New chalicothere materials from the Late Miocene of Fugu, Shaanxi, China

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\textbf{Summary}

In 1997, when the first author of this paper investigated the field geology together with Professor Di Shixiang and Technician Zhao Jufa in northern Shaanxi Province of China, we learned that one of the Laogaochuan Village (Fig. 1) residents in Fugu County had collected a number of mammalian fossils. We visited this farmer and his collections, and knew that the fossils were from the Lamagou gully’s red sandy clay layer near the bottom of the gully (Fig. 2). Above the fossil-bearing bed there is about a hundred meter thick sequence of Quaternary loess and Neogene red sandy clay sediments. Usually farmers dug a horizontal tunnel that could only hold one or two people and kept going forward as far as possible with a very small light on their heads. What fossils they encountered, they would dig and transfer back outside the tunnel. Many fossil specimens were damaged to different degrees just at the locality. Several years ago we bought a number of this kind of fossils from another farmer. For research, we selected for purchase some new materials including the chalicothere, which we had never found previously. All the fossils were from the same locality, the same layer and belong to the same fauna (Lamagou fauna, Xue et al., 1995). This paper deals with the chalicothere. There are two palates, and three well-preserved mandibles, all with complete to almost complete cheek tooth rows.

All of the chalicothere specimens were very well preserved (apart from those parts damaged during collecting), especially the tooth cusps, which often are newly erupted and very little worn. Based on the taphonomy, we could determine that when the chalicotheres died they were in their young or medium ages and were living in favorable environmental conditions. A strong natural calamity happened suddenly; these unfortunate animals died and were buried in situ very quickly without any obvious transportation. Therefore, it is valuable to study and
describe these fossils in detail.

After finishing the preliminary work, we determined that our chalicotherium specimens represented at least three individuals, and could be assigned to the genus *Nestoritherium*, but were different from other published species, such as *N. sivalense*, *N. wuduense*, and *N. linxiaense*. Therefore we establish here a new species for the materials from Fugu: *Nestoritherium fuguense* sp. nov.

**Class Mammalia Linnaeus, 1875**

**Order Perissodactyla Owen, 1848**

**Family Chalicotheriidae Gill, 1872**

**Subfamily Chalicotheriinae Gill, 1872**

**Genus Nestoritherium Kaup, 1859**

**Type species** *Nestoritherium sivalense* (Falconer & Cautley, 1843).

**Revised diagnosis** Anisodont Chalicotheriinae with upper molars square or rhombic in shape. Protocone large, strong, and isolated; protoconule (if developed) close to the paracone and with no protoloph connection to the protocone. Mandible strong, heavy, gradually increasing in height, and thickened posteriorly. Lower incisors extremely reduced or lost. Lower canines well developed. Ratio of premolar/molar length low (<40%). Cingulum well-developed, especially at the anterior and posterior parts. Some cement present at the lower part of the lower cheek teeth.

**Nestoritherium fuguense** sp. nov.

(Figs. 3-6; Tables 1-3)

**Holotype** NWUV 1397 is a well-preserved palate with right and left cheek tooth rows (Fig. 3); NWUV 1396 is a pair of lower jaws with almost complete cheek tooth rows (Fig. 5). The two specimens belong to the same individual. All the teeth were worn slightly to moderately.

**Referred specimens** NWUV 1398, a palate with well preserved cheek tooth rows (Fig. 4); NWUV 1394 and 1395, two mandibles with right and left cheek tooth rows (Fig. 6). NWUV 1399.1–5 are isolated teeth.

**Locality and horizon** All specimens are from Lamagou gully, Laogaochuan Village, Fugu County, Shaanxi Province (Fig. 1). The red sandy clay of the lower part of the Lamagou Formation. Early Late Miocene (Bahean or late Vallesian) (Fig. 2).

**Diagnosis** A species of *Nestoritherium* with a curved upper cheek teeth row that is buccally convex and anteriorly converging, but a straight lower cheek teeth row. Dental formula 0?.0?.3.3/ 0.1.3.3. Lower canines robust. Upper molars rhombic in shape. Protocones of upper molars large, strong, and isolated, and composed of two parts: the square-round base and the round conical top. Protoconule well-developed, very close to the paracone, and connecting with the paracone by a paraloph. Metaloph strong and extending well lingually. “Metastylid” present and connected with the metaconid like a double knot after wear. Lower
jaw symphysis extending posteriorly to opposite p3-p4. Rostral part of the lower jaws longer than in other species of *Nestoritherium*.

**Description of the palate and upper teeth** The Fugu chalicotherium is a species of medium- to large-sized perissodactyl with strong and thick upper and lower jaws, brachyodont teeth, and somewhat reduced and simplified premolars.

NWUV 1397 is a complete palate (Fig. 3) with an arched trough shape, deepest anteriorly (19 mm deep at the P2-3 level) and shallower posteriorly (7.4 mm at the M3 level). There are two pairs of palatal foramina. The anterior pair is situated at the protocone level of M1 with 21 mm long and 3.5 mm wide grooves that are parallel to each other; 46 mm behind the former is another pair of palatal foramina at the protocone level of M3, with posterior grooves of 25 mm in length, 4 mm in width and 4 mm in depth. The choanal opening is at level of M3. A groove is present between the ventral border of the zygomatic arch and M3. Upper cheek teeth are arranged tightly, especially the three premolars, with the anterior part of their ectoloph even inlaid into the posterior part of the adjacent tooth. None of the upper premolars is molarized. NWUV 1398 is another palate of a younger individual (Fig. 4); its palate is flat, quite different from that of NWUV 1397.

In the following description of the upper cheek teeth, we follow Chen et al. (2012) in referring to the small cuspule lingually adjacent to the paracone as the protoconule. This is the same cusp termed the paraconule in Anquetin et al. (2007), Coombs (2009), Fahlke et al. (2013), and many other recent authors.

M1 is medium-sized and forms a nearly square column; the occlusal surface is flat and slightly wider than long. It has a typical W-shaped ectoloph and V-shaped central valley that changed to U-shaped when worn. The paracone is quite similar to the metacone but a little bit lower, both cusps reaching the midline of the tooth. The protocone, which occupies about two-thirds of the lingual side of M1, is large and isolated, and consists of two parts, the mesa-like base and high pointed apex. The protocone lies slightly posterior to the paracone and protoconule. The protoconule is weak and close to the paracone, sometimes connecting with the paracone and forming a short paraloph, but never touching the protocone. Therefore, we prefer to call the connecting loph paraloph rather than protoloph. The hypocone is slightly taller but smaller than the protocone. The hypocone and metacone seem to have been connected; there is a deep furrow between them, only because the anterior surface of these two cones is a triangular plane with the same inclined angle. After wear the cusps would become lower, and the lower part near the bottom seems to connect as a metaloph that is strong and extends well linguually. There are three interior valleys: the anterior one is narrow and thin, the middle one (central valley) is deep and wide, and the posterior one (postfossette) is short, wide and crescent-shaped. The cingulum starts from the middle of the anterior surface, and then continues around the protocone as a ridge separated from the protocone by a thin furrow. On the lingual side it changes to a very slender line adhering to the crown and continues as a low buttress occluding the entrance of the central valley. The buccal cingulum is very thin, and
there is no posterior cingulum.

M2 and M3 are the larger and largest teeth respectively. Both have a wide-rhomboid shape and are only slightly worn. The ectoloph, which is strongly lingually inclined, passes beyond the midline of the tooth. The paracone is thicker than the metacone, and the parastyle and mesostyle are strong and curved. On M3, the external wall of the metacone and metastyle is subparallel to the anteroposterior axis of the tooth. The protocone seems to be composed of two parts: the base is larger and forms a rounded square, while the tip is conical, with its anterior, posterior and buccal sides separated by thin furrows. The protoconule is well developed, isolated, and closer to the paracone. The paraloph extends lingually and diminishes at the anterior-buccal base of the protocone; it does not touch the protocone. As on M1, the cingulum on M2 and M3 is well developed on the anterior and lingual sides. The postfossette on M3 is slightly pinched compared to that on M2.

All the upper premolars have three roots. P2 is the smallest tooth, forming a triangular column; its occlusal surface has a transverse loph. P3 forms a rectangular column, which is wider than P2 and has two transverse lophs. P4 forms an oblique rectangular column, and is much larger than P3. Its ectoloph is straight; the two transverse lophs are well-developed; the paracone is sharply convex; the paraloph is short, slender, and slightly curved posteriorly; the protocone occupies almost the whole lingual side of P4; the protoconule is present, far from the protocone and very close to the paracone. The central valley of the lingual side forms a V-shaped pit, surrounded by three ridges. Cingula are well developed along the anterior and posterior sides. The measurements of the upper cheek teeth of *Nestoritherium fuguense* are listed in Table 1.

