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甘肃庆阳早更新世马属(奇蹄目，马科)一新种[1)]

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摘要 记述的庆阳马新种(*Equus qingyangensis* sp.nov.)是一种中等大小的真马，生活于早更新世泥河湾期。庆阳马的材料相当丰富，包括大量头骨、颊齿和肢骨化石，标本采自甘肃庆阳巴家嘴。新种肢骨的纤细度小于欧亚大陆和北美已知的早期真马，它的原始特征还包括浅的眶前窝、沿鼻骨中缝的深沟、长的上颊齿原尖和深的下颊齿外谷等。庆阳马以中等的尺寸和纤细的肢骨显著区别于华北地区广泛分布的大型而粗壮的三门马(*E.sanmeniensis*)。

关键词 甘肃，早更新世，马科

中图法分类号 Q915.877

1961年薛祥煦和王永焱在甘肃庆阳巴家嘴采得大量哺乳动物化石，化石产于剖面底部的砂层中，时代为早更新世早期。化石种类非常丰富，包括直隶狼(*Canis chihliensis*)、似贾氏獾(*Meles* cf. *M. chiai*)、似桑氏鬣狗(*Hyaena* cf. *H. licenti*)、剑齿虎(*Megateron* sp.，*Epimachairodus* sp.，*E.* cf. *E. crenatidens*)、野猫(*Felis* sp.)、似长鼻三趾马(*Hipparion* cf. *H. sinensis*)、似李氏野猪(*Sus* cf. *S. lydekkeri*)、大角鹿(*Megaloceros* sp.)、鹿(*Cervus* sp.)、羚羊(*Gazella* sp.)、似中国羚羊(*G.* cf. *G. sinensis*)、古中华野牛(*Bison palaeosinensis*)、牛科(Bovidae indet.)、似鼢鼠(*Myospalax* cf. *M. arvicolinus*)、丁氏鼢鼠(*M. tingi*)等(王永焱等，1966，1982)，以及大量马属(*Equus*)的头骨、颊齿和肢骨标本。本文记述其中的一个马属新种。

NWUV系西北大学地质系脊椎动物化石编号。

1 标本记述

奇蹄目 Perissodactyla Owen，1848

马科 Equidae Gray，1821

马属 *Equus* Linnaeus，1758

庆阳马 *Equus qingyangensis* sp. nov.

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(图版Ⅰ～Ⅲ；表 1～4)

正型　NWUV 1128，头骨中后段，保存全部颊齿，约 12 岁(图版Ⅰ，1)。

其他标本　1) NWUV1134，下颌骨中前部，雄性，约 8 岁，牙齿仅缺右 m2～3(图版Ⅰ，2、3)；2) NWUV1129，头骨，雄性，犬齿以前断失(图版Ⅱ)；3) NWUV1130，头骨，雄性，枕部断失；4) NWUV1131，头骨，幼年，残破，带完整乳齿列；5) NWUV1132，头骨，幼年，残破；6) NWUV1133.1，上颌骨，幼年，残破；7) NWUV 1135，下颌骨，幼年，吻部断失；8) NWUV 1133.2，下颌骨，幼年，上升枝断失；还包括带齿列的上颌残部 8 件、带齿列的下颌残部 14 件、吻端残部 7 件、孤立上乳齿 35 枚、孤立下乳齿 15 枚、孤立门齿 8 枚，以及大量头后骨骼(图版Ⅲ)。所有标本保存在西北大学地质系。

特征　中等大小；鼻切迹底部在 P2 后部水平，眶前窝浅且边界不清，沿鼻骨中缝有深沟；上颊齿原尖较长，马刺不发达；下颊齿内谷呈典型的 V 形，外谷深，在臼齿上深入双叶颈内，甚至与内谷底接触，下马刺出现频率高；肢骨纤细，第三掌骨中段宽指数小于 13.5，第三跖骨中段宽指数小于 12.0，是欧亚大陆肢骨最纤细的早期马类。

名称来源　Qingyang，庆阳，化石产地的行政区名。

地理分布　华北渑池及西北庆阳等地区。

地质时代　早更新世，泥河湾期。

描述　头骨：髁间切迹窄，副乳突粗强，基结节粗糙但隆起弱。翼管位于颞翼靠近蝶骨体处，翼状嵴高耸，但翼管后孔的下部外边缘从腹面仍能看到。鼻额部的额面近扁平而光滑，且相当宽阔，自眶后收缩处向两侧轻微倾斜，眶上孔和眼眶上缘只略低于额面，额外嵴前部有一切迹。颞骨颧突前端位于眼眶的一半处，颧突在头骨的相对位置较低，颞髁横椭圆形，略向外突，为头骨腹面最宽处，关节窝中部深，向内侧变浅。颞嵴粗强。面嵴高耸，前端在 P4 中附尖水平，眶前窝浅且边界不清。齿槽结节粗大，上颌结节圆隆，上颌隐窝又大又深。腭突上腭沟自 P3 前缘水平开始，越往后越深，在 M3 原尖后端水平与腭管前孔相接。犬齿齿槽强烈外突，成为吻部腹缘的最宽处。硬腭后缘中央位于 M3 前缘稍后水平。翼突的骨体非常扁平，后部张开。沿鼻骨中缝有深沟，鼻骨侧面较陡，顶面很宽，鼻颌切迹底部位于 P2 后部水平。眶缘上前方有一小的泪结节，泪骨的面部前后长远远超过眼眶长的 1/2。颧骨颧突末端已超过眼眶后缘而达于颞窝前缘之下。犁骨切迹呈深的弧形(测量数据见表 1)。

