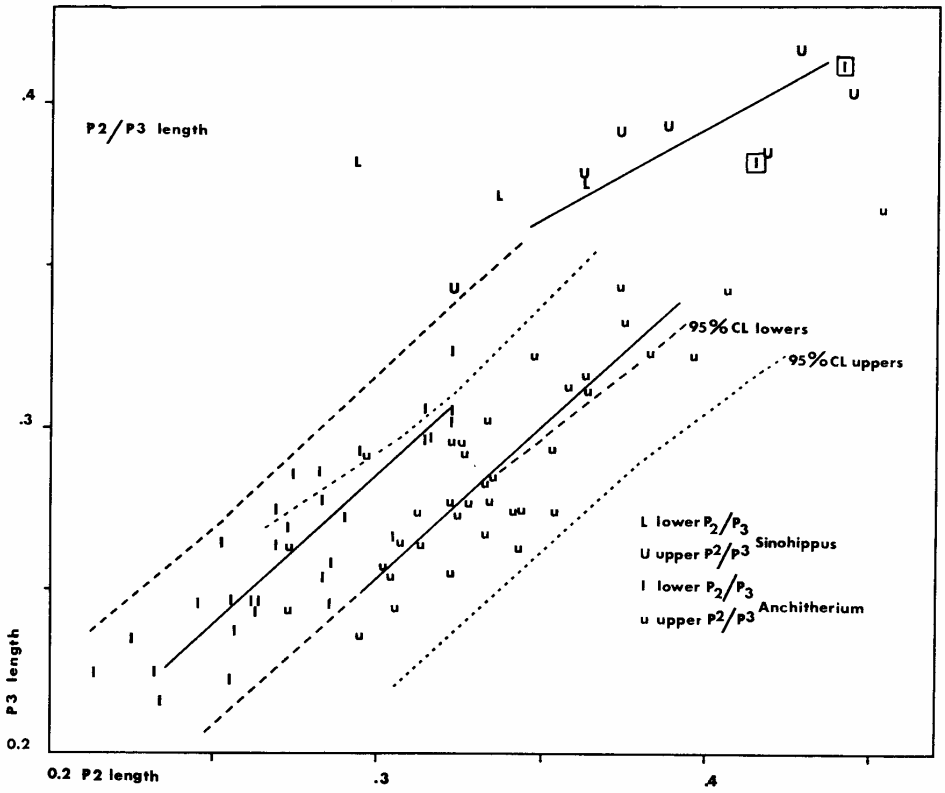
The most marked difference between *zitteli* and *Hypohippus* relate to the development of the preorbital fossa. As set down for *Hypohippus* in Osborn's characters 7 and 8: 'Lacrymal fossa deep, narrow, and superior in position' and 'No malar fossa'. In a skull of *S. zitteli* (AMNH 38-L-272) from Ma Chi Lieu Kou, north-west Shansi, the fossa is very wide and large, lacking sharp boundaries except posteriorly; it thus resembles the fossa of Old World *Anchitherium* (e.g. Kowalevski 1873, pl. III. 50, and crushed skull from Sansan, Paris, 158), rather than that of New World *Hypohippus* (e.g. *H. osborni*, *H. affine*).

Of the tooth characters common to *Sinohippus* and *Hypohippus* Osborn (1918, p. 203) mentioned the reduced M3/3. In post-Barstovian *Hypohippus* both the anterior (P2/2) and posterior (M3/3) peripheral cheek teeth are reduced relative to their neighbours (P3/3 and M2/2) (Forsten 1973, figs. 1–4). *Sinohippus* resembles *Hypohippus* in these regards (text-figs. 1–2). In Old and New World *Anchitherium* the relative size and/or growth of the peripheral teeth is different (Forsten 1973, figs. 1–4; this paper text-figs. 1–2). The alleged reduction of the posterior part of M1–2/1–2, with respect to the anterior part of P3–4/3–4, which according to Zhai (1962, pp. 54–55) distinguishes *Sinohippus*, is not confirmed by my data. The shape of the intermediate premolars and molars of *Sinohippus* is the same as that of corresponding teeth of *Anchitherium* and *Hypohippus*. In all anchitheriines the trigonid is narrower than the talonid in the premolars, while the opposite is true of the molars; this in fact allows identification (Forsten 1970, pp. 4–5).

