

维氏大唇犀（奇蹄目，犀科）头骨的个体发育¹⁾

邓涛

(中国科学院古脊椎动物与古人类研究所 北京 100044)

摘要 临夏盆地晚中新世地层所产的维氏大唇犀 (*Chilotherium wimani*) 化石非常丰富, 包括不同年龄的个体。本文通过对维氏大唇犀不同年龄个体的分析和对比, 详细地了解其个体发育情况。由于犀类的种内变异较大, 个体发育特征将为更精确的鉴定提供帮助。维氏大唇犀头骨随年龄变异的一些特征如下: 顶嵴逐渐加强; 脑颅由圆隆而低矮变为高陡而狭窄; 头骨顶面的凹陷逐渐加深呈显著的马鞍形; 顶嵴间平面逐渐变宽; 眶上结节从无到发达; 鼓后突与关节后突从贴近到愈合; 鼻骨背面逐渐隆突; 枕嵴侧缘从平滑到中部收缩。维氏大唇犀上颊齿的磨蚀速度远大于下颊齿。雄性的头骨比雌性的尺寸更大, 结构更强壮, 头骨顶面凹陷更强烈, 鼻骨更厚实, 鼻骨侧缘下垂更轻微, 鼻切迹和上颌骨颜面部都更高。

关键词 犀科 个体发育 中新世 临夏盆地

CRANIAL ONTOGENESIS OF *CHILOTHERIUM WIMANI* (PERISSODACTYLA, RHINOCEROTIDAE)

DENG Tao

(Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences Beijing 100044)

Abstract Fossils of *Chilotherium wimani* from the Late Miocene in the Linxia Basin are very abundant, including many individuals of different ages. On the basis of the analysis and comparison in individuals of different ages, we can better recognize species of the chilothere. Since the variation in a rhinocerotid species is relatively great, ontogenetic characters can provide some help for the more accurate identification. The following skull characters of *Ch. wimani* vary with the age: parietal crest becomes gradually stronger; braincase becomes narrow and high from round and low; depression on the skull top deepened gradually to form a marked saddle; surface between the parietal crests widens step by step; supraorbital tubercle becomes well developed from absent; posttympenic process very close to the postglenoid process at first but fused to the latter finally; the nasal top becomes rounder gradually; lateral margin of occipital crest smooth but constricted centrally at older age. The degree of wear in upper cheek teeth of *Ch. wimani* is much greater than

1) 中国科学院知识创新工程项目 (KZCX2-103)、院长基金特别支持项目、古生物与古人类学科基础研究特别支持基金项目 (990303) 和国家重点基础研究发展规划项目 (G2000077700) 资助。

邓涛, 男, 38岁, 博士, 研究员, 从事新生代哺乳动物化石与气候环境演变研究。

in the lower. Compared to the female skull of *Ch. wimani*, the male has a larger size, stronger built, deeper depression on the skull top, thicker nasals, weaker nasal side drooping, and higher nasal notch and maxillary face.

Key words Rhinocerotidae, ontogenesis, Miocene, Linxia Basin

Chilotherium wimani was established by Ringstrom based on the materials from Fugu, Shaanxi, but he had only a few specimens^[1]. Deng described more fossils of *Ch. wimani* from Fugu, so the characters of this species are recognized on more detailed and complete information^[2]. The Hipparion fauna from the Linxia Basin is very similar to that from Fugu, rhinoceroses being dominant instead of hippariones. Chilotheres are the most abundant in the rhinocerotids from Linxia, including many individuals with different ages. Four species of the genus *Chilotherium* from Baode were recorded by Ringstrom in 1924, but none have individuals of different ages. The specimens of *Ch. wimani* are mainly old individuals. The materials from the Linxia Basin provide an example that allows us to recognize the growth of the dominant chilotheres in the Late Miocene, through the analysis and comparison of individuals of *Ch. wimani* in different ages. Because the variation in a rhinocerotid species is relatively great, the analysis in this paper can provide some help for more accurate identifications.

The specimens of *Ch. wimani* studied here are collected from different localities in Hezheng and Guanghe counties of the Linxia Basin. A detailed field correlation proves that these localities are from the same horizon, i.e. the top of the Liushu Formation in the late Late Miocene^[3] with grey orange or yellow brown silty mudstone or muddy siltstone.