下颌骨：骨体厚，舌面光滑，呈勺状凹入，下颌联合处的骨缝清晰，颏面隆突，表面粗糙。全部下门齿发育完整的齿坎。水平枝外面光滑，上下向轻微突隆，颏孔靠近下颌骨体，约在齿槽间隙的下部中央，在颏孔水平齿槽间隙最窄。水平枝下缘平直，厚而圆润，血管切迹位于后部 1/3 处。下颌角变厚，向外有粗唇，向上逐渐变窄，至髁状突之下已相当薄锐，髁状突向前下方急剧倾斜(测量数据见表 2)。

上颊齿：DP1 普遍存在。P2 端附尖小，中附尖宽而中凹，原尖短宽，舌缘微凹，马刺非常短小，次尖短粗，次尖沟浅 V 形，前、后尖外壁平直，釉质褶皱简单，原脊、后脊平，前窝前壁外侧有一个很小的弧点(islet)。P3 前附尖宽大，顶平而前倾，中附尖与前附尖相似而略小，原尖短宽，具浅的中凹，后谷宽大，马刺细小，轻微次尖收缩，次尖沟 V 形，前、后尖外壁弧形凹入，釉质褶皱简单，原脊、后脊斜。P4 与 P3 相似，差别在于原尖较扁长，无次尖收

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表1 庆阳马(新种)头骨测量

Table 1 Skull measurements of *E. qingyangensis* sp. nov. (mm)

测量项 measures	NWUV 1128	1129	1130	1132	1133.1
1. 吻部长 muzzle length	—	—	150	—	—
2. 腭长 palatal length	137.3	134.3	—	114.5	90.7
3. 犁骨长 vomerine length	140.0	136.8	—	—	109.4
4. 犁骨后长 post-vomerine length	—	97.6	—	—	—
5. 腭后长 post-palatal length	—	225.0	—	—	—
7. 前臼齿列长 premolar row length	86.7	98.6	99.0	79.5	110.0
8. 臼齿列长 molar row length	85.8	83.0	87.0	—	—
9. 上颊齿列长 upper cheek tooth row length	170.0	180.0	182.0	—	—
10. 内鼻孔长 choanal length	90.0	—	—	—	89.5
11. 内鼻孔最小宽度 minimal breadth of the choanae	41.5	—	—	36.6	33.8
12. 内鼻孔最大宽度 maximal breadth of the choanae	52.3	—	—	43.7	35.2
13. 腭宽 palatal breadth	73.9	—	—	66.8	61.0
16. 颞窝长 length of fossa temporalis	83.5	*77.0	—	—	75.6
17. 颅底骨与筛孔间长度 length between basion and the foramen ethmoidalis	—	*145.0	—	—	—
18. 额宽 frontal breadth	230.0	—	—	—	127.1
19. 颧骨间宽度 bizygomatic breadth	222.0	—	—	—	136.0
24. 眼后线 posterior ocular line	—	*160.0	—	—	—
25. 颜面高 facial height	—	*120.0	—	—	—
26. 颅骨高 cranial height	111.3	—	—	—	—
28. 眼眶前后径 antero-posterior diameter of the orbit	64.5	68.0	—	—	—
29. 眼眶上下径 dorso-ventral diameter of the orbit	56.0	~52.0	—	—	41.3
30. 鼻~门齿缺长度 length of the naso-incisival notch	—	—	~190.0	—	—
31. 颊长 cheek length	—	177.0	—	—	—
37. 眶下孔后部在齿缘上高度 height of the back of the preorbital fossa above the alveolar border	—	72.6	—	—	53.0

注:测量项编号据 Eisenmann *et al.*(1988)。带*的数据为受挤压后的估计数据,仅供参考。

表2 庆阳马(新种)下颌骨测量

Table 2 Mandible measurements of *E. qingyangensis* sp. nov. (mm)

测量项 measures	NWUV 1134	1135	1133.2	1136
2. 吻部长 muzzle length	126.8	—	101.0	—
3. 前臼齿列长 premolar row length	98.8	105.2	111.2	106.8
4. 臼齿列长 molar row length	88.5	—	—	—
5. 下颊齿列长 lower cheek tooth row length	186.0	—	—	—
6. m3齿槽后部与上升枝后边缘间距离 distance between the back of alveole of m3 and the posterior edge of the ascending ramus	—	135.0	—	—
7. 吻部宽 muzzle breadth	62.2	—	37.0	—
8. 髁状突处下颌骨高度 height of the mandible at the condyle	—	180.0	—	—
9. 上升枝高 height of the ascending ramus	—	163.0	—	—
11. p4与m1间颌高 height of the jaw between p4 and m1	92.0	64.8	67.0	77.0
12. p2前颌高 height of the jaw in front of p2	72.2	45.2	45.6	55.3
13. 下颌联合长 length of the symphysis	99.5	—	59.5	—
14. 下颌联合最小宽度 minimal breadth of the symphysis	36.5	29.9	34.0	—
15. 齿槽缘与m3后部至髁状突顶部连线间角度 angle between the alveolar line and the line connecting the back of m3 and the top of the condyle	—	32°	—	—