Neither do the other tooth characteristics listed by Zhai, e.g. well-developed styles, little angulated metaloph, and elongated teeth, differentiate *Sinohippus* from *Hypohippus*. With increase in size, the lower cheek teeth of *Sinohippus* do indeed increase slightly faster in length than in anterior breadth (l/b = 0·968), but in the upper cheek teeth breadth increases faster than length (l/b = 1·277). The teeth are thus not particularly elongated. The morphology of the cheek teeth of *Sinohippus* differs little from that in *Hypohippus*, except that in P^2 the protoloph is usually quite short, often with increased wear connecting to the paracone instead of to the ectoloph, and the hypoconulid of the lowers is reduced. Cingula are developed as in most *Hypohippus* (Osborn 1918, p. 203).

As in *Hypohippus*, shear along the crests of the teeth was enhanced in *Sinohippus*. There was vertical shear along the ectoloph, followed by shear along the metaloph parallel to occlusal motion resulting in vertical, wedge-shaped wear surfaces along the lophs (e.g. AMNH 33-L-278).

[Palaeontology, Vol. 25, Part 3, 1982, pp. 673–679.]

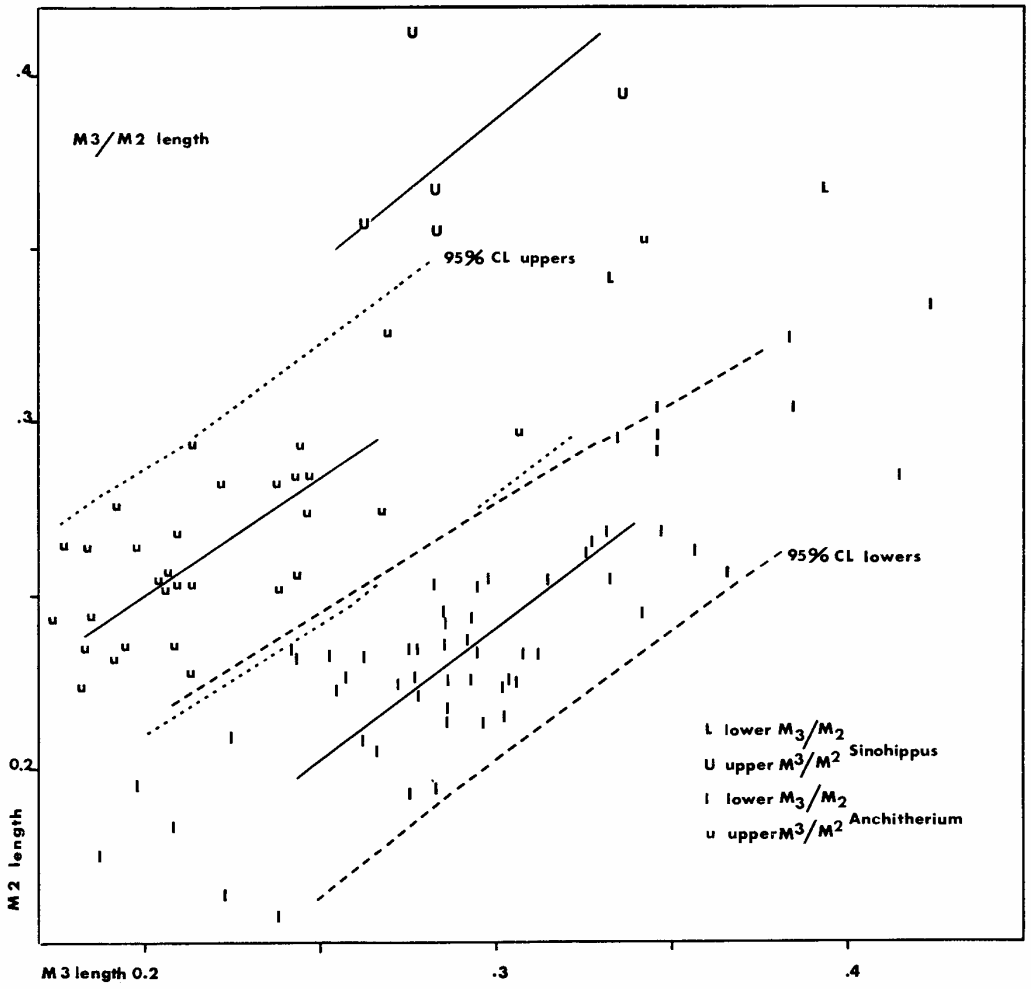


TEXT-FIG. 1. P3 length plotted against P2 length in Old World anchitheriines. Reduced major axis fitted to lowers and uppers of *Anchitherium*, and to uppers of *Sinohippus*. Ninety-five per cent confidence limits (95% CL) drawn for the samples of *Anchitherium*. Log data.

Limb bones