**Description of the mandibles and lower teeth** There are three well-preserved mandibles with slightly worn cheek teeth (Figs. 5, 6; Table 2). Their rostrum and ascending ramus have in all specimens been broken off. Of the anterior teeth, only the canine alveoli are preserved.

The mandible is sturdy and heavy. The horizontal ramus increases in height gradually from anterior to posterior; the highest part, approximately 66.8 mm, is at the m1 level. The thickness of the mandible changes only slightly. The lingual surface of the horizontal ramus is almost flat, but the buccal surface is swollen. A retromolar space occurs on the mandible posterior to m3. The right and left lower jaws intersect at an angle of 25°, and the symphysis extends posteriorly as far as the boundary of p3 and p4. The upper surface of the symphysis forms a concave trough, while the lower surface has rugosely projecting bone, but there is no tuberosity present beneath the symphysis. Anterior to the premolars, the rostrum rises gradually. The diastema anterior to p2 is about 28 mm long with a sharp ridge starting from the lingual side of p2. In anterior view, there is a pair of depressions, each about 8 mm×6.5 mm in diameter, on the broken rostrum (Fig. 6A); these should be the alveoli of lower canines that stretched anteriorly. There is only a very narrow space between these two alveoli, and thus it is very difficult to say whether there was space for any incisors. We have tried to use X-ray
views, but did not see any traces of incisors. Therefore we have recorded the lower incisor count as 0.

All lower cheek teeth are arranged tightly along a straight line (Fig. 5A), and there is no curvature appears along with the shape change of the lower jaw. For this reason, the anterior part of the tooth row is closer to the buccal side of lower jaw and the posterior part is closer to the lingual side. The teeth notably increase in size from anterior to posterior. The length of p2 is only 1/7 that of m3; and the length of the molar-row is 2.5 times that of the premolar row (Table 3).

The lower molars increase in size from m1 to m3 with typical double V-shaped lophids (Fig. 5A); the trigonid of m1 is unusual in having an angled “U” shape, this occurs because its paraconid is positioned more posterolingually, making the paralophid parallel to the metalophid. The “metastylid” is well developed, only a little lower than the metaconid; these two cones connected together like double knots after wear. The talonid of m1 is wider and deeper than the trigonid. The cingulum is well developed on the anterior and posterior sides, and a thin cingulum can also be seen buccally at the entrance of the outer valley (it is still thin but higher on m3).

The p2 is the smallest and simplest tooth, with only one conid, two roots, and a very weak cingulum. The p3 is triangularly column-shaped. The anterior and posterior lobes have not been formed completely, but their precursors have appeared. The trigonid is higher and larger than the talonid; the protoconid is the tallest and largest cuspid, and is formed by two thin, curved enamel slices; its buccal surface is square and slightly convex, while the lingual surface inclines anteriorly. The paraconid is low, narrow, and sharp, while the metaconid is vase-shaped, small, and narrow in its upper part and wider at the base, nestling closely to the protoconid. The talonid is relatively short (only half the length of the trigonid), but wider than the latter, the hypoconid is breast-shaped, and the entoconid is a small isolated projection. The cingulum is weak, thin but high. The p4 is a rectangular column, twice the length of p3, and is partly molarized, with typical W-shaped lophids. The trigonid is higher but narrower than the talonid. Both of the lingual valleys are U-shaped, and the posterior one is much wider and lower than the anterior one. The paraconid is small but projects clearly. The protoconid is large and lies next to the metaconid, which is a taller and more precipitous triangular cusp, with a swollen lingual wall; a small “metastylid” appears on the posterior ridge of the metaconid. The sharp paralophid inclines forward from the protoconid to the paraconid, the heights of the hypoconid and protoconid are almost the same, and the entoconid is stout and strong. On the buccal valley there is a little cement.

By observation of dental characters, we suggest that the Fugu chalicotheres died as young adults: their teeth are fully erupted but have not been worn deeply, and are preserved very well. The P/p2-3 are too small to chew much food; the fourth premolars (especially p4) and first molars were the main teeth for chewing food in these individuals, and the crown surface is relatively flat and getting lower and lower, so that even the roots are curved laterally. The
second and third molars are the larger and the largest teeth and would come more into use as the animals aged, their crown surfaces becoming more worn and the high cusps gradually changing to low and flat.

**Comparison and discussion** The described Fugu fossil specimens clearly belong to the Chalicotheridae. This family contains two subfamilies: Chalicotheriinae and Schizotheriinae. The wide unelongated upper molars, brachydont cheek teeth, robust and thick mandible with elongated symphysis extending to the boundary of p3 and p4, and well developed lower canine all totally conform to the features of Chalicotheriinae rather than Schizotheriinae (Coombs, 1989; Anquetin et al., 2007). For the purpose of analyzing the relationships of their new species *Nestoritherium linxiaense*, Chen et al. (2012) recognized six genera of Chalicotheriinae: *Butleria*, *Kalimantsia*, *Chalicotherium*, *Anisodon*, *Hesperotherium*, and *Nestoritherium*. We have used the same data matrix (Chen et al., 2012, appendices I and II, excluding Character 31) to test the phylogenetic relationships of *N. fuguense*; these characters are scored on Table 4. We recoded Character 13 of *N. linxiaense* (anterior border of zygomatic arch at the level of the mesostyle of M2) and Character 56 of *N. wuduense* as 1 (“metastylid” of lower molars strong, as per Xue and Coombs, 1985, and contra Anquetin et al., 2007, character 51), and coded the lower teeth and jaws of *Chalicotherium brevirostris* according to Liu and Zhang (2012). The analysis results in three most parsimonious trees, and their strict consensus is shown in Fig. 7.

*Butleria* is from the African Early Miocene (Butler, 1965; de Bonis et al., 1995; Coombs and Cote, 2010) and is a relatively basal genus within the Chalicotheriinae. *Kalimantsia* is from the Late Miocene of Bulgaria (Geraads et al., 2001, 2006). *Butleria* and *Kalimantsia* differ in a number of ways from *Nestoritherium fuguense* and will not be further discussed or compared here.

The genus *Chalicotherium* is based on *C. goldfussi* Kaup (1833) from the Vallesian (MN9) fauna of the Dinotheriensande in the area of Eppelsheim, Germany. Anquetin et al. (2007) and Fahlke et al. (2013) have recently discussed this species and clarified which other European materials are or are not potentially referable to this species. In particular, the robust Henndorf (Austria, MN12-13) mandible, referred to *C. goldfussi* by Schaefer and Zapfe (1971), is now considered to belong to a member of the anisodont lineage of the Chalicotheriinae and not to *Chalicotherium*. *C. goldfussi* differs from the Fugu chalicothere in having clearly developed alveoli for three paired lower incisors (Anquetin et al., 2007), a P4 protoloph not stopping at the protoconule, a longer premolar/molar length ratio, and the posterior cingulum on M3 not reaching the hypocone summit. Further, the M2 and M3 of *C. goldfussi* are more square than rhombic-shaped. It seems clear that *Chalicotherium* did not have the anteriorly shortened skull and lower jaws that we see in the anisodont lineage, but such shortening is apparent in the Fugu chalicothere. Therefore *N. fuguense* is not attributable to *C. goldfussi* or to the genus *Chalicotherium*.

*Chalicotherium brevirostris* (Colbert, 1934) has long been known from a skull preserved from the Middle Miocene Tunggur Formation, Nei Mongol, China. The skull does not
have associated lower jaws and several possible candidates for the mandible of this species have since been suggested (Hu, 1959; Wang and Wang, 2001). The jaw described by Hu was scored by Chen et al. (2012) as “C. cf. C. brevirostris”, and it was named as a new species, *Chalicotherium hebeiense* by Chen and Liu (2013). More recently, Liu and Zhang (2012) described left and right mandibles from Tunggur that more convincingly represent the lower jaws of *C. brevirostris*. While the link of *C. brevirostris* to *C. goldfussi* is tenuous (Anquetin et al., 2007; Fahlke et al., 2013), this species is clearly not referable to *Anisodon* or *Nestoritherium*. Among other characters, *C. brevirostris* differs from *N. fuguense* in having three lower incisors, a less thickened lower jaw, and upper molars with less reduction of the protoloph.

Anquetin et al. (2007) recognized a derived lineage of Chalicotheriinae that included *Anisodon* and *Nestoritherium*, subsuming *Nestoritherium* within *Anisodon*. As Chen et al. (2012) noted, this *Anisodon* lineage also includes *Hesperotherium* Qiu, 2002, which was not evaluated by Anquetin et al. (2007). Chen et al. (2012) also maintained *Nestoritherium* as a separate genus; their analysis recovered a monophyletic genus *Anisodon*, consisting of *A. grande*, *A. salinum*, and *A. macedonicum*. On the other hand, Fahlke et al. (2013) and our analysis here (Fig. 7) have not found a clearly monophyletic genus *Anisodon* and instead suggest that *A. macedonicum* lies closer to *Nestoritherium* than does the more basal type species *A. grande*. Numerous characters of *N. fuguense*, including P2 wider than long and an incomplete paraloph on P3 and P4 so that the protoconule is isolated from the protocone, suggest that it belongs to the broad anisodont lineage, and thus more detailed comparison with species in this group is appropriate.

