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云南禄丰古猿化石地点的犀科化石[1)]

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摘要:描述了产自云南禄丰古猿化石地点的犀科化石禄丰无鼻角犀新种(*Acerorhinus lufengensis* sp. nov.)和林氏山西犀相似种(*Shansirhinus* cf. *S. ringstroemi*)。*A. lufengensis* 的个体较大;原尖不收缩或微弱收缩,次尖几乎不收缩,反前刺缺失或非常微弱;前臼齿前尖肋强壮;臼齿前刺短小,无内齿带,除M3外无小刺;下前臼齿的下内脊呈横向;下门齿呈特别粗壮的獠牙状。从 *A. lufengensis* 的一系列进步性状判断,它的时代至少不会早于M3外脊和后脊分界明显的 *A. palaeosinensis*,应相当于晚中新世的NMU10或MN12,年龄约7 Ma。*S.* cf. *S. ringstroemi* 具有丰富的釉质褶皱、微弱的前尖肋、非常强大的前刺、强烈收缩的原尖、发达的齿桥和中窝、角状的U形内谷、连续的内齿带、膨大成方形的次尖等。在这个种内,体型有增大的趋势,釉质褶皱向增强的方向发展,中窝数量增多,而禄丰标本在尺寸上略小于甘肃临夏的上新世最早期材料,釉质褶皱也相对更弱,中窝仅有一个。因此,禄丰 *S.* cf. *S. ringstroemi* 的时代应该略早,出现于晚中新世的7 Ma左右是比较合理的解释。

关键词:云南禄丰,古猿地点,中新世,犀科

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云南禄丰的石灰坝哺乳动物群是在1975年随着禄丰古猿的出土而大量发现的,从那时开始,中国科学院古脊椎动物与古人类研究所和云南省博物馆组成的联合考察队对石灰坝地点进行了5次发掘(1975, 1976, 1980, 1981, 1983)。石灰坝动物群的哺乳动物化石相当丰富,祁国琴(1979)发表了一个综合性的研究报告,在化石名单中报道了34种动物,其中有两种犀科动物,分别列为 *Aceratherium* sp. nov. 和 *Chilotherium* sp. nov.。此后对石灰坝动物群的各个门类有不同程度的进一步研究,Qiu and Qiu (1995)的文章中已将动物群的种类增加到90种以上。不过,此后再无关于禄丰两个犀科化石种的正式描述。中国南方晚中新世的哺乳动物化石地点相当稀少,与北方这一时期的情况正好相反。禄丰的犀科化石材料丰富,这对于了解犀科的进化过程、迁徙扩散以及其气候环境背景都具有重要的意义。对这批犀科化石标本的深入研究表明,它们代表无角犀亚科中的两个种,即禄丰无鼻角犀新种(*Acerorhinus lufengensis* sp. nov.)和林氏山西犀相似种(*Shansirhinus* cf. *S. ringstroemi*)。本文是对这些犀科化石详细的研究报道。

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描述所用犀科牙齿术语主要依 Antoine (2002, fig. 72),其中下颊齿的术语参考邱占祥、王伴月(2007,图7)。文中缩写:IVPP Loc.,中国科学院古脊椎动物与古人类研究所化石地点编号;IVPP V,中国科学院古脊椎动物与古人类研究所脊椎动物化石编号。

犀科 Rhinocerotidae Owen, 1845

无角犀亚科 Aceratheriinae Dollo, 1885

无鼻角犀属 *Acerorhinus* Kretzoi, 1942

禄丰无鼻角犀(新种) *Acerorhinus lufengensis* sp. nov.

(图 1-2; 表 1-2)

Aceratherium sp. nov. Qi, 1979, p. 19

Aceratherium sp. nov. Qi, 1985, p. 64

Aceratherium sp. Qiu and Qiu, 1995, p. 64

正型标本 IVPP V 15980,可能属于同一个体的右 P3、左 M1-M3(图 1A)、残破的右 M1 和 M2、残破的右 i2。

正型标本产出层位 云南省禄丰县石灰坝禄丰古猿化石地点(IVPP Loc. 75033) D 剖面第 3 层(见祁国琴,1985),晚中新世。

归入标本 V 15981, 残破 M2; V 15982.1-4, 4 枚 i2; V 15982.5, p2; V 15982.6, 同一个体的左右 p2; V 15982.7, dp2; V 15982.8-9, 2 枚 p3; V 15982.10-12, 3 枚 p4; V 15982.13-16, 4 枚 m1。这些化石主要产自 D 剖面第 5 层。

种名来源 禄丰代表了该种的化石产地。

特征 个体较大的无鼻角犀。原尖不收缩或微弱收缩,次尖几乎不收缩。反前刺缺失或非常微弱。上前臼齿前尖肋强壮。上臼齿除 M3 外无小刺,前刺短小,无内齿带。下前臼齿的下内脊完全呈横向。下门齿呈特别粗壮的獠牙状。

描述 P3:冠面前宽后窄,而内、外长度接近。前附尖强壮而突伸,顶端浑圆。前尖肋极为发达,呈半圆形强烈突出,但向齿冠基部方向突出程度降低。外脊其余部分平直,后尖肋微弱。后附尖长,齿冠末端截平。原尖、次尖大而圆,舌缘隆突,皆不收缩,两尖大小相近。原脊、后脊平行而后倾,原脊宽阔,略长于窄的后脊。无反前刺。尽管 V 15980 相应位置破损,但能够判断有中窝存在。中谷狭窄,接近齿冠基部处因原尖和次尖的膨大而封闭,并形成宽浅的 V 形内谷。后谷封闭成近横向的椭圆形。前齿带厚实,从牙齿前缘中央向内侧下倾。无外齿带,内齿带仅残留于中谷口。牙齿内、外壁釉质表面有密集的水平纹。

M1:冠面前宽后窄、外长内短。前附尖宽短,伸向前外方,至齿冠基部仍突出于牙齿前缘。外脊轻微起伏,前附尖褶宽缓,前尖肋不明显。后附尖较短。原尖大而圆,微弱收缩。次尖与原尖大小相近。原脊和后脊近平行后倾,原脊宽,略长于唇侧变窄的后脊。前刺短粗,无小刺,反前刺位置仅略为膨大。中谷狭窄,后谷窄深。前齿带在内半部发达,向齿冠基部方向倾斜并消失于原尖前内角。无内、外齿带,后齿带中央有 V 形切口。釉质表面竖纹明显。

M2:前附尖强壮,比 M1 的窄。从外侧看,齿冠前、后缘都向下收缩并略呈弧形。外脊波曲,前附尖褶显著,前尖肋强壮并向齿冠基部方向减弱,后附尖褶宽浅。后附尖长,齿冠末端截平。原尖在接近齿冠基部时有微弱的收缩,次尖略小于原尖。原脊宽,后脊稍窄。小刺无(V 15980 左 M2)或有(V 15980 右 M2)。中谷内部狭窄,向谷口方向逐渐开阔。后谷呈窄深的 V 形,在齿冠下部封闭。其余特征与 M1 相同。