Limb bones referable with certainty to *S. zitteli* are not known, but from the Meotian–Lower Pontian of Altan Teeli, Mongolia, there is a partial hind foot (PIN, numberless) comprising left MT III, II, and IV, phalanx 1^{III}, 1^{II}, and 1^{IV}, of a large anchitheriine, possibly *S. zitteli*. Anchitheriine teeth have not been found at Altan Teeli, but *Sinohippus* did occur in Mongolia: Schlosser (1924, p. 68; Taf. V. 10) referred a lower tooth fragment from Olan Chorea to *Hypohippus zitteli*, and from the Upper Miocene–Lower Pliocene of Hua Te, Inner Mongolia, there is a skull fragment with left P^{2-4} (PIN 2203–5) of this species.

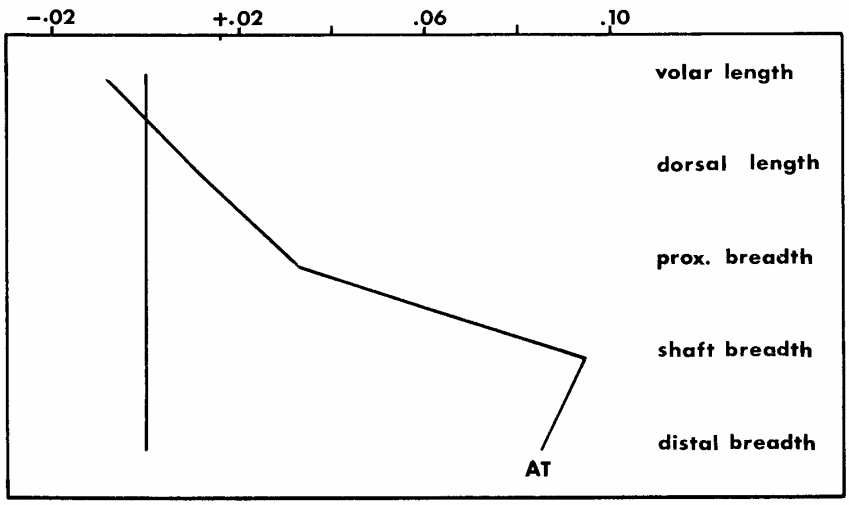
The metapodial from Altan Teeli is short, very robust, and anteroposteriorly flattened. The side toes are also very robust, the whole podial rather resembles that of a rhino. Phalanx 1^{III} is typically anchitheriine, however, with concave proximal volar scars for the attachment of the cruciate ligaments, and a broad, rugose scar for the central sesamoidean ligament. Compared with *Hypohippus* of similar size from the Lower Clarendonian of Cherry County, Nebraska (AMNH material), the podial and phalanx of *Sinohippus* are considerably more robust (text-figs. 3–4). MT III of large European forms of Upper Helvetian–Vindobonian *Anchitherium* (e.g. from Sansan, Steinheim, and La Grieve) are also more slender than those of *Sinohippus*. A scattergram (text-fig. 5) with phalanx 1^{III} mid-shaft breadth plotted against dorsal length, shows that Old World anchitheriines in general were more massive than the New World forms.