注: 测量项编号据 Eisenmann *et al.* (1988)。

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缩。M1 前附尖和中附尖窄,原尖中凹分原尖为前短后长的两叶,后谷窄深,无马刺,次尖窄长,次尖沟 V 形,釉质褶皱相当简单,前尖外壁深凹,后尖外壁平直,原脊、后脊斜。M2 与 M1 相似,但次尖沟更窄更深。M3 前附尖前倾,中附尖近方形,后附尖宽大,向后突伸而成为双角形后缘的外角,原尖扁长,中凹宽浅,内谷窄深,无马刺,次尖圆而后突,形成双角形后缘的内角,次尖内有一个釉质环,釉质褶皱微弱,原脊斜,后脊较平(测量数据见表 3)。

表3　庆阳马(新种)颊齿测量

Table 3　Cheek tooth measurements of *E. qingyangensis* sp. nov.　(mm)

上颊齿	标本数	测量项	平均值	最小值	最大值	下颊齿	标本数	测量项	平均值	最小值	最大值
u. teeth	n	mes.	$\bar{x}$	min.	max.	l. teeth	n	mes.	$\bar{x}$	min.	max.
P2	3	L	39.0	38.7	39.5	p2	10	L	34.9	31.0	39.1
	4	W	27.5	27.0	28.4		10	W	15.1	14.2	16.5
	4	PL	7.9	7.4	8.3		10	FL	14.9	12.5	17.2
	3	PI	20.3	18.7	21.3		10	FI	42.8	36.4	46.7
P3	4	L	29.6	27.5	31.0	p3	6	L	30.1	29.0	32.4
	4	W	29.1	27.4	30.2		6	W	16.2	13.3	18.7
	4	PL	11.1	9.8	12.3		6	FL	15.1	14.0	17.1
	4	PI	37.7	32.0	42.0		6	FI	50.2	46.4	52.8
P4	4	L	28.3	25.7	29.5	p4	7	L	28.9	28.0	30.4
	4	W	28.6	26.8	29.7		7	W	16.2	14.1	17.9
	4	PL	12.4	11.3	13.6		7	FL	12.8	9.3	16.0
	4	PI	44.0	38.4	47.9		7	FI	44.3	33.2	52.6
M1	4	L	25.4	23.2	27.3	m1	7	L	26.8	26.0	28.1
	4	W	26.8	25.8	28.0		7	W	14.2	12.5	15.8
	4	PL	11.9	11.1	12.7		7	FL	9.3	6.9	12.2
	4	PI	46.5	41.4	54.7		7	FI	34.5	26.3	43.4
M2	4	L	27.1	25.4	28.5	m2	6	L	27.1	26.2	27.9
	4	W	26.3	25.2	27.8		6	W	13.7	12.5	15.3
	4	PL	13.1	11.9	14.4		6	FL	8.9	8.0	10.4
	4	PI	48.7	42.0	55.4		6	FI	33.0	30.1	37.7
M3	3	L	30.9	28.9	33.3	m3	2	L	33.9	31.6	36.2
	4	W	23.9	23.0	24.9		2	W	12.2	11.1	13.2
	4	PL	13.7	11.8	15.1		2	FL	9.0	7.9	10.0
	3	PI	44.5	38.8	52.2		2	FI	26.3	25.0	27.6

注:L长度,W宽度,PL原尖长度,PI原尖指数,FL后谷长度,FI后谷指数。

下颊齿:p2 下前尖向前突伸,末端圆,下原尖外壁突,与下前尖之间有收缩,下马刺发育,外谷浅,下后尖火焰状,下后附尖更偏向舌侧,后角尖锐,内谷浅,近 V 形,下内尖鸟喙状,后谷底呈宽缓的褶曲。p3 下原附尖存在,外谷较长,接近双叶颈外缘,下马刺发育,下次尖外壁突,下后尖加大,呈带宽柄的圆球形,下后附尖柄细而短,后角尖锐,内谷窄 V 形,下内尖近方形,较大,前、后谷底上隆。p4 与 p3 相似,但下后附尖和下内尖更小,内谷较宽。m1 比前臼齿小得多,下原尖外壁凸隆而饱满,外谷宽而深,末端与内谷底相连,下马刺较小,下后尖呈带宽柄的方形,下后附尖很小,柄极细短,内谷 V 形,谷底尖锐,下内尖卵圆形,较小,前、后谷底上隆。m2 与 m1 很相似,但尺寸更小,内谷底由于与外谷底贴近而

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变得扁平。m3下前附尖横贯牙齿前缘，下原尖外壁微凹，外谷深入双叶颈内，与内谷紧密接触，内、外谷底变平，下马刺较小，下次尖外壁轻微褶皱，下后尖略呈带柄的圆球形，下后附尖更小更圆，下内尖扁长，下次小尖很大，强烈后伸，末端浑圆，前、后谷底强烈上隆(测量见表3)。

第三掌、跖骨：庆阳马的头后骨骼标本相当丰富，限于篇幅，本文仅讨论最具代表性的第三掌、跖骨，整个头后骨骼的研究将另文发表。第三掌骨骨体呈显著的半圆柱形，背面长轴近于直立，小掌骨的末端到达整个骨体的1/2到2/3中间处；在掌骨近端的1/3处有滋养孔，滋养孔靠近内侧；掌面近端悬韧带的附着面上部隆起，向后略微超出近端关节面的后缘；近端与头状骨的关节面前缘较高，与钩骨的关节面为长条形，前宽后窄，外倾，前半部凹陷，与头状骨关节面在前缘的夹角为190°，在后缘的夹角为180°，即两关节面的后缘线是平直的；远端关节的中嵴在背面的突起程度小于掌面，中嵴上方有凹陷或无，远端结