HMV is the specimen number of Hezheng Fossil Museum.

1 Description and measurements

1.1 HMV 0770

An infant (about 1.5 years) skull (Fig. 1) with DP1~DP4, and its M1 has not erupted. This specimen is incomplete, and collected from Moshigou in Xinzhuang Village, Hezheng County.

The sutures have not fused. The top of skull is smooth, and there is a shallow saddle-shaped depression on the frontal. There is a fine longitudinal groove and a marked central suture between the nasals. The parietal crest is faint and low. The braincase is round.

The degrees of wear in the milk premolars become slight gradually from DP2 to DP4, and that of DP1 is the slightest. The median valleys on all milk premolars are open and wide, and there are rich but fine plications. The worn surface of DP1 is triangular; the protocone is weak; the metaloph is narrow, with anterior and posterior fine plications; and the posterior valley is closed. The protoloph of DP2 does not connect with the ectoloph, and bends backward lingually; the hypocone is large; both the crochet and antecrochet connect with the crista so that two median sinuses form; and the metastyle is sharp and long. Both the parastyle fold and metacone fold of DP3 and DP4 are marked; the metacone is narrow and long; there are pillars on the entrance of the median valley. The protocone and hypocone of DP3 are of the same size

but do not expand, and the antecrochet connects with the crista to form a median sinus. The hypocone of DP4 is smaller than the protocone; the crista is absent; and there is an enamel ring at the bottom of the crochet (Table 1, 2).

Table 1 Measurements of upper cheek teeth of *Chilotherium wimani* (mm)

Measures	HMV	HMV	HMV	HMV	HMV	HMV	HMV	HMV	HMV
	0770 (infant)	0381 (infant)	0675 (young)	0380 (young)	0363 (adult)	0060 (adult)	0063 (old)	0094 (old)	0082 (old)
DP1 L	20	20	20	19.3	21.4	21.5	—	13	18
W	17	16	17.5	18	17	17.7	—	17.4	17
H	18	15.5	17.3	16	13	14.3	—	0	3.5
P2 L	*37	*36.6	*32.5	28	25	29.8	—	25	17
W	29	31	32	29	29.7	35.4	—	28.4	22
H	23	27	8	29	20	29.4	—	6	0
P3 L	*42	*44	*37.4	36.4	40	37	31	24.5	24
W	38.5	37.7	37.5	45.5	45.4	52.5	46	36	38.2
H	30.5	25.7	10	34	34.8	33.5	23	0	0
P4 L	*49.5	*50.5	*47.7	*50	44.5	44	36.5	33.2	35.7
W	44.8	45	45	45.6	48.3	59.3	55.7	54.5	50
H	33	37	31.8	26	47	41	27.5	12	7.8
M1 L			51	51.5	50.7	55	43.6	37	33.5
W			56	56.8	57	62.5	58	59.6	57
H			49	47.5	42	47	29	17.3	5.7
M2 L					57	62	52	52.6	45
W					61.4	65	57.5	61.6	55.3
H					57.7	53.5	39	32	13
M3 L						49	42	52.5	51.5
W						53.4	53.7	55.6	52.7
H						46	43	34.5	36.6

* milk tooth; L = length; W = width; H = height; “—” means not preserved.

1.2 HMV 0381

An infant (about 3 years) skull (Fig. 1) with erupting M1 from the alveolus. It was collected from Yangjiashan in Sanhe Village, Hezheng County.

The central groove of the occipital crest is wide and shallow. The frontal is slightly concave, and the largest width of the skull top is at the level of the lacrimal tubercle. The nasal is narrow with a coarse tip, and its unfused suture forms a long, deep and fine groove. The parietal crests are round, low and straight, and the shortest distance between them is in their connection with the occipital crest at posterior end. The braincase is round. There are three infraorbital foramina: two near the bottom of the nasal notch on the maxillary face and one on the maxillary upper margin, among which only the posterior one on the maxillary face has no front groove. The posttympanic process is very close to the postglenoid one. The serrulate suture between the parietal and temporal bones is clear. The largest distance between the outer margins of the cheek tooth rows is at the level of DP4.

