Chinese Turolian *Hipparion* in the Lagrelius Collection

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The Chinese hipparions in the Lagrelius Collection in Uppsala are discussed with reference to specimens described by Sefve (1927) and undescribed material in Uppsala, the American Museum of Natural History, New York, the Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, Beijing, and the Museum of Natural History, Tientjin.

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Introduction

Schlosser (1924) described *Hipparion richthofeni* Koken race *mongolium* from Harr Obo, Ertemte, and Olan Chorea in northeastern China (Inner Mongolia); Sefve (1927) erected several new species of *Hipparion* for crania and limb-bones from northern China. The material described by Schlosser and Sefve is housed in the Lagrelius Collection of the Paleontological Institute, Uppsala. The Lagrelius Collection contains one of the largest collections of Chinese *Hipparion* in the world. Other collections are in the American Museum of Natural History, New York, in the Institute of Vertebrate Paleontology and Paleanthropology of the Chinese Academy of Sciences, Beijing, and in the Museum of Natural History, Tientjin. I have studied the specimens in these collections; they may be partly derived from the same fossil localities and represent the same species.

The Chinese *Hipparion* material chiefly consists of crania; limb-bones and isolated teeth are rare. Cranial material is difficult to analyse quantitatively as it is scarce, fragmentary, and distorted by compression. A tendency to delimit species and higher taxa of hipparions by typologically evaluating skulls is presently in vogue (Forstén, 1983). This paper attempts, in a preliminary way, to clarify the taxonomy of the Chinese Turolian hipparions, earlier discussed by Forstén (1968, 1978) and Żhegello (1978), by a combination of quantitative and qualitative methods.

Methods

I measured the skulls and jaws of *Hipparion* specimens according to methods given by Gromova (1952). The orbit-preorbital fossa distance was plotted against the distance P^2-orbit (Gromova's measure No. 11) as a measure of skull-size (Fig. 1). Such plots show a grouping of forms of *Hipparion* that differ in the relative position of the fossa (Forstén 1980, 1983). I measured length and breadth (enamel to enamel) of the occlusal surface of the cheek-teeth and plotted them in scattergrams. Due to the shape of the tooth crowns, differences in individual age cause rather wide variation in size and proportions of the occlusal surface, however. For the plication count and protoconal length of the upper cheek-teeth see Table 1. I compared the limb-bone measurements in scattergrams (Figs. 2, 3, 4, 5).

Abbreviations

AMNH = American Museum of Natural History, New York, U.S.A.
GIN = Institute of Geology, Academy of Sciences, Moscow, USSR.
IVPP or V = Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, Beijing, China.
PIN = Institute and Museum of Paleontology, Academy of Sciences, Moscow, USSR.

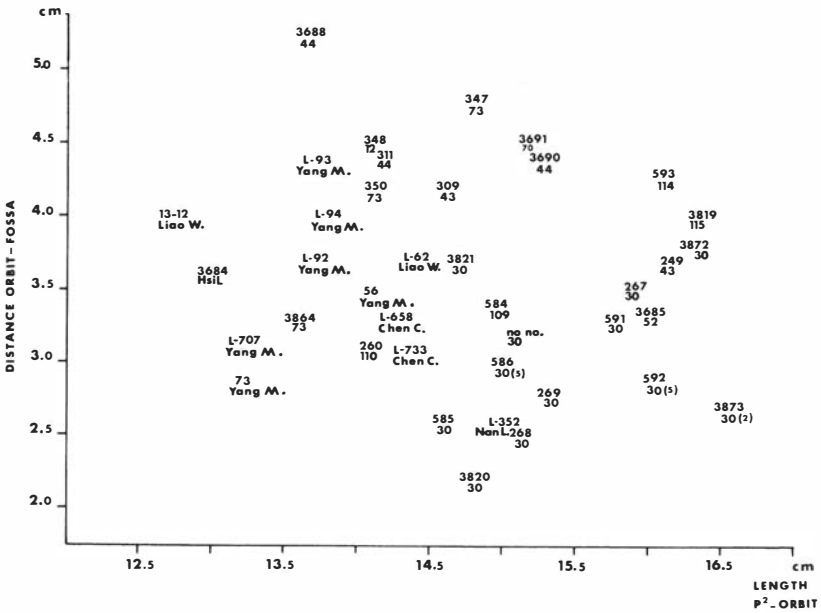

Fig. 1. Orbit-preorbital fossa distance plotted against P^2-orbit distance for Chinese Turolian hipparions. Each observation is denoted by the specimen number (upper number) and the locality number or abbreviation (lower number). Abbreviations are: Chen C. = Ch'en-Chia-Mao-Kou; Hsi L. = Hsi Liang; Liao W. = Liao-Wang-Kou; Nan L. = Nan-Liang-Kou; Yang M. = Yang-Mu-Kou.

PMU.M. = Lagrelius' Collection, Paleontologiska Museet, Uppsala Universitet, Sweden.

THP = Museum of Natural History, Tientjin, China.

Description

HARR OBO, INNER MONGOLIA, NE CHINA: Schlosser (1924) described a subspecies *mongolicum* of *H. richthofeni* from Harr Obo. The material consists of: lower P_2-M_2 (PMU.M. 3212-3216); M_{1-2} (3217); P^2, P^{3-4}, and M^1 (3218–3220); and a second phalanx. P_2-M_2 are well worn; they may belong to one individual. The M_{1-2} (3217) does not belong to the same tooth-row. The uppers are little worn and may belong to a third individual. The teeth are rather large and moderately hypsodont. The protocone of the uppers has an anterior spur. The phalanx is large (Fig. 4).

SHANXI, PAO-TE-HSIEN, YÜEH-CHIA-LI, LIU-WAN-KOU, LOC.52: From Loc. 52 Sefve (1927, p. 32–34, Fig. 16. Taf. V 19) described *H. kreugeri* (skull PMU.M. 3685; limb-bones, Sefve, 1927, p. 53). In addition, there are a skull fragment (315), a juvenile palate (253), a jaw (328) and jaw fragments (327, 8478, 8480, 8501, 8511 and 8512), a distal metapodial (339), a proximal metacarpal III (8502), two phalanges 2 (340 and 8509), and a distal tibia (334). The preorbital fossa of 3685 is shallow and situated close to the orbit (Fig. 1). There may be an anterior fossa level with P^2. The limb-bones are gracile (Fig. 4).