表4 庆阳马(新种)第三掌、跖骨测量

Table 4 Third metapodial measurements of *E. qingyangensis* sp. nov. (mm)

测量项 measures	NWUV 1151 (McIII)	1152 (McIII)	1153 (McIII)	1154 (MtIII)	1155 (MtIII)	1156 (MtIII)
1. 最大长度 maximal length	253.0	255.0	240.0	267.0	281.0	277.0
2. 内侧长 medial length	243.0	243.0	229.0	259.0	273.0	264.0
3. 最小宽度(中段宽) minimal breadth near the middle of the bone	33.7	34.0	32.0	29.1	33.2	33.3
4. 中段厚 depth of the diaphysis near the middle of the bone	29.0	29.0	26.0	27.3	31.1	32.1
5. 近端关节宽 proximal articular breadth	49.5	53.4	50.5	46.5	49.0	48.3
6. 近端关节厚 proximal articular depth	36.3	34.0	37.0	34.0	38.5	36.0
7. 对头状骨关节面最大径 maximal diameter of the articular facet for the third carpal	42.7	45.0	47.0	42.7	44.6	41.0
8. 对钩骨前关节面径 diameter of the anterior facet for the fourth carpal	16.1	15.3	11.4	~11.3	~11.6	11.7
9. 对小多角骨关节面径 diameter of the articular facet for the second carpal	4.5	5.0	3.5	—	7.0	8.4
10. 远端结节宽 distal maximal supra-articular breadth	48.0	51.0	47.5	42.0	46.0	44.5
11. 远端关节宽 distal maximal articular breadth	47.5	47.8	46.0	—	45.1	44.0
12. 远端中嵴厚 distal maximal depth of the keel	36.4	35.0	36.4	35.3	36.5	34.1
13. 远端外髁最小厚度 distal minimal depth of the lateral condyle	29.0	27.3	28.0	26.5	27.1	25.3
14. 远端内髁最大厚度 distal maximal depth of the medial condyle	32.8	31.0	31.5	30.0	30.5	29.4
15. 中嵴背~掌侧间角度 angle measuring the dorso-volar development of the keel	113°	110°	112°	115°	105°	105°
16. 对钩骨后关节面径 diameter of the posterior facet for the fourth carpal	8.3	7.5	7.0			
中段宽指数(3/1) middle shaft index	13.3	13.3	13.3	10.9	11.7	11.9

注：测量项编号据Eisenmann *et al.*(1988)。MtIII的第7项为对外楔骨关节面最大径、第8项为对骰骨关节面径、第9项为对中楔骨关节面径，无第16项。

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节宽度大于或小于远端关节宽度。第三跗骨骨体圆柱形,稍向前弯曲,骨干外侧近端关节面之下的动脉沟倾斜,自前上方斜伸向后下方,至第四跗骨下端转而下行,进入骨体后面,内侧同一位置有一浅压迹;滋养孔位置较高;近端关节面中央的凹陷部粗糙,外侧的切迹很深,前缘圆隆,横行嵴沿血管沟的后外侧转向下方变宽;对中楔骨与外楔骨关节面间的前缘夹角为 145°,对骰骨与外楔骨关节面间前缘夹角为 190°,即相对内折;远端关节面与掌骨情况类似,中嵴在掌侧仍然比背侧更加高耸。第三掌、跗骨都非常纤细(测量数据见表 4)。

2　比较与讨论

从牙齿上看,庆阳马与三门马有着明显的区别。首先,庆阳马的颊齿尺寸较小,对比泥河湾的三门马(Teilhard *et al.*, 1930; Forsten, 1986),庆阳马小于或至多略等于三门马颊齿尺寸的下限,也小于 Zdansky(1935)主要在渑池采集的三门马化石。刘后一(1973)认为周口店的三门马略小于泥河湾的三门马,但其颊齿尺寸仍然大于庆阳马。因此,颊齿小于三门马是庆阳马的一个重要特征。其次,庆阳马的马刺不发达,除青年个体的标本以外,庆阳马的马刺都非常微弱,而成年个体的上臼齿也没有马刺,这一点与三门马很不相同。三门马的马刺在上前臼齿上非常发达,在上臼齿上通常也相当显著,如 Teilhard *et al.* (1930)的图版 VI,4 的标本无论在前臼齿还是在臼齿上马刺都非常发达,又如刘后一(1973)的图版 I,1,马刺也是在整个颊齿列上都相当发达,至少非常明显,这与庆阳马的情况不同,庆阳马只在磨蚀非常轻微的 NWUV 1129 号标本上有较明显的马刺。庆阳马的下颊齿除了在尺寸上小于三门马以外,在形态特征上的差别不大。从 Teilhard *et al.* (1930)的泥河湾标本看,三门马下颊齿的下马刺通常都不发育,如其图版 VI,2、图版 VI,3 的下颊齿从 p2 到 m3 都完全没有下马刺。刘后一(1973,图版 II,4、5)的周口店三门马的下颊齿也没有下马刺,但他的文章插图中有一些颊齿有明显的下马刺,特别是 V2635.3～4 的齿列下马刺发达。下马刺的发育情况与磨蚀程度有关,磨蚀强烈的老年个体都没有下马刺。在巴家嘴标本中有不少老年个体,在磨蚀到接近齿根时,整个釉质结构变得相当简单,下马刺也随之消失。但总的说来,三门马的下马刺出现频率较低,而对庆阳马而言,下马刺的出现频率相当高,这可以作为二者在下颊齿上的一个区别。