*Nestoritherium fuguense* has several characters in common with *Anisodon macedonicum* that do not occur in *A. grande*: a longer jaw symphysis, reduction of lower incisors (much reduced in the holotype of *A. macedonicum* and lost in mandibles from Titov Veles and Henndorf that might be referable to *A. macedonicum*; see Anquetin et al., 2007), a notch in the anterior cingulum in front of the protocone, and the posterior cingulum crest on M3 reaching the hypocone summit. It differs in that the mandibular ramus is less thickened and robust, the ratio of the lengths of the premolar/molar rows is less reduced, and the “metastylid” on lower molars is less developed in *A. macedonicum*. Despite many similarities, *N. fuguense* is thus not referable to *A. macedonicum* or to any of the other species that Chen et al. (2012) referred to *Anisodon*.

*Hesperotherium* is a derived Early Pleistocene anisodont chalicotheriine from China and has been considered to be a directed descendant of *Nestoritherium* (Qiu, 2002; Tong and Qiu, 2009). Its incisors and canines are lost, premolars are reduced, upper molars have no protoconule, and the metaloph is much reduced. In the Fugu fossils, the lower canine and the protoconule of molars are developed very well, and the metaloph of M2 and M3 is not only longer but also stretched posterolingually. Clearly, the Fugu fossils differ from *Hesperotherium* in very important characters, and therefore it cannot belong to the genus *Hesperotherium*. 
Finally, the Fugu chalicotherium fossils show many features in common with *Nestoritherium*, such as: upper tooth row curved from side view, mandibles robust with the ramus curved upward and increasing in height posteriorly, lower incisors absent (or strongly reduced), lower canine well developed, and similar ratios of premolar/molar row length. Thus the Fugu fossil chalicotherium resembles *Nestoritherium* much more than any other genus. However, the fit with *Nestoritherium*, as characterized by Chen et al. (2012), is not perfect, and we have modified (above) the diagnosis of *Nestoritherium* accordingly to incorporate species, such as *N. fuguense*, that have a well-developed protoconule, strong and lingually extended metaloph, and well-developed “metastylid.” On the other hand, the diagnosis of *Nestoritherium* would present no issues if the contained species were included within a broad genus *Anisodon*, as recommended by Anquetin et al. (2007).

There are three previously named species of *Nestoritherium*. The type species is *N. sivalense* from the Early Pleistocene of India (Falconer, 1868); in this late species the protoloph and protoconule are completely lost or retain only slight traces, as also occurs in *Hesperotherium*. *N. wuduense* comes from the lower part of the Upper Miocene in Wudu, Gansu, China, and is represented only by an adult and a juvenile lower jaws (Xue and Coombs, 1985); the skull and upper dentition of this species thus remain unknown. As in *N. fuguense*, the “metastylid” is developed and somewhat independent of the metaconid in lower molars of *N. wuduense* (Xue and Coombs, 1985; contra Anquetin et al., 2007 and Chen et al., 2012). However, the mandible and lower cheek teeth of *N. fuguense* are more robust and massive than those of *N. wuduense*. In *N. fuguense*, the lower cheek tooth row is straight, while in *N. wuduense* it is more curved, especially tapering inward anteriorly at an angle of about 21° between the premolars and the molars so that the distance between the left and right p2s is 31 mm, much smaller than 42 mm in *N. fuguense*. The trigonid and talonid basins of the lower molars of *N. fuguense* are wider and more elevated at their bases than those of *N. wuduense*. Therefore, the Fugu material is not *N. wuduense*. The third species of *Nestoritherium* is *N. linxiaense* from Linxia, Gansu, China, also from the early Late Miocene (Chen et al., 2012), which includes both cranial and upper and lower dental material.

The palates, teeth, and jaws of *N. linxiaense* and *N. fuguense* can readily be compared and show many similarities: 1) much reduced or absent lower incisors, 2) reduced premolar/molar length ratios (<40%), 3) M3 posterior cingular crest reaching the hypocone summit and postfossette somewhat pinched, 4) curved upper molar row, and 5) a thickened mandibular corpus with its height increasing posteriorly. However, the two species are clearly different in the length of the symphysis (longer in *N. fuguense*), the degree of development of the protoconule and paraloph on upper molars (stronger in *N. fuguense*), the length of the diastema between the canine and p2 (~25 mm in *N. fuguense*, compared to 19.2 mm in *N. linxiaense*), and “metastylid” development on lower molars (stronger in *N. fuguense*). Furthermore, the upper molars of *N. fuguense* are more rhombic (square-shaped in *N. linxiaense*), P4 is slightly more molarized, two pairs of foramen are present on the palate (one in *N. linxiaense*), and the
shape of the anterior lower jaw suggests a longer rostrum. The preceding differences confirm that the Fugu chalicotherium is not referable to *N. linxiaense* and thus represents a new species, *Nestoritherium fuguense*. Fig. 7 suggests that *N. fuguense* and *N. linxiaense* are closely related to one another.

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**陕西府谷发现的晚中新世爪兽新材料**

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**摘要**: 产自陕西府谷晚中新世喇嘛沟组红色砂质泥岩中的爪兽化石, 其颌骨及牙齿保存得相当完好, 为研究有关牙齿的细微结构及分类提供了宝贵材料。其颌骨及牙齿都很粗壮厚实。上齿列颊侧弯曲; 下齿列菱形或正方形; 原尖粗大, 孤立; 原小尖发育, 靠近前尖, 甚至与前尖相接呈短的前脊; 无后尖; 前、中、后尖相接; 前、后尖皆发育很好。下犬牙较粗大; 下颊齿呈一条直线排列; 下前臼齿退缩不太大; 下后附尖发育较好, 磨用后, 常与下后尖连成并联蒂状。除第四前臼齿臼齿化外, 其他前臼齿皆未臼齿化。府谷爪兽归入奈王爪兽属(*Nestoritherium*), 但与已发表过的种都有明显差异, 特建一新种: 府谷奈王爪兽(*Nestoritherium fuguense* sp. nov.)。当时动物之大量死亡, 可能主要是突发的自然灾害如沙尘暴所引起, 死后未经长距离搬运。

**关键词**: 陕西府谷, 晚中新世, 爪兽亚科, 奈王爪兽

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1997年秋, 本文第一作者与邸世祥教授和赵聚发高级技师到陕北做野外地质考察, 得知府谷县老高川(图1)一姓人家储存有许多化石标本, 便前去观看。据称, 化石皆采自当地喇嘛沟红色粘土靠底部的地层中(图2), 与我们过去采集到的大量化石标本出于同一个地点的相同层位和时代(Xue et al., 1995, 2006), 经协商该刘家愿将其中部分标本转让给我们作研究用。本文研究的是其中几件保存较好的爪兽化石标本。

近年来, 中国的新近纪爪兽化石有较多的发现和研究报道, 尤其是陈少坤等(2012)不仅报道了甘肃临夏盆地晚中新世的一个爪兽亚科(*Chalicotheriinae*)新种临夏奈王爪兽(*Nestoritherium linxiaense*), 还对该亚科作了系统发育分析。本文研究的府谷奈王爪兽化石主要有头骨下半部的前颌骨、硬腭、上领骨及左右两侧的前齿列, 以及下颌骨及左右颊齿列。这些化石都保存得很好, 按埋藏学原理及对化石标本的分析, 这些动物死亡时正值其青壮年阶段, 身体各部都发育得很好, 所有牙齿都已发育成熟, 除第二、三臼齿磨用得很少外, 其他牙齿都已有不同程度的磨用; 颌骨的每一部分, 每一颗牙的结构和特点都显示得非常明显。这些动物很可能死于突然发生的自然灾害(如沙尘暴等), 死后
图1 府谷奈王爪兽(新种)化石地点陕西府谷喇嘛沟的位置
Fig. 1 Locality of Nestoritherium fuguense sp. nov. in Laogaochuan, Fugu, Shaanxi, China

图2 府谷奈王爪兽(新种)产自喇嘛沟地点的下化石层
Fig. 2 Stratigraphy of Nestoritherium fuguense sp. nov. from the lower fossiliferous bed in the Lamagou gully

几乎未经搬移，就地埋藏。府谷喇嘛沟产出的化石数量之多，种类之丰富，保存之完好，令人惊叹！可惜的是，在该处采集到的所有化石都是赋存在距地表几十上百米深的黄土和红土沉积层系列的靠下部，是由当地居民在很深的沟底侧坡挖不足一人高、几百至几千米长，弯弯曲曲的洞子，见什么就挖什么，拉出洞外或就地按卖出价格的高低将化石打碎，分类，这种做法对标本无疑造成很大的损坏。本文作者认为对这样难得的好化石标本应该作详细的研究。