SHANXI, PAO-TE-HSIEN, YÜEH-CHIA-LI, LIU-WAN-KOU, LOC. 31: From this locality, Sefve (1927, p. 26, Taf. V 20a–b) referred specimens to *H. fossatum* (skull fragment, PMU.M. 299) and (1927, p. 26, Fig. 14) to *H. richthofeni* (jaw, 3686). In addition to Sefve's material, I have seen a juvenile skull (588), two jaws (8334 and 8337), and deciduous dentitions (8320, 8329 and 8330) and snouts (8327, 8328, 8331 and 8332), a metatarsal III (8333), an astragalus (8341), and the distal end of an astragalus (8335). The preorbital fossa of 588 is small and shallow with a slight posterior pocket. The fossa extends from a level with M^2 to the posterior half of DP^4. There is also a shallow posterior pocket on 299. The fossa is situated rather far in front of the orbit. The nasal slit is level with the posterior half of P^2. In early stages of wear, the lower premolars have a flaring and wide metaconid-metastylid "tie" (Sefve 1927, Fig. 14). The limb-bones are small and very gracile (Figs. 2, 5).

In the American Museum there are specimens (two skulls. 13-L 62 and 49-B 12; two jaws, 58-L

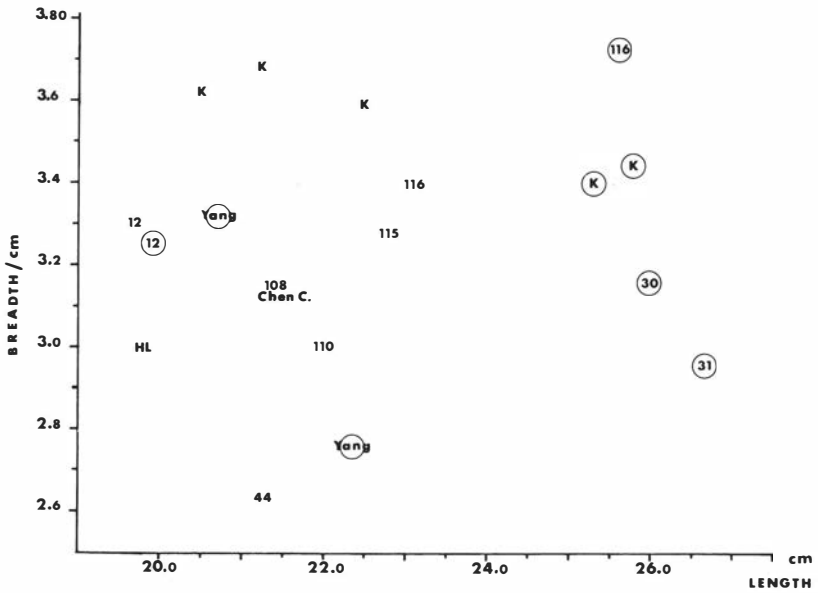

Fig. 2. Metapodial distal articular breadth plotted against total metapodial length for Chinese Turolian and Pliocene hipparions. Circled specimens = metatarsal III, uncircled = metacarpal III. Specimens denoted by locality number or abbreviation (Chen C. = Ch'en-Chia-Mao-Kou; Yang = Yang-Mu-Kou; HL = Hsi Liang; K = Kueite).

576 and a juvenile, 13-L 62; and a distal metapodial and phalanx 2, 83-L 725) from Liao Wang Kou in northwestern Shanxi, from localities that may correspond to localities 31 and 52 in the Lagrelius Collection. On 49-B 12 the fossa is marked only by a posterior rim, being otherwise weakly developed. On 13-L 62, the fossa is pear-shaped and lacks well defined rims, except posteriorly. In their position far in front of the orbit and in their shallowness, the fossae of the AMNH specimens resemble those from Loc. 31 (Fig. 1). The nasal slit ends level with or in front of the P^2. The plication count of the cheek- teeth is medium to low, and the protocone is short (Table 1). Measurements of the single phalanx 2 (83-L 725) fall among those from Loc. 52 (Fig. 4).

SHANXI, PAO-TE-HSIEN, YÜEH-CHIA-LI, SHEN-SHU-TSUI, LOC. 44; Sefve (1927, p. 29–32, Fig. 15, Taf. V 16–18) referred specimens

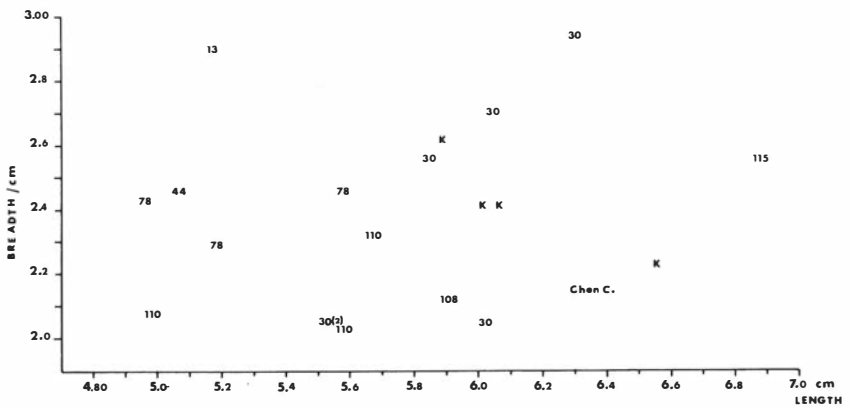

Fig. 3. Phalanx 1 mid-shaft width plotted against phalanx 1 volar length for Chinese Turolian and Pliocene hipparions. Specimens denoted by locality number or abbreviation (Chen C. = Ch'en-Chia-Mao-Kou; K = Kueite).

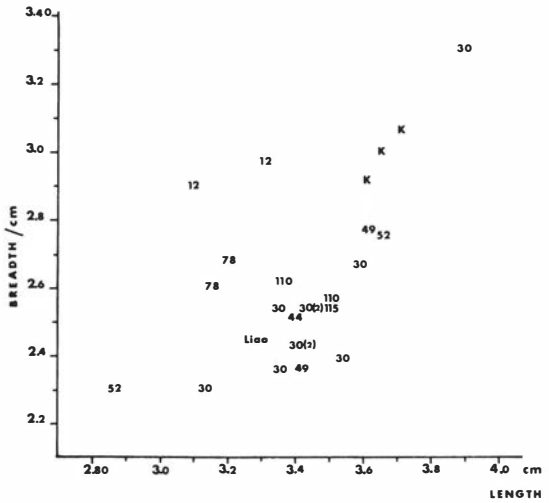

Fig. 4. Phalanx 2 mid-shaft width plotted against phalanx 2 volar length for Chinese Turolian and Pliocene hipparions. Specimens denoted by locality number or abbreviation (Liao = Liao-Wang-Kou; K = Kueite).

from Loc. 44 to *H. coelophyes* (skulls PMU.M 311 and 3688), (1927, p. 26–29, Taf. IV 13) *H. fossatum* (skull 3690), and (1927, p. 9–13, Fig. 10) *H. hippidiodus* (palatal fragment 247 and jaw 254–255). In addition to these specimens, there are a skull (7361), six jaws (254, 275, 312, 313, 8410 and 8446), deciduous dentitions (8409, 8425, 8426, 8429 and 8435) and snouts (8404, 8405, 8406, 8407 and 8408), a complete metacarpal III (8413), a proximal and distal metatarsal III (395 and 8421), a phalanx 1 (8414) and 2 (8419), and three proximal (8401, 8402 and 8411) and one distal radius fragments (8412) in the Lagrelius collection. The preorbital fossa of 311, 3688 and 3690 is narrowly oval and shallow. It is defined posteriorly with a pocket and rim. The fossa is situated rather far in front of the orbit (Fig. 1). The nasal slit is level with the P^2. The limb-bones are small and gracile (Figs. 2, 3, 4).

