

A new *Euprox* from the Late Miocene of Yuanmou, Yunnan Province, China, with interpretation of its paleoenvironment

Dong Wei¹ Liu Jianhui² Pan Yuerong¹

1. Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044;

2. Yunnan Archaeology Institute, Kunming 650118

Abstract The present paper systematically describes an *Euprox robustus* sp. nov. identified during recent laboratory work on the collected material. *Euprox* is a group of earliest cervids with true antlers. The new species is the third one of the genus discovered in China. Judged by its morphologic characteristics, the new species feed on juicy and tender leaves of dicotyledon. It implies that the vegetation of its epoch in the Yuanmou Basin is a kind of southern subtropical evergreen forest and the climate is humid and temperate with evident seasonality. The latter is mostly influenced by the monsoon and secondly by the latitude.

Keywords: *Euprox*, Cervidae, Artiodactyla, Yuanmou, Late Miocene

Yuanmou Man, dated at 1.7Ma, was considered for a long time as the earliest fossil man in China and even in Eurasia^[1]. The research for the ancestor earlier than Yuanmou Man is the main aim of most paleoanthropologists and paleontologists. From 1987 to 1990, a joint team composed of Yunnan Museum, Chuxiong Cultural Relics Bureau and Yuanmou Man Museum carried out a preliminary excavation at Zhupeng, Xiaohe areas in the Yuanmou Basin, and unearthed a large quantity of hominoid and mammal fossils^[2]. To understand better the human origin and evolution, the Program "Research of the Origin and Evolution of Early Man and Its Environmental Background" supported by the State Special fund for difficult subjects within the 9th Five-year Plan was launched in the beginning of 1998. Within the framework of this program, a joint team by the institute of Vertebrate Paleontology and Paleoanthropology of Chinese Academy of Sciences and Yunnan Archaeology Institute and Yuanmou Man Museum carried out a new series of excavations from 1998 to 2001 in the Yuanmou Basin and collected many new materials of hominoid and mammal fossils. These materials are very useful to the study of early

human origin and evolution, as well as to the interpretation of the paleoenvironment and paleozoogeography. Because artiodactyls, especially those of herbivores, are very sensitive to the climatic and environmental changes, the study of this group is of great importance to the interpretation of the paleoenvironment. During the systematic study of the group, a new species of *Euprox* has been identified. In the previous records, only *Euprox* cf. *furcatus*^[3] from Shanxi Province and *Euprox* sp.^[4-5] from Tunggur and the Qaidam Basin were reported in China. The collected materials were rare or fragmental and related studies were not detailed. The discovery of the new species is very significant not only to the understanding of this genus, but also to that of cervid phylogeny and Yuanmou hominoid fauna. The new species is described and its environments were interpreted below. The anatomic terminology used in this paper is based on that of Heintz^[6], Janis and Scott^[7] and Dong^[8].

1 Systematic Description

Mammalia Linnaeus, 1758
Artiodactyla Owen, 1848
Cervoidea Simpson, 1930
Cervidae Gray, 1821
Muntiacinae Pocock, 1923
Euprox Stehlin, 1928
Euprox robustus sp. nov.

1997: *Dicrocerus* sp. Pan^[9]

Type specimen a nearly complete right antler with complete pedicle and a small part of frontal (PDYV0875) collected from 9905T₁ of the Hominoid Locality at Leilai, Yuanmou Basin.

Included Specimens a right antler with complete main beam and broken brow tine and pedicle (PDYV0876); a broken base of shed antler (PDYV0381); a fragment of maxilla with PD²~M² (PDYV1481); a right M¹ (PDYV1398); a left M¹ (PDYV1721); a right M² (PDYV1191); a fragment of left mandible with P₃~M₃ (PDYV1583); a fragment of right mandible with P₄~M₃ (PDYV1129). These specimens are collected from Locality 8603 of Baozidonqing at Zhupeng Village, Locality 8801 on the Butterfly Hill of Xiaohe Village and 9905T₁ of the Hominoid Locality at Leilai, all in the Yuanmou Basin.

Type Locality Locality 9905T₁ of Leilao in the Yuanmou Basin.

Type Stratum Lower part of Xiaohe Formation.

Etymology The new species is very robust compared with the other species of the genus and to name the species by this character.