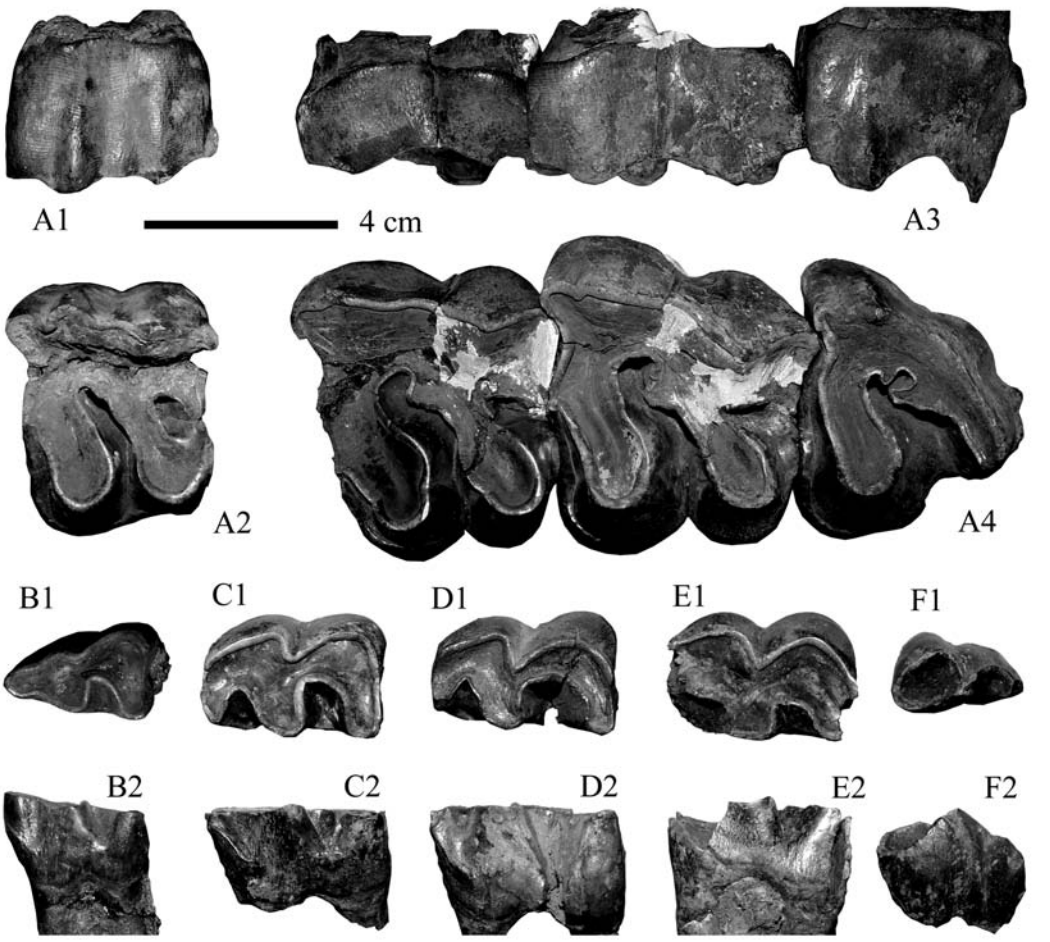

图 1　禄丰无鼻角犀新种的颊齿

Fig. 1 Cheek teeth of *Acerorhinus lufengensis* sp. nov.

A. V 15980, upper cheek teeth, holotype, 1–2. right P3, reverse, 1. labial view, 2. occlusal view, 3–4. left M1–M3, 3. labial view, 4. occlusal view; B–F. lower cheek teeth, 1. occlusal view, 2. lingual view, B. V 15982.5, right p2, C. V 15982.8, left p3, reverse, D. V 15982.10, right p4, E. V 15982.15, right m1, F. V 15982.7, left dp2

M3:冠面轮廓呈三角形,接近齿冠基部变为四边形。前附尖突伸,前附尖褶宽浅,前尖肋不显。原尖大而圆,不收缩。前刺粗壮而前伸,末梢略弯向唇侧。小刺发达,无反前刺。外后脊略呈弧形,原脊宽而直,微弱后倾。中谷宽大,谷口开阔。前齿带相当厚实,占

据牙齿前缘大部,向外方上升并在接近前附尖处到达冠面,向内侧方向包裹原尖前内角。无内、外齿带,后齿带板状,中央有缺口。

表 1 禄丰无鼻角犀新种上颊齿测量

Table 1 Measurements of upper teeth of *Acerorhinus lufengensis* sp. nov. (Length×Width×Height, mm)

Tooth	V 15980	V 15981
P3	45.6×58.7×31.4	
M1	57.8×68.7×24.6	
M2	59.6×71.3×34.5	62.1× — ×36.6
M3	53.5×63.3×37.8	

i2:呈大型的獠牙状,从齿冠到齿根弧形弯曲(图 2)。齿冠舌侧磨蚀面长可达 107.8 mm (V 15982.2, 图 2B),为弧形凹面,显著短于齿根,其下端已进入齿根部分。齿冠基部为牙齿最宽处,向舌侧方向突出。齿冠横截面为扁的三角形,内角尖锐,前、后外角钝圆,前面和外面平滑。齿根横截面为扁的椭圆形,末端较粗,表面有细小密集的纵向和横向沟纹,形成网格状纹饰。

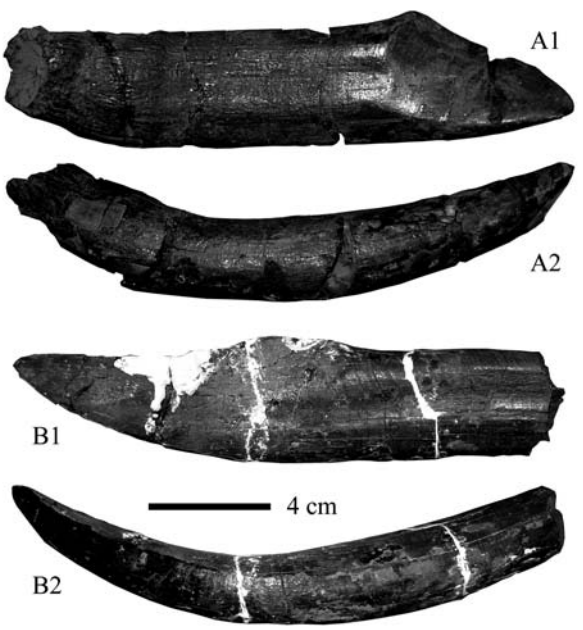

图 2 禄丰无鼻角犀新种的下第二门齿

Fig. 2 Lower second incisors of *Acerorhinus lufengensis* sp. nov. A. V 15982.3, right i2; B. V 15982.2, left i2; 1. lingual view, 2. lateral view

dp2(图 1F):外沟在冠面顶部呈 V 形,但很快向齿冠基部方向变得宽浅。下前脊分叉成两支,一支前伸并内弯,一支平伸。下后脊与下内脊在舌侧连贯而使后叶形成封闭的椭圆形,其长轴后倾。前齿带横贯齿冠中部,后齿带从外向内陡峭上升,无内、外齿带。外壁釉质表面垂向纹饰发达。

p2(图 1B):外沟呈宽浅的 U 形,向齿冠基部方向基本保持不变,外沟褶显著。齿冠内、外下缘中央呈弧形凹陷。下原脊直向前伸,末端尖,内、外侧收缩成宽浅的沟。下原尖、下后脊和下后尖共同组成宽大的菱形。下内脊横向。后谷开阔,冠面 U 形,内面 V 形。齿带仅断续微弱发育于内侧,在前、后谷口可见。外壁釉质表面有细密的横纹,而垂向纹饰微弱。

p3(图 1C):外沟 V 形,向齿冠基部方向变浅。下前脊处宽大,略前倾,内端尖锐。前叶下原尖处呈锐角,下后脊微弱后倾。后叶更宽,下内脊横向。下后尖略大于下内尖,舌缘都较平直。自冠面看,前、后谷相

当深,皆近 U 形,后谷比前谷约大一倍。自舌侧看,后谷呈纵向上窄深的 V 形,但底部被一段齿带遮挡;前、后谷较浅,其底部距齿冠基部还分别尚有 10 mm 和 9 mm。前齿带在内侧高且水平,在外侧无。无外齿带,外沟基部有微弱的齿柱。内齿带除存在于后谷口外,前谷前缘的内齿带与前齿带连贯,从前上方向谷底延伸。

p4 与 p3 相似,不同的是 p4 的外沟更宽深,下前脊比较退化;从冠面看,前谷 V 形,远小于后谷;后谷口没有齿带发育(图 1D)。

m1(图 1E):外沟呈宽深的 V 形,向齿冠基部方向变浅。舌侧齿冠下缘中央呈弧形凹陷。前叶下原尖处圆隆,下原脊与下后脊之间的夹角近直角,在中等磨蚀的牙齿上已无下前脊。下后脊后倾,而下内脊后倾的角度更大。下后尖舌缘平直,后缘呈直角。自冠面看,前、后谷相当浅,前谷 U 形,后谷 V 形。从舌侧看,后谷纵向呈 V 形,其底部距齿冠基部尚有 8 mm。前、后齿带微弱,无内、外齿带。

表 2　禄丰无鼻角犀新种下牙测量

Table 2　Measurements of lower teeth of *Acerorhinus lufengensis* sp. nov. (Length×Width×Height, mm)