我们经仔细观察记述，测定有关数据和进一步较广泛地对比与讨论，认为府谷爪兽化石应属奇蹄目爪兽科中的爪兽亚科，与该亚科中的奈王爪兽属有较多相同或相似的特点，可将之归入奈王爪兽属，但与奈王爪兽属已有各种都有明显而重要的差别，故特建立一个新种府谷奈王爪兽(Nestoritherium fuguense sp. nov.)。

1 系统描述

哺乳纲 Class Mammalia Linnaeus, 1875
奇蹄目 Order Perissodactyla Owen, 1848
爪兽科 Family Chalicotheriidae Gill, 1872
爪兽亚科 Subfamily Chlicotheriinae Gill, 1872
奈王爪兽属 Genus Nestoritherium Kaup, 1859

属型种 Nestoritherium sivalense (Falconer & Cautley, 1843)。

地质时代 晚中新世-早更新世。

修订属征 上臼齿方形或菱形。原尖发育很好，大而孤立；原小尖发育好或弱，与前尖较近，二者相连呈短脊或不连；无原脊。下颌粗壮厚重，向后升高增厚；m3后与下颌上升支之间间隙小或稍大。下门齿极弱或无。下犬齿粗大或细微。前臼齿与臼齿的长度之比低(<40%)。齿带发育，尤其是前、后齿带。有(或无)少量白垩质分布在下颊齿牙冠下部。

府谷奈王爪兽(新种) Nestoritherium fuguense sp. nov.

正型标本 保存较完好的同一个体的上、下颌骨和完整颊齿列。西北大学地质学系古脊椎动物化石系统编号：NWUV 1397 (上颌，图3)、1396 (下颌，图5)。

其他标本 1) NWUV 1398, 一对经过粘补可以弥合在一起的腭板及左、右上颌骨(图4); 2) NWUV 1394, 一件年轻个体的下颌骨，右水平支中部p4-m1之间受挤压向内侧凹陷，m2之后的骨体断损，左p2、p3及右p2丢失(图6B); 1)和2)可考虑为同一个体。

产地、层位及时代 陕西省府谷县老高川乡喇嘛沟，喇嘛沟组红色砂质粘土层，晚中新世早期(灞河期)。

种名来源 Fugu, 府谷，新种正型标本化石产地所在县名称的汉语拼音。

新种特征 上颊齿列向外侧弧形弯曲并向前趋中，但下颊齿列直。齿式0?.0?.3.3/0.1.3.3。下犬齿粗大。上臼齿菱形，其前、后脊都较长，向后内侧斜伸，原尖大，由方圆形底座及其上的圆锥体组成，完全孤立；原小尖明显可见，靠近前尖，有的已与前尖相连形成较短小的前脊；后脊发达，向舌侧延伸。下臼齿下后附尖发育，较下后尖稍低，磨蚀后两尖呈并联蒂状。下颌联合后延至p4前侧结束。下颌后缘长于Nestoritherium其他种。

2 标本描述

上颌部及上牙 上颌粗壮，厚实。在二上齿列之间的前方为前颌骨，已遭断失(图3和4)，因而是否有上门齿和犬齿，不得而知。NWUV 1397的上颌骨在口腔内的上部相当宽阔，从与前颌骨的交界处向后约78 mm大致相当于M1的后方位置。上颌骨与硬腭的交界，在这段超过30 mm宽的水平上颌骨板范围内，上颌骨呈口朝下向上隆起的反槽形，隆起最高处约在相当于左右P2-3之间，高达19 mm。之后，腭板继续向上隆起，但
隆起的高度已逐渐减低，直到相当于M3的后端，腭板上隆仅6–7 mm。换句话说，颊齿
冠底与上颌骨和硬腭板之间有19–6 mm的高差，其间会形成一个比容纳一般食物要大得多的大口腔。该颌骨上的缝合线粗强，但愈合程度很差，与年轻个体的表现一致。在硬
腭板最靠前的两侧，相当于M1原尖的水平位置上有一对前腭孔，左右彼此对称，其外
侧缘较直，而内侧缘弧形，孔的后端深3 mm，向后逐渐变浅，左右后孔端间距38 mm，
前段间距21.5 mm。孔具前导沟，长21 mm，宽3.5 mm。向后距前腭孔约46 mm，位于
M3原尖水平有后腭孔，孔宽约4 mm，深约4 mm，左右二孔前端间距约43 mm。其后导沟
向外侧倾斜，全长约25 mm，沟的二侧缘近于平行。前孔端后与后孔前端间距45 mm。
标本NWUV 1398是一较年轻的个体，经修复显示腭板宽平，不向上拱成弧形，腭孔较
窄小且保存不全，其臼齿的前、中附尖所具有的特征都比NWUV 1397标本的提前出现在
前一个牙上。

上颊齿低冠，属丘型-新月型齿，无白垩质，排列紧挤，尤其是前臼齿间彼此
嵌合。前臼齿未白齿化，其前臼齿列长与白齿列之比为37.4%。NWUV 1397的
P2-4依次明显增大变宽，每个牙外脊的前端向前稍向外斜伸，叠置前一牙外脊
的后部之上，或者说前一牙外脊的后端嵌入相邻后一牙外脊前端之内约3–4 mm，
使后牙的前附尖叠覆在前牙的后外壁上(图3)。标本NWUV 1398无此特点(图4)。

前臼齿3个齿根，1内2外，内侧者较粗大。臼齿具4个齿根，内、外侧各两
个。M1的4个齿根中，除了后外侧的一个，其他3个齿根都有一定程度的向外
突弯，甚至暴露在上颌骨之上，这可能与该动物主要靠M1-2咀嚼食物有关。

P2: 是前齿中的最小者，三角锥柱形，外壁向外微凸呈缓弧形；内侧冠骨平凹，面
上由纵向细骨纹。前尖高大，在外脊上的位置偏后，为扁三角锥形，锥顶略偏后，外
壁向外隆起呈纵向长脊，尖端向前下延约到一半处，向前肿凸呈乳头状；前尖末端嵌
入P3前壁靠外侧的1/3处，约3 mm深。原尖为高约5 mm，尖端朝上的桃形齿尖，该尖通
过一细骨与外侧主尖舌侧壁的中部相连。内、外侧齿带发育，外齿带高约3.4 mm。标
本NWUV 1398的横脊薄，其前内和后外侧底部都有一个较低的凹窝，前面的比后面的
位置低，前、后窝约等大；齿带从齿的后外侧起，绕经整个外侧壁后，转到前端肿突之
外，再到前内角，终止于原尖前壁下，齿带较高较厚，其顶面呈波浪形。

P3: 长方柱形，宽大于长，其外侧长于内侧。外壁平，仅中段稍外突。外脊直向前
伸，末端处前附尖呈一小褶皱，中央的前尖高。原尖乳突状，唇、后侧倾斜，舌、前侧
较陡。中谷呈圆锥形深窝，底部窄细，外壁陡立，开口朝前。后脊从外脊后端伸出并与
原尖相连。NWUV 1397 (磨蚀标本)外脊前端(前尖)内壁有一弱的宽肋状突起，而未磨蚀
的NWUV 1398标本上前尖发育。P3的舌侧一半构造较简单，只有一个较粗壮的原尖，
该尖的舌侧壁外凸，陡峭，前后二壁较平，分别较缓地向前、后倾斜。从原尖顶向前到
后尖舌侧前止，在原尖后外侧斜坡壁上长出如城墙式的薄壁，厚1.2 mm，高2–3 mm，其
顶犹如城墙垛口那样高低不平整，与前尖不相接。原尖到前尖的前外侧坡壁隆起，但不
发出多余的脊或骨棱，给人的印象是原尖从其尖顶分别向前及后外各伸一臂，在前、后尖
脚下终止，不与之相接，而是隔有一深沟。原小尖居中并略靠近唇侧。齿带发
育，内齿带在原尖处向尖顶攀延，前齿带顶有许多梳状细脊，外齿带从后侧绕到前外侧。

P4: 比P3大许多，斜长方柱形，宽明显大于长，外脊及二横脊都已发育。外脊直长，其外壁明显向舌侧倾斜，在未磨蚀标本NWUV 1398上表现更为明显。外脊顶有三个突起，位于中间的前尖突起最高，其内侧稍向前偏移发育成一短脊，该短脊向舌侧缓缓下延到牙齿前内侧角处以沟和原尖相隔。由于该短的脊未与原尖相连，不能称之为原脊，而只能称为前脊。前脊细而短，略向后弯。前附尖呈半圆形，在唇侧形成直到冠底的肋柱；最后端的齿尖在唇面的突起较低。后脊略向前倾斜，与原尖后部相连。原尖几

![图3 府谷奈王爪兽(新种)正型的上颌骨(NWUV 1397)带左、右P2-M3](image)