Diagnostic A large *Euprox*. Its antler crown

REPORTS

and pedicle are robust. The pedicle is thick and long, inclines backward. The main beam and the brow tine sprout abreast from the burr but diverge from each other a little distance from the burr. The main beam and the brow tine are curved, but not strong. The burr and antler decoration by longitudinal grooves and crests are developed. Cheek tooth crown is brachyodont. The precingulum, entocingulum and postcingulum are present and linked with each other. Neocrista and spur on upper molars are developed. The *Palaeomeryx* fold is absent on the lower molars.

Description The type specimen PDYV0875 (Figure 1(a)) is a nearly complete right antler with complete pedicle (see Table 1 for measurements). The pedicle is completely preserved, and with a small part of frontal associated at its proximal end. Judged by the proportion of the pedicle, burr and antler crown, the specimen is of a young adult individual. The pedicle sprouts from the frontal and develops straightly. It inclines backward above the skull. The pedicle is relatively long and very thick. Its surface is generally smooth, and its proximal end prolongates on the frontal by a pedicle ridge. The proximal cross section of the pedicle is evidently oval, and the distal cross section is nearly circle. The anterior, posterior and medial parts of the burr are well preserved. But the lateral part is broken. The burr is composed of a series of developed bony nodes and appears as an oval cluster of pearl ring. The maximum diameter of the antler base is located medial-laterally; its minimum diameter antero-posteriorly. The main beam and

brow tine sprout out abreast from the burr, and diverge from each other 23.4 mm above the burr. The main beam is long, and tapered. It grew laterally first and turned backward gradually. The brow tine is also tapered and curved, but less curved than the main beam. The decoration of the antler is developed longitudinal grooves and crests on the surface of the main beam and the brow tine.

The included specimen PDYV0876 is a right antler (Figure 1(b)). Its main beam is well preserved, but the brow tine and pedicle are broken (see Table 1 for measurements). The pedicle is little preserved, only the part 7.3 mm from the burr is preserved, the rest of the pedicle is missing. The cross section of the pedicle at the end near the burr is nearly circle. The lateral part of the burr is well preserved, but the anterior, medial and posterior parts of the burr are missing. The burr was well developed before being broken. It was composed of a series of developed bony nodes and appeared as an oval cluster of pearl ring before broken. It is impossible to measure its maximum and minimum diameters due to its broken state. The antler crown is simply composed of a main beam and a brow tine. The maximum diameter of the antler base is located medial-laterally and the minimum antero-posteriorly. The main beam and the brow tine sprout abreast from the burr and diverge from each other at 30 mm above the burr. The main beam is nearly completely preserved. It is tapered, developed firstly laterally and turned backward and upwards gradually at about 64 mm from the burr. The

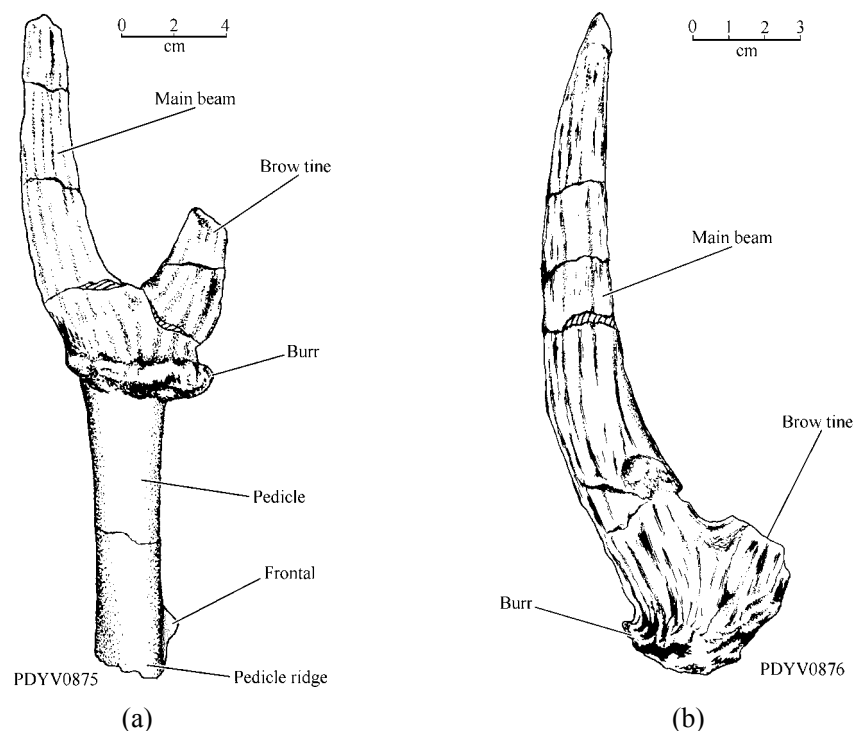


Figure 1 The type specimen (a) and included specimen (b) of *Euprox robustus* sp. nov. from Yuanmou

brow tine is broken and missing. The decoration of the antler is of longitudinally distributed grooves and crests on the surface of the antler crown. It is well developed.