On the tooth row, the deepest degree of wear is from the posterior part of DP1 to the

parastyle of DP2, and the degree of wear from DP2 to DP4 is reduced in turn. The lingual cingulum of the milk premolars is weak, and the median valley is open. The worn surface of DP1 is triangular, with weak protoloph and large hypocone. There is a median sinus on DP2 and DP3. The protocone of DP2 is smaller than the hypocone, while the protocone of DP3 and DP4 is larger than the hypocone, with a marked parastyle fold. There is a strong pillar on the entrance of the median valley of DP4 (Table 1, 2).

Table 2 Measurements of skulls of *Chilotherium wimani* (mm)

Measures	HMV 0770 (infant)	HMV 0381 (infant)	HMV 0675 (young)	HMV 0380 (young)	HMV 0363 (adult)	HMV 0060 (adult)	HMV 0063 (old)	HMV 0094 (old)	HMV 0082 (old)
3	—	363	436	~474	—	—	500	528	483
4	—	99.6	131	136	250	—	162	161	132
7	—	—	217	—	214.5	250	256	277.5	248
9	50	45	58	59	66	66	62.6	81	74.5
13	—	—	—	—	—	281	277.5	303.5	~247
15	—	108	~126	—	154	141	156	152.5	168.4
16	—	~153	192.3	—	~188	184	214.7	202.5	187.5
17	—	35	24.3	28	39	54.5	52.6	67	60
20	120	125	144.6	157	—	155	160	184.8	143
21	—	213.7	250.5	~258	~272	—	280	263	248.5
22	59.5	70	86.8	96	85	90	96	98	75
23	—	—	91	—	134	125.5	137.7	148	120
25	82	88	125.5	117	144	—	—	158	121
26	105	120	147	150	171	158.7	167	192	139
27	—	—	—	—	166	165.3	162.5	185	155.5
28	46	51	54	58	43.4	—	—	39	44
29	49.5	67.5	54	60	50	—	56	47.2	40
30	—	—	—	—	72	—	56	63.5	48
31	—	—	51	37	43	36	50	46	—
32	—	—	120.4	109.5	108	~110	124.5	109.8	—

Measure numbers according to Reference [4].

1.3 HMV 0675

A young (about 4 years) skull (Fig. 1) with all milk premolars and an erupting M2. It was collected from Gucheng in Alimatu Village, Guanghe County.

The sutures are clear. The occipital surface is smooth, and the occipital condyles, foramen magnum and notch between condyles are very wide. The central suture of the nasals is a fine groove, and the tip is coarse. The frontal is slightly concave. The parietal crests are marked but not high, and the distance between is narrow, being 24.3 mm at the narrowest place. The postorbital process is absent. The largest width of the skull top is between the supraorbital tubercles. There are three infraorbital foramina. The maxillary upper margin is very wide, but on which the infraorbital foramen is very small. The braincase is high, with a round outer wall. The postglenoid process is robust, the paroccipital process declines backward, and the posttympanic process is very close to the postglenoid one but unfused. The largest distance

between the outer margins of the cheek tooth rows is at the level of M1.

The degree of wear of DP2 and DP3 is deepest, DP4 and the posterior part of DP1 second, and M1 is slight. The worn surface of DP1 is triangular, with the median and posterior fossettes. The crown of DP2 is worn to near the base so that the median and posterior fossettes are very small. The median and posterior valleys are also closed. The protocone of DP4 is constricted strongly; the antecrochet is wide and short; the hypocone is not constricted, and the entrance of the median valley is wide. The narrow and long crochet of M1 extends forward and near the protoloph. DP4 and M1 have a weak parastyle fold (Table 1, 2).