**Fig. 3** Holotype palate (NWUV 1397), with left and right P2-M3, of *Nestoritherium fuguense* sp. nov.

A. 腹视 ventral view; B. 侧视 lateral view
乎占有牙齿的整个内侧。原小尖明显靠近前尖，而离原尖较远。中谷呈三脊包围的V形窝，其前外及后内壁缓倾，后外壁陡或甚至反倾，开口在前内角处。前、后齿带发育成脊形，后齿带顶有锯齿，内齿带在原尖处中断，外齿带微弱。P4的前、后脊都伸向

图4 府谷奈王爪兽(新种)的亚成年个体上颌骨(NWUV 1398)带左P3-M2和右P2-M2
Fig. 4 Young adult palate (NWUV 1398), with left P3-M2 and right P2-M2, of Nestoritherium fuguense sp. nov.
A. 腹视 ventral view; B. 侧视 lateral view
原尖，无次尖。P4的冠面形态与臼齿的已更相近，但其外脊与外壁却无臼齿上的W形弯曲，故上前臼齿没有一个臼齿化。

M1: 中等大小，近斜方柱形，牙外侧长32 mm, 内侧长30.7 mm, 前宽38.2 mm, 后宽29 mm, 宽略大于长，牙经磨用后冠面较平且露出相当多的齿质。4个齿根，内外侧各两个，内侧的两个上部彼此连为一体，其前宽长36 mm, 直到齿根尖部才稍分开，实际上是一个宽大的根。原尖之下约全齿根约为其后侧次尖下齿根宽的1.6倍。除两个外侧的齿根外，其他齿根都未有一定程度的向外弯突，甚至暴露在上颌骨之外。外脊呈典型的宽W形，外前谷呈宽深的V形，磨蚀后呈U形。外脊上的前尖与后尖大小相近，前尖比后尖稍低，两尖都已向内伸几达齿轴中线，在磨蚀严重时向尖侧退缩(NWUV 1397)。前附尖的形状在冠面较方，向齿冠基部变为半圆柱形，粗大，柱宽11 mm, 向唇侧外凸，其前壁的釉质层较直，伸向舌侧，被前齿带相截而中断。中附尖在外脊中部偏后，在冠面窄而突伸，向齿冠基部变为较宽大(7 mm)的柱形。后附尖外壁几乎平，但其前侧和舌侧冠壁的齿质面很陡，几乎与冠底面垂直。后附尖微弱或无。原尖为肥大、孤立的圆锥柱体，占据该牙尖舌侧的前2/3宽度，其舌侧冠壁陡而尖侧的则缓，其下部是一长方形缓

图5 府谷奈王爪兽(新种)正型的下颌骨(NWUV 1396)带左p2-m3和右p3-m3
Fig. 5  Holotype mandible (NWUV 1396), with left p2-m3 and right p3-m3, of Nestoritherium fuguense sp. nov.  
A. 咀面视 occlusal view; B. 侧视 lateral view
缓隆起的台面或底座，其上才是高尖的圆锥柱体，原尖顶部被较多地磨用后，尖顶已不存在，代之的是一个内径为5.8 mm的釉质环。原小尖弱，靠近前尖，磨蚀较重时消失。次尖比原尖稍高，但宽小，略偏唇侧。冠面视可见从外脊向舌侧伸出两条近于平形的短横脊，位于前面者起于前尖，向舌侧延伸不远即消失于原尖前外侧的前窝内，与原尖不连；位于后面者向舌侧延伸不远也倾没于次尖中下部。由于后尖与次尖位置相近，大小相当，当上下牙咬合时，二尖同时受下牙的磨蚀而在其前侧出现一面积较大向前方倾斜的磨蚀面，给人的印象是后尖与次尖已连成一脊，实际上二尖原来也是彼此孤立的，要说相连也只是在底部，尚未见到二尖顶全连在一起的情况，后尖与次尖之间仍有一较宽深的齿质沟。后脊较长，向后内侧斜伸。中谷深而开阔，磨蚀严重时底部形成封闭的釉质环，直径2.5 mm (NWUV 1397)。后谷新月形，中等宽度，较短。前谷细窄。前齿带嵴形，起于牙前端中部，以一细沟与原尖相隔，向内延到原尖前内角转弯处，齿带顺势转向舌侧，紧贴在原尖舌侧壁上，厚度变薄。内齿带连续，中谷口有一枚发达的齿柱。外齿带发育，细线状。无后齿带。外谷的底部有薄的白垩质。

M2: 斜菱柱形。牙的外侧壁强烈向舌侧倾斜，前尖及后尖向舌侧伸展已大大超过牙列中轴线，前尖较后尖粗大。前附尖未磨蚀时呈鸟头状弯曲，磨蚀后露出齿质深槽，槽顶半圆形，其外侧釉质层边缘有一些细齿状小槽。前附尖尖和中附尖尖发达，呈弧形弯曲。中附尖尖圆柱形，向下逐渐变大。前外谷V形。原尖大而高耸，总体呈方圆锥形，占据舌侧很大的面积，底部是近圆角的方形(或前-后向的长方形)，后侧与次尖前壁以中谷底的线状细沟分开，前端与前齿带也以线状细沟分界，锥顶纵向长，呈弧形细棱

图6 喇嘛沟地点的两件府谷奈王爪兽(新种)下颌骨
Fig. 6 Two mandibles of Nestoritherium fuguense sp. nov. from Lamagou
A. NWUV 1395, 前视 anterior view; B. NWUV 1394, 侧视 lateral view
薛祥煦等：陕西府谷发现的晚中新世爪兽新材料

表1 府谷奈王爪兽（新种）上颊齿的测量与比较

<table>
<thead>
<tr>
<th>Specimens</th>
<th>Items</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
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<td>NWUV 1397</td>
<td>L</td>
<td>13.6</td>
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<td>17.5</td>
<td>21.8</td>
<td>22.4</td>
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<tr>
<td></td>
<td>W</td>
<td>13.4</td>
<td>13.7</td>
<td>21.4</td>
<td>21.8</td>
<td>27.4</td>
<td>28.0</td>
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<td></td>
<td>L/W×100</td>
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<td>88.4</td>
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<td>18.0</td>
<td>19.8</td>
<td>20.0</td>
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<tr>
<td></td>
<td>W</td>
<td>15.0</td>
<td>20.3</td>
<td>20.7</td>
<td>27.0</td>
<td>28.0</td>
<td>34.8</td>
</tr>
<tr>
<td></td>
<td>L/W×100</td>
<td>103.3</td>
<td>88.6</td>
<td>88.95</td>
<td>71.4</td>
<td>97.7</td>
<td>117.7</td>
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<tr>
<td>N. linxiaense (Chen et al., 2012)</td>
<td>L</td>
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<td>14.1</td>
<td>14.8</td>
<td>18</td>
<td>20</td>
<td>29.1</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>15.3</td>
<td>19.8</td>
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<td>25.5</td>
<td>28.7</td>
<td>33.7</td>
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<tr>
<td></td>
<td>L/W×100</td>
<td>86.9</td>
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<td>74.7</td>
<td>69.5</td>
<td>70.6</td>
<td>77.6</td>
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<tr>
<td>N. sivalense (Tong, 2006)</td>
<td>L</td>
<td>12.5</td>
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<td>17.7</td>
<td>22.0</td>
<td>21.7</td>
<td>22.0</td>
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<tr>
<td></td>
<td>W</td>
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<td>40.4</td>
<td>39.4</td>
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<tr>
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<td>L/W×100</td>
<td>85.0</td>
<td>97.1</td>
<td>77.0</td>
<td>69.4</td>
<td>103.5</td>
<td>92.4</td>
</tr>
<tr>
<td>C. brevirostris (Colbert, 1934)</td>
<td>L</td>
<td>12.5</td>
<td>15.0</td>
<td>17.5</td>
<td>29.0</td>
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<td>18.0</td>
<td>23.0</td>
<td>32.0</td>
<td>40.0</td>
<td>41.0</td>
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<tr>
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<td>L/W×100</td>
<td>104.2</td>
<td>83.3</td>
<td>76.1</td>
<td>90.6</td>
<td>97.5</td>
<td>100.0</td>
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<tr>
<td>A. grande (Zapfe, 1979)</td>
<td>L</td>
<td>12.0</td>
<td>16.4</td>
<td>18.0</td>
<td>18.2</td>
<td>22.0</td>
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<tr>
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<td>W</td>
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<td>19.7</td>
<td>25.0</td>
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<td>L/W×100</td>
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<td>109.3</td>
<td>88.8</td>
<td>92.8</td>
<td>79.8</td>
<td>88.0</td>
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<td>N. sinense (Li &amp; Deng, 2003)</td>
<td>L</td>
<td>18.6</td>
<td>31.3</td>
<td>49.3</td>
<td>49.3</td>
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</tr>
<tr>
<td></td>
<td>W</td>
<td>29.6</td>
<td>36.7</td>
<td>52.6</td>
<td>55.8</td>
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</tr>
<tr>
<td></td>
<td>L/W×100</td>
<td>62.8</td>
<td>85.3</td>
<td>93.7</td>
<td>88.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: L. length; W. width; l. left; r. right.
和124.8 mm (右), p2-m3长171 (左)和170 mm (右), p2-p4/m1-m3为0.363 (左)和0.376 mm (右)。