Table 1 Antler measurements of *Euprox robustus* sp. nov. from Yuanmou (in mm)

	PDYV0875	PDYV0876	PDYV0381
Medial length of pedicle	64.2		
Lateral length of pedicle	104.7		
Maximum diameter of proximal pedicle	31.1		
Minimum diameter of proximal pedicle	24.2		
Maximum diameter of distal pedicle	32.5	30.4	33.2
Minimum diameter of distal pedicle	29.7	28.8	26.3
Thickness of burr	10.7	12.6	
Maximum diameter of burr	69.3		
Minimum diameter of burr	54.2		
Length of antler base	23.4	29.6	21.1
Maximum diameter of proximal antler base	56.8	45.2	44.7
Minimum diameter of proximal antler base	31.1	31.8	31.9
Length of the main beam	128.9	173.2	
Maximum diameter of proximal main beam	31.6	34.2	
Minimum diameter of proximal main beam	27.4	30.6	
Length of the brow tine	88.5		
Maximum diameter of proximal brow tine	28.1		
Minimum diameter of proximal brow tine	19.9		

Another included specimen PDYV0381 is a broken antler base (see Table 1 for measurements). Because it is a shed antler, there is no association with pedicle. This specimen was subjected hard transportation during preservation that all projected parts of the specimen are grounded and worn. The anterior and medial parts of the burr are preserved but worn, and posterior and lateral parts of the burr are missing. Judged by the preserved parts, the morphological characters of this specimen is the same as those two described above. The burr should be composed of a series of developed bony nodes and appears as an oval cluster of pearl ring in the well-preserved condition. It is impossible to measure the maximum and minimum diameters and the thickness of the burr due to its broken state. But it is possible to measure the maximum and minimum diameters of the pedicle on the shed surface associating the burr and the pedicle. The antler crown is simply composed of a main beam and a brow tine. The main beam and the brow tine sprout abreast from

the burr and bifurcate at 21 mm from the burr. Both main beam and brow tine are broken off a little distance from their bifurcation.

As for maxilla material, only one broken right maxilla PDYV1481 is collected. Its associated teeth are DP²⁻⁴ and M¹⁻². The dental morphology is described below (see Table 2 for measurements):

DP² the tooth is brachyodont. It is composed of anterior and posterior lobes. The anterior lobe is formed by protocone on the lingual side and paracone on the buccal side; the posterior lobe is formed by metaconule on the lingual side and metacone on the buccal side. The paracone and metacone are linked by their cristas. Entoflexus is well developed and separates the protocone and the metaconule.

DP³ the tooth is composed of an anterior lobe and a posterior lobe or of four selenodont cusps. The anterior one is narrower and that the posterior one is wider. The anterior lobe is formed by protocone on the lingual side and paracone on the buccal side; the posterior lobe is formed by metaconule on the lingual side and metacone on the buccal side. Entoflexus is well developed. The molarization of the tooth is significant.

DP⁴ the tooth is composed of four main cusps in two lobes. The lingual cusps are wider than those of the buccal. The tooth is well molarized. But the accessory elements of the tooth such as neocrista, spur, entostyle, cingulum etc. are absent.

M¹ the tooth is composed of four selenodont main cusps. The lingual main cusps are lower than those of the buccal, but wider and more curved. The neocrista and entostyle are present and evident, but not strong. The metaconule fold is absent. The spur (pli cabaline) is present and developed. The mesostyle is mediumly developed and protrudes buccally. The precingulum is present but very weak. The entocingulum is evident and appears on the base of the entostyle. Postcingulum is weak and appears as vestige on the posterior and lingual base of the postmetaconule crista. The trigon basin is wider than the talon basin.