In one jaw (8410), the slightly worn premolar row is long and the ramus is deep beneath the P_4. However, in front of the P_2, the jaw is not unusually deep. The large size of the first variables is possibly due to the youth of the animal, the jaw being medially deep because of the great height of the emerging P_4. Also, a palatal fragment (247) is large. Real heterogeneity at this locality is indicated in plots of the length and breadth of the occlusal surface of the upper cheek-teeth, the measurements on the teeth of 247 falling well outside and proximal to those of 311, 3688 and 3690.

SHANXI, PAO-TE-HSIEN, CHI-CHIA–KOU, YANG-MU–KOU, LOC. 49: From Loc. 49 Sefve (1927, p. 18–20, 53, Fig. 12 and p. 92, Taf. III 11) described *H. plocodus* (two palates, PMU.M. 3824, 3825; a jaw, 256; and a limb-bone 8464), and referred (1927, p. 35, 37) a palate to *H. platyodus* (342). In addition, there are two palatal fragments (8472 and 8473), a juvenile skull (8469), two senile jaws (8470 and 8474), two phalanges 2 (264 and 8462), a calcaneum and an astragalus linked together (8460), a distal astragalus (8461), and a distal fragment of a juvenile radius (8458). The American Museum has material from Yang Mu Kou, northwestern Shanxi, which may correspond to Loc. 49. There are eight skulls (1-No. 56, No. 67, No. 73, 20-L 88, 20-L 92, 20-L 93, 20-L 94, 79-L 707), a jaw (79-L 707), two complete metatarsal III's (No 114), a proximal metacarpal III (83-L 641) and four distal metapodials (83-L 641, 83-L 728, 84-L 721).

The preorbital fossae of the AMNH specimens are situated far in front of the orbits (Fig. 1). The fossae are pear-shaped and well defined, except in 20-L 88 and 79-L 707, in which they are shallow, consisting only of a posterior rim and a slight pocket. The juvenile skull (8469 in the Lagrelius Collection) has also a shallow hollow in the cheek, but no fossa. The nasal slit is shallow. Anteriorly it ends level with the anterior tip of the P^2 or even 2,5 cm in front of the P^2. In the AMNH specimens the teeth have short protocones and differ from the teeth from Loc. 49 in having less plications and

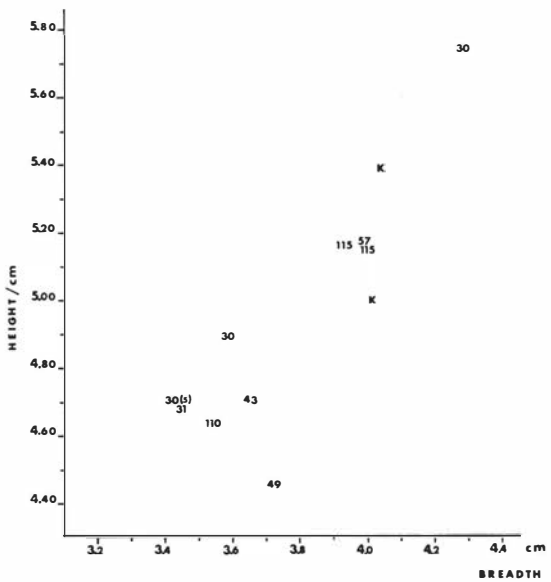

Fig. 5. Astragalus height plotted against astragalus distal articular breadth for Chinese Turolian and Pliocene hipparions. Specimens denoted by locality number or abbreviation (K = Kueite).

Table 1. Plication count and protoconal length of Chinese Turolian hipparions. (Abbreviations: OR = Observed Range; N = Number of observations; M± S_M = Mean with standard error; s = standard deviation).

Locality and form	Plication count				Protoconal length			
	OR	N	M±S_M	s	OR	N	M±S_M	S
Shansi, Pao-Te:								
Loc. 30 (small)	2 –33	56	15.09±0.98	7.32	0.53–0.77	45	0.65±0.87	5.80
30 (large)	23 –38	7	28.93±2.10	5.56	0.74–0.87	7	0.80±1.84	4.88
43	3 –32	28	19.82±1.30	6.87	0.56–0.74	34	0.66±0.81	4.72
44	2 –33	19	19.61±2.03	8.87	0.53–0.82	20	0.67±1.63	7.30
49	17 –34	15	27.50±1.20	4.63	1.52–0.76	15	0.63±2.16	8.34
52	6 –28	7	13.57±4.37	11.58	0.57–0.86	9	0.71±3.70	11.18
108	7 –27	11	17.50±2.33	7.75	0.53–0.83	10	0.67±2.87	9.07
109	25 –32	4	27.5		0.59–0.68	4	0.64	(one individual)
43 (1)	27 –33	4	29.7		0.88–1.13	4	1.06	(one individual)
Shansi, Wu Hsiang:								
Loc. 70, 71, 73 & Hsia Kou	13 –43	24	29.79±1.85	9.08	0.53–0.95	42	0.70±1.44	9.31
Shansi, Yu She:								
Hsi Liang	30 –32	4	31					(one individual)
Ch iao Chia	24 –30	5	27.3		0.55–0.70	8	0.63	(two individuals)
Shansi (AMNH):								
Chen-Chia-Mao-Kou	17 –28	4	22.5 ±2.04	4.08	0.56–0.77	4	0.63±2.04	4.08
Liao-Wang-Kou	3 –27	4	17.5 ±5.40	10.80	0.57–0.76	8	0.66±2.10	5.94
Yang-Mu-Kou	7 –24	10	15.5 ±1.53	4.83	0.48–0.83	26	0.63±1.63	8.33
Shensi, Fu-Ku:								
Loc. 51	24 –37	4	28.8		0.69–0.79	4	0.74	(one individual)
Kansu:								
Loc. 115 & 116	4 –33	27	11.02±1.22	6.33	0.58–0.83	30	0.69±1.13	6.18
Honan:								
Loc. 11, 12 & 13	13 – 33	30	23.17±1.01	5.53	0.53–0.92	35	0.70±2.32	13.74

lacking crenellations (Table 1). The limb-bones from Loc. 49 and Yang Mu Kou are small and gracile (Fig. 2, 4, 5), but one metatarsal III (AMNH 114) is quite short and therefore appears to be relatively massive. (Fig. 2).