Specimen No.	Tooth	Measurement	Specimen No.	Tooth	Measurement
V 15980	i2	40.7×26×—	V 15982.9	p3	37.7×26.2×25.9
V 15982.2	i2	43.3×19.1×106.7	V 15982.10	p4	40.1×27.4×32.8
V 15982.3	i2	45.4×24.5×80.3	V 15982.11	p4	40.9×26.7×27.6
V 15982.7	dp2	30.5×20×25.8	V 15982.12	p4	~41×28.4×31.1
V 15982.5	p2	29.5×20.2×25.6	V 15982.13	m1	42.1×28.5×16.7
V 15982.6	p2	30.1×21.1×27	V 15982.14	m1	40×30.5×15
V 15982.8	p3	38.7×24.9×23	V 15982.15	m1	40.5×27×25.5

比较　禄丰的上述标本在下门齿的大小、颊齿的冠高和冠面形态结构以及个体较大等特征上均与 *Acerorhinus* 属一致,而与 *Chilotherium*、*Subchilotherium*、*Shansirhinus*、*Alicornops*和 *Aceratherium* 等明显不同。与 *Acerorhinus* 属的已知种比较,禄丰上述标本的前臼齿有非常强壮的前尖肋,臼齿不发育反前刺,原尖收缩非常微弱或不收缩,内齿带完全缺失。这些标本最初被认为是 *Aceratherium* 属的一个新种(祁国琴,1979,1985),但其下门齿特别粗壮并弧形弯曲,这是 *Acerorhinus* 的特点(邱占祥等,1987:549),明显大于 *Aceratherium* 的下门齿并具有更大的弯曲度,因此应归入 *Acerorhinus* 属。

Acerorhinus 属目前已知有 5 个有效种,都出现在晚中新世,它们是:*A. zernowi* (Borissiak, 1914, 1915)、*A. tsaidamensis* (Bohlin, 1937)、*A. palaeosinensis* (Ringström, 1924)、*A. hezhengensis* (邱占祥等,1987)和 *A. fuguensis* (邓涛,2000)。在这些种中,禄丰标本在臼齿不发育反前刺和原尖收缩微弱的特点上与 *A. zernowi* 相近,而其余的 4 个种都在 M1 和 M2 上有显著的反前刺,原尖的收缩也相对更强。在上臼齿的内齿带发育程度上,禄丰标本与 *A. tsaidamensis* 都无内齿带,其余的 4 个种有的内齿带相当发达,如 *A. zernowi* (Borissiak, 1915, pl. II),有的在中谷口还有残留的齿带,如 *A. fuguensis* (邓涛,2000,图版 I)。此外,禄丰标本与 *A. zernowi* 的不同还在于前者前臼齿的内齿带不发达,仅断续分布于中谷口,在次尖外完全缺失,前尖肋要强大得多,而 *A. zernowi* 上前臼齿的内齿带相当发达,并且与前、后齿带连贯,前尖肋则非常微弱;与 *A. tsaidamensis* 的区别还有:禄丰标本

上臼齿的后附尖褶非常浅,后谷窄深,M1 的次尖前壁光滑,而 *A. tsaidamensis* 的后附尖向外后方翘出的程度很大,以至形成一个显著的后附尖褶,后谷也因此而变得宽大,其 M1 次尖前壁有一个指向舌侧的小褶皱(Bohlin, 1937, figs. 90, 91);与 *A. palaeosinensis* 的区别还在于禄丰标本上臼齿 M2 的中谷开放,M3 不发育中窝,下前臼齿的下内脊呈横向,而 *A. palaeosinensis* 的 M2 的中谷被延伸到后脊的反前刺封闭,M3 的前刺与小刺连接形成中窝,下前臼齿的下内脊显著向后倾斜(Ringström, 1924, pl. IX, fig. 7; pl. X, fig. 4);与 *A. hezhengensis* 的区别还有:禄丰标本的前臼齿后脊虽然比原脊窄,但并不细弱,M3 的外后脊外壁平滑,而 *A. hezhengensis* 的前臼齿后脊非常细弱,与膨大的次尖形成鲜明的对比,M3 外后脊的外后角在齿根之上 15 mm 处有一向后伸出的部分(邱占祥等,1987:547);与 *A. fuguensis* 的区别还在于禄丰标本前臼齿的原脊宽阔,臼齿的前刺短粗,M3 发育小刺,而 *A. fuguensis* 前臼齿的原脊朝外脊方向逐渐变窄,臼齿的前齿长大,M3 没有小刺。

由上面的比较可以看出,禄丰的这些标本代表了一个不同于 *Acerorhinus* 属目前已知种的新种,我们称其为禄丰无鼻角犀 *Acerorhinus lufengensis* sp. nov.。

时代 禄丰古猿地点产化石的层位根据哺乳动物群对比被认为属于中国晚中新世保德期的 NMU10(Qiu et al., 1999),相当于欧洲 Turolian 期的 MN11(邓涛,2006)。不过,最近的古地磁研究表明石灰坝 D 剖面的绝对年龄为 6.9 ~ 6.2 Ma (岳乐平、张云翔,2006)。*A. lufengensis* 的一些特征是比较原始的,如原尖收缩弱、不发育反前刺等。实际上,在 *Acerorhinus*属内,*A. lufengensis* 与 *A. zernowi* 最相似。然而,*A. lufengensis* 也有不少相当进步的性状,如前臼齿的内齿带不发达,比 *Acerorhinus* 属中已知各个种的都弱;臼齿完全缺乏内齿带,而 *A. zernowi* 的臼齿有发达的内齿带,*A. hezhengensis*, *A. palaeosinensis* 和 *A. fuguensis* 至少在臼齿的中谷口有内齿带存在;M3 的外后脊平滑,而 *A. zernowi*, *A. palaeosinensis*和 *A. hezhengensis* 的 M3 的外后脊在外后角存在明显的界线。*A. zernowi* 分布于欧洲乌克兰、土耳其和希腊等地晚中新世 Vallesian 期的 MN9 – 10 和 Turolian 期的 MN11 (Heissig, 1999);*A. tsaidamensis* 和 *A. fuguensis* 分别发现于青海柴达木盆地和陕西府谷的晚中新世早期,即灞河期的 NMU9;*A. hezhengensis* 发现于甘肃临夏盆地晚中新世灞河期的 NMU9 和保德期的 NMU10(Deng et al., 2004)。*A. palaeosinensis* 发现于山西保德晚中新世晚期,即保德期的 NMU10。从 *A. lufengensis* 的一系列进步性状判断,它的时代至少不会早于 M3 外脊和后脊分界明显的 *A. palaeosinensis*,应相当于 NMU10 或 MN12,年龄约为 7 Ma,与古地磁的测年结果匹配。至于 *A. lufengensis* 在 *Acerorhinus* 属里的系统演化关系,由于仅有牙齿而缺乏头骨和下颌骨材料,尚难进行准确的判断。

山西犀属 *Shansirhinus* Kretzoi, 1942

林氏山西犀(相似种) *Shansirhinus* cf. *S. ringstroemi* Kretzoi, 1942

(图 3-4; 表 3-4)

Chilotherium sp. nov. Qi, 1979, p. 19
Chilotherium sp. nov. Qi, 1985, p. 64
Chilotherium sp. Qiu and Qiu, 1995, p. 64

标本 V 15983,属于同一个体的右 P2-P4 和 M3(图 3B);V 15984.1,DP1;V 15984.2,

同一个体的左右 DP1;V 15984.3,DP2;V 15984.4-9,6 枚 P2;V 15984.10-12,3 枚 P3;V 15984.13-16,4 枚 P4;V 15984.17,M1;V 15984.18-20,3 枚 M3;V 15985.1-10,10 枚 i2;V 15985.11,dp1;V 15985.12,p2;V 15986,左下颌残段,保留 p3 和 p4(图 4A),以及单独的右 p3 和 p4;V 15985.13,p4;V 15985.14,m1;V 15987,右下颌残段,保留残破的 m1 和完整的 m2(图 4B);V 15985.15-18,4 枚 m2;V 15985.19-24,6 枚 m3。

产地和层位　云南省禄丰县石灰坝禄丰古猿化石地点(Loc. 75033) D 剖面,主要产自第 5 层,少数产自第 1 层(V 15985.3)、第 4 层(V 15984.1, 9, 14;V 15985.17, 24)和第 6 层(V 15985.22)。晚中新世。

描述　DP1(图 3A):牙齿冠面呈三角形,长略大于宽,与其他颊齿相比非常小。外脊前部窄,后部变宽,约为前部一倍。无原尖和原脊,次尖强烈膨大,后脊略后倾。小刺和前刺微弱。后谷封闭成一个小的椭圆。前内齿带显著,无外齿带。外壁平滑,釉质表面的纵向树纹(参见 Antoine, 2002, fig. 77B)显著。