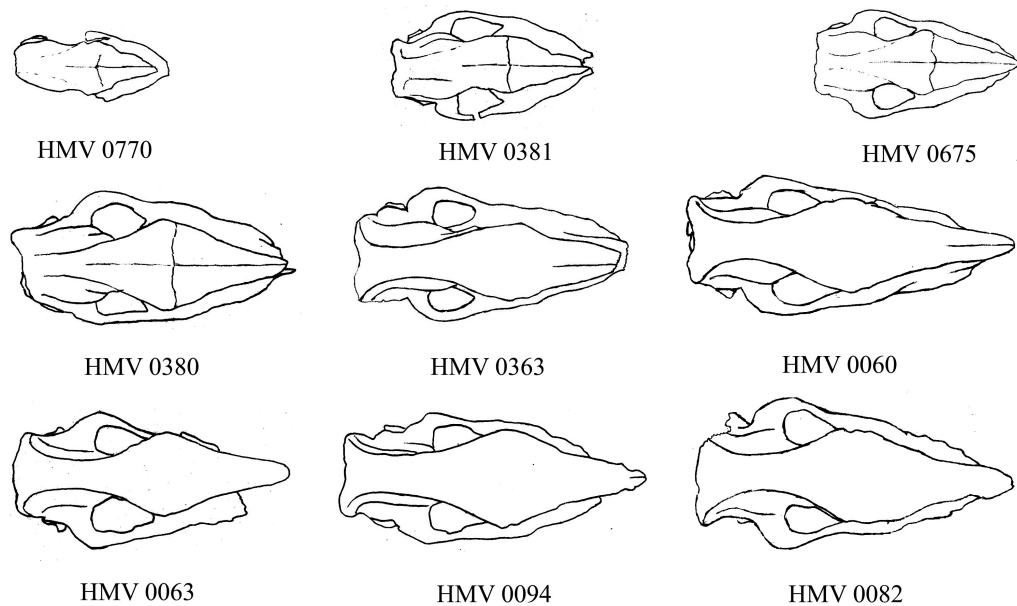


Fig. 1 Skulls of *Chilotherium wimani* with different ages (top view, $\times 1/15$)

1.4 HMV 0380

A young (about 7 years) skull (Fig. 1) with unworn M2, and its DP2 and DP3 has lost but DP4 still exists. It was collected from Houshan in Alimatu Village, Guanghe County.

The sutures have not fused. The occipital surface is smooth. The largest width of the skull top is between the supraorbital tubercles, and there is a depression on the frontal. The nasals are wide, and a fine groove is along the central suture. The parietal crests become weak backward, and the distance between is narrow, being 28 mm at the narrowest place. The braincase is high, with a round outer wall. The postorbital process is absent, and the supraorbital process is small. There are three infraorbital foramina, and all of them are on the maxillary face. The suture between the parietal and temporal bones still is clear, but its serrulation has disappeared. The postglenoid process is a robust wedge with three edges, and the posttympanic process is very close to the postglenoid process.

The degree of wear of DP1 and DP4 is deepest, M1 second, and P2 and P3 slightest. The worn surface of DP1 is triangular. The anterior, lingual and posterior cingula of P2 are

continuous but low; the median valley is closed; the protoloph is very narrow and weak, and the antecrochet is small and bifurcate. The lingual cingulum of P3 is discontinuous and forms low pillars at the entrance of the median valley; the protoloph and metaloph are very narrow on the worn surface; the crochet is small while the antecrochet is absent; the median valley is open. The lingual cingulum of DP4 is absent; there are pillars at the entrance of the median valley, and the metastyle fold is wide and deep. The lingual cingulum of M1 is absent too; the crochet is well-developed and extend to near the protoloph; the parastyle is long and sharp; the parastyle fold is weak (Table 1, 2).

1.5 H MV 0363

An adult (about 11 years) skull (Fig. 1) with the erupting M3. It is in bad condition and collected from Houshan in Alimatu Village, Guanghe County.

The sutures are fused completely. The paxwax pit is large and deep. The frontal surface on the skull top is strongly concave to form a marked saddle. The nasals are wide and long, with a round and smooth top. The parietal crests rise obviously, and a surface forms between them. The braincase is high, with a declining outer wall sideward. The maxillary face is coarse, on which there are three infraorbital foramina. The postorbital is absent, and the supraorbital tubercle is weak. The posttympanic process is very close to the postglenoid process, and the paroccipital process declines backward. The largest distance between the outer margins of the cheek tooth rows is at the level of the parastyle of M1.