SHANXI, PAO-TE-HSIEN, CHI-CHIA-KOU, CHEN CHIA MAO KOU, LOC. 108: From Loc. 108 Sefve (1927, p. 7) listed *H. richthofeni,* but described no fossil material. From Loc. 108 there is a jaw in the Lagrelius Collection (355), several deciduous dentitions (8607, 8609 and 8611), a complete metacarpal III (8615), a phalanx 2 (8599), and a juvenile phalanx 1 (8617). The American Museum has material (skulls, L-62, 70-L 658 (juvenile) and 88-L 733 (adult); jaws, L 62 (juvenile) and L 62 (senile), 70-L 658, 88-L 733; a complete metacarpal III, No. 117; a distal metapodial 83-L 730; and a phalanx 1, 83-L 730) from Chen Chia Mao Kou, northwestern Shanxi, a locality that may correspond to Loc. 108.

On the AMNH specimens, the preorbital fossae either are weak with a posterior rim (88-L 733) or are defined only as slight hollows in the cheeks (70-L 658). The nasal slits are level with the middle of the P^2s. The plication counts are medium and the protocones are short (Table 1). The limb-bones from Loc. 108 and Chen Chia Mao Kou are slender, especially phalanx 1 (83-L 730), which is long and narrow (Figs. 2, 3).

SHANXI, PAO-TE-HSIEN, CHI-CHIA-KOU, WANG-CHIA-LIANG-KOU, LOC. 110: Sefve (1927, p. 13–18) referred a juvenile skull with the M^2 emerging (PMU.M. 260) from Loc. 110 to *H.dermatorhinum.* Additional material from this locality includes a jaw (8619), a complete metacarpal III (15002), two phalanges 2 (8637 and 8642), three phalanges 1 (8635, 8636 and 8643), an astragalus (8634), and a distal radius (kept in the Zoological Museum, Helsinki). The fossa of 260 is well defined. An anterior fossa level with DP^2 may be present. The nasal opening is not unusually deep. All the limb-bones are small and gracile (Figs. 2, 3, 4, 5).

SHANXI, PAO-TE-HSIEN, CHI-CHIA-KOU, SANG-CHIA-LIANG-KOU, LOC. 43: Sefve (1927, p. 29–32) referred specimens to *H. coelophyes* (skull fragments, PMU.M. 309, 3689) and (1927, p. 13–18, Fig. 11) *H. dermatorhinum* (palate, 3823 from Loc. 43 (1)) and described

(1927, p. 9–13, Figs. 6, 8, 9, Taf. IV 12) *H. hippidiodus* (skull fragments, 248, 249, 250 (juvenile), 3818) for specimens from Loc. 43. In addition to the referred material, there are five fragments of skulls (590, 594, 595 (juvenile), 596, AMNH 26346), two jaws (314 and 8379), two distal metapodials (393 and 8387), a proximal metacarpal III (8371), an astragalus (8774), and two distal tibiae (8377 and 8378).

The preorbital fossae are at most faint with small posterior rims or barely defined pockets (309, 595). Usually there is no fossa, only a slightly rugose area (249, 596, 3689, 3818, AMNH 26346). The nasal slit of 3818 is level with the middle of the P^2. The cranial material from Loc. 43 is heterogeneous, as plots on occlusal length and breadth of the teeth indicate. The teeth are large in the skulls 248, 249, 596, 3818, and 250, as well as in a jaw (8379). A preorbital fossa is lacking in 249 and 596, as well as in the skulls 3689 and AMNH 26346 with small teeth. The large palate 3823 from Loc. 43(1) differs from the large specimens at Loc. 43 in having much longer protocones of the upper teeth (Table 1). The two size categories of teeth correspond to those at Loc. 44.

SHANXI, PAO-TE-HSIEN, T'AI-CHIA-KOU, LOC. 30: Loc. 30, with its sub-localities 30 (2) and 30 (5), is the richest of the fossil localities represented in the Lagrelius Collection. Sefve (1927, p. 13–18, Taf. I 1–3) described *H. dermatorhinum* (subadult skull, PMU.M. 3872, palate, 261), and (1927, p. 26–29, 51, Taf. IV 14–15) *H. fossatum* (skull, 3821 a+b and limb-bones), and referred (1927, p. 20–26, 48–52, Fig. 13, taf. II 5, 6) specimens to *H. richthofeni* (skulls 267, 268, 269, 3820, and 3873 from Loc. 30 (2), and limb-bones). Additional material from Loc. 30 includes seven skulls (585, 591, 7357, 7359 and 7362: from Loc. 30(5) 586 and 592), several skull fragments (7988, 8285, 8286 and 8287: from Loc. 30(2) 8268; from Loc. 30(5) 7948, 7955, 7957 and 7976), lots of more or less complete jaws (262, 271, 274, 277, 343, 382, 587, 3822 a+b, 7918, 7951, 7952, 7953, 7954, 7956, 7958, 7975, 7977, 7978, 7979, 7980, 7989, 7990, 7992, 7993, 7995, 7996, 8277, 8278, 8279, 8280, and 8219; from Loc. 30(2) 589, 8274 and 8275; from Loc. 30(5) fragments of juvenile jaws 7967, 7968, 7970, 7971, 7972, 7973, 7974 and AMNH 26347). There are also numerous deciduous dentitions (7967, 7968, 7970, 7971, 7973 and 7974) and snouts (7960, 7961, 7963, 7964, 7966, 8257, 8258, 8259 and 8260). The limb-bones consist of three proximal metatarsal III's (392, 281 to which belong astragalus M 280 and calcaneum M 279, and 8293 from Loc. 30 (2)), six distal metapodials (307, 582, 285 to which belong phalanx 1 and 2 of the same number, 583 to which belong phalanx 1 and 2 of the same number, 8270 and 8295), nine phalanges 2 (285, 286, 583, 8300 and 8384; from Loc. 30(2) 8309, 8310, 8314 and 8317), five phalanges 1 (285, 297, 583 and 8302; from Loc. 30(2) 8306), three astragali (280, 305, and one 7985 from Loc. 30 (5)), three distal tibiae (8267, 8271 and 7984 from Loc. 30 (5)), and a proximal radius (390).

In the large, sub-adult skull, 3872, which Sefve (1927, p. 13–18, Taf. I 1–3) described as *H. dermatorhinum,* the preorbital fossa is oval, with a shallow posterior pocket placed relatively close to the orbit (Fig. 1). The nasal slit is very deep and wide (Sefve 1927, Taf. I 1–3). The cranial characters are confirmed by two adult skulls with jaws (unnumbered) from Shanxi, Pao-Te-Hsien, kept in the IVPP. Some other cranial specimens in Uppsala appear to belong to *H. dermatorhinum* (e.g. the skull fragments 261, 304, and 7359, and the rami 262 and 7978). The premolar rows of these specimens are long and the rami are deep. The plication count is as a mean higher and the protocone longer in the uppers of the large specimens than in the rest of the sample from Loc. 30 (Table. 1). These teeth resemble those of 3823 from Loc. 43 (1), which Sefve (1927, p. 13–18, Fig. 11) referrerd to *H. dermatorhinum,* but the protocones of 3823 are longer.