M² the tooth is similar to M¹. The neocrista, entostyle and spur are all developed. Metaconule fold is absent. Mesostyle is developed and protrudes buccally. The precingulum is weak and appears on the anterior and lingual base of the preprotocrista. The entocingulum is present and appears on the anterior and posterior base of entostyle. Postcingulum is weak and appears as vestige on the posterior and lingual base of the postmetaconule crista. The trigon basin and the talon basin are similarly sized.

There are some other isolated M¹, M² and M³, their morphological characters are very similar to those of the M¹ or M² on the maxilla PDYV1481. All these teeth have cingula, and they are developed on some specimens (Figure 2 (a)).

REPORTS

The lower dentition is relatively well preserved on a left mandible (PDYV1583) with $P_3 \sim M_3$ (Figure 2 (b)), but P_2 is missing. The teeth are described below:

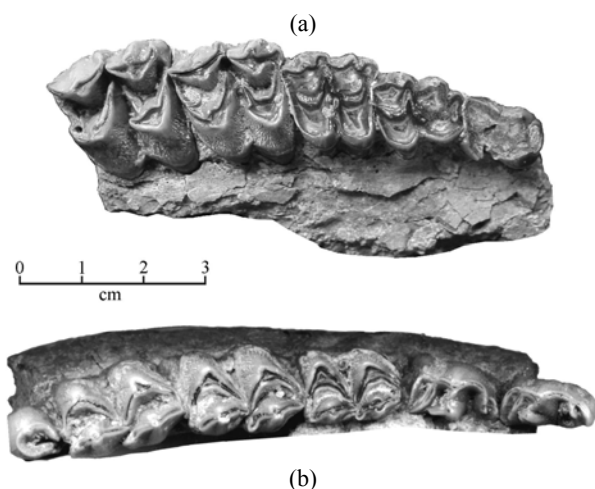


Figure 2 Cheek teeth of *Euprox robustus* sp. nov. (a): right $PD^2 \sim M^2$ (PDYV1481), occlusal view; (b): left $P_3 \sim M_3$ (PDYV1583), occlusal view

P_3 The paraconid is completely isolated from the periconid. The paraflexid, trigonid basin, entoflexid and talonid basin are present and opened lingually. A metaconid is not large nor is it anteriorly or posteriorly extended, and consequently the trigonid basin is extremely large and broad. But hypoconid extends backward and tends to enclose the entoflexid. A “*Palaeomeryx* fold” is present but not large.

P_4 The periconid has a tendency to become fused with the paracone. The paraflexid, trigonid basin, entoflexid and talonid basin are present and opened lingually. Hypoflexid is present but not well developed. A metaconid is well developed and extends backward but does not enclose entoflexid. The entoconid is developed and extends backward and tends to enclose the trigonid basin. A “*Palaeomeryx* fold” is present.

M_1 It is composed of four main selenodont cusps. The buccal main cusps are more robust but more brachyodont than those of the lingual. The precingulid is present but not developed. The ectostylid is developed. The *Palaeomeryx* fold, ectocingulid and postcingulid are absent.

M_2 It is very similar to M_1 , but its dimensions are evidently larger than those of the latter.

M_3 The tooth is composed of three lobes. The first and second lobes are relatively larger, especially the first one. The third lobe is quite small and is composed of hypoconulid on the buccal side and entoconulid on the lingual side. The former is larger than the latter. The *Palaeomeryx* fold, precingulid, postcingulid and ectocingulid are all absent.

There is another fragment of right mandible with $P_4 \sim M_3$ (PDYV1129) which are morphologically very

similar to the above described teeth (see Table 2 for measurements).

Table 2 Dental measurements and hypsodont index of *Euprox robustus* sp. nov. (in mm)

Specimen	Tooth	Length	Width	Height	Hypsodont Index
PDYV1481	DP^2	14.5	9.4	6.3	43.23
	DP^3	15.0	12.1	4.4	29.28
	DP^4	14.5	14.6	5.2	35.59
	DP^{2-4}	43.2			
	M^1	17.6	17.0	11.9	67.65
PDYV1398	M^2	19.1	20.1	13.6	70.95
	M^2	18.8	22.5	9.8	51.97
PDYV1721	M^1	18.6	23.7	9.0	48.22
PDYV1191	M^2	20.1	25.0	10.3	51.49
PDYV8603	M^3	19.8	24.0	14.0	70.58
	P_3	16.0	7.9	13.5	84.36
	P_4	16.4	8.3	12.6	77.26
	M_1	17.8	11.2	10.4	58.14
PDYV1583	M_2	20.0	13.8	12.6	62.84
	M_3	27.0	13.7	14.4	53.33
	M_{1-3}	67.6			
PDYV1129	P_4	17.2	10.4	10.4	60.44
	M_1	18.9	12.8	8.7	46.09
	M_2	19.5	15.3	11.1	5.64
	M_3		14.9	11.7	