The degree of wear is reduced from DP2 to M2 in turn. The worn surface of DP1 is a round triangle; the median fossette is a very small enamel ring; the protoloph is fine and small, and the ectoloph and metaloph are wide and large. The median and posterior valleys of P2 are closed, with a wide bridge; the crochet is narrow and long; the parastyle fold is wide and shallow; the paracone rib is weak, and the hypocone is much larger than the protocone. The antecrochet of P3 presses close to the hypocone so that the median valley is closed, but the bridge has not appeared; the posterior valley is open; the crochet is robust and long; the hypocone is round and slightly larger than the protocone, and the lingual cingulum is well-developed. The median valley of P4 is open; the fine crochet and crista connect with each other to form a very big median sinus on the worn surface; the protocone is much larger than the hypocone, and the lingual cingulum is low. The antecrochet of M1 is wide and short; the size of the protocone is similar to that of the hypocone; the entrance of the median valley is narrow; the lingual cingulum reduces to be pillars at the entrance of the median valley; the crochet is large and long; the median sinus is very big; the posterior cingulum is thick, and the parastyle fold is weak. The parastyle of M2 is projecting strongly; the protoloph is wide and long; the metaloph is narrow and short; the crochet is large and long; the median sinus is large and long but narrow; the antecrochet is absent; the entrance of the median valley is wide (Table 1, 2).

1.6 H MV 0060

An adult (about 15 years) skull (Fig. 1) with slightly worn M3. It was compressed laterally and collected from Tianjia in Alimatu Village, Guanghe County.

The occipital surface is coarse, and its height is obviously higher than its width. The foramen magnum is high and sharp, and the paxwax pit is deep. The central groove of the occipital crest is wide and shallow, and the two sides of this crest are steep and unconstricted centrally. The frontal is a saddle-shaped depression. The top of the nasal is round and the two side margins droop at the base. The parietal crests is strongly projecting laterally to form a brim, and the surface between them is flat. The braincase is narrow, with a high and steep outer wall. The postorbital is weak, but the supraorbital tubercle is well-developed. There are three infraorbital foramina, but they are not symmetrical on the two sides, being several tiny infraorbital foramina more on the right maxillary face. The posttympanic process fuses with the postglenoid process at the latter's half to form a close pseudoauditory meatus. The basioccipital tubercle, pterygoid process, maxillary tubercle, posttympanic process and the lower margin of the zygomatic arch are relatively coarse. The premaxillary bones are narrow and long, and connect with each other at their tips. The anterior margin of the palate is at the level of the anterior part of DP1. The distance from the notch between the condyles to the premaxillary tip is 540 mm long. The largest distance between the outer margins of the cheek tooth rows is at the level of M2.

The exterior wall of the cheek teeth is flat, without parastyle fold and paracone rib. The median valley of DP1 is open while the posterior one is closed and forms an enamel ring. P2 and P3 have median and posterior fossettes as well as a median sinus, and there is a low cingulum at their entrance of the median valley. The hypocone of P2 is much larger than the protocone, while the hypocone of P3 is equal to the protocone. The median valley of P4 is open, with a low cingulum at its entrance; the posterior valley is closed, and the crista is absent. The crochet of M1 is strong; the crista also is absent; the end of the antecrochet extends to reach the narrow entrance of the median valley; the lingual cingulum is absent, and the posterior valley is closed. The crochet of M2 is robust and extends forward strongly; the antecrochet is weak; the median and posterior valleys are wide; the protocone is larger than the hypocone, and there is a low cingulum on the lingual margin of the protocone. The worn surface of M3 is triangular, and there is a robust pillar at the entrance of the median valley (Table 1, 2).

1.7 HMV 0063

An old (about 30 years) skull (Fig. 1) with deeply worn premolars. It was slightly extruded leftward and the part in front of P3 is lost. It was collected from Shilei in Guanfang Village, Guanghe County.

The paxwax pit is wide and deep. The occipital crest has no central groove, but its side margins are constricted centrally. The frontal depression on the skull top is deep and obviously saddle-shaped. The skull top is the widest between the supraorbital processes. The nasal bones are strong, with a round top surface and a coarse tip. The parietal crests are projecting laterally to become a brim, with a wide surface between them. The braincase is high, with a steep outer wall. The postorbital is weak, but the supraorbital tubercle is well-developed. There are three infraorbital foramina, among which the one on the upper maxillary margin is very small. The

posttympanic process fuses with the postglenoid process to form a closed pseudoauditory meatus. The paroccipital and postglenoid processes are short and robust, and their ends are at the same level. The posttympanic process is thick. The central longitudinal crest on the basioccipital bone is very high. The temporal condyle is narrow and long. The largest distance between the outer margins of the cheek tooth rows is in front of M2.