DP2(图 3G):前附尖细窄而强烈突伸,末端微弱中凹。外壁强烈波状起伏,有发达的前尖肋和微弱的后尖肋,中附尖隐约可见。后附尖长,强烈向外弯曲。原尖和次尖向齿冠基部方向逐渐膨大,原尖收缩向基部方向加强,但前收缩沟一直微弱。反前刺短小,前刺长大,小刺缺失。原脊窄长,长于后脊。后脊窄短,向后弯折。中谷口开阔,后谷宽大。前、后齿带发达,无内、外齿带。

P2:前附尖粗壮而强烈突伸,前尖肋宽缓而微弱,后附尖长。原尖圆,不收缩,向齿冠基部方向逐渐变大,但明显小于强烈膨大的次尖。原脊短而窄,与外脊连接处收缩最窄,以至形成一个宽深的 V 形前窝。后脊细窄,向后弯折。前刺 1 ~2 个,呈细小的釉质褶皱,在后脊上的位置不稳定,有时形成中窝(V 15984.7,图 3F)。小刺宽缓,原脊上也常发育一个釉质刺(反小刺 antecrista,V 15984.5,图 3C)。中谷整体窄深,在接近基部处封闭。后谷深,几乎被后齿带封闭成后窝。前齿带发达,有时有锯齿状的趋势。内齿带发育于中谷口。

P3:前附尖强壮而突伸,末端浑圆。外脊平直,前尖肋发达。后附尖长,齿冠末端截平。原尖圆,收缩显著,从齿冠顶部到基部方向逐渐变大。次尖强烈膨大。原脊、后脊向后倾斜强烈,两脊间近平行。原脊略呈弧形,略长于后脊,后脊中部窄。前刺细长而向唇侧弯曲,与小刺连接形成中窝。前刺近末梢处有收缩,后脊在中窝内有两枚发达的刺状褶皱(V 15983,图 3B2)。中谷整体窄深,反前刺伸达次尖而将中谷封闭,在舌侧形成宽大的内谷。后谷窄深,接近封闭。前、内、后齿带发达,仅在中、后谷口略有下降,在次尖处稍有中断,齿带边缘有不规则的锯齿现象(V 15983,图 3B2),齿带的最低点位于原尖前收缩沟处。未磨蚀的 V 15984.12 齿冠高度为 51.1 mm。

P4:与 P3 非常相似,其差别在于:P4 的后附尖末端略向外翘;反前刺较短,接近齿冠基部时才将中谷封闭;原脊显著长于后脊。

M1:标本(V 15984.17,图 3D)磨蚀严重,已接近齿冠基部。冠面轮廓呈宽远大于长的矩形,牙齿外壁中央凹陷。原尖大,扁圆,舌缘隆突,在接近齿冠基部处有显著的前收缩沟。原脊宽、后脊窄,二者平行后倾,近等长。无前刺和小刺。中谷封闭成半圆形环,后谷封闭成扁长形。有分为前、后两支的内谷,前支深,后支浅并构成次尖的前收缩沟。前齿带仅保留下倾的内侧末段,无内、外齿带。

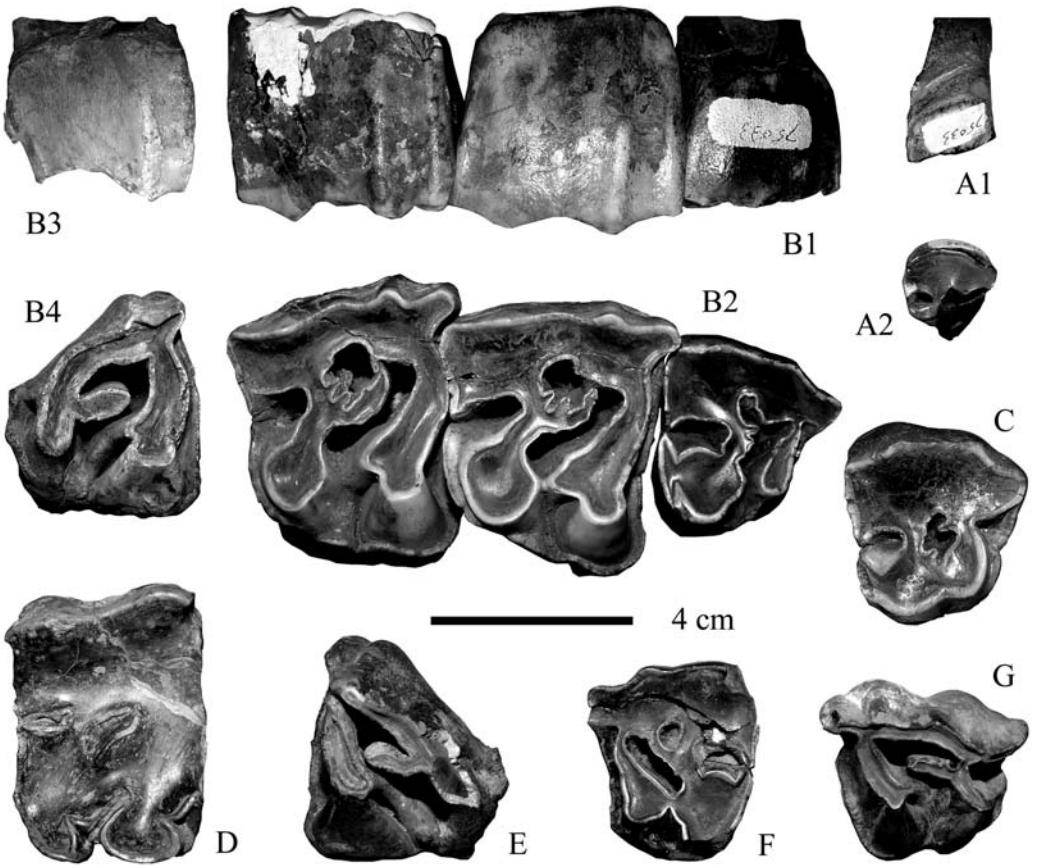

图 3 林氏山西犀相似种的上颊齿

Fig. 3 Upper cheek teeth of *Shansirhinus* cf. *S. ringstroemi*

A. V 15984.2, right DP1; B. V 15983, 1–2. right P2–P4, 3–4. right M3; 1, 3. labial view, 2, 4. occlusal view; C–G. occlusal view, C. V 15984.5, right P2; D. V 15984.17, right M1; E. V 15984.18, left M3; F. V 15984.7, left P2; G. V 15984.3, left DP2

表 3 林氏山西犀相似种上颊齿测量

Table 3 Measurements of upper teeth of *Shansirhinus* cf. *S. ringstroemi* (Length×Width×Height, mm)

Specimen No.	Tooth	Measurement	Specimen No.	Tooth	Measurement
V 15984.1	DP1	21.8×20.5×19.5	V 15983	P4	47.4×62.4×41.4
V 15984.2	DP1	19.4×18.6×12	V 15984.13	P4	—×57.7×30.4
V 15984.3	DP2	43.9×41.3×31.4	V 15984.14	P4	41.3×57.7×18.6
V 15983	P2	36.7×43.5×28.7	V 15984.15	P4	42.8×55.3×18.5
V 15984.4	P2	36.7×45.8×19.4	V 15984.16	P4	43.1×58.9×34
V 15984.5	P2	38×43.7×24.1	V 15984.17	M1	38.9×57.1×11.5
V 15984.6	P2	31.6×41.6×14.8	V 15983	M3	41.8×50.4×34.8
V 15984.8	P2	32.7×44.2×19.7	V 15984.18	M3	45×52.8×50.5
V 15983	P3	46.8×58.2×43	V 15984.19	M3	41.8×51.3×31
V 15984.10	P3	46×53.5×29	V 15984.20	M3	41.3×52.6×45.3
V 15984.12	P3	43.5×54.5×51.1			