2 Comparison and Discussion

The above described antlers are of some dicrocervine characters such as parallel outshoot of the main beam and the brow tine, the small distance between the bifurcation and the burr, fork-like antler crown etc. They are similar to those of *Dicrocerus grangeri* from the Middle Miocene of Tunggur in Inner Mongolia^[10], *Dicrocerus* cf. *elegans* from the Middle Miocene of Nanjing in Jiangsu Province^[11] and European *Dicrocerus elegans*^[12-13]. But their longer pedicle and especially developed burr, a new derived character of muntiacine^[14-15] show that these specimens are of characteristics of *Euprox* that can distinguish these specimens from those of the dicrocervines. They are therefore attributed to the *Euprox*. Compared with those of *Euprox* cf. *furcatus* from the Late Miocene in Shanxi Province^[3], they are dimensionally similar to each other (Table 3), and they both have developed burr and antler decoration of longitudinal grooves and crests, but the pedicle of the Yuanmou specimens is longer and thicker, the main beam and the brow tine are more robust and the angle between them is larger. Compared with the *Euprox* sp. from the Late Miocene of the Qaidam^[5, 16], the pedicle of the latter is much longer, and that the Yuanmou specimens have more robust main beam and brow tine

(Table 3). Compared with the *Euprox* sp. from the Middle Miocene of Tunggur in Inner Mongolia [4, 10], the Yuanmou specimens are evidently more robust than the Tunggur specimens. Compared with the European *Euprox furcatus*^[17~18], they all have developed burr, the position of bifurcation of the main beam and the brow tine and antler decoration are very similar, but again, the Yuanmou specimens are more robust.

Table 3 Comparison of average measurements of different species of *Euprox* (in mm)

	<i>E. robustus</i>	<i>Euprox</i> sp.	<i>E. cf. furcatus</i>
Medial length of pedicle	64.2	102.5	43.6
Maximum diameter of distal pedicle	32.0	25.0	24.3
Minimum diameter of distal pedicle	28.3	22.2	22.3
Thickness of burr	11.7	10.1	8.3
Maximum diameter of burr	69.3	53.0	47.2
Minimum diameter of burr	54.2	39.6	42.0
Length of antler base	24.7	26.7	31.0
Maximum diameter of proximal antler base	48.9	36.3	44.4
Minimum diameter of proximal antler base	31.6	23.1	34.0
Length of the main beam	151.1	141.0	136.2
Maximum diameter of proximal main beam	32.9	25.6	27.5
Minimum diameter of proximal main beam	29.0	19.6	19.0
Length of brow tine	88.5	67.5	84.7
Maximum diameter of proximal brow tine	28.1	21.8	20.2
Minimum diameter of proximal brow tine	19.9	17.7	16.5

Based on the measurement, the ruminant selenodont cheek teeth from the Yuanmou Hominoid localities can be classified into four groups. The three of them are of smaller dimensions that can be attributed to tragulids, and the biggest one is evidently of a cervid. Due to the limits of the preservation status of the fossils, all cervid materials do not have the association between the antler, skull and mandible. There is no direct evidence to indicate that which cervid teeth are related to which identified antlers. Fortunately, there is only one group of relatively bigger antlers, i.e. those of *Euprox robustus* sp. nov., the other antlers are evidently of smaller cervids. The attribution of cervid teeth to the big antlers of *Euprox robustus* sp. nov. is dimensionally logic. It is more practical to attribute the dimensionally matchable antlers and teeth from the same locality and same

stratum to the same species than to attribute them into two different species according to the law of parsimony, although the possibility that they belong to two independent species, one represented by antlers and the other by teeth, still exists.

With regard to the morphological characteristics of the dental specimens from Yuanmou, it is remarkable that the precingulum, entocingulum and postcingulum are present on the upper cheek teeth, and these cingula are linked with each other along the lingual base of the tooth crown. The cingula are sometimes very evident (Figure 3). There are no other particular morphological characteristics on the dental specimens of the new species from Yuanmou compared with those of other muntiacine species. There are no records of muntiacine specimens from the Siwaliks for comparison. Based on the above mentioned comparisons, these Yuanmou specimens are very unique and represent a species never documented. It is therefore necessary to attribute them to a new species to supplement the knowledge of the cervids.