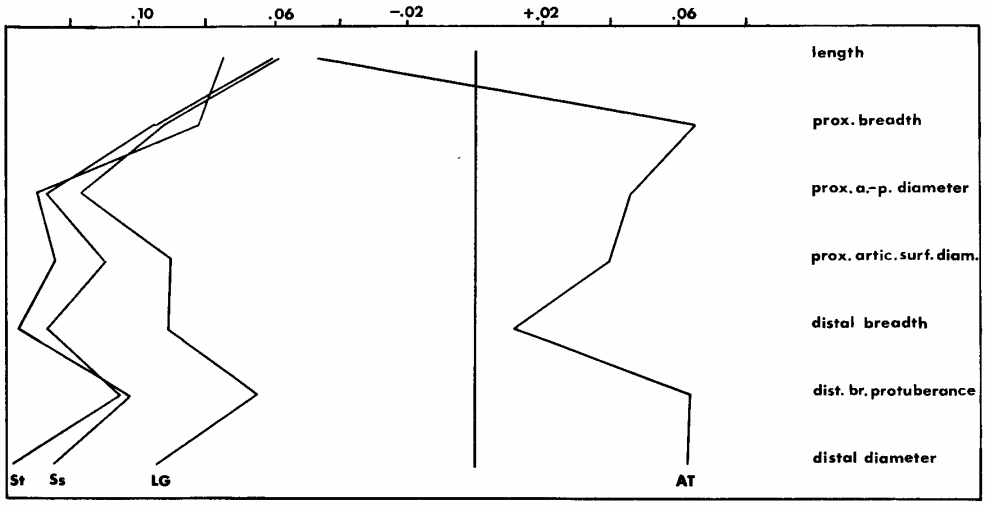
TEXT-FIG. 2. M2 length plotted to M3 length in Old World anchitheriines. Reduced major axes fitted to lowers and uppers of *Anchitherium*, and to uppers of *Sinohippus*. Ninety-five per cent confidence limits (95 % CL) drawn for the samples of Anchitherium. Log data.

DISCUSSION

The wide, ill-defined preorbital fossa and robust proximal phalanx place *Sinohippus* among the Old World anchitheriines. *Sinohippus* may have evolved from *Anchitherium* as Sondaar (1971, pp. 250–251) suggested. The scarcity of Upper Miocene anchitheriines in Eurasia is not positive evidence for evolution *in situ*; the possibility of repeated immigration of anchitheriine horses from the New World in the Middle and Upper Miocene cannot be excluded. The monotypic genus *Paranchitherium* Borissiak, with the single species *Karpinskii*, has been found in the Upper Helvetian–Vindobonian fauna of Belometžetskaya, Georgian S.S.R. (Borissiak 1938, 1945; Gabunia 1973), but nowhere else. *Paranchitherium* is much closer to New World *Parahippus* Leidy