The fossae are usually well defined in the rest of the skulls from Loc. 30. They are wide, reaching down towards the facial crest, and vary from shallow to rather deep. A shallow posterior pocket may be present or lacking (586). The preorbital fossa is situated relatively close to the orbit (Fig. 1). An anterior fossa level with the P^2 is present in 267, 268, 269, 586, 591, 3820, 3873, and probably 585 and 3821. The nasal slit reaches from a level with the anterior tip of the P^2 to between the P^{3-4}. In some specimens (586, 3820, 3873, and possibly 269), the nasals extend down laterally and bend inward, forming tubes (Sefve 1927, p. 23, Taf. III 7,8).

The majority of the limb-bones are small and gracile (Figs. 2, 3, 4, 5). They may belong with the majority of the skulls. In addition, there are a few large bones, possibly belonging to the large cranial fragments. The large specimens tend to occur in association; 281-280-279 is a proximal metatarsal III with astragalus and calcaneum, 285 and 583 are distal metapodials with associated phalanges 1 and 2. Evidently the two distal tibiae from Loc. 30 (8267 and 8271) are also large.

SHANXI, PAO-TE-HSIEN, CHI-CHIA-KOU, HUANG-LU-KOU, LOC. 109: There is a single skull (PMU.M. 584), from Loc. 109. The oval-

rounded preorbital fossa is placed moderately far in front of the orbit (Fig. 1). There is an anterior fossa level with the P^2. The nasal slit is rather deep; it extends on a level with the posterior half of the P^2.

SHANXI, HO-CHÜ-HSIEN, NAN-SHA-WA-HUA-TAN, LOC. 114: There is a senile skull (PMU.M. 593) and left and right rami (8630), possibly all of one individual, a palatal fragment (8632) and juvenile jaw (8631). The preorbital fossa is long-oval, rather deep in the middle, and placed moderately far in front of the orbit (Fig. 1). There is a posterior pocket.

SHANXI, WU-HSIANG-HSIEN, HSI-KOU-TSUN, CHING-KOU, LOC. 70: Sefve (1927, p. 34–38, Fig. 17–18, Taf. VI 21) described *H. platyodus* (skull and jaw, PMU.M. 369 a+b) from Loc. 70. Additional material consists of two jaws (344 and 8552), a distal metapodial (8527), an astragalus (8516), and a calcaneum (8517). The preorbital fossa is almost circular with a deep posterior pocket placed far in front of the orbit (fig. 1). The nasal slit is level with the anterior tip of the P^2.

SHANXI, WU-HSIANG-HSIEN, TUNG-TSUN, TOU-CHIAO-KOU, LOC. 73: Sefve (1927, p. 39–43, 45–48, Figs. 20–22) described *H. ptychodus* from Loc. 73 (skulls, PMU.M. 347, 350 (subadult), and 3864, limb bones). Additional material consists of a jaw (353) and jaw fragments (8554, 8555, 8557 and 8558), a distal portion of a juvenile metapodial (8579), a proximal portion of a metacarpal III (360), a distal portion of a tibia (371), and a radius (358). The preorbital fossa is narrowly oval with a deep posterior pocket. The fossa is situated well in front of the orbit (Fig. 1). The nasal slit is shallow, it extends to a level one cm in front of the P^2. The limb-bones are small and slender.

SHANXI, WU-HSIANG-HSIEN, TUNG-TSUN, TOU-CHIAO-KOU, LOC. 78: Sefve (1927, p. 7) recorded *H. ptychodus* from Loc. 78, but did not specifically mention fossil material. The material from Loc. 78 comprises limb-bones: A distal portion of a metapodial (PMU.M. 374), phalanges 2 (379, 380), and phalanges 1 (375, 376, 377). The limb-bones are small, but the phalanges are relatively slightly more robust than those from the localities mentioned earlier (Figs. 3, 4).

Wu-Hsiang-Hsien in Shanxi has yielded additional material: Loc. 71 (Hu-Tzu-Kou), a jaw (8514) of a rather small form; Loc. 77 (Hao-Chia-Po), Sefve (1927, p. 7) recorded *H. ptychodus* and there is a distal tibia (8582); Loc. Chai-Chang-Kou, Sefve (1927, p. 7) recorded *H. richthofeni* and there are three rami (8862, 8863 and 8864).

SHANXI, YU-SHE-HSIEN, HSI LIANG, YU CHIAO TSUN: From Hsi Liang Sefve (1927, p. 43–45, Fig. 23) described *H. tylodus* (skull, PMU.M. 3684). The preorbital fossa is oval and posteriorly deep. It is placed far in front of the orbit (Fig. 1). An anterior fossa (Sefve 1927, p. 44) is possibly present. The nasal slit ends at a level just in front of the P^2. There is a small, slender metacarpal III (15000) and distal metatarsal III (15001) (Fig. 2).

SHANXI, YU-SHE-HSIEN, TAN TSUN, CHIAO CHIA KOU: Sefve (1927, p. 38–39, Fig. 19) described *H. parvum* from Chiao Chia Kou (left and right palatal fragments, PMU.M. 345 and 346). Additional material includes a skull fragment (8826) belonging to a jaw (8827), and a distal portion of a metapodial (396).

HENAN, HSIN-AN-HSIEN, CHEN-KOU-WAN (also SHANG YIN KOU): Loc. 12, Sefve (1927, p. 42, 52–53) recorded *H. ptychodus* (skull PMU.M. 348 and limb-bones) and (1927, p. 33) *H. kreugeri* (skull, 316) from Loc. 12. Since these species were both characterized by material from other localities (Loc. 73 and Loc. 52 respectively), and since the hipparion from Henan (Loc. 11, 12, and 13) appears to be distinct, Forstén (1968, p. 78, Pl. 4) proposed a new name, *H. sefvei,* for this species. The type is a metacarpal III (335) (also see Sefve 1927, p. 52). Additional material from Loc. 12 consists of several skull fragments (7856, 7865, 7867, 7868, 7873, 7874, 7875, 7876 and 7877), four jaw fragments (356, 7878, 7886 and 7887), three proximal metatarsal III's (394, 333, and 7869), a complete metatarsal III (336), a distal portion of a metapodial (7885), three phalanges 2 (397, 7849 and 7882), two distal portions of tibiae (333, 391), and three distal portions of radii (7870, 7871 and 7883). The preorbital fossa of 316 is almost circular; it is shallow with a narrow posterior pocket. It is situated far in front of the orbit (Fig. 1). In 348 the fossa is deep posteriorly. The limb-bones are small but stocky (Figs. 2, 4).