M3:冠面轮廓呈三角形,与前部颊齿相比尺寸较小。前附尖强烈突伸,前尖肋发达。原尖显著收缩,舌缘较平,有时向基部方向形成宽浅的凹陷(V 15983,图 3B4)。反前刺短小,但在齿冠基部延伸到中谷口。前刺粗壮发达,强烈向前突伸。外后脊弧形,后尖肋显著,后沟宽浅,向齿冠基部方向加深。原脊略呈弧形,微弱后倾。前齿带发达。内齿带不连续,中谷口有齿柱,有时相当发达(V 15984.18,图 3E)。后齿带呈高耸的板状,中央有 V 形缺口。

i2:尺寸较小,从齿冠到齿根的弯曲度较缓。齿冠舌侧磨蚀面长约 44 mm,远小于齿根长度(93 mm),它的下端与齿根之间形成明显的界线(V 15985.1,图 4H),有时也深入齿根部分(V 15985.2)。齿冠横截面为三角形,前内和后内角都很尖锐,前外角钝圆,前面平,外后面微隆。齿根的表面有密集的细小纵向沟纹,其末端较粗,横截面为椭圆形。上述特征可能代表这个种的雄性门齿,而有几枚下门齿可能属于雌性个体,V 15985.3 为其典型代表(图 4G),与雄性下门齿的差别在于:尺寸更小(表 4);齿冠的磨蚀面倾斜度很小,接近牙齿的横截面方向;齿冠高度很低,磨蚀面在较低的一侧已进入齿根部分。类似的雌雄性的下门齿区别可以在 *Hispanotherium beonense* 上发现(Antoine, 2002, fig. 89)。

表 4　林氏山西犀相似种下牙测量

Table 4　Measurements of lower teeth of *Shansirhinus* cf. *S. ringstroemi* (Length×Width×Height, mm)

Specimen No.	Tooth	Measurement	Specimen No.	Tooth	Measurement
V 15985.1	i2	25.5×17.5×50.7	V 15985.13	p4	42.3×23.6×46.5
V 15985.2	i2	30.2×25.7×29.8	V 15985.14	m1	47.6×27.1×31.6
V 15985.3	i2	23.1×17.7×15.8	V 15985.15	m2	45×27.3×24.5
V 15985.4	i2	28×18×22.2	V 15985.16	m2	44.4×26.2×24.5
V 15985.5	i2	23.7×17.1×39.5	V 15985.17	m2	45.7×25.4×18.9
V 15985.6	i2	21.4×15.6×–	V 15985.18	m2	44.8×23.6×36
V 15985.7	i2	27.6×18×41.5	V 15987	m2	45.1×28.1×30
V 15985.9	i2	24.4×19.4×23.5	V 15985.19	m3	45.5×24.4×30.4
V 15985.10	i2	23×15.6×23.8	V 15985.20	m3	44.8×23×24.9
V 15985.11	dp1	17.6×10.2×11.8	V 15985.21	m3	42.8×24.7×25.5
V 15985.12	p2	30.9×16.6×35.9	V 15985.22	m3	–×26.5×29.3
V 15986	p3	38.6×19.1×16.1	V 15985.23	m3	42.5×22.8×38.2
V 15986	p4	41.1×22.4×20.5	V 15985.24	m3	45×23.6×22.7

dp1(图 4C):具有齿冠三倍高度的齿根。牙齿相当扁,外壁圆隆,内壁较平。下原脊直向前伸,向齿冠基部方向变宽。下后脊和下内脊平行后倾,后谷窄深。

p2(图 4D):外沟呈宽浅的 V 形,向齿冠基部方向变得平缓。下原脊直向前伸,内、外侧显著收缩成沟。前叶下原尖处宽圆。下内脊横向。无内、外齿带,后谷口开阔。外壁釉质表面有细密的横纹,而垂向纹饰向上方汇聚。未磨蚀的 V 15985.12 齿冠高度为 35.9 mm。

p3:外沟窄深的 V 形。下前脊宽短,前叶下原尖处呈直角。下后尖前后向扁长,其前壁的收缩显著。下内尖前壁轻微收缩,下内脊向后倾斜。后谷口呈纵向上窄深的 V 形。无内、外齿带。

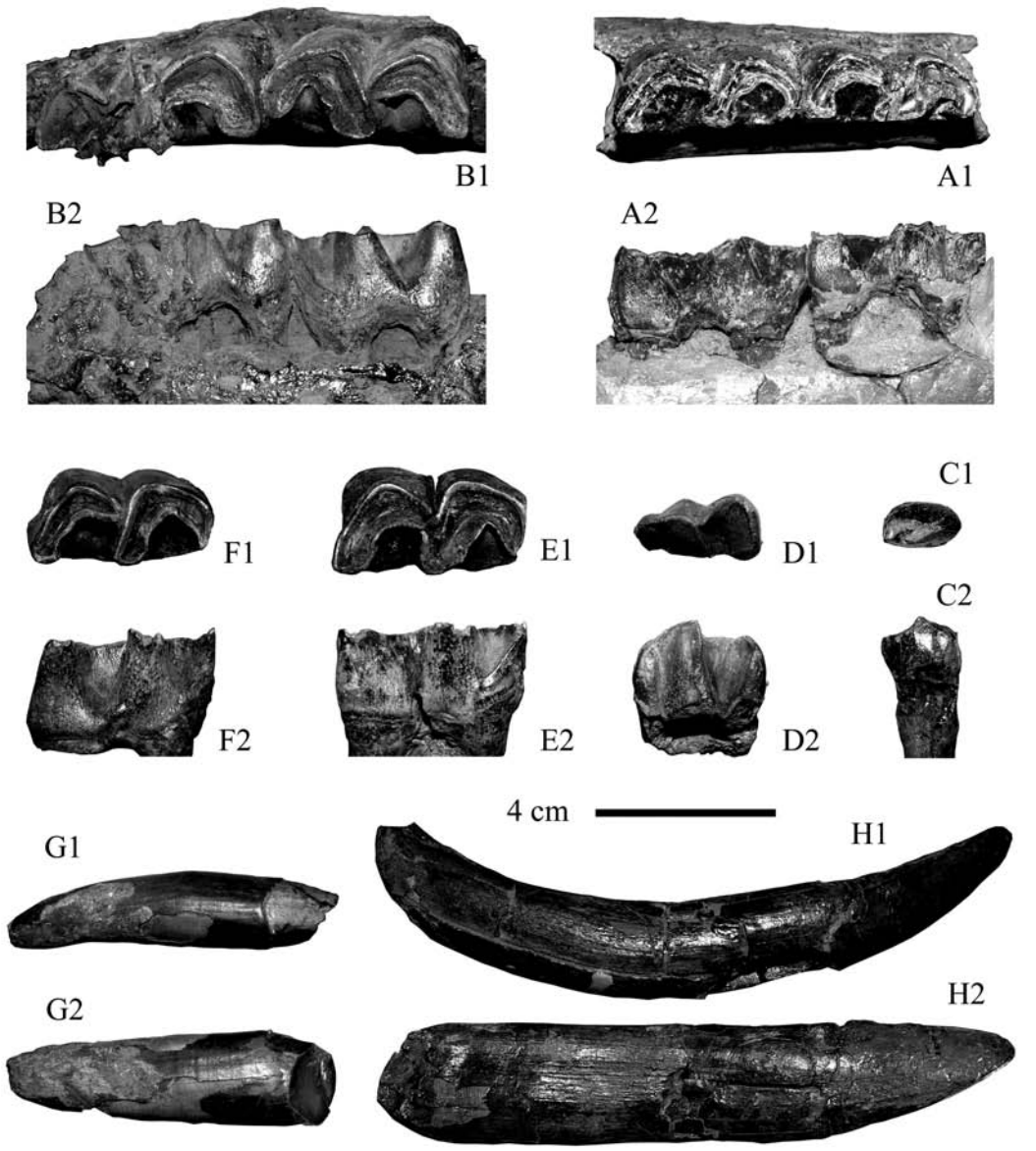

图 4 林氏山西犀相似种的下牙

Fig. 4 Lower teeth of *Shansirhinus* cf. *S. ringstroemi*

A–F. lower cheek teeth, 1. occlusal view, 2. lingual view; A. V 15986, fragmentary left mandible with p3 and p4; B. V 15987, fragmentary right mandible with m1 and m2; C. V 15985. 11, left dp1; D. V 15985.12, right p2; E. V 15985.15, left m2; F. V 15985.20, left m3; G–H. lower i2, 1. lateral view, 2. lingual view; G. V 15985.3, left, female; H. V 15985.1, right, male

p4:与 p3 相似,差别在于 p4 的下前脊细长,下内尖不收缩,后谷口宽大。未磨蚀的 V 15985.13齿冠高 46.5 mm。

m1:外沟窄 V 形,在接近齿根处变浅。下前脊较宽,向舌侧的延伸中等。前叶下原尖

处呈直角,下后尖前壁有轻微的收缩。下内脊向后倾斜。后谷口呈纵向上窄深的 V 形。前、后齿带弱,无内、外齿带。外壁具密集的横纹,但垂向的树纹更明显。

m2(图 4E)与 m1 相似,差别在于 m2 的后谷更开阔,下内脊后倾的程度更大一些,前、后齿带的外侧部分发达。

m3(图 4F):外沟呈窄深的 V 形,向齿冠基部方向逐渐变浅。下前脊微弱,前叶下原尖处呈角状,接近直角。下后尖前壁有一显著的收缩,下内尖舌缘平直,下内脊后倾。无内、外齿带。牙齿后壁中央显著凹陷,其底部为粗糙的后齿带。未磨蚀的 V 15985.23 齿冠高 38.2 mm。