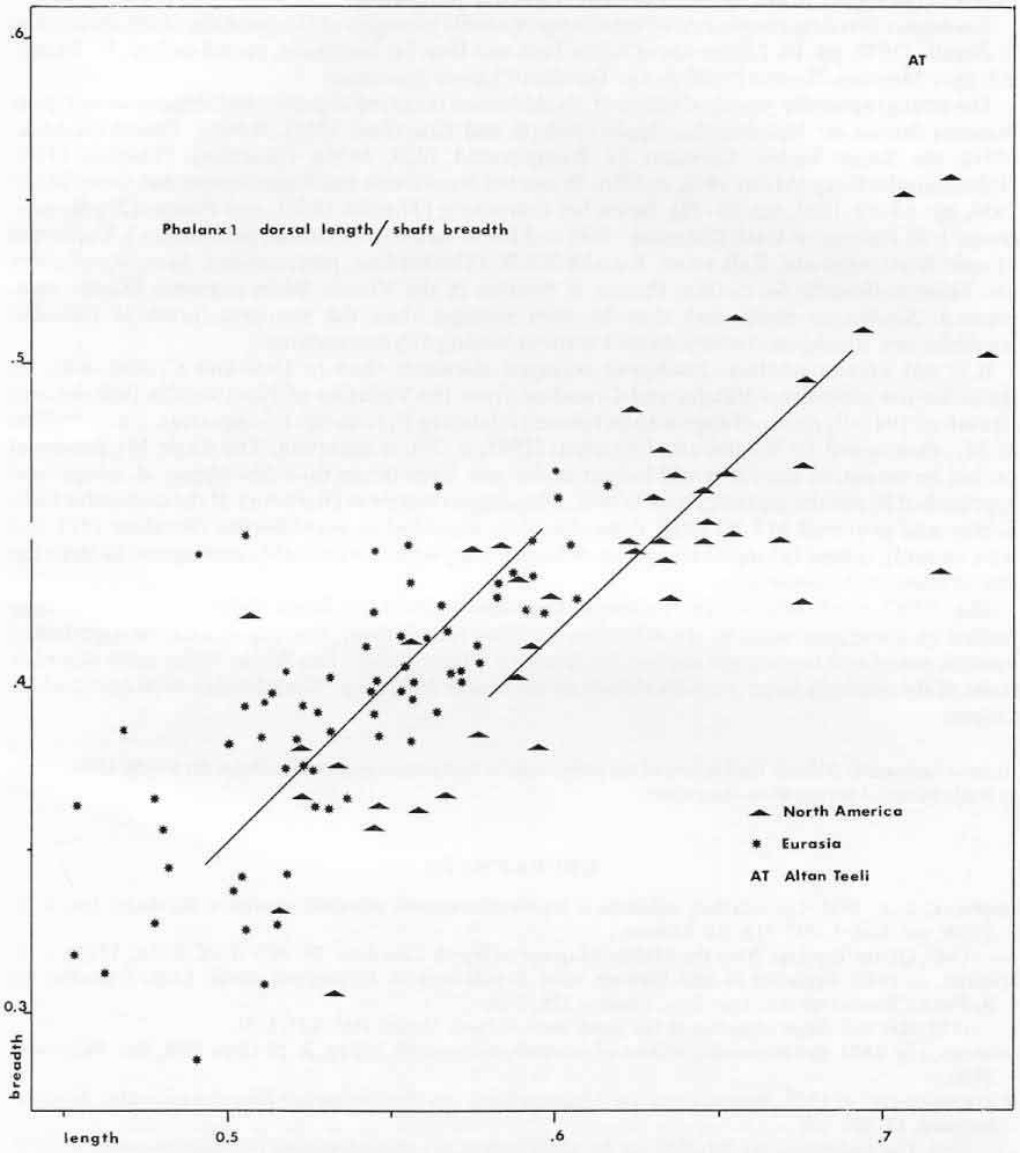
TEXT-FIG. 3. Ratiodiagram (Simpson 1941) comparing phalanx 1 of *Sinohippus* from Altan Teeli (AT) with *Hypohippus* (standard) from the Lower Clarendonian, Cherry County, Nebraska.



TEXT-FIG. 4. Ratiodiagram (Simpson 1941) comparing MT III of *Sinohippus* from Altan Teeli (AT), *Anchitherium* from Steinheim (St), Sansan (Ss), and La Grieve (LG) with *Hypohippus* (standard) from the Lower Clarendonian of Cherry County, Nebraska.

(e.g. *P. nebrascensis* Peterson), than to *Anchitherium*, in having a connected crochet, thin cement, and rather well-developed metaconid and metastylid (Borissiak 1938, 1945). It may represent an episodic immigration from the New World.