与欧亚大陆上分布广泛的古马(*E. stenonis*)相比,庆阳马与其共同点在于马刺都不发达。在 *E. stenonis*的不同亚种中,臼齿上的马刺都与庆阳马一样,非常微弱,甚至缺失(Eisenmann, 1980, Pl. XVIII, XIX)。但是,仅从上颊齿上看,庆阳马与古马也是不同的,古马是一种原尖相对较短的马,而庆阳马的原尖则相对较长。再从下颊齿看,古马下前臼齿的下后尖根部收缩很强烈,形成一个细颈(Azzaroli *et al.*, 1993, Pl. IV,2),而在庆阳马中,前臼齿的下后尖向后部逐渐收敛,但幅度很小,并不形成一个明显的颈部。

与中国早更新世马属的其他种相比,庆阳马与它们较易区别。黄河马(*E. huanghoe-nsis*)的材料较少,仅有孤立的上颊齿发现(周明镇等,1959),它以硕大的尺寸和宽短的原尖区别于庆阳马的中等尺寸和窄长原尖。云南马(*E. yunnanensis*)的尺寸与庆阳马接近(Colbert, 1940; 刘后一等, 1974),但它的下颊齿外谷不伸入双叶颈内,这与庆阳马外谷深

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入双叶颈内甚至与内谷底接触的情况相差较远。德氏马(*E. teilhardi*)的一个重要的特征是下门齿缺失齿坎(Eisenmann, 1975),而所有庆阳马的下门齿标本都发育完整的齿坎,与德氏马完全不同。

巴家嘴的标本中有好几件庆阳马的头骨化石,包括幼年、青年、成年和老年个体的标本,当然,保存情况不一,没有完整的头骨,但根据各个标本的综合来看,对庆阳马的头骨能够作出比较全面的了解。与牙齿的情况对应,庆阳马的头骨也小于三门马。泥河湾的三门马体型巨大,Teilhard *et al.* (1930)将其列为三门马的第一个特点。他们所根据的一件头骨头长 650mm,头基长达 585mm,当然,这是已发现的三门马中最大的一个,但山西祁县的三门马头基长也有 522mm(Zdansky, 1935)。与它们相比,庆阳马头骨的尺寸是比较小的,庆阳马头骨的基底长约 509mm(见表 1)。

马属的肢骨对确定不同的种具有非常重要的意义,它对于不同种类的体形大小有着准确的指示作用。从度量上看,庆阳马的第三掌骨全长介于泥河湾所谓的大型(255～283mm)与小型(213～220mm,即德氏马 *E. teilhardi*, Eisenmann, 1975)"三门马"之间,与周口店标本的掌骨长度相近(刘后一, 1973),但巴家嘴标本比泥河湾和周口店的三门马都要纤细。Zdansky(1935)描述的一些掌骨长 229～263.5mm,与巴家嘴标本相仿,但比巴家嘴标本粗壮;Zdansky(1928)描述一件周口店第 1 地点的完整左掌骨,长 255mm,中段宽 40mm,更比巴家嘴的粗壮。实际上,对比第三掌骨的中段宽指数,巴家嘴的第三掌骨相当一致,都为 13.3,而欧洲的 *E. stenonis*的中段宽指数为 14.9～16.3(Eisenmann, 1979),亚洲的 *E. sivalensis* 为 14.3～14.9,Teilhard *et al.* (1930)的泥河湾三门马为 14.8～16.1,德氏马(即所谓的小型"三门马")为 14.6～15.5,法国 Ceyssaguet 的马属化石为 14.3～15.2,都远比庆阳马粗壮。其他人后来也研究了较多的三门马化石,Zdansky(1935)描述的华北各地的标本,中段宽指数为 14.4～14.6,Zdansky(1928)描述的周口店第 1 地点的第三掌骨中段宽指数为 15.6,刘后一(1973)测量的同一地点的标本指数为 15.4～16.3,其他的数据还有周口店第 9 地点的 15.1～15.5(Teilhard, 1936)、第 13 地点的 16.8(Teilhard *et al.*, 1941),山西祁县的 16.0～16.3(Zdansky, 1935)等也都远大于庆阳马,北美的 *E. conversidens* 为13.8～16.3(Dalquest, 1967)。综上所述,庆阳马的第三掌骨长度介于三门马和德氏马之间,但比所有已知的 stenonid 真马的肢骨都要纤细。庆阳马的第三跖骨中段宽指数分别为 10.9、11.7、11.9(见表 4),比其他的 stenonid 真马都低,泥河湾三门马为 12.5～15.5、德氏马为 12.5,Ceyssaguet的马化石为 15.3(Teilhard *et al.*, 1930),周口店第 9 地点的三门马为 13.4～13.7(Teilhard, 1936),第 13 地点的为 13.5(Teilhard *et al*, 1941),欧洲的 *E. stenonis*为 13.0～14.0 (Eisenmann, 1979),北美的 *E. simplicidens* 为 12.7～14.0 (Azzaroli *et al.*, 1993), *E. conversidens* 为 11.9 ～ 12.8, *E. niobrarensis* 为 13.3 (Dalquest, 1967),只有 Zdansky(1935)描述的华北各地三门马的 11.5～12.9 与刘后一(1973)描述的周口店第 1 地点三门马的 11.4～13.5 的下限与庆阳马的上限接近。而 Zdansky 的标本相当庞杂,其中有的可能属于庆阳马,如河南渑池的标本。总的说来,庆阳马的第三跖骨与第三掌骨一样,都是相当纤细的,明显地区别于欧亚大陆和北美早更新世的其他马属化石。