下颌水平支高，由前边的40~50 mm向后升高到60 mm以上，颌骨体的最大高度一般在m1下方，可达66.8 mm。颌骨体厚度由前向后缓慢增大，从p2前后的介于30~40 mm之间到m3最大可增厚到47 mm左右。水平支的内侧较平，其增厚主要表现在颌骨外侧向外的膨大。左右二颌骨的前部约成25°相交而成形下颌联合，该联合向后延伸到p4前方，向前则缓缓向上急剧收缩变窄成吻突。联合部的舌面下凹呈V形弧面，长约55 mm不等，其两侧长有p3和p2, p2之前为一长约28 mm的犬齿虚位，犬齿虚位骨体的上缘是较薄的棱嵴，棱嵴外侧颌骨体收缩成一圆形凹窝，又向前颌骨体断缺，该处左右宽约25 mm,从其前端断面可见其左右侧端各有一直径为8~6.5 mm的窝洞(图6A)，按其位置应为左右二犬齿的牙槽所在，犬齿向前伸出。联合部的唇面较平，中间有一前前后向的粗细不等的骨质嵴。m3与上升支之间的间隙较小，不如临夏标本的大(陈少坤等, 2012, 图5)。颊齿从前向后显著增大，排列紧密。前臼齿小，p2的长度几乎只有m3长的1/7, 白齿列长约为前臼齿列长的2.5倍。下颌联合部后缘在p3/p4界线水平，NWUV 1395的间隙最窄处35 mm, NWUV 1396的间隙最窄处30.7 mm。

p2: 小而简单，前后长的锥柱形，单尖双根。除NWUV 1395标本的p2呈前外-后内

### 表2 府谷奈王爪兽(新种)的下颌骨测量

<table>
<thead>
<tr>
<th>Specimens</th>
<th>Items</th>
<th>Teeth</th>
<th>p2</th>
<th>p3</th>
<th>p4</th>
<th>m1</th>
<th>m2</th>
<th>m3</th>
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<tbody>
<tr>
<td>NWUV 1395</td>
<td>H</td>
<td>l</td>
<td>53</td>
<td>55.2</td>
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<td>61.5</td>
<td>64</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>56.2</td>
<td>55</td>
<td>56</td>
<td>61.0</td>
<td>64</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>l</td>
<td>37</td>
<td>34.5</td>
<td>35.3</td>
<td>38.2</td>
<td>39.8</td>
<td>41.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>34.0</td>
<td>33.0</td>
<td>34.0</td>
<td>36.0</td>
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<tr>
<td></td>
<td>Ld</td>
<td>44.2</td>
<td>40.0</td>
<td>47.0</td>
<td>53</td>
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</tr>
<tr>
<td></td>
<td>Bd</td>
<td>63.3</td>
<td>72.0</td>
<td>80.0</td>
<td>88.0</td>
<td>100</td>
<td>106</td>
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</tr>
<tr>
<td>NWUV 1396</td>
<td>H</td>
<td>l</td>
<td>58.6</td>
<td>60.2</td>
<td>63.2</td>
<td>64.5</td>
<td>—</td>
<td>—</td>
</tr>
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<td>r</td>
<td>54</td>
<td>59</td>
<td>62</td>
<td>70</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>l</td>
<td>38.6</td>
<td>40.7</td>
<td>38.5</td>
<td>39.5</td>
<td>43.0</td>
<td>46.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>r</td>
<td>41.5</td>
<td>40.0</td>
<td>43.0</td>
<td>42.5</td>
<td>43.0</td>
<td>47.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ld</td>
<td>40</td>
<td>41</td>
<td>45</td>
<td>54</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bd</td>
<td>83</td>
<td>88</td>
<td>98</td>
<td>110</td>
<td>124</td>
<td>149</td>
<td></td>
</tr>
</tbody>
</table>

| N. linxiaense | H     | 54.5 | 55.3| 58.5| 62.9| 68.0| 90.0|     |
| C. hebeiense  | H     | 50.9 | 54.0| 60.2| 65.5| 75.5| 83.3|     |
| A. grande     | H     | 43.9 | 46.0| 49.2| 57.7| 62.4| 73.0|     |
| N. sinense    | H     | 28.8 | 34.3| 40.6| 53.5| —   | —   |     |
|               | l     | 53   | 36.5| 55  | 60  | 69  | 75  |     |
|               | r     | 44   | 44.5| 55  | 58  | 61.2| 82  |     |
| N. wuduense   | T     | 31.5 | 32.5| 36  | 33  | 35.6| 34.3|     |
|               | r     | 29(?)| 31(?)|     |     |     |     |     |
|               | Ld    | 79.5 | 91  | 105 |     |     |     |     |
|               | Bd    |     |     |     |     |     |     |     |

Notes: m+m1=metaconid+metaconulid; H. height of mandibular below (m+m1) of each tooth; T. thickness of mandibular below (m+m1) of each tooth; Ld. lingual distance below (m+m1) of the same tooth on the left and right jaws; Bd. buccal distance below (m+m1) of the same tooth on the left and right jaws; l. left; r. right.
向斜置于颊齿列之最前端，几与颊齿列的主轴线呈正交外，其他的都是正常生长。齿冠呈横长的菱形锥状体，其主尖居中偏外侧，呈乳突状高高耸起，其外壁很陡呈弧形，内壁缓斜。通过主尖有一条较明显的棱嵴沿齿冠前外侧及后内侧壁从上而下发育。肥大、光滑的主尖和其后的小附尖之间有向后伸的细沟。后内侧冠壁中部有一尖端朝上的锥形附尖发育，其棱嵴在附尖中部变得低平且有数个小圆形凹坑，棱嵴两侧还有几条更细的棱。局部有微弱齿带。

**p3**: 显著大于**p2**，呈三角柱形。双叶未完全形成，但已有下三角座和下跟座的锥形，前者高且长大(NWUV 1395)。下原尖高大粗圆，由内外两片弧形釉质层相合而成，其外侧冠壁完整，近方形，缓缓外隆，齿冠顶长向外斜，显得嵴很厚；而内侧冠壁则稍向前倾。下前尖窄，位置低矮。下后尖从上到下从窄细变到宽大，紧紧贴附在下原尖后部。下跟座较短，仅有下三角座长的1/2，但比下三角座明显横宽，中上部有瓶颈状的收缩。下次尖为粗壮的乳突状。下后脊细窄，居于牙齿中轴。下内尖为小而低的孤立小突起。后谷宽浅。齿带微弱，薄而高。有的标本，如NWUV 1394则相反，下三角座很短，仅为一陡直的紧贴在主尖前的三角形板状前壁；下跟座长大，仅有一位置居中的主尖，主尖的外侧壁圆弧形，内侧壁较外侧者稍平，其前后者都有从尖顶分别向前下和后下延伸的斜沟，后沟后端有一中等高的小尖。牙后外角的齿带发育最好。