比较　Schlosser (1903)根据在中国收集到的几枚地点不明的犀牛牙齿建立了一个新种 *Rhinoceros brancoi*,其特点是前臼齿的前刺和小刺上有丰富的釉质褶皱、中窝两到三个、齿桥发达;臼齿的原尖强烈收缩、前刺和反前刺粗大、前尖肋微弱。Ringström (1927)描述了一段带有完整颊齿列的上颌,产自山西榆社,定名为 *Rhinoceros* aff. *brancoi*,其牙齿相似于 Schlosser 的标本,但釉质褶皱较弱。Kretzoi (1942)认为 *R. brancoi* 的性状相当独特,建议建立一个新属 *Shansirhinus*。除 *S. brancoi* 以外,他又根据 Ringström (1927)的 *R.* aff. *brancoi* 的标本建立了一个新种 *S. ringstroemi*。*S. ringstroemi* 的齿冠低于 *S. brancoi*,其釉质褶皱明显弱于后者。Heissig (1975)将 *Rhinoceros brancoi* 修订为 *Chilotherium brancoi*。然而,*R. brancoi* 丰富的釉质褶皱、强烈分叉或三分叉的前刺和发达的齿桥并不是 *Chilotherium*的特点。Deng (2005)根据在临夏盆地发现的带有全部牙齿的头骨和下颌骨材料确认了 *Shansirhinus* 属的有效性。

禄丰标本上颊齿相当小的 DP1、丰富的釉质褶皱、微弱的前尖肋、非常强大的前刺、强烈收缩的原尖、发达的齿桥和中窝、角状的 U 形内谷、连续的内齿带、膨大成方形的次尖等,与 *Shansirhinus* 的特征一致,显然应该归入该属。另一方面,*S. brancoi* 前臼齿的前刺和小刺上的釉质褶皱又多又长,前刺强烈分叉甚至三分叉,这些特征与禄丰标本不同。禄丰标本相对较弱的褶皱及其他特征与 Ringström (1927)和 Deng (2005)分别在榆社和临夏发现的 *S. ringstroemi* 的对应特征相同。Schlosser (1903)和 Ringström (1927)描述的材料只有上颊齿而无下牙,但在甘肃临夏盆地发现的与头骨连在一起的下颌骨(V 13764)提供了 *S. ringstroemi* 确切的下门齿和下颊齿特征。禄丰标本的 i2 呈较小的獠牙状,与临夏标本一致;禄丰下颊齿上的一个重要的特征是下后尖前壁有一个清楚或至少是可辨的收缩,这一特点在临夏的下颊齿上也可以见到(Deng, 2005, fig. 6)。在云南元谋的班果曾经发现过一段带 P2–M1 的不完整右上颌骨,被定为一个新种元谋大唇犀(*Chilotherium yunnanensis*)(汤英俊等,1974),Deng (2005)已将其修订为 *S. ringstroemi*,禄丰标本也与其非常相似。

禄丰的 *S.* cf. *S. ringstroemi* 标本与在同一地点发现的另外一个无角犀亚科成员 *Acerorhinus*相比,后者前臼齿的前尖肋非常发达、内齿带不连续、原尖不收缩、前刺和齿桥微弱或缺失;i2 巨大,磨蚀面在后方;下颊齿的下前脊微弱或缺失、下前臼齿的下内脊呈横向。上述特点与 *S. ringstroemi* 截然不同。山西犀发达的次级结构和釉质褶皱使它更容易取食难嚼的草本植物(Deng, 2005),可能与同一环境中的无鼻角犀存在生态上的差异,各自占据不同的生态位。

时代 此前发现的 *S. ringstroemi* 分布于中国的山西榆社、甘肃临夏和天祝(郑绍华,1982)、云南元谋,其时代为晚中新世的保德期和早上新世的高庄期(NMU10-12),相当于MN12-15(Deng, 2005)。在这个种内,体型有增大的趋势,釉质褶皱向增强的方向发展,中窝数量增多,如元谋班果的 P2 和 P3 就有两个中窝(汤英俊等,1974:63),榆社韩家洼的 P2 也有两个中窝(邱占祥、阎德发,1982:125)。而禄丰标本在尺寸上略小于甘肃临夏的上新世最早期材料,釉质褶皱也相对更弱,中窝仅有一个,这也就是我们将禄丰标本订为相似种的原因。因此,禄丰 *S.* cf. *S. ringstroemi* 的时代应该略早,出现于晚中新世晚期的NMU10,年龄约 7 Ma 是比较合理的解释。

RHINOCEROTIDS (MAMMALIA, PERISSODACTYLA) FROM *LUFENGPITHECUS* SITE, LUFENG, YUNNAN

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Key words Lufeng, Yunnan, China; hominoid site; Miocene; Rhinocerotidae

Summary

The rhinocerotid fossils from the *Lufengpithecus* site in Lufeng, Yunnan, were collected during the period from 1975 to 1983. They were preliminarily identified as *Aceratherium* sp. nov. and *Chilotherium* sp. nov. (Qi, 1979, 1985). A further study of these fossils indicates that they represent a new species of *Acerorhinus* and a species of *Shansirhinus*, respectively. In this paper, terminology of rhinocerotid teeth mainly follows Antoine (2002, fig. 72), and that of lower teeth is according to Qiu and Wang (2007, fig. 7). IVPP Loc. and IVPP V are the locality and specimen prefixes of Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, respectively.

Rhinocerotidae Owen, 1845
Aceratheriinae Dollo, 1885
Acerorhinus Kretzoi, 1942
Acerorhinus lufengensis sp. nov.

(Figs. 1-2; Tables 1-2)

Aceratherium sp. nov. Qi, 1979, p. 19
Aceratherium sp. nov. Qi, 1985, p. 64
Aceratherium sp. Qiu and Qiu, 1995, p. 64

Holotype IVPP V 15980: right P3, left M1-M3, broken right M1 and M2 (Fig. 1A), and broken right i2 of one and the same individual.

Horizon of holotype Level 3 of Section D of the *Lufengpithecus* site (IVPP Loc. 75033, see Qi, 1985, fig. 5) at Shihuiba in Lufeng, Yunnan; Late Miocene.

Referred specimens V 15981: a broken M2; V 15982.1-4: four i2; V 15982.5: a p2; V 15982.6: two p2 of one and the same individual; V 15982.7: a dp2; V 15982.8-9: two p3; V 15982.10-12: three p4; and V 15982.13-16: four m1. Most of them were collected from Level 5 of Section D.

Etymology Lufeng is the county where the fossil locality of this new species is situated.

Diagnosis A large-sized *Acerorhinus*. Protocone not or weakly constricted; hypocone

scarcely constricted; antecrochet absent or very weak; and paracone rib strong on premolars. Crochet short and lingual cingulum absent on molars. Crista absent on M1–2. Entolophid transverse on lower premolars. Lower second incisors robustly tusk-like.

Description The P3 has a very prominent parastyle. The paracone rib is strong and semicircular, but becomes weak towards the crown base. The protocone and hypocone are of the same size; they are large and rounded, with no constriction. The protoloph is wide and the metaloph is narrow; they are parallel to each other and posteriorly oblique. The medifossette is present, but the antecrochet is absent. The median valley is narrow and closed near the crown base, and forms a V-shaped lingual groove due to the enlargement of the protocone and hypocone. The postfossette is closed, forming a transverse oval. The anterior cingulum is inclined from the center to the protocone. The labial cingulum is absent and the lingual cingulum faintly remains on the entrance of the median valley. Dense horizontal lines are present on the enamel surface.