HENAN, HSIN-AN-HSIEN, CHEN-KOU-WAN, Loc. 11: Sefve (1927, p. 7), recorded *H. ptychodus* from Loc. 11 without detailing his material. There are three skull fragments (PMU.M. 351, 7860 and 7864) and a jaw (357). The material resembles that from Loc. 12.

HENAN, HSIN-AN-HSIEN, T'AI-P'ING-KOU, LOC, 29: Sefve (1927, p. 7) referred to *H. ptychodus* from Loc. 29, but without detailing his material. There is a jaw (7941) with well worn teeth, rather larger than those from Chen Kou Wan.

Henan has provided further material from: Loc. 13 (Chen-Kou-Wan), a posterior phalanx 1 (7922) (Fig. 3); Loc. 57 (Sung-Chin-Chiang, Shang-Kou), Sefve (1927, p. 7) recorded *H. ptychodus* and there is a single astragalus (8482) (Fig. 5); Loc. 58 (Kou-Yü, Tiao-Tsui), there is a skull fragment (AMNH 26345) and a distal metapodial (8548). The preorbital fossa of AMNH 26345 is deep with a wide posterior rim. From Loc. 59 (Cheng Tsun, Wa-Kou) there is a jaw (8518) and a proximal metacarpal III (8523).

SHAANXI, FU-KU-HSIEN, WU-LAN-KOU, PEI-HOU-KOU, Loc. 51: Sefve (1927, p. 13) recorded *H. dermatorhinum* from Loc. 51 (left and right upper tooth rows, PMU.M. 258 and 259). The teeth are large, but the protocones are rather short.

GANSU, KING-YANG-HSIEN, CHIAO-TZU-CHUAN, MU-CHIA-TSUI-KOU, LOC. 115: Sefve (1927, p. 9–13, Fig. 7) recorded *H. hippidiodus* (skull; PMU.M. 3819) from Loc. 115. This skull was designated the lectotype (Forstén 1968, p. 73, Pl. 3). Additional material from Loc. 115 consists of a skull fragment (AMNH 26344), several jaw fragments (388, 8678, 8715, 8717, 8733, 8770, 8783 and 8785 and AMNH 26344) four distal portions of metapodials (257, 8737, 8739 and 8797), five proximal portions of metatarsal III's (8735, 8736, 8765, 8793 and 8799), a proximal metacarpal III (8798), a complete metacarpal III (8737), two astragali (8761 and 8792), two phalanges 2 (8790 and 8794), and a phalanx 1 (8791). The preorbital fossae are absent. In 3819 there is a slightly rugose area about four cm in front of the orbit. In AMNH 26344 the cheek is flat.The limb-bones are larger than those from most localities mentioned earlier, although they are smaller than the large bones from Loc. 30 (Figs. 2, 3, 4, 5).

In the IVPP and THP there is material of *Hipparion* from Gansu, King-Yang-Hsien. The skulls (THP 00263, 00892, 04470, 04471) resemble those from Loc. 115 and 43 in having faint preorbital fossae with a posterior rim but otherwise lacking clear limits. The skulls, teeth, and limb-bones are smaller than those from Loc. 115, but resemble the small specimens from Loc. 43.

GANSU, KING-YANG-HSIEN, CHIAO-TZU-CHUAN, CHAO-TZU-KOU, LOC. 116: Sefve (1927, p. 6, 53) recorded *H. kreugeri* from Loc. 116 on the basis of jaw fragments and limb-bones. The material consists of three senile jaws (PMU.M. 317, 330, 331), a complete metacarpal III (338), and a metatarsal III (341). The material from Loc. 116 resembles that from Loc. 115 (Fig. 2).

Morphology

SKULL: I found no differences in skull proportions (e.g., relative snout lenght, palatal or frontal width) between the various local forms of *Hipparion* in the Lagrelius Collection. Although the placement of the preorbital fossa relative to the orbit is at least partly a function of skull-size, the Chinese Turolian hipparions can roughly be separated into forms with the fossa placed relatively close to the orbit and forms with the fossa placed relatively far in front of the orbit (Fig. 1). There is no sharp difference between these groups. The AMNH skulls from Ch'en-Chia-Mao-Kou and those from localities 109, 110, and 114 in the Lagrelius Collection are intermediate. Skulls from a single locality tend to cluster together indicating similar placement of the fossa relative to the orbit.

In a local sample of skulls, the fossa is roughly similar in morphology as well as in relative placement. When located far in front of the orbit, the fossa is simple; i.e., there is a single preorbital fossa (except possibly PMU.M. 3684 from Hsi-Liang). When placed close to the orbit, the fossa tends to be double; in addition to the fossa proper, there is an anterior fossa level with the P^2 (e.g., at localities 30, 30(2) 30(5), 109 and probably at localities 52 and 110). A double fossa is also present on two skulls (41-L 352 and 42-L 333 (juvenile) in the AMNH collection) from the Turolian of Nan-Liang-Kou, northwestern Shanxi and in one skull (V 4659) from Shui-Ling-Kou, Hohsien, southwestern Shanxi. In the Chinese Turolian hipparions, the preorbital fossa tends to be shallow and weakly defined, even lacking. The fossa is shallow and weak in skulls from localities 31, 44, 43, and Liao-Wang-Kou (AMNH), weak or lacking in skulls from localities 43, 115, and Ch'en-Chia-Mao-Kou (AMNH). The fossa is usually well defined in skulls from localities 30, 110, 109, 12, 70, 73, Hsi-Liang, and 114, whereas in the skulls from Yang-Mu-Kou (AMNH) both weak and well defined fossae occur. The nasal slit is mostly shallow, extending posteriorly to a level with the P^2. In skulls from Loc. 30 the nasal slit is deep.

TEETH: In the Chinese Turolian hipparions the number of enamel plications on the occlusal surface of the P^3–M^2 varies. The mean plication count is medium to low in the hipparions in the steppe faunas of Shanxi and Gansu, and higher in those of the woodland faunas of Shanxi and Henan (Table 1). The protocones are oval and rather short, except in the large palatal fragment (PMU.M. 3823) from Loc. 43 (1). However, for most local samples the means are biased by small sample size and by the frequent inclusion of the left and right P^3–M^2's

of single individuals in the sample; these teeth tend to be more similar to each other in plication count and protoconal length than do teeth of different individuals, thus causing spurious "homogeneity" of the sample. The enamel pattern of the lower permanent cheek-teeth is hipparionid; i.e. with an oval metaconid and angular metastylid. The lowers from Henan are slightly caballoid; i.e., with a somewhat angular metaconid, as well as metastylid.

LIMBS: The Chinese Turolian hipparions are generally small and slender. *Hipparion* from localities 115 and 116 is larger than most other local forms, and some limb-bones, as well as jaws and skull fragments, from Loc. 30 indicate a large form at this locality. *Hipparion* from Harr Obo may be as large as the latter. *Hipparion* from Henan, although small, had a relatively stocky build (Figs. 2, 3, 4).