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EQUUS QINGYANGENSIS SP. NOV. (PERISSODACTYLA, EQUIDAE) FROM THE EARLY PLEISTOCENE OF QINGYANG, GANSU, CHINA

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Key words　Qingyang, Gansu, Early Pleistocene, Equidae

Summary

In 1961, Xue Xiangxu and Wang Yongyan collected a lot of mammalian fossils from Bajiazui of Qingyang County, Gansu Province. The fossils come from the sandy beds in the bottom of the section, including *Canis chihliensis*, *Meles* cf. *M. chiai*, *Hyaena* cf. *H. licenti*, *Megateron* sp., *Epimachairodus* sp., *E.* cf. *E. crenatidens*, *Felis* sp., *Hipparion* cf. *H. sinensis*, *Sus* cf. *S. lydekkeri*, *Megaloceros* sp., *Cervus* sp., *Gazella* sp., *G.* cf. *G. sinensis*, *Bison palaeosinensis*, Bovidae indet., *Myospalax* cf. *M. arvicolinus*, and *M. tingi*, etc. (Wang *et al.*, 1966, 1982). Among the materials there are many skulls, mandibles, cheek teeth and limb bones of the genus *Equus*. A new species of *Equus* is described in this paper.

NWUV is the prefix to the vertebrate fossils in Department of Geology, Northwest University.

1 Description

Perissodactyla Owen, 1848

Equidae Gray, 1821

***Equus* Linnaeus, 1758**

***Equus qingyangensis* sp. nov.**

(pls. I ~ III; Table 1~4)

Holotype　NWUV 1128, the middle and back of a skull with all cheek teeth, about 12 years (Pl. I, 1).

Referred specimens　1) NWUV 1134, the front and middle of a mandible without right m2~ 3, male, about 8 years(Pl. I, 2, 3); 2) NWUV 1129, a skull without muzzle, male (Pl. II); 3) NWUV 1130, a skull without occipital region; 4) NWUV 1131, a broken juvenile skull with complete milk cheek tooth rows. 5) NWUV 1132, a broken juvenile skull; 6) NWUV 1133.1, a broken juvenile upper jaw;

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7) NWUV 1135, a juvenile mandible without muzzle; 8) NWUV 1132.2, a juvenile mandible without ascending ramus. Other specimens include 8 upper and 14 lower fragmental jaws with cheek tooth rows, 7 fragmental muzzles, 35 upper and 15 lower isolated milk cheek teeth, 8 isolated incisors, and a lot of limb bones (Pl. III). All specimens are preserved in Department of Geology, Northwest University.

Diagnosis Middle size. The nasal notch extends above the back of P2. The praeorbital pit is shallow with an indistinct border. A deep groove is along the nasal suture. The upper teeth have long protocones and weak pli caballine. The lower teeth have typical V-shaped linguaflexids and deep ectoflexids that penetrate into the isthmuses or even touch the linguaflexids on the lower molars. The limb bones are slender. The metacarpal middle shaft index is smaller than 13.5 and the metatarsal smaller than 12.0 . It was the early species of *Equus* with the most slender limb bones in Eurasia.

Etymology Named after "Qingyang" County, Gansu Province, where the new species is found.

Distribution Northwestern and northern China.

Age Nihewanian, Early Pleistocene.

Description Skull: the intercondyloid notch is narrow. The paramastoid process is robust. The basilar tubercle is rough and lightly projecting. The pterygoid canal is in the temporal wing near the sphenoid bone. The pterygoid process is very high but the postforamen of pterygoid canal can be seen in ventral view. The frontal surface is level and smooth as well as very wide, and it lightly inclines laterally from the postorbital constraction. The supraorbital foramen and the upper orbital margin are lightly lower than the frontal surface. There is a notch in the front of the extrafrontal crest. The anterior end of the zygomatic process of the temporal bone reaches the half of the orbit, and the zygomatic process is relatively low in the skull. The temporal condyle is transversally oval and lightly projecting outwards, and its position is the widest in the skull. The glenoid cavity is deep in the middle and becomes shallow in the interior. The temporal crest is robust and strong. The facial crest is much projecting and its anterior end extends above the mesostyle of P4. The praeorbital pit is shallow with an indistinct border. The alveolar tuber is great and the maxillary tuberosity is round. The maxillary recess is big and deep. On the palatine process, the palatine sulcus develops from the level before P4 and becomes deep postwards till reaches the anterior palatine foramen in the level after the protocone of M3. The canine alveole is strongly projecting outwards so that this position is the widest in the muzzle. The center of the posterior margin of the palate is in the level before M3. The pterygoid bone is very thin and opens behind. A deep groove is along the nasal suture. The nasal side surface is steep and top surface is wide. The nasal notch

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extends above the back of P2. A small lacrimal tabercle is on the upper front of the orbit. The facial length of the lacrimal bone is much longer than the half of the orbit. The zygomatic process of the zygomatic bone goes beyond the orbital posterior border and reaches the front of the temporal fossa. The vomer notch is a deep curve.