The M1 has a wide and short parastyle. The ectoloph is slightly undulated, with a shallow parastyle fold and a weak paracone rib. The protocone is large, rounded, and weakly constricted. The hypocone has the same size as the protocone. The protoloph is slightly longer and wider than the metaloph; they are parallel to each other and posteriorly oblique. The crochet is robust and short, but the crista and antecrochet are absent. The median valley and postfossette are narrow. The lingual half of the anterior cingulum is well-developed. The lingual and labial cingula are absent and the posterior cingulum is middle-grooved. Vertical lines are present on the labial wall.

The M2 has a narrower parastyle than do the M1's. The parastyle fold and paracone rib are marked, but the latter disappears near the crown base. The metastyle is long, with a flat end, and the metastyle fold is shallow. The protocone is weakly constricted near the crown base and the hypocone is slightly smaller than the protocone. The crista is absent (V 15980, left M2) or present (V 15980, right M2). The median valley is narrow inside, but has a broad entrance. The postfossette is deeply V-shaped and closed in the lower part of the crown. Other characters of the M2 are similar to those of the M1.

The M3 is triangular in occlusal shape. The parastyle is prominent, the parastyle fold is shallow, and the paracone rib is faint. The protocone is large and rounded, with no constriction. The crochet is strong, the crista is large, and the antecrochet is absent. The ectometaloph is smooth. The protoloph is straight and slightly posteriorly oblique. The median valley is wide and has a broad entrance. The anterior cingulum is thick. The labial and lingual cingula are absent. The posterior cingula are plank-like and middle-grooved.

The i2 is huge and curved from its root to the crown (Fig. 2), with a 107.8 mm-long wear surface (V 15982.2, Fig. 2B). The cross section of the crown is narrowly triangular in shape, with a sharp inner angle, but rounded anterior and posterior outer angles. The cross section of the root is narrowly oval and the surface of the root has dense transverse and longitudinal grooves.

The p2 has a U-shaped labial groove with a marked ectolophid fold. The protolophid is anteriorly prominent and has a sharp end. The protoconid, metalophid and metaconid are fused to each other, forming a lozenge. The entolophid is transverse. The posterior valley is wide, occlusally U-shaped and lingually V-shaped. The lingual cingulum is faintly present on the entrances of the anterior and posterior valleys (Fig. 1B). Dense horizontal lines are present on the labial wall.

The p3 has a V-shaped labial groove that becomes shallow towards the crown base. The paralophid is transversely wide and has a sharp interior end. The trigonid is acute at the protoconid. The metalophid is slightly posteriorly oblique and the entolophid is transverse. The talonid is wider than the trigonid. The metaconid is slightly larger than the entoconid, and both

have a flat lingual margin. On the occlusal surface, the anterior and posterior valleys are deeply U-shaped. The posterior valley is lingually V-shaped. The labial cingulum is absent and the lingual cingulum is weak (Fig. 1C). The p4 is similar to the p3, but the p4 has a deeper labial groove, a shorter paralophid, and a V-shaped anterior valley on the occlusal surface (Fig. 1D).

The m1 has a wide and deep V-shaped labial groove that gradually becomes shallow. The trigonid is rounded and right-angled at the protoconid. The paralophid is reduced. The metalophid is posteriorly oblique, and the entolophid is more strongly oblique. On the occlusal surface, the U-shaped anterior valley and V-shaped posterior valley are shallow. The labial and lingual cingula are absent (Fig. 1E).

Comparison The Lufeng specimens have the same characters as *Acerorhinus* in regard to the size of the lower second incisors, and the crown height and occlusal structures of the cheek teeth, which are different from those of *Chilotherium*, *Subchilotherium*, *Shansirhinus*, *Alicornops* and *Aceratherium*. Compared to the known species of *Acerorhinus*, the paracone rib of the Lufeng specimens is very strong on the premolars, the antecrochet and lingual cingulum are absent on the molars, and the protocone is not or weakly constricted on the molars. These specimens were initially considered as a new species of *Aceratherium* (Qi, 1979, 1985), but their lower incisors are robust and curved, which is diagnostic of *Acerorhinus* (Qiu et al., 1987: 549), and are obviously larger and more strongly curved than the lower incisors of *Aceratherium*. As a result, they should be referred into the genus *Acerorhinus*.

To date, five valid species of the genus *Acerorhinus* have been described: *A. zernowi* (Borissiak, 1914, 1915), *A. tsaidamensis* (Bohlin, 1937), *A. palaeosinensis* (Ringström, 1924), *A. hezhengensis* (Qiu et al., 1987) and *A. fuguensis* (Deng, 2000). All of them appeared in the Late Miocene. The Lufeng specimens are most similar to *A. zernowi* in lacking the antecrochet and having weak constriction of the protocone on the molars. The other four species have a marked antecrochet and a stronger protocone constriction on the M1 and M2. The Lufeng form and *A. tsaidamensis* share an absence of the lingual cingulum on the molars. Of the four remaining species, some, such as *A. zernowi* (Borissiak, 1915, pl. II), have well-developed lingual cingula, and some, such as *A. fuguensis* (Deng, 2000, pl. I), have a cingulum remaining on the entrance of the median valley.

The Lufeng specimens further differ from *A. zernowi* in having a weak cingulum and a strong paracone rib on the premolars. Other differences between the Lufeng specimens and *A. tsaidamensis* are a very shallow metastyle fold, a deep postfossette, and a smooth anterior wall of the hypocone on the molars of the former. The Lufeng specimens further differ from *A. palaeosinensis* in having an open median valley on the M2, an absence of a medifossette on the M3, and a transverse entolophid on the lower premolars. Other differences between the Lufeng specimens and *A. hezhengensis* are a moderate width of the metaloph on the premolars and a smooth labial wall of the ectometaloph on the M3 of the former. The Lufeng specimens further differ from *A. fuguensis* in having a wide protoloph on the premolars, a short crochet on the molars, and a marked crista on the M3. It appears that the Lufeng specimens represent a new species of *Acerorhinus*, named here as *A. lufengensis*.

Age Based on mammal correlations, the fossil beds of the *Lufengpithecus* site were considered to be within NMU10 of the Late Miocene Baodean (Qiu et al., 1999), corresponding to MN11 of the Turolian (Deng, 2006). However, recent paleomagnetic dating indicated that the age of Section D at Shihuiba was 6.9 ~ 6.2 Ma (Yue and Zhang, 2006). Some characters of *A. lufengensis* are primitive, such as weak constriction of the protocone and absence of the antecrochet. In fact, *A. lufengensis* is most similar to *A. zernowi* among the genus *Acerorhinus*. On the other hand, *A. lufengensis* also has many derived characters, such as weakness or absence of the lingual cingulum on the upper cheek teeth, and a smooth labial wall of the ectometaloph

on the M3. *A. zernowi* was distributed in Ukraine, Turkey, and Greece during MN9–11 of the Late Miocene (Heissig, 1999). *A. tsaidamensis* and *A. fuguensis* were found from the early Late Miocene in the Qaidam Basin, Qinghai, and Fugu, Shaanxi, respectively. *A. hezhengensis* was collected from NMU9–10 of the Late Miocene in the Linxia Basin, Gansu (Deng et al., 2004). *A. palaeosinensis* was found from NMU10 of the late Late Miocene in Baode, Shanxi. Judging from the derived characters of *A. lufengensis*, its age should not be earlier than that of *A. palaeosinensis*, whose ectoloph and metaloph on the M3 have obvious differentiation. As a result, the fossil beds of the *Lufengpithecus* site correspond to NMU10 or MN12 of the late Late Miocene and have an age of about 7 Ma.

Shansirhinus Kretzoi, 1942
Shansirhinus cf. *S. ringstroemi* Kretzoi, 1942

(Figs. 3–4; Tables 3–4)

Chilotherium sp. nov. Qi, 1979, p. 19
Chilotherium sp. nov. Qi, 1985, p. 64
Chilotherium sp. Qiu and Qiu, 1995, p. 64

Material V 15983: right P2–P4 and M3 of one and the same individual (Fig. 3B); V 15984.1: DP1; V 15984.2: right and left DP1 of one and the same individual; V 15984.3: DP2; V 15984.4–9: six P2; V 15984.10–12: three P3; V 15984.13–16: four P4; V 15984.17: M1; V 15984.18–20: three M3; V 15985.1–10: ten i2; V 15985.11: dp1; V 15985.12: p2; V 15986: a fragmentary left mandible with p3 and p4 (Fig. 4A), and isolated right p3 and p4; V 15985.13: p4; V 15985.14: m1; V 15987: a fragmentary right mandible with incomplete m1 and complete m2 (Fig. 4B); V 15985.15–18: four m2; and V 15985.19–24: six m3.