There are a nearly complete right antler, two fragmental antlers and some upper and lower cheek teeth (YV2537.1~45) unearthed from Locality 8603 at Baozidongqing of the Yuanmou Basin, Locality 8704 at the Butterfly Hill of Xiaohe Village^[9]. They were identified as *Dicrocerus* sp. by the previous study on the Yuanmou Hominoid Fauna^[9]. These specimens are morphologically the same as those of the new species and can be assigned to the same species.

Euprox was named by Stehlin^[14] during his study on the cervids from Steinheim in Germany. He grouped the primitive cervids with two tined antlers into two genera: *Dicrocerus* and *Euprox*. The former has two tined antlers without evident burr, and the latter has the antlers with evident burr. According to the observation on the evolution of antlers, the antler evolved from non-deciduous to deciduous, and the burr is the result of seasonal replacement of the antlers and it is therefore regarded as an important derived character in the phylogeny of cervids. It is also used to distinguish the primitive antlers and advanced antlers^[19~20]. Based on the evolution of antlers, the *Dicrocerus* and *Euprox* should be closely related, or the former might be the direct ancestor of the latter, and the latter might give birth or evolve to *Metacervulus*.

3 The Interpretation of the Paleoenvironment of *Euprox* from Yuanmou

The existence of *Euprox* in China was firstly reported by Colbert^[4] during his study on the mammalian material from Tunggur housed in American Museum of Natural History. Vislobokova^[5] indicated that the genus was present in the Qaidam Basin in the Late Miocene. The other record of this

REPORTS

genus is that of Zdansky's "*Dicrocerus cf. furcatus*" from the Late Miocene of Shanxi Province^[3]. Because its antler has developed burr that it should be attributed to *Euprox cf. furcatus*. Based on the comparison of the specimens from the Tunggur and the Qaidam, the present authors think they can be attributed to the same species. This species is different from the *Euprox cf. furcatus* from Shanxi and the new species from the Yuanmou Basin by its peculiar long pedicles. The species from the Yuanmou Basin is therefore the third species of the genus discovered in China. The discovery of the new species from the Yuanmou Basin extends the geographic distribution of this genus from the northern and northwestern China to southwestern China. It is worthwhile to indicate that the precingulum, entocingulum and postcingulum are evident and linked with each other on the upper molars in many specimens from the basin. (Figure 3). This primitive character implies the age of the species is rather old, very likely of Late Miocene. This deduction is in accordance with the results of the study on micromammals from Leilao^[21], and also similar to the geochronological distribution of the genus. The genus is present from MN6 to MN10 of Late Miocene in Europe^[18], in Tunggurian of the Middle Miocene and Baodean of the Late Miocene in northern and northwestern China.

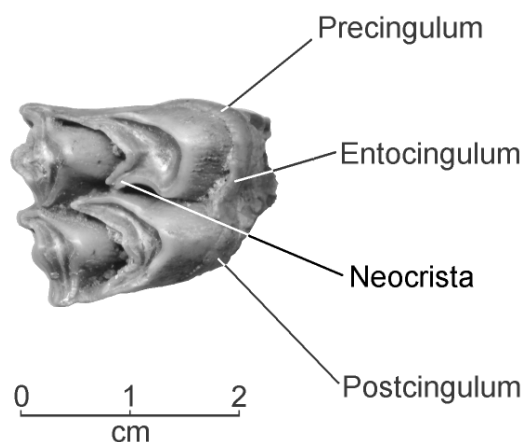


Figure 3 Right M¹ of *Euprox robustus* sp. nov. (PDYV1398) from Yuanmou, occlusal view