Sinohippus paralleled *Hypohippus* in reduction of P2/2 and M3/3 and in pronounced shearing crests of the teeth. *Hypohippus* occurred in the Barstovian and Clarendonian, replacing *Anchitherium*



TEXT-FIG. 5. Phalanx 1 mid-shaft breadth plotted against dorsal length in Eurasian and North American *Anchitherium* and *Hypohippus*. Reduced major axis fitted to the data. AT = *Sinohippus* from Altan Teeli. Log data.

over most of its range in North America. So far *Hypohippus* has not been found in the Upper Miocene fauna of Eurasia. Although in *Sinohippus* the reduced peripheral teeth and shearing crests were derived characters resembling *Hypohippus*, I believe *Hypohippus* and *Sinohippus* evolved in parallel. Both *Sinohippus* and *Hypohippus* (as well as some stratigraphically late *Anchitherium*) have been found occasionally in association with hypsodont-selenodont horses. They may have filled similar niches in the Upper Miocene fauna of their respective continents.

Sinohippus zitteli represents one of the stratigraphically youngest of the Anchitheriinae. According to Žegallo (1978, pp. 13, 21) the age of Altan Teeli and Hua Te, Mongolia, as well as Loc. 31, Shansi, is Upper Meotian–?Lower Pontian, i.e. Turolian–?Lower Ruscinian.

The stratigraphically youngest forms of *Anchitherium* occurred together with *Hipparion* in Upper Miocene faunas at: Nombrevilla, Spain (Villalta and Crusafont 1945); Soblay, France (Sondaar 1971); the Rhine Valley, Germany (v. Koenigswald 1929, 1931); Gaiselberg (Thenius 1950), Holzmannsdorfberg (Mottl 1970, p. 140), Brunn bei Nestelbach and Lassnitzhöhe bei Graz (Mottl 1954, pp. 64–65; 1955, pp. 51–58), Strass bei Lohnsburg (Thenius 1952), and Prottes (Zapfe, pers. comm.), all Austria; at Uşak (Ozansoy 1969) and Esme-Akçaköi (Sondaar, pers. comm.), Turkey; at Mogila Bortkutbai and Kalkaman, Kazakh S.S.R. (Tleuberdina, pers. comm.). Most occurrences are Vallesian/Middle Sarmatian; Prottes is Pontian in the Vienna Basin sequence (Zapfe, pers. comm.). *Sinohippus zitteli* may thus be even younger than the youngest forms of Eurasian *Anchitherium*. *Sinohippus* became extinct without leaving any descendants.

It is not known whether *Sinohippus* occurred elsewhere than in East and Central Asia. In *Anchitherium sampelayoi* Villalta and Crusafont from the Vallesian of Nombrevilla (Villalta and Crusafont 1945) P_2 does not appear to be reduced relative to P_3 (text-fig. 1, in squares). The reduction of M_3, maintained by Villalta and Crusafont (1945, p. 76), is uncertain. The single M_3 preserved cannot be measured since it is still lodged in the jaw. Even larger than *Sinohippus*, *A. sampelayoi* approached in size the gigantic, New World, *Megahippus matthewi* (Barbour). If the astragalus from Soblay and proximal MT III from Esme-Akçaköi, identified as anchitheriine (Sondaar 1971 and pers. comm.), indeed belong to this group of horses, they would presumably correspond to teeth the size of those of *A. sampelayoi*.

Zhai (1962, p. 55) believed the Vallesian *Anchitherium* from the Rhine Valley to be more closely related to *Sinohippus* than to *Anchitherium aurelianense* (Cuvier), but this cannot be ascertained because peripheral tooth pairs are lacking from the Rhine Valley. The Rhine Valley teeth resemble those of the similarly large *Anchitherium* from the Upper Helvetian–Vindobonian of Sansan and La Grieve.

Acknowledgements. I thank the keepers of the collections in many museums and institutes for kindly allowing me to study material pertinent to this paper.

REFERENCES

BORISSIAK, A. A. 1938. Ob ostatkah anhiteria iz sredne-miozenovih otlozenii severnovo Kavkaza. *Izv. A. N. SSSR, ser. biol.* **1**, 207–218. [In Russian.]

—— 1945. On the Equidae from the Middle Miocene of North Caucasus. *Tr. PIN A. N. SSSR*, **13** (1), 1–52.