Locality and horizon Section D of the *Lufengpithecus* site (Loc. 75033) at Shihuiba in Lufeng, Yunnan, mainly from Level 5, but a few from Level 1 (V 15985.3), Level 4 (V 15984.1, 9, 14; V 15985.17, 24), and Level 6 (V 15985.22). Late Miocene.

Description The DP1 is triangular in occlusal shape, slightly longer than wide, and very small compared to the other cheek teeth. The protocone and protoloph are absent. The hypocone is greatly enlarged. The metaloph is slightly posteriorly oblique. The crista and crochet are weak. The postfossette is closed, forming a small oval. The antero-lingual cingulum is marked, but the labial cingulum is absent (Fig. 3A). The enamel of the labial wall is corrugated.

The P2 has a robust and prominent parastyle. The paracone rib is weak and the metastyle is long. The protocone is rounded, not constricted, and is gradually enlarged towards the crown base, but is smaller than the expanded hypocone. The protoloph is short and is very narrowly connected to the ectoloph. The metaloph is narrow and posteriorly curved and has one or two enamel plications. The crista is wide and, sometimes, the medifossette is present (V 15984.7, Fig. 3F). The median valley is narrow and closed near the crown base. The postfossette is deep and almost closed by the posterior cingulum. The lingual cingulum is present on the entrance of the median valley.

The P3 has a robust and prominent parastyle. The ectoloph is straight, with a strong paracone rib. The metastyle is long and has a flat end. The protocone is rounded, constricted, and enlarged towards the crown base. The hypocone is strongly expanded. The protoloph is longer than the metaloph, and both are greatly posteriorly oblique. The crochet connects to the crista, forming a medifossette with two big enamel plications on the metaloph (V 15983, Fig. 3B2). The median valley is narrow and closed by the antecrochet, forming a wide lingual groove. The postfossette is narrow, deep, and almost closed. The anterior, lingual, and posterior cingula are well-developed.

The P4 is very similar to the P3, but its metastyle has a labially curved end, the antecrochet is shorter, and the protoloph is obviously longer than the metaloph.

The M1 (V 15984.17, Fig. 3D) specimen is greatly worn. The protocone is large and narrowly rounded, with a marked anterior groove. The protoloph is wider than the metaloph, but both have a similar length. The labial and lingual cingula are absent.

The M3 is triangular in occlusal shape. The parastyle and paracone rib are strong. The protocone is constricted and has a flat or grooved lingual margin (V 15983, Fig. 3B4). The antecrochet is short, but extends to the entrance of the median valley near the crown base. The crochet is robust. The ectometaloph is curved, with a metacone rib and a posterior groove. The protoloph is slightly posteriorly oblique. A well-developed pillar is present on the entrance of the median valley (V 15984.18, Fig. 3E). The posterior cingulum is highly plank-like and deeply middle-grooved.

The i2 is small and slightly curved and has a 44 mm-long wear surface (Fig. 4H). The cross section of the crown is triangular in shape, with sharp anterior and posterior inner angles but a rounded anterior outer angle. The cross section of the root is oval in shape.

The labial and lingual cingula are absent on the lower cheek teeth. The p2 has a shallow V-shaped labial groove. The protolophid is straight and prominent, with labial and lingual grooves. The protoconid is wide and rounded. The entolophid is transverse (Fig. 4D). The p3 has a deep V-shaped labial groove. The paralophid is wide and short. The trigonid is right-angled at the protoconid. The metaconid is narrow antero-posteriorly, with a constriction on its anterior wall. The entolophid is posteriorly oblique. The posterior valley is lingually V-shaped. The p4 resembles to the p3, but its paralophid is narrow and long, and the posterior valley is broad.

The m1 has a narrow V-shaped labial groove. The paralophid is moderately wide and long. The constriction on the anterior wall of the metaconid is weak. Other characters are similar to those of the p4. The m2(Fig. 4E) and m3 resemble the m1, but the m2 has a broader posterior valley and a more oblique entolophid, and the m3 has a reduced paralophid and a middle-grooved posterior valley of the entolophid (Fig. 4F).

Comparisons Schlosser (1903) described a new rhinocerotid species, *Rhinoceros brancoi*, based on some isolated teeth without an exact locality from China. The morphological characters of those teeth are very peculiar. On the premolars, rich enamel plications are developed around the crochet and crista, two or three medifossettes are present on each premolar, and a strong lingual bridge connects the protoloph to the metaloph. On the molars, the protocone is strongly constricted, the crochet and antecrochet are well-developed, and the parastyle fold is weak on the labial wall. Ringström (1927) described a maxillary with complete cheek teeth from Yushe, Shanxi, as *Rhinoceros* aff. *brancoi*, and its teeth are similar to those of Schlosser's specimens, but have less enamel plications. Kretzoi (1942) considered the features of *R. brancoi* to be relatively distinct and suggested the establishment of a new genus, *Shansirhinus*. In addition to *S. brancoi*, he described another species, *S. ringstroemi*, based on the maxillary of *R.* aff. *brancoi* that was described by Ringström (1927). The tooth crown of *S. ringstroemi* is lower than that of *S. brancoi* and its enamel plications are much weaker than those of the latter. Heissig (1975) revised *Rhinoceros brancoi* into *Chilotherium brancoi*. However, the numerous enamel plications, the strongly bifurcate or trifurcate crochets, and the well-developed lingual bridges of *R. brancoi* are not characters of the genus *Chilotherium*. Deng (2005) reconfirmed the validity of the genus *Shansirhinus* based on a skull and mandible with complete dentition from the Linxia Basin, Gansu.

The characters of the upper teeth of the Lufeng specimens, such as the relatively small DP1, rich enamel plications, a weak paracone rib, a robust antecrochet, a strongly constricted protocone, a well-developed bridge and medifossette, an angularly U-shaped lingual groove, a

continuous lingual cingulum, and a squarely expanded hypocone, are identical with those of *Shansirhinus*, so they should be referred into this genus. The enamel plications of the Lufeng specimens are weaker than those of *S. brancoi*, but similar to those of *S. ringstroemi* from Yushe and Linxia (Ringström, 1927; Deng, 2005). The small tusk-like i2 from Lufeng resembles those of *S. ringstroemi* (V 13764). A weak constriction on the anterior wall of the metaconid is also present on the lower cheek teeth of *S. ringstroemi* from Linxia (Deng, 2005, fig. 6). An incomplete right maxillary with P2–M1 (V 4316) from Banguo in Yuanmou, Yunnan was described as a new species, *Chilotherium yunnanensis* (Tang et al., 1974), but Deng (2005) revised it into *S. ringstroemi*. The Lufeng specimens are very similar to the teeth from Banguo.

S. cf. *S. ringstroemi* from Lufeng differs from *Acerorhinus* found at the same locality, because the latter has a stronger paracone rib, a discontinuous lingual cingulum, an unconstricted protocone, a weak or absent crochet and bridge on premolars, huge i2 with a posterior wear surface, a reduced or absent paralophid on the lower teeth, and a transverse entolophid on the lower premolars.

Age *S. ringstroemi* was previously found from the Late Miocene Baodean and Early Pliocene Gaozhuangian (NMU10 – 12 or MN12 – 15) of Yushe in Shanxi, Linxia and Tianzhu (Zheng,1982) in Gansu, and Yuanmou in Yunnan. Within this species, size was tended to increase, enamel plications became strong, and medifossettes became numerous. For example, the P2 and P3 from Banguo, Yuanmou (Tang et al., 1974:63), and the P2 from Hanjiawa, Yushe (Qiu and Yan, 1982:125), have two medifossettes. The Lufeng specimens have a smaller size and weaker enamel plications than do those from the earliest Pliocene of the Linxia Basin, and they have a single medifossette on each premolar, which is a reason why we identify the Lufeng specimens as *S.* cf. *S. ringstroemi*. Therefore, the age of *S.* cf. *S. ringstroemi* from Lufeng should be earlier than that of the Linxia specimens, and the late Late Miocene NMU10 at about 7 Ma is a reasonable conclusion.

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