Mandible: The bone is thick, and its lingual surface is smooth and spoon-shapedly concave while the mental surface is swelling and rough. The suture of the symphysis is distinct. The external surface of the horizontal ramus is smooth and swelling vertically. The mental foramen is on the lower middle of the diastema. The lower margin of the horizontal ramus is flat and straight as well as thick and round. The vasorum notch is in the behind 1 / 3 of the horizontal ramus. The angle of the mandible is thick with a rough lip and becomes thin upwards. The condyloid process is strongly declined forwards down.

Upper cheek teeth: DP1 exists generally. The anterstyle of P2 is small. The premolars have wide and short protocones with weak middle grooves, large parastyles with flat tops inclined forwards, wide and middle-grooved mesostyles, weak pli caballine, and short and wide hypocones. The molars have narrow para- and mesostyles, deeply middle-grooved protocones, no pli caballine, narrow and long hypoconal grooves, simple enamel plications, and inclined protolophes and metalophes. The M3 has a double-angle posterior margin, a narrow and long protocone, and an isolated enamel lake.

Lower cheek teeth: The paraconid of p2 is strongly projecting with a round end. The lower premolars have protostylids, developed pli caballinid, short ectoflexids, round metaconids with handles, metastylids with sharp posterior angles, and approximately square entoconids. The lower molars have small pli caballinid, square metaconids with handles, very small metastylids, oval entoconids, and deep ectoflexids that penetrate into the isthmuses and touch the linguaflexids so that the bottoms of the ecto- and linguaflexids become flat. All of the lower teeth have V-shaped linguaflexids and swelling bottoms of the pre- and postflexids. The m3 has a narrow and long entoconid and a large hypoconulid that is strongly projecting postwards.

Third metapodials: The limb bones of *E. qingyangensis* are very rich, but the most representative metapodials are discussed in this paper because of the limited space. The distal ends of the second and fourth metacarpals reach the position between the 1 / 2 and lower 2 / 3 of the third metacarpal. A nutrient foramen is on the upper 1 / 3 of the McIII. On the proximal end of Mc III, the articular facet for the Os carpale IV is a long inverse trapezium that has a 190° front angle and a 180° back angle with the articular facet for the Os carpale III. The position of the nutrient foramen of the third metatarsal is relatively higher. On the proximal end of the MtIII, the central depression is rough and the external notch is deep. The front angle between the

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articular facets for the Os tarsi II and III is 145°. The front angle between the articular facets for the Os tarsi III and IV is 190°. The distal sagittal crests of the McIII and MtIII are lower ahead than behind. The metapodials of *E. qingyangensis* are very slender.

2 Comparison and discussion

E. qingyangensis has obvious differences from *E. sanmeniensis* on their teeth. Firstly, the tooth size of *E. qingyangensis* is smaller than or at most equal to the lower limit of *E. sanmeniensis* from Nihewan (Teilhard *et al.*, 1930; Forsten, 1986), and smaller than that of *E. sanmeniensis* collected mainly from Mianchi County, Henan Province by Zdansky (1935). Liu (1937) considered that *E. sanmeniensis* from Zhoukoudian is lightly smaller than that from Nihewan, but its tooth size is still larger than that of *E. qingyangensis*. Secondly, the pli caballine of *E. qingyangensis* are not developed. Except young individuals, the pli caballine of *E. qingyangensis* are very weak or even absent in the adult. On the other hand, the pli caballine of *E. sanmeniensis* are well-developed on its premolars and very marked on its molars generally. For example, on the specimen of Teilhard *et al.* (1930, Pl. VI, 4), the pli caballine are very well-developed on its premolars and molars. On the specimen of Liu (1973, Pl. I, 2), the pli caballine are rather well-developed or at least very marked on the whole tooth rows. Only in the lightly worn specimen of NWUV1129, *E. qingyangensis* has obvious pli caballine. Thirdly, the development of pli caballinid is relevent to the worn degress, however, the pli caballinid frequences of *E. qingyangensis* are higher than those of *E. sanmeniensis*, which can be regarded as a difference between their lower teeth.

The pli caballine of *E. stenonis*, distributed widely in Eurasia, are very weak or absent like *E. qingyangensis* (Eisenmann, 1980, Pl. XVIII, XIX). However, the protocones of the former are shorter than those of the latter. The roots of metaconids of *E. stenonis* contract strongly so that become narrow necks (Azzaroli *et al.*, 1993, Pl. IV, 2), while those of *E. qingyangensis* reduce postwards gradually but do not form obvious necks.

The materials of *E. huanghoensis* are very rare, only including some isolated upper cheek teeth (Chow *et al.*, 1959), however, their large sizes and wide-short protocones are different from the middle sizes and narrow-long protocones of *E. qingyangensis*. The tooth size of *E. yunnanensis* is similar to that of *E. qingyangensis* (Colbert, 1940; Liu *et al.*, 1974), but the former ectoflexids do not penetrate into the isthmuses while the latter penetrate or touch the linguaflexids. *E. teilhardi* lacks of cups on its lower incisors (Eisenmann, 1972). On the contrary, all incisors of *E. qingyangensis* have complete cups.

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The skull of *E. qingyangensis* is smaller than that of *E. sanmeniensis*. A skull of *E. sanmeniensis* from Nihewan is very large because its vertex length is 650mm and its basilar length is 585mm (Teilhard *et al.*, 1930). The basilar length of *E. sanmeniensis* from Qixian, Shanxi is 522mm (Zdansky, 1935). On the other hand, the basilar length of *E. qingyangensis* is about 509mm (see Tab. 1).