The new species has well-developed antlers that implies they were well nourished. It implies in turn that its food and related minerals for developing antlers are abundant. Judged by its brachyodont cheek teeth and long cingula, the new species feed on juicy and tender leaves of dicotyledon. Such vegetation could only be developed in a humid and temperate climate, and it should be a kind of southern subtropical evergreen forest. The burr on the antlers of the new species is well developed (Figure 1), it could infer that the climate of the epoch in the basin was

evidently seasonal. The seasonal replacement of antlers made the burr became well developed. Based on the study of extant cervids, the replacement of antlers is controlled by the seasonal cycle of endocrine of the cervids. And this cycle is mainly influenced by annual difference of sunlight^[19-20]. The Yuanmou Basin is located within 25° ~ 26° N. latitudes, very close to the tropic of Cancer. The annual difference of the sunlight irradiated on the earth's surface is much less than that in the northern and northwestern China with much higher latitudes. Because the annual difference of sunlight irradiated on the earth's surface in the Yuanmou Basin is small, the seasonal climatic change in the basin during the new species' epoch should be influenced by some other factors. Due to the coverage of clouds, sunlight will be greatly reduced on the earth's surface during cloudy seasons. The distribution of the clouds is evidently influenced by the movement of humid air. It could infer that the annual difference of sunlight irradiated on the earth's surface in the Yuanmou Basin during that time was mainly influenced by the monsoon across the basin, and secondly by the altitude.

Because *Euprox robustus* is a big *Euprox*, its preys should be large enough to succeed in hunting it. The carnivores unearthed from the Yuanmou Basin associated with *Euprox robustus* counted at least 21 species^[22]. Among them, *Amphicyon* sp., *Indarctos sinensis*, *Martes cf. zdanskyi*, *Proputorius* sp., *Eomellivora cf. wimani*, *Trochotherium yuanmouensis*, *Vishnuictis* sp., *Vishnuictis yuanmouensis*, *Ictitherium hipparionum*, *Hyaena* sp. and *Machairodus cf. maximiliani* etc. about 11 carnivorous species are capable of hunting *Euprox robustus*. Among these carnivores, *Machairodus cf. maximiliani* is the main prey and natural enemy of *Euprox robustus*. Under such living conditions, it could survive only if it can escape well its preys and feed itself well. *Euprox robustus* sp. nov. mainly feed on juicy and tender leaves of dicotyledon, it shares the southern sub-tropic evergreen forest with other herbivores of the Yuanmou Basin. When a herbivore is feeding leaves among bushes and shrubs, its eyeshot is greatly limited by the branches of trees and is vulnerable to the preys under the coverage of jungles. The ruminants can browse quickly and store the food in the stomach, then go to some safer place to ruminate the stored food and carefully chew it while raising head supervising their territory with maximum eyeshot. This strategy makes the ruminants defense themselves more successfully from their preys. *Euprox robustus* sp. nov. is a high ruminant, its viability is much stronger than that of non-ruminant browsers e.g. its accreting forest hipparions. The latter went extinct in the Pliocene but the ruminant browsers have survived to the present. The rumination is an important factor of their successful survival.

As mentioned above, the Yuanmou Basin in the Late Miocene is of southern subtropical evergreen forest with rich faunas, the climate is humid, temperate, seasonal and influenced by monsoon. The ecological environment in the basin is very similar to that of the Late Tertiary in East Africa. Liu Tungsheng and Wang Qian^[23] suppose such monsoon influenced environment in the Late Miocene of the Yuanmou Basin is also a probable cradle for the hominid origin, and it is a right location to search for early hominid traces. A great number of hominoid fossils have been collected in recent investigations^[24] that gives more and more clues to the study of human origin and evolution. With the development of such research, the hypothesis that the Yuanmou Basin is a probable cradle for early hominid origin will be tested.

Acknowledgment The present work was supported by the Pandeng Project of the Ministry of Science and Technology of China (PD980002). The present authors would like to acknowledge all members of Yunnan Team for joint fieldwork and collecting the materials. The Zhang Xingyong Team of former Yunnan Museum and Mr Jiang Chu of the Yuanmou Man Museum worked for a long time in the basin to collect the materials and to trace the fossil localities. Professors Qiu Zhanxiang and Chen Guanfang of the IVPP gave constructive advice for the preparation of the manuscript. Dr. Liu Liping of the IVPP helped to take digital photograph of the specimens. The present authors would like to express their great gratitude to the above mentioned people for their kindness and time.