FORSTEN, A. 1970. Variation in and between three populations of *Mesohippus bairdii* Leidy from the Big Badlands, South Dakota. *Acta Zool. Fennica*, **126**, 1–16.

—— 1973. Size and shape evolution in the cheek teeth of fossil horses. Ibid. **137**, 1–31.

GABUNIA, L. K. 1973. *Belometzetskaya fauna iskopaemih pozvonoznyh*, 138 pp. A. N. Grus. SSR, Inst. Paleobiol., Tbilisi.

v. KOENIGSWALD, R. 1929. Bemerkungen zur Säugetierfauna des rheinhessischen Dinotheriensandes. *Senckenbergiana*, **11**, 267–279.

—— 1931. Die Bedeutung der Equiden fur die altersstellung des rheinhessischen Dinotheriensandes. *Zentrbl. Mineral., Geol. u. Paläontol*, Abt. B, pp. 42–48.

KOWALEVSKI, W. 1873. Sur l'Anchitherium aurelianense Cuv. et sur l'histoire paléontologique des chevaux. Part I. *Mém. l'Acad. Imp. Sci. St. Petersbourg, Ser. 7e*, t. **20** (5), 1–73.

MOTTL, M. 1954. Hipparion-Funde der Steiermark. *Mitteil. Mus. Bergbau, Geol. u. Technik* **13,** 43–71.
——1955. Anchitherium-Funde aus dem Unterpliozän der Steiermark. Ibid. **15,** 51–58.
——1970. Die jungtertiären Säugetierfaunan der Steiermark, sudost Österreich. Ibid. **31,** 79–161.
OSBORN, H. F. 1918. Equidae of the Oligocene, Miocene, and Pliocene of North America, iconographic type revision. *Mem. Am. Mus. nat. Hist.* N.S. **2,** pt. 1, 1–217.
OZANSOY, F. 1969. Sur la longévité des faunes à Hipparion et les faunes de vertebres fossiles dans la region de la mer Égée Anatolienne. *Bull. Mineral Res. & Explor. Inst. Turkey*, **72,** 130–134.
SCHLOSSER, M. 1903. Die fossilen Säugethiere Chinas nebst einer Odontographie der recenten Antilopen. *Abh. math.-phys. Kl. k. Bayer. Akad. Wiss.* **22,** Abt. 1, 1–221.
——1924. Tertiary Vertebrates from Mongolia. *Palaeontologia Sinica*, ser. c, **1** (1), 1–119.
SIMPSON, G. G. 1941. Large Pleistocene felines of North America. *Am. Mus. Nov.* **1136,** 1–27.
SONDAAR, P. Y. 1971. An Anchitherium from the Vallesian of Soblay (Ain, France). *V^e Congr. int. Neogène médit. (Lyon 1971)*, 247–252.
THENIUS, E. 1950. Uber den Nachweis von Anchitherium aurelianense im Pannon des Wiener Becken. *Anz. Österr. Akad. Wiss. Wien, math.-nat. Kl.* **87**.
——1952. Die Säugetierreste aus dem Jungtertiär des Hausruck und Kobernausserwaldes (O.-Österreich) und die Alterstellung der Fundschichten. *Jb. Geol. Bundesanstaltes 1952* **95** (1), 119–144.
VILLALTA, J. F. and CRUSAFONT, M. 1945. Un Anchitherium en el pontiense Espanol: Anchitherium sampelayoi nov. sp. *Notas y Comunic. Inst. Geol. y Minero de Espana*, **14,** 15–79.
ZDANSKY, O. 1935. Equus und andere Perissodactyla. *Palaeontol. Sinica*, **6** (5), 1–54.
ŽEGALLO, V. I. 1978. Gipparioni Zentralnoi Asii. *Sovmestn. sovetsko-mongolsk. paleontolog. ekspedizia, Trudy*, **7,** 1–155.
ZHAI, REN-JIE. 1962. On the generic character of '*Hypohippus zitteli*'. *Vertebrata Palasiatica*, **6** (1), 48–56.

ANN FORSTEN
Zoological Institute
University of Helsinki
Helsinki
Finland

Typescript received 10 June 1981