The limb bones of *Equus* have a very important significance for the determination of different species. The greatest length of the McIII of *E. qingyangensis* is between those of *E. sanmeniensis* (255～283mm, Teilhard *et al.*, 1930) and *E. teilhardi* (213～220mm, Eisenmann, 1975), and similar to that of *E. sanmeniensis* from Zhoukoudian (Liu, 1973). But the McIII of *E. qingyangensis* is more slender than those of all known stenonid horses because its middle shaft index is 13.3 (Tab. 4) while that of *E. stenonis* in Europe is 14.9～16.3 (Eisenmann, 1979), *E. sivalensis* in Asia is 14.3～14.9, *E. sanmeniensis* is 14.8～16.1 and *E. teilhardi* is 14.6～15.5, the fossils of *Equus* from Ceyssaguet in France is 14.3～15.2 (Teilhard *et al.*, 1930), *E. sanmeniensis* from the localities of northern China is 14.4～16.3 (Zdansky, 1935) and from the localities of Zhoukoudian is 15.1～16.8(Zdansky, 1928; Teilhard, 1936; Teilhard *et al.*, 1941; Liu, 1973), and *E. conversidens* in North America is 13.8～16.3(Dalquest, 1967). Correspondingly, the middle shaft index of the MtIII of *E. qingyangensis* is 10.9～11.9(Tab. 4) and smaller than those of other stenonid horses because those of *E. sanmeniensis* is 12.5～15.5 and *E. teilhardi* is 12.5 from Nihewan, *Equus* from Ceyssaguet is 15.3, *E. sanmeniensis* from the Locality 9 and 13 of Zhoukoudian is 13.4～13.7, *E. stenonis* in Europe is 13.0～14.0 (Eisenmann, 1979), *E. simplicidens* is 12.7～14.0(Azzaroli *et al.*, 1993), *E. conversidens* is 11.9～12.8, and *E. niobrarensis* is 13.3 in North America (Dalquest, 1967). Only the lower limits of *E. sanmeniensis* from the localities of northern China (11.5～12.9, Zdansky, 1935) and from the Locality 1 of Zhoukoudian (11.4～13.5, Liu, 1973) are close to the upper limit of *E. qingyangensis*. To sum up, this new species has very slender metapodials and is much different from other Early Pleistocene species of *Equus* in Eurasia and North America.

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图版说明(Explanations of plates)

图版 I(Plate I)

Equus qingyangensis sp. nov.

1. NWUV 1128, 头骨(Skull), 腹视(Ventral view), ×3/8; 2. NWUV 1134, 下颌骨(Mandible), 顶视(Dorsal view), ×3/10; 3. NWUV 1134, 下颌骨(Mandible), 侧视(Side view), ×3/10

图版 II(Plate II)

Equus qingyangensis sp. nov., NWUV 1129, 头骨(Skull), ×3/10

1. 顶视(Dorsal view); 2. 腹视(Ventral view); 3. 侧视(Side view)

图版 III(Plate III)

Equus qingyangensis sp. nov., ×1/2

1. NWUV 1152, 左第三掌骨(Left McIII), 前视(Anterior view); 2. NWUV 1152, 左(Left)McIII, 外视(External view); 3. NWUV 1155, 左第三蹠骨(Left MtIII), 前视(Anterior view); 4. NWUV 1155, 左(Left) MtIII, 内视(Internal view)

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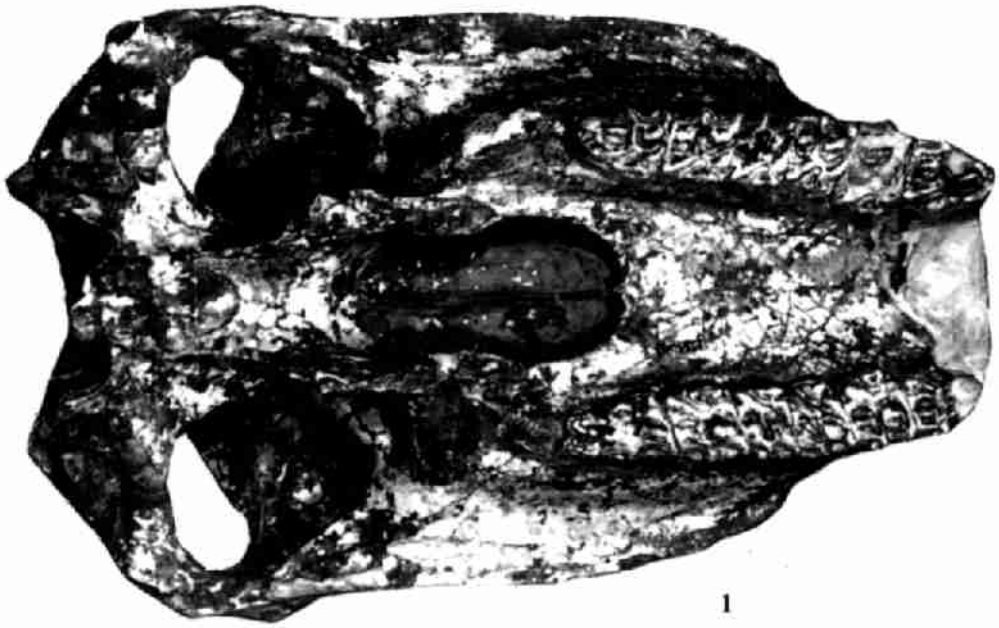

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