Ecology

Following Schlosser (1903), Kurtén (1952, p. 6–32) separated the faunas of the Chinese fossil localities into "forest" or *gaudryi*-faunas in the south (Henan and Shanxi, Wu-Hsiang-Hsien and Yu--She-Hsien) and "steppe" or *dorcadoides*-faunas in the north (Shanxi, Pao Te Hsien, Locs. 30, 31, 108, 110; Ho Chü Hsien; and Gansu), with intermediate "mixed" fauna localities at Shanxi, Pao-Te-Hsien, Locs. 43, 44, 49, 52, and 109; and Shaanxi, Fu-Ku-Hsien. Kurtén (1952) characterized the faunas on the basis of the species included in them.

In China, *Hipparion* occurs in all types of faunas. There are no clear differences in size or morphology between *Hipparion* from the "forest" faunas and those in the "steppe" faunas, except, possibly, in the plication count of the teeth and in the relative position of the preorbital fossa. In the "forest" faunas, *Hipparion* tends to have more enamel plications and the fossa placed relatively farther in front of the orbit than *Hipparion* in the "steppe" faunas (Table 1 and Fig. 1).

Stratigraphy

There are no clear stratigraphic differences between the various Chinese *Hipparion* faunas represented in the Lagrelius Collection. Excepting ecological factors, the faunal composition is similar (Kurtén, 1952). All faunas are considered "Pontian", i.e., Turolian, in age. Žhegallo (1978, p. 21, Fig. 80), by correlating with hipparions in the Mongolian stratotype, postulated considerable differences in age between the various Chinese faunas. He believed that they may span the Upper Vallesian up to and including the Upper Ruscinian.

Kurtén (this volume) found certain differences between the hyaenas in the Chinese *Hipparion* faunas. *Ictitherium sensu stricto* is present in the faunas of Loc. 49 and Honan, as well as at Pikermi. The faunas of Locs. 30, 43, 108, and 109 have *Thalassictis wongi* in common with the faunas of Samos, whereas a slightly different (either more advanced or more primitive) form occurs at Locs. 110 and Gansu, as well as at Maragheh. *Thalassictis* at Loc. 49 is intermediate. This would place the majority of the Chinese localities within a narrow Turolian age-bracket.

Pliocene and Pleistocene hipparions in China

Post-Turolian hipparions are poorly represented in the Lagrelius Collection. Sefve (1927) reported *Proboscidipparion sinense,* new genus and species, from Loc. 39, Henan, Mien-Chih-Hsien, Lan-Kou, and recorded *H. ptychodus* from Chia-Mo-Ssu in the Kueite Valley, Gansu (now Qinghai). According to Bohlin (1938), the fauna of Chia-Mo-Ssu is Upper Pliocene. Forstén (1968, p. 73) referred the material from the Kueite Valley to *H. hippidiodus* on the basis of limb-bone size and proportions. The single tooth (an upper P, 3087) from that locality is badly preserved and not diagnostic. However, although the bones resemble those of *H. hippidiodus* from Locs. 115 and 116, the lack of dental and cranial material makes a specific identification uncertain. There is also a considerable time-hiatus between "Pontian" *H. hippidiodus* from Locs. 115 and 116 and the Upper Pliocene Kueite Valley hipparion. The material from the Kueite Valley is best left as *H.* sp.

The dentally well-defined early Villafranchian species *H. houfenense* Teilhard & Young is not represented in the Lagrelius Collection. Žhegallo (1978, p. 21, 116–117), on the basis of the literature (i.e., Sefve 1927, p. 17, Fig. 11), referred a palate with right and left tooth-rows (PMU.M. 3823 from Loc. 43(1) to *H. houfenense.* Although the teeth of 3823 resemble those of *H. houfenense* (e.g., AMNH 96-B 1031 from Hsia-Chuang, eastern Shanxi, and THP 10508 from Matzekou, Yü She Basin, Shanxi, of Qui, Huang & Kuo 1980, Pl. 1, Fig. 3) in their long, flat protocones, they differ in their weakly defined metastyles. Sefve (1927, p. 17) originally believed 3823 to belong to *H. dermatorhinum.* The specimen, which is the only one from Loc. 43 (1), should be left as *H.* sp. (Forstén 1968, p. 78).

Taxonomy

Sefve (1927) recognized eleven species of *Hipparion,* ten of which were new, in the Lagrelius Collection on skull and tooth morphology. Forstén (1968) retained three of Sefve's species, and erected a new name for a fourth.

H. dermatorhinum Sefve 1927.

LECTOTYPE: Subadult skull, PMU.M. 3872, from Loc. 30 (Sefve 1927, p. 13–18, Taf. I 1–3; Forstén 1968, p. 76).

DEFINITION: Large; preorbital fossa oval, defined all around, placed relatively close to the orbit; nasal slit very deep.

DISCUSSION: To this species probably belong the large cranial and limb-bone specimens from Loc. 30. They indicate a rather high plication count, longish protocones of P^3-M^2 (Table 1), and moderately gracile limbs (Figs. 3, 5).

H. hippidiodus Sefve 1927

LECTOTYPE: Skull, PMU.M. 3819, from Loc. 115 (Sefve 1927; Fig. 7: Forstén 1968, p. 73, Pl. 3).

DEFINITION: Middle-sized to large; preorbital fossa lacking; cheek-teeth little or moderately plicated and hypsodont; limbs gracile.

DISCUSSION: The material from Loc. 116 probably belongs to this species and possibly some large cranial specimens from Loc. 43 (PMU.M. 248, 249, 596, 3818) and 44 (PMU.M. 247), although the teeth of these specimens are larger than those from Loc. 115. Some other specimens from Loc. 43 (309, 595, 3689) resemble *hippidiodus* in lacking a fossa but differ in having smaller teeth, especially if compared with the large specimens at Loc. 43. Also the limb-bones are smaller than those from Loc. 115. Skulls from Gansu, King-Yang, in the Chinese collections lack fossae, but are smaller than the skull from Loc. 115, as are the limb-bones.

H. sefvei Forstén 1968

HOLOTYPE: Metacarpal III, PMU.M. 335, from Loc. 12 (Forstén 1968, p. 78, Pl. 4).

DEFINITION: Middle-sized; preorbital fossa rounded with posterior pocket, placed far in front of the orbit; upper cheek-teeth moderately to richly plicated, lowers somewhat caballoid with pointed metaconid and metastylid; moderately to quite hypsodont; limbs robust with short metapodials.

H. plocodus Sefve 1927

LECTOTYPE: Palate, PMU.M. 3824, from Loc. 49 (Sefve 1927, p. 18–19; Forstén 1968, p. 66). Referred specimens are from localities 31, 43, 44, 49, 70, 73, Hsi Liang, and Chiao Chia Kou.