The median and posterior fossettes as well as the entrance of the median valley form three closed enamel rings; the crochet is short and robust, and the exterior wall is flat. P4 is similar to P3; its V-shaped groove out of the entrance of the median valley is nearly closed by the low lingual cingulum; the crochet is narrow and long, and the parastyle fold is clear. Although M1 is worn deeply, the median valley still is open; the crochet is short and robust; the end of antecrochet extends lingually; the exterior wall is flat; the posterior valley is closed and forms an enamel ring; there are low pillars at the entrance of the median valley. M2 is similar to M1; its parastyle and metastyle are longer; there is no pillar at the entrance of the median valley, and the end of the antecrochet extends backward. The antecrochet and crista are very small; the median valley is wide, and there are pillars at the bottom of the entrance of the median valley.

1.8 HMV 0094

An old (about 35 years) skull (Fig. 1). Its teeth from DP1 to P3 were worn to reach their roots, and P4 and M1 close to their roots. It was collected from Yangjiashan in Sanhe Village, Hezheng County.

The occipital is coarse, and the paxwax pit is deep. The central groove of the occipital crest is very wide and shallow, and the side margins are constricted at the upper one third. The skull top is strongly concave to be deeply saddle-shaped, and the lowest position is at the center of the frontal and 60 mm away from the connecting line between the tip of the nasal and the center of the occipital crest. The nasals are strong, with a coarse tip and a round back, as well as slight longitudinal depression and drooping two side margins on the posterior part. The parietal crests are strongly projecting laterally to become a brim, and the flat surface between them is wide, being 67 mm. The braincase is high, and its outer wall is so steep that it is nearly vertical and becomes very narrow. The postorbital process is absent. The supraorbital tubercle is well-developed, and so are the upper orbital margin, maxillary face and the inner surface of the zygomatic arch are relatively coarse. The posttympanic process is thick and coarse, and it fuses with the postglenoid process closely. The postglenoid and paroccipital processes are robust. On the two sides of the central crest on the basioccipital bone there are deep grooves. The pterygoid process, maxillary tubercle and basioccipital tubercle are also relatively coarse. The temporal condyle is narrow and long.

There is no enamel structure left from DP1 to P3. P4 retains two closed enamel rings of the median and posterior fossettes as well as a V-shaped groove and low cingulum out of the entrance of the median valley. The posterior valley of M1 is open. There is a narrow and deep groove lingually out of the median fossette, and there are small pillars at the entrance of this groove. The protocone and hypocone of M2 are very large; the protocone has deep anterior and posterior grooves as well as the low cingulum on its anterior lingual margin; the hypocone is

unconstricted; the base of the antecrochet is very wide, and its sharp end is narrow and long to extend to the entrance of the median valley; there are small pillars at this wide entrance; the crochet extends to reach the protoloph and forms a median sinus; the connections of the protoloph and metaloph with the ectoloph are relatively narrow; the parastyle is wide, large and projecting strongly, and the exterior wall is flat, straight and smooth. The worn surface of M3 is triangular; the protoloph is wide; the protocone is weakly constricted; the anterior cingulum is well-developed; there are pillars on both of the lingual margin of the protocone and at the entrance of the median valley; the posterior cingulum is well-developed and becomes high and wide labially; the parastyle is wide and projecting; the exterior wall is smooth; the base of the antecrochet is grave-shaped, and its narrow and long end extends to reach the entrance of the median valley; the crista is short and robust, and the median valley is wide (Table 1, 2).

2 Comparison and discussion

Based on the size increase of different parts of the skull, the growth of *Chilotherium wimani* can be divided into four stages: infant, young, adult and old (Fig. 2). Each stage is determined by the erupting sequence of the cheek teeth: in the infant stage, M2 has not erupted, and the crowns of the milk premolars are relatively high; in the young stage, M2 has erupted but M3 not, and all milk premolars retained or DP4 has not fallen off at least; in the adult stage, M3 erupts at the beginning and is worn slightly at the end, and the premolars as well as M1 and M2 are worn moderately; in the old stage, M3 is worn moderately at the beginning, and its premolars are worn deeply or even fallen off. The age judgment of these skull is based on modern white rhinoceros (*Ceratotherium simum*)^[5] and the black rhinoceros^[6]. Some variable characters of *Ch. wimani* along the age are as follows:

1) The parietal crest is weak during the infant stage, gradually marked during the young, relatively high during the adult, and strongly projecting laterally to form a brim during the old.