**p4**: 长方柱形，约有两个p3长，已发育有像臼齿那样完整的W形外脊和U形的前、后谷，可以认为是p4已臼齿化的表现。从p4起下三角座与下跟座长短相近，前者较后者

### Table 3 The measurements of lower cheek teeth of Nestoritherium fuguense sp. nov. (mm)

| Specimens  | Items | Left | Right | | | |
|------------|------|------|-------|------|------|------|------|------|------|
|            |      | p2   | p3   | p4   | m1 | m2 | m3 | p2   | p3   | p4   |
| NWUV 1394  | L    | 21.5 | 34.6 | 47.5 | 15 | 22.5 | 33 | | |
|            | W    | 15.1 | 19.8 | 25.5 | 10.6 | 15 | 19.2 | 24.2 | |
|            | L/W(%) | 142.3 | 174.7 | 186.2 | 141.5 | 150.0 | 171.8 | |
|            | Tr.L | 12.6 | 14 | 18 | 6.3 | 12.2 | 13.6 | 18.9 | |
|            | Tr.W | 15.1 | 19.7 | 25 | 10 | 14.8 | 19 | 23.8 | |
|            | Ta.L | 9 | 21 | 28.2 | 9 | 10 | 21.2 | |
|            | Ta.W | 15 | 19.5 | 24.6 | 10.5 | 15 | 19.2 | |
| NWUV 1395  | L    | 7.4 | 13.6 | 23.8 | 29.4 | 40.8 | 48 | 10.2 | 13 | 22 | 29.5 | 40.2 | 44.4 | |
|            | W    | 10.4 | 11.2 | 15.4 | 17.4 | 22.4 | 25.7 | 9.8 | 10 | 16.4 | 20.7 | 25 | 27 | |
|            | L/W(%) | 71.1 | 121.4 | 154.0 | 169.0 | 182.1 | 186.7 | 104.0 | 130.0 | 134.1 | 112.5 | 194.2 | 164.4 | |
|            | Tr.L | 9 | 9 | 11 | 16 | 19 | 8.5 | 10 | 12 | 15 | |
|            | Tr.W | 10 | 15.5 | 17.8 | 22.2 | 25.6 | 9.6 | 16.6 | 20.8 | 25 | 25 | |
|            | Ta.L | 4.5 | 14 | 18.3 | 25 | 30 | 5 | 12.3 | 18 | 25 | 30 | |
|            | Ta.W | 11.2 | 6.7 | 18 | 23 | 26 | 11 | 16 | 17.2 | 23 | 26 | |
| NWUV 1396  | L    | 10 | 12.7 | 23.1 | 32.4 | 44.2 | 51 | 12 | 22.3 | 31 | 43.5 | 50 | |
|            | W    | 7.8 | 11.3 | 13 | 21.4 | 26.7 | 28.7 | 12 | 17.3 | 20.8 | 27 | 28 | |
|            | L/W(%) | 128.7 | 112.4 | 177.7 | 151.4 | 165.5 | 177.7 | 100.0 | 128.9 | 149.0 | 161.1 | 178.5 | |
|            | Tr.L | 7.3 | 8 | 10.2 | 12.5 | 16.2 | 19.7 | 7.5 | 10 | 12 | 16 | 18.3 | |
|            | Tr.W | 7.7 | 10.4 | 13 | 21 | 27 | 29 | 11.6 | 17 | 21 | 27.3 | 28.7 | |
|            | Ta.L | 2.5 | 4.5 | 12.4 | 20 | 27.4 | 30.4 | 6 | 12.5 | 19 | 27.3 | 32 | |
|            | Ta.W | 7.2 | 11.4 | 17 | 21.6 | 28 | 28 | 10 | 17.5 | 22 | 27 | 29 | |

Notes: L. length; W. width; Tr. trigonid; Ta. talonid.

薛祥煦等：陕西府谷发现的晚中新世爪兽新材料
高，下前尖小但明显凸起，位于前脊舌侧1/3处。下前脊从下原尖向前内侧急剧下斜。下原尖大，高度仅次于下后尖，后者呈高耸陡直的三角锥形，其舌侧隆凸。下后附尖尚未完全形成，仅在下后尖下方的棱上有一个很小的凸起。下次尖的高度与下前尖相当，下内尖肥大，呈乳突状。下跟座高而窄，后谷更开阔但低下。下后尖底部内、外侧有短而发育，或高而薄的齿带，其他各部位齿带微弱或无。外中谷底有少许白垩质。

m1: W形脊完整。下前尖仍很不发育，低小，但明显存在，位置向后向唇侧偏移，更靠近下后尖，使其前脊的内侧大半段变得更低直，与原脊近于平行，致前叶呈角状的U形。下原尖、下次尖和下内尖都发育得很好。下跟座呈典型的V形脊，比下三角座长而宽，后谷大且深。下后附尖已很完整，比下后尖稍低小一点，磨用后连成一体，使其舌侧壁较宽平，长度大于下内尖。前、后齿带发达，外齿带在外中谷口显著，内齿带微弱。冠壁上有薄的白垩质。

m2: 主要特点与m1的基本一样，只是比m1更长大，下前尖更小。该牙已稍被磨用，冠面上的几个主要齿尖(除下前尖外)仍尖稍高起。下三角座与下跟座的宽度相近，但前者比后者短得多。下前尖更弱小，前叶呈原形的V形，但谷底较平。下后尖比下附尖明显高而大，该双尖的内侧壁呈尖底很宽的三角形陡直壁。后谷底成V形沟。下内尖呈孤立的高粗尖锥形。外谷贯通齿冠，其前、后壁相向陡倾，壁上有较深而宽的磨蚀面。牙齿内、外壁下部有较高的齿带，有的齿带上还有纵向的螺纹状线纹。

m3: 是下颊齿中最长的一颗牙。前、后叶皆为V形，不过，下三角座下跟座短。下后附尖较下后尖小，两尖并列成双锥状。下前尖仍然发育低小，未受磨蚀时仅可见直径约1 mm的尖锥。下前脊呈低矮的线状凸起，前谷底较平，其出口处已很接近下前尖的后壁。后谷向前方偏移。下后尖的前、后壁较对称。外谷更高更陡倾。前、后齿带发达，外齿带高而薄，内齿带微弱。近牙冠底见有薄薄的白垩质层。

总之，从上述对府谷爪兽下颊齿的综合观察和分析看，其p1已明显退失；p2及p3的大小、结构及磨用程度都很相近；p4及m1比其前面的两个前臼齿要大，比其后面的两个臼齿却明显地小，但牙已被磨用得很多，冠面已被磨得很平，m1的齿根甚至向外弯曲，说明该二牙是该动物生活时在较长时间里使用得最多，也是着力最大的牙；m2和m3则是最大的两颗牙，齿冠面的齿尖结构最宽松，被磨用的也很少，说明该动物尚属青、中年阶段。

3 比较和讨论

府谷爪兽为中-大型，其牙齿比其他属种的都要大或稍大。颊齿齿冠宽而低，上颊齿为典型的丘型-新月型齿，下颊齿为丘型-脊型齿。齿式：0.2.0.3.3/0.1.3.3，属爪兽科(Chalicotheriidae)无疑。爪兽科包括两个亚科：Schizotheriinae和Chalicotheriinae。府谷老高川的爪兽颊齿低冠，下颊较粗壮、厚实，下颌联合终止于p4前方，明显与Schizotheriinae的不同，而应属于Chalicotheriinae(Coombs, 1989)。在Chalicotheriinae中现已有6个属：Butleria, Kalimantsia, Chalicotherium, Anisodon, Hesperotherium和Nestoritherium。府谷老高川爪兽的上齿列无论侧视或冠面视都是弧形，M1的后半及
M2的前半部分是弧形的最大弯曲处；左右P2间的腭板宽55 mm，M3间的腭板宽72 mm，二者相差17 mm。这些特点与以Chalicotherium goldfussi为属型种，齿列呈直线排列的Chalicotherium很不相同(Zapfe, 1979; Heissig, 1999)。

Chalicotherium属以德国Eppelsheim地区Dinotheriensande的Vallesian (MN9)期动物群中的C. goldfussi Kaup (1833)为属型种。Anquetin et al. (2007)和Fahlke et al. (2013)最近讨论了这个种，其结论是欧洲的其他材料有属于这个种的，也有的不是。特别是被Schaefer and Zapfe (1971)归入C. goldfussi的奥地利Henndorf (MN12-13)的粗壮下颌骨，现在认为属于爪兽亚科中anisodont谱系的一个成员，而不属于Chalicotherium。C. goldfussi的下臼齿三角座为U形，而在府谷的三个下颌骨上只有个别下臼齿的下三角座略显U形，其他的都呈V形。因此，府谷的爪兽与C. goldfussi共同的特征太少，而重要的差异较多且突出，不能归属于Chalicotherium。在上臼齿的原尖粗大、孤立，原小尖发育较好这两个特点上，府谷的爪兽与Chalicotherium brevirostris (Colbert, 1934)和C. hebeiense (胡长康, 1959; 陈少坤、刘艳, 2013)都有一定的相似性。与Anisodon相比，二者都有较粗大的下犬齿，无原脊，原小尖发育很好且孤立，并与前尖相近，甚至连成短的前脊，上臼齿的后脊发育较直而长(Anquetin et al., 2007), 这些是府谷爪兽和Anisodon相似的地方。只是Anisodon有发育较好的下门牙，而府谷爪兽由于标本吻尖部没有保存，两犬齿齿槽相距很近，似无容纳门牙的足够空间，有可能门齿已退失不存在(经X光透视也未见门齿的迹象)。另外Anisodon的下颌水平支下缘平直，府谷的下颌骨较粗壮硕大，从犬齿虚位后端起，下颌骨上缘向后逐渐抬升，使颌骨上缘呈向前倾斜的窄面，而下颌骨下缘从m2起向后逐渐向下扩大使颌骨下缘逐渐呈弧形翘起，同时下颌体变得厚实粗壮。此特点是府谷爪兽与Anisodon的一个明显区别。


说，“上臼齿原小尖弱”，府谷的发育很好；“后半叶萎缩”，府谷的上M3外后半叶都是较长且向后内斜伸；“下臼齿下附尖无或极弱”，府谷的有发育较好的下后附尖，它与下后尖一起经磨蚀后常连成并联状，只是比下后尖稍低矮一点。府谷爪兽的p4除下内尖尚未与下次尖相连外，其W型外脊已基本形成，与臼齿一样其下三角座明显小于但稍高于下跟座。府谷爪兽在属级的归属上似乎介于Anisodon和Nestoritherium之间。不过，Anisodon上、下门牙都存在，单就考虑这一点，府谷的爪兽也归不到Anisodon中去。