DEFINITION: Middle-sized to small; preorbital fossa oval, from well defined to weak, even lacking, placed relatively far in front of the orbit; upper cheek-teeth moderately to richly plicated; lower cheek-teeth hipparionid; hypsodont; limbs gracile.

DISCUSSION: Forstén (1968, p. 66–72) synonymized the rest of the *Hipparion* material in the Lagrelius Collection with *H. plocodus* Sefve, a species originally described from Loc. 49 (Sefve 1927, p. 18–20). Within this complex of local forms various character states occur in a mosaic manner. There are no characters useful for clear-cut differentiation of species. Size and limb-bone proportions are similar. Two groups may be separated on the basis of the placement of the preorbital fossa relative to the orbit.

1) Among the hipparions with the fossa placed far in front of the orbit, those from localities 31, 43, and 44 have a fossa defined only by a posterior rim or slight pocket, or totally lacking. The skulls from Ch'en-Chia-Mao-Kou (AMNH) resemble those from localities 31, 43, and 44 in morphology of the fossa, but the fossa is placed relatively closer to the orbit. The plication count of the P^3-M^2 is moderate to low in all these samples (Table 1). *Hipparion* from the localities Hsi-Liang, 58, 70, and 73 has a well defined, even deep, oval to rounded fossa with a posterior pocket. The plication count is high (Table 1). The placement of the fossa relative to the orbit is unknown in *Hipparion* from Loc. 49, but in the single, juvenile, skull (8469) the fossa lacks clear boundaries. The plication count is high (Table 1). In the skulls from Yang-Mu-Kou (AMNH), the fossa varies from well defined and deep, to weakly defined. The plication count is low (Table 1). *Hipparion* from Yang-Mu-Kou thus, combines characters of the various other hipparions with the fossa placed far in front of the orbit. In addition, one of the metatarsal III's (PMU.M. 114) from Yang-Mu-Kou resembles that of *H. sefvei* in its stockiness (Fig. 2).

2) The small hipparions from Loc. 30 (together with those from Locs. 52, 109, and 110) may be separated from the rest of the forms synonymized with *H. plocodus* in Forstén (1968, p. 66–72). In the former the fossa is placed relatively close to the orbit and tends to be double. The fossa is usually well defined. The teeth cannot be separated from those at localities 31, 43, and 44 (Table 1), and the limb-bones resemble all the local forms in this size group (Figs. 2, 3, 4, 5). The skulls from Nan-Liang-Kou (AMNH) resemble those from Loc. 30.

Sefve (1927, p. 20–26, Fig. 13, Taf. II 5–6) referred the material from Loc. 30 to *H. richthofeni.* Koken (1885) originally described *H. richthofeni*

from isolated teeth of uncertain origin, inadequate for taxonomic characterization. Gromova (1952) suggested that *H. richthofeni* should be dropped, and I (1978) concur (but see Žhegello, 1978). Sefve (1927, p. 26–29, Taf. IV 13–15) also erected *H. fossatum* for a skull from Loc. 30 (PMU.M. 3821 a + b). The nasal opening is deep in this skull, reaching a level with the mid-P^3; the fossa is shallow with a slight posterior pocket and is placed rather far in front of the orbit (Fig. 1). An anterior fossa may be separated from the fossa proper, but this portion of the skull is fragmentary (Sefve 1927, Taf. IV 13–15). Sefve compared 3821 with specimens from Loc. 31, 43, and 44. I do not believe that more than two species occur at Loc. 30, i.e., the large *H. dermatorhinum* and a smaller form, to which 3821 probably belongs. The name *H. fossatum* Sefve is available for the small form from Loc. 30.

H. fossatum Sefve 1927

LECTOTYPE: Senile skull and jaw, PMU.M. 3821 a+b (Sefve 1927, p. 26–29, Taf. IV 14–15). Referred specimens are from localities 30, 52, 109, and 110.

DEFINITION: Middle-sized; preorbital fossa oval, stretching down towards the facial crest, weak to well defined, placed relatively close to the orbit; frequently double; upper cheek-teeth moderately to richly plicated; lower cheek-teeth hipparionid; hypsodont; limbs gracile.

Proboscidipparion sinense Sefve

LECTOTYPE: Senile skull and jaw, PMU.M. 3925, 3926, from Loc. 39, Henan, Mien-Chih-Hsien, Lan-Kou (Sefve 1927, p. 55–67, Figs. 24–25, Tafs. IV 22–24, VII 25–26).

DEFINITION: Very large; preorbital fossa absent; nasal opening very deep and narrow; nasals probably short; upper cheek-teeth richly plicated and crenellated, protocones oval; lower cheek-teeth caballoid.

DISCUSSION: Material in the IVPP shows that the genus *Proboscidipparion* comprises at least two species: the stratigraphically late *P. sinense* and an older, smaller, species called *P. "pater"* (Matsumoto) (Qui, pers.comm.). The specimens in the Lagrelius Collection, i.e. the type and a left juvenile ramus (PMU.M. 1326) from Loc. 32, Shanxi, Chi-Hsien, Hsiao-Fu-Tsun, Tung-Tai (referred by Zdansky, 1932, pp. 23–25, Taf. II 4, to *Equus sanmeniensis*) represent *P. sinense*. A left juvenile ramus (1318) and a proximal MC III, referred by Zdansky (1932, p. 46 and 39) to *Proboscidipparion sinense,* belongs to *Equus*. An isolated, right lower molar (2881) from Shanxi, Fen-Yang, left by Zdansky (1932, pp. 47–48, Taf. VI 10) as Equidae incertae sedis, represents a *Proboscidipparion,* but it is uncertain which one of the known species. The co-occurrence of *Proboscidipparion* and *Equus* at Fen-Yang is not sure (Zdansky, 1932, footnote p. 35).

Two juvenile skulls in the AMNH, 66-B 825 from Hsia Chuang and 64-B 799 from Hsia Kou, both southeastern Shanxi, represent one or the other of the species of *Proboscidipparion.*

H. tchicoicum Ivanjev

LECTOTYPE: Jaw (PIN 3381-53) from Beregovaja, Burlatskaja ASSR, Soviet Central Asia, (Žhegallo 1978, p. 87, Fig. 54B).

DEFINITION: Very large; very large preorbital fossa placed ?close to the orbit; upper cheek-teeth with low, strongly curved crowns; moderately plicated, thin enamel, rounded protocone; lowers lacking, or with very weak, cingular stylids.

DISCUSSION: There is a left jaw fragment from Hebei, Xuan-Hua-Hsien, Hsia-P'o-Ti with part of P_2, P_{3-4} (15003), as well as a distal metatarsale III (14183), referable to *H. tchicoicum.* This species is represented in the Yu-She Basin in faunas of a Ruscinian-Villafranchian age (IVPP and AMNH material) and in Soviet Central Asia (PIN and GIN material). The occurrence at Hsia-P'o-Ti together with *Equus* is stratigraphically younger than the occurrences mentioned above.

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