2) The braincase is round and low during the infant stage, being approximately a hemisphere; high gradually during the young, but its outer walls still are round on two sides; narrow noticeably during the adult, and its outer walls becoming a steep slope; and higher and narrower during the old, and its outer walls being nearly perpendicular.

3) The depression on the skull top is very shallow during the infant stage, deepened gradually during the young, strong to be markedly saddle-shaped during the adult, and concave more strongly so that the nasals rise upward and the occipital elevation is high during the old.

4) The surface between the parietal crests becomes wider step by step from the infant to

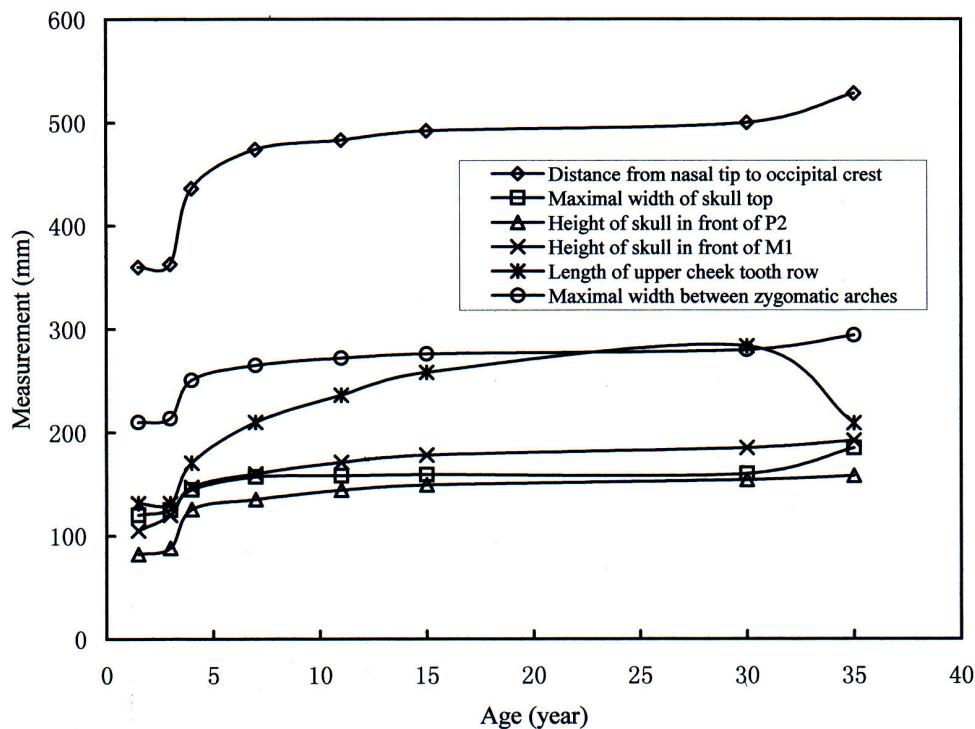


Fig. 2 The relative growth curves of skulls of *Chilotherium wimani*

the old stages generally; it is relatively narrow before the adult, and different from those of the other chilothere species; but it becomes very wide during the old, and identical with the character of the typical chilothere species.

5) The suture is marked during the infant and young stages, and its serration is weaker gradually. The suture disappears during the adult.

6) The supraorbital tubercle is absent during the infant stage, appeared from the young, apparent during the adult, and well-developed and becoming coarse during the old.

7) The posttymppanic process is very close to the postglenoid one, but has not fused during the infant and young stages. They fuse together and form a closed pseudoauditory meatus.

8) A fine groove forms along the unfused central suture on the back of nasal during the infant and young stages; the nasal becomes round after the suture fuses during the adult stage, and this tendency becomes stronger during the old.

9) The largest distance between the outer margins of the cheek tooth rows moves backward from DP4 to M2 along with the eruption of molars, but stays at the level of M2 after the adult.

10) The lateral margin of occipital crest is smooth from the infant to the adult stages, but constricted centrally during the old.

Based on the observation on *Ch. wimani*, the degree of wear of the upper and lower cheek teeth is not identical, but very different. The speed of wear of the upper cheek teeth is much

faster than that of the lower cheek teeth. If we determine age based on skull and mandible of the same individual independently, a wrong conclusion would be drawn that the skull belongs to an old individual whereas the mandible belongs to an adult one.