Nestoritherium fuguense有几个性状与Anisodon macedonicum相同而与A. grande不同，包括更长的下颌联合部、退缩的下门齿(在A. macedonicum的正型上严重退缩，
在产自Titov Veles和Henndorf可能归入A. macedonicum的标本上已失去；见Anquetin et al., 2007)、原尖前面的前齿带具有一个缺口、M3的后齿带崎延伸到次尖顶部。A. macedonicum的下颌支在厚度和粗壮程度上相对较低，前臼齿列与臼齿列的长度比率退缩程度较小，下臼齿下附尖较弱。因此，尽管有不少相似性，但N. fuguense不能归入A. macedonicum或陈少坤等(2012)列于Anisodon之内的任何种。

Hesperotherium是一个出现时代较晚，比较特化的类别。该属的门齿、犬齿及下p1皆已退化不再存在，上臼齿无原小尖，后半叶萎缩等(邱占祥, 2002; 邱占祥等, 2004; 同号文, 2006; 同号文、邱占祥, 2009), 这些相当特有的特征与府谷爪兽的明显不同，二者很难对比。不过，从Hesperotherium与府谷爪兽各自具有的特点看，应该确信府谷爪兽是要比前者古老许多，时代也早许多的类型。

陈少坤等(2012)所表述的Nestoritherium属征有欠缺，我们根据包括N. fuguense在内的种进行了修订，增加了发达的原小尖、粗壮并向舌侧延伸的后脊、显著的下后附尖等性状。不过，如果这些种按Anquetin et al. (2007)的意见被包括在广义的Anisodon之内，则其原来的属征是合适的。

在Nestoritherium属中已有3个种。一个是N. sivalense, 发现于印度早更新世(Falconer, 1868), 从其上臼齿的原脊、原小尖皆已完全退化，或仅仅残留一点痕迹看，是一个比较晚近时代的种，N. fuguense比它古老，其原尖、原小尖及下犬齿等都发育得很好，二者不能对比。第二个种是N. wuduense, 该种有成年和未成年的下颌骨及齿列各一块(Xue and Coombs, 1985), 发现于甘肃武都上中新统，头骨和上牙情况未知。与N. fuguense相似，N. wuduense下臼齿的下附尖发育，略微独立于下后尖(Xue and Coombs, 1985), 与Anquetin et al. (2007)和陈少坤等(2012)的看法相反。N. fuguense与N. wuduense有一些相同或相近的特征，如二者都有发育较好的下次尖和下次小尖，都有发育较好的下犬齿，但前者的下颌骨和牙齿显得比后者的要粗壮厚实得多，其下颌齿排列在一条直线上，而不像后者那样颊齿列随颌骨水平支有明显和不明显的两个弯曲，尤其是前臼齿和臼齿间就有约21°的转折，使左右p2前的颌骨的内侧距仅有31 mm宽，而府谷的却是42 mm, 较前者要宽大得多；府谷下臼齿内侧的前、后谷都较N. wuduense的宽缓，谷底也较高，显然二者不属同一种。第三个种是N. linxiaense, 该种的下门齿已退失、下犬齿发育，其上臼齿的原小尖和原脊已逐渐退化，后脊发育程度较差，下颌骨粗壮，水平支下缘呈弧形，向后逐渐增大(陈少坤等, 2012)。
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薛祥煦等：陕西府谷发现的晚中新世爪兽新材料

N. fuguense与N. linxiaense有诸多相近的地方，如下门齿严重退缩甚至缺失，前臼齿列与臼齿列的长度之比下降(<40%), M3的后牙带伸达次尖顶部且短而窄，上臼齿列弯曲，下颌骨厚实并向后变高。但仔细对比，发现二者存在不少重要的区别：如府谷种有两对腭孔，而临夏种为一对；府谷种的下颌联合向后延至p4前缘结束，而临夏种的仅延至p2前缘水平；府谷种的下颌骨突部在前臼齿之前较快地向前收缩且向上翘起，不像临夏种的那样向前收缩不明显且向下斜伸；府谷种下犬齿与p2间齿隙更长(~25 mm), 临夏种为19.2 mm; 府谷种的下颊齿列从前向后始终排在一条直线上，不受颚骨体形状变化的影响，因此前臼齿在颚骨水平支上稍偏斜侧，而臼齿列稍靠舌侧，临夏种的下齿列在p4前明显地随颚骨向内弯转；府谷种的p4除下内尖尚未与下次尖相连外，其W型外脊已形成，与臼齿一样其下三角座明显小于但稍高于下跟座；临夏种的p4虽被称为“亚臼齿化”，实际上该牙的“W”型结构不明显，尚不成熟，而“下三角座明显大于下跟座”；府谷种的下臼齿不仅有下后附尖，而且发育较好，仅比下后尖稍低下，二者在被磨蚀后显示并联状，临夏种只在m3的描述中提到“下后附尖近于消失”。府谷种的p4和下臼齿冠壁下部有不同等不等的白垩质分布，临夏种的未见记述。

N. fuguense的上臼齿不像N. linxiaense的那样呈方形，而是呈前外-后内向倾斜的菱形，这是由于前附尖柱及后脊发育好，内尖大高所致；府谷种的P4略微更臼齿化；上牙的后脊所占位置比临夏种的稍窄，只约冠面的1/3, 牙的外脊也不如临夏种的那样明显内倾；府谷种的上臼齿都有发育很好、独立、与前附尖相距较近的原小尖；前尖、原小尖、原尖三者不在一条直线上；原尖非常发育，孤立，位于牙舌侧中-前部，占据舌侧一个很大的面积；前尖的前、后及外侧都有深沟与邻区相隔；由于原尖孤立，前尖与原尖不相连，没有原脊出现；原小尖虽也孤立存在，但当前尖和原小尖都经较多磨蚀后，二者就会连接呈一短的脊，或可称为前脊，这些情况是在临夏种中所没有的。

上述这些区别是明显的，显示府谷奈王爪兽Nestoritherium fuguense sp. nov. 与Miotherium的性状矩阵对N. fuguense进行编码和分析（表4, 但Character 31因定义不清未用于计算), 并重新编码Nestoritherium linxiaense的Character 13和N. wuduense的Character 56为1, 根据Liu and Zhang (2012)对Chalicotherium brevirostris的下颌骨和下牙特征进行了编码。最后得到3个最大简约树，其严格合意树见图7, 均显示N. fuguense与N. linxiaense构成姐妹群关系。最大简约树步长为95, 一致性指数为0.64, 保留指数为0.68; 严格合意树步长为99, 一致性指数为0.61, 保留指数为0.65。

从府谷爪兽的前臼齿退化程度并不很突出，下犬齿较粗大，下颌联合的终止点靠后，下颊齿列直，还有个别下三角座呈U形，上牙的原尖、原小尖都很发育，仍保持孤立状态，齿带发育，下颊齿冠下部保留有白垩质特征，府谷爪兽化石比同属其他种保留有较多的较原始特征。

陕西府谷的喇嘛沟动物群(Xue et al., 1995, 2006)与临夏盆地晚中新世柳树组的大深沟动物群很相似，二者有很多相同的种类，如Dinocrocuta gigantean, Hyaenictitherium wongii, Hipparion chiai, Chilotherium wimani, Samotherium sp.和Miotragocerus sp.等，喇
图7 包含府谷奈王爪兽（新种）的爪兽亚科严格合意树
Fig. 7 Strict consensus tree of the subfamily Chalicotheriinae including Nestoritherium fuguense sp. nov.

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消息

第四届国际古生物学大会在阿根廷门多萨市召开

2014年9月28日～10月3日，第四届国际古生物学大会在阿根廷门多萨市召开。国际古生物学大会（IPC）为四年举办一次的世界范围的古生物学盛会，是全球古生物学界最高规格的学术会议，为全球的古生物学者提供了展示和交流的机会。

本次会议安排24个主题会场，内容涉及无脊椎动物与脊椎动物主要门类的演化，形态功能学，埋藏学和地层学等多方面内容，共有来自世界各地900多名古生物学者参加。中国科学院古脊椎动物与古人类研究所周忠和等，以及中国科学院南京地质与古生物研究所，中国地质大学和首都师范大学等机构的研究人员参加了此次会议。周忠和院士是本次会议的召集人之一，在“热河生物群”主题会议中做了有关热河生物群近年来主要研究进展的大会报告；我国学者还做了有关有颌类早期演化、滑体两栖类、中生代鸟类和新生代哺乳动物最新研究进展的报告。在本次会议中，还完成了换届选举，周忠和院士当选为国际古生物协会主席。来自日本和法国的学者分别汇报了举办第5届国际古生物大会的申报计划。

(王敏)