References

- 1 Qian F. On the age of "Yuanmou Man" -- A discussion with Liu Tungsheng *et al.* Acta Anthropologica Sinica, 1985, 4(4): 324~332
- 2 He Z Q ed. Yuanmou Hominoid fauna. Kunming: Yunnan Science & Technology Press, 1997. 1~270
- 3 Zdansky O. Fossile Hirsche Chinas. Palaeontologica Sinica, 1925, 2(3):1~94
- 4 Colbert E H. Some cervid teeth from the Tung Gur Formation of Mongolia, and additional notes on the genera *Stephanocemas* and *Lagomeryx*. American Museum Novitates, 1940, 1062:1~6
- 5 Vislobokova I A. The Fossil Deer of Eurasia. Moscow: Sciences Press, 1990. 1~208
- 6 Heintz E. Les Cervides villafranchiens de France et d'Espagne. Mémoire du Muséum National d'Histoire Naturelle, 1970, 22(2):1~206
- 7 Janis C M, Scott K M. The interrelationships of higher ruminant families, with special emphasis on the members of the Cervioidea. American Museum Novitates, 1987, 2893:1~85
- 8 Dong W. A morphological analysis of cheek teeth of Eurasian Pliocene cervids. In: Ohtaishi N, Sheng H L, eds. Deer of China. Amsterdam: Elsevier Science Publishers B V, 1993. 65~72
- 9 Pan Y R. Artiodactyla. In: He Z Q, ed. Yuanmou Hominoid fauna. Kunming: Yunnan Science & Technology Press, 1997. 118~119
- 10 Colbert E H. Tertiary deer discovered by the American Museum Asiatic Expeditions. American Museum Novitates, 1936, 854: 1~21
- 11 Chow M, Wang B Y. Fossil vertebrates from the Miocene of northern Kiangsu. Vertebrata PalAsiatica, 1964, 8(4):341~354
- 12 Viret J. Artiodactyla. In: Piveteau J, ed. Traité de Paléontologie. Paris: Masson et Cie Edit, VI, volume 1, 1961. 1038~1084
- 13 Ginsburg L, Azanza B. Présence de bois chez les femelles du cervidé miocène *Dicrocerus elegans* et remarques sur le problème de l'origine du dimorphisme sexuel sur les appendices frontaux des Cervidés. Comptes Rendus de l'Académie des Sciences, Séries II, 1991, 313:121~126
- 14 Stehlin H G. Bemerkungen über die Hirsche von Steinheim am Aalbuch. Eclogae Geologicae Helvetiae, 1928, 21:245~256
- 15 Thenius E. Zur Kenntnis der fossilen Hirsche des Wiener Beckens, unter besonderer Berücksichtigung ihrer stratigraphischen Bedeutung. Der Annalen des Naturhistorischen Museums in Wien, 1948, 56:262~307
- 16 Bohlin B. Eine tertiäre Säugetier-Fauna aus Tsaidam. Palaeontologica Sinica, Series C, 1937, 14(1):1~71
- 17 Azanza B. Sur la nature des appendices frontaux des cervidés (Artiodactyla, Mammalia) du Miocène inférieur et moyen. Remarques sur leur systématique et leur phylogénie. Comptes Rendus de l'Académie des Sciences, Séries II, 1993, 316:1163~1169
- 18 Gentry A W, Rössner G E, Heizmann E P J. Suborder Ruminantia. In: Rössner G E, Heissig K, eds. The Miocene Land Mammals of Europe. Munich: Verlag Dr. Friedrich Pfeil, 1999. 225~258
- 19 Bubenik A. Epigenetical, morphological, physiological, and behavioral aspects of evolution of horns, prohorns and antlers. In: Bubenik G A, Bubenik A B, eds. Horns, Prohorns and Antlers. New York: Springer-Verlag, 1990. 1~113
- 20 Bubenik A. Evolution of cranial protuberances of Cervoids from velericorn stage into annually deciduous antlers. In: Ohtaishi N, Sheng H L, eds. Deer of China. Amsterdam: Elsevier Science Publishers B V, 1993. 44~55
- 21 Ni X J, Qiu Z D. The micromammalian fauna from the Leilao, Yuanmou hominoid locality: Implications for biochronology and paleoecology. Journal of Human Evolution, 2002, 42:535~546
- 22 Zong G. Carnivora. In: He Z Q, ed. Yuanmou Hominoid fauna. Kunming: Yunnan Science & Technology Press, 1997. 69~89
- 23 Liu T S, Wang Q. Story of monsoon — A new environmental hypothesis of origination of hominid: A preliminary account. Acta Anthropologica Sinica, 2000, 19(Supp.):1~7
- 24 Zheng L, Zhang X Y. Hominoid fossils. In: He Z Q, ed. Yuanmou Hominoid fauna. Kunming: Yunnan Science & Technology Press, 1997. 21~60

(Received November 3, 2002)