HMV 0082 is a specimen of *Ch. wimani* with associated skull (Fig. 1) and mandible collected from Moshigou in Xinzhuang Village, Hezheng County. It is a relatively old individual. Its premolars from DP1 to P3 were worn to the root, of which the left P3 is lost. Its P4 and M1 were also worn close to the root. The age characters of the skull include that the middle groove of the occipital crest is wide and shallow, and its lateral margins are constricted widely and deeply at the lower one third; the supraorbital tubercle is very coarse; the parietal crests become strong edges, and between them there is a concave surface; the posttympanic process is fused with the postglenoid process at middle to form a closed pseudoauditory meatus; on the skull top, both the upper orbital margins are parallel. The degree of wear of M1 is deeper than that of P4. The median and posterior fossettes of P4 are still relatively large, while those of left M1 have disappeared completely with only enamel on the labial and lingual sides, and those of right M1 have reduced to two very small enamel rings. The posterior valley of M2 is closed to form a posterior fossette. Only the crown of M3 is still kept at a high level. On the other hand, characters of old age in the mandible are not obvious. The incisors are still large and long, with 114 mm long crown and 54 mm wide crown base. It is more important that the lower cheek teeth have not been worn deeply. The m1 is worn the deepest; its connection between trigonid and talonid is wide; the anterior valley has disappeared; anterior and posterior walls of posterior valley have been completely closed. The p4 is worn less than m1, which is identical with upper cheek teeth. However, p2 and p3 are not worn deeply, which is different from upper teeth. In fact, the most worn position of lower cheek teeth is from the talonid of p4 to the trigonid of m2. The comparison between crown heights of upper and lower cheek teeth of this specimen is shown in Table 3, which is an important reference for determination of the age of isolated mandibles in *Chilotherium*.

Table 3 Comparison of crown heights between upper and lower cheek teeth of an old *Ch. wimani*

		(mm)					
Upper teeth	DP1	P2	P3	P4	M1	M2	M3
	3.5	0	0	7.8	5.7	13	36.6
Lower teeth							
	dp1	p2	p3	p4	m1	m2	m3

As in most rhinocerotids, there are sexual differences between male and female individuals of *Ch. wimani*. The most marked difference is the size of tusk-like i2, the male i2 is stronger and larger than the female. Moreover, male and female skulls have different features.

HMV 0082 is a female individual, and HMV 0094 is a male; both of them have the same age. Comparing these two skulls, the male one has a larger size and stronger built than the female. The main measurements of HMV 0094 are larger than those of HMV0082, and the

former's nasal, supraorbital tubercle and three articular processes on the occipital part are stronger. The cranial dorsal profile of the male is strongly concave, whereas the female is nearly flattened. HMV 0082 is a very old individual, but its cranial dorsal profile is still flattened. From the above-mentioned discussion, cranial dorsal profile becomes more and more concave as its age increases, which should be a character of the male. The difference between male and female nasal bones are also obvious. The male nasal is very thick with a lentoid transverse section, while female nasal is thin with a half-lentoid transverse section. The male nasal margin is slightly drooping only near the bottom of nasal notch, while the female begins to be drooping near nasal tip markedly. The male nasal notch and maxillary face are higher than those of the female. The female occipital surface is more quadrate, i.e. the difference between lower and upper widths of the occipital surface is small (width ratio of HMV 0082 is 0.90), while the male occipital surface is higher but narrower (width ratio of HMV 0094 is 0.76). The male pterygoid processes are open, while the female's are narrow. The side constriction is on the upper part of the occipital crest of the male, but on the lower part of the female. The female has marked postorbital process, but the male weak or absent. The male surface between parietal crests is flat, but the female concave. The male braincase is narrower and higher, and zygomatic arch is wider and thicker. Because the female supraorbital tubercle is weaker than the male, the female upper orbital margins are parallel. On the other hand, the male upper orbital margins have an angle, where forms the largest width of the skull top.

Acknowledgements I thank Prof. Qiu Zhanxiang, Prof. Wang Banyue, Dr. Wang Xiaoming, and Dr. Ni Xijun in the field crew of the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing. I am grateful to Dr. P. O. Antoine of Museum d'Histoire Naturelle de Toulouse in Toulouse, and Dr. C. Guerin of Departement des Sciences de la Terre, Universite Lyon I – Claude-Bernard in Lyon for their helps in various ways.

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