

Notoungulata from the Paleocene of Jiangsu, South China

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From
Mesozoic and Cenozoic Red Beds of South China
Selected Papers from the "Cretaceous-Tertiary Workshop,"
Nanxiong, Guangdong Province

Edited by
Institute of Vertebrate Paleontology, Paleoanthropology
&
Nanjing Institute of Paleontology
Science Press, 1979
pp. 387-394

Translated By Will Downs
Bilby Research Center
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November, 1989

Introduction

The Notoungulata are an extinct as well as diverse group of mammals. Partial skeletons of this group were first discovered by Charles Darwin in the second decade of the nineteenth century when he conducted research under the auspices of the British Museum (Natural History) in the South American country of Argentina. This discovery subsequently led to wide notoriety. Later, due to in-depth research in South America, relatively abundant and taxonomically diverse notoungulate faunas were recovered from different stratigraphic horizons in the Eocene and Paleocene. North America and Asia are the only other two continents that preserve fossil notoungulate material of the Notioprogonia, which is a relatively primitive and archaic suborder of the order Notoungulata that was present for a relatively short period of time and restricted principally to the Paleocene, and Early and Middle Eocene periods. Furthermore, as this taxon is relatively widespread, it undoubtedly may be used as a significant basis for stratigraphic subdivision and correlation. To date, there are ten genera composing three families within the Notioprogonia. The Arctostylopidae is the only family distributed in both Asia and North America. The first discovery of this suborder in China occurred from the Eocene deposits of the Xinjiang Autonomous region in 1966. More recently, however, successive discoveries of numerous and taxonomically diverse notoprogoniids have been made in South China including Anwei, Jiangxi, and Guangdong provinces, in addition to the Inner Mongolia Autonomous Region of North China. This constitutes enormous progress, because from one aspect, these discoveries are beneficial to the recognition of faunal characteristics, whereas from another aspect they are certainly significant to research into the systematic relationships and paleogeography of the notoungulates and the origin of the notioprogoniids.

The material described in this text was partially derived from two stratigraphic horizons of the Paleocene of Dayu, Jiangxi Province. By means of research and taxonomic comparisons of this material, the author believes two subfamilies may currently be recognized within the Arctostylopidae; the Asiostylopinae and the Arctostylopinae.

I Description of Material

Notoungulata Roth 1903

Notioprogonia Simpson 1934

Arctostylopidae Schlosser 1923

Diagnosis for family: Small Notioprogoniidae from Asia and North America. Dental formula is 3-1-4-3/3-1-4-3 with dentition tightly compressed. Molars brachydont to slightly hypsodont. Premolars simple with upper and lower fourth premolars nonmolariform to submolariform. Upper molars lophate with M^{1-2} subtriangular to generally quadrate in form. M^3 triangular and lacking secondary structures on the crown (such as anterior spur, etc.). Lower molars biselenodont, trigonid reduced and compressed, talonid basin extended, and entoconid either completely or slightly lophate (from Schlosser, 1923, revised and amended).

Asiostylopinae subfam. nov.

Diagnosis: Molars brachydont. M^{1-2} triangular to subtriangular in shape, slight swelling on labial wall of crown, and labial wall not flat and straight. Metaloph present on M^3 . Lower molars maintain a reduced trigonid, anterior crests correspondingly unreduced, entoconid slightly lophate and extends slightly labially but does not clearly connect to the cristid obliqua (selenolophid).

Asiostylops gen. nov.

Type species: *Asiostylops spanios* sp. nov

Diagnosis: As for species.

Asiostylops spanios sp. nov

(Plate I, Fig. 1; Text Figs. 1, 2)

Type specimen: A fragmentary skull and relatively complete mandible. Anterior portion of the right ramus is damaged. Specimen #V5042.

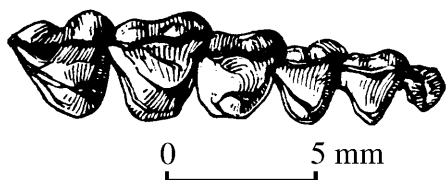


Figure 1: Occlusal view of *Asiostylops spanios*
right P2/-M3/ (V5042)

Species Diagnosis: Upper premolars simple with distinct labial cusps. Hypocone absent but parastyle extremely well developed. The ectoloph is relatively long with a moderately deep labial reentrant. The precingulum is narrow and postcingulum slightly broad. The P₄ talonid is short and lophate. Lower molar trigonids are short with unreduced anterior crests. The paraconid is situated at the center anterior tooth crown. The metaconid is high and projected. The talonid basin is situated lower than the trigonid. The entoconid is slightly lophate and situated precisely in the center of the talonid basin but does not connect to the cristid obliqua.

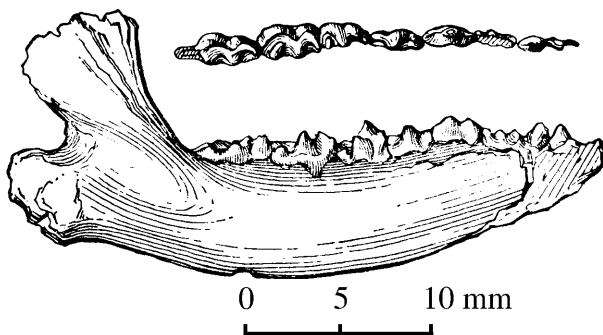


Figure 2: Left mandible of *Asiostylops spanios* (V5042)
Occlusal view (upper), Lingual view (lower)

Locality and Stratigraphic Position: Lannikeng cross-section, Late Eocene Chijiang Formation. IVPP Locality 73039, 1/2 kilometer southwest of Laolingbei, Qinglong Commune, Tayu, Jiangxi Province.

Description: A damaged skull with the general morphology of a relatively short face and rather robust zygomae. The infraorbital foramen is situated above the P₄.

The incisors are not preserved. Canines are relatively small (from the perspective of both alveolae). Molars are brachydont, tightly compressed, and a diastema is absent. Anterior upper premolars are simple. P¹ is small; P² is slightly larger than P¹, and maintains a single principal cusp and a relatively longer ectoloph. The P³ is nearly equivalent in size to the P⁴ with its ectoloph slightly longer than the P². There is a distinct paracone, but indistinct preparacrista; labial wall is relatively flat and even, protocone low, and pre- and postcingula are thin. P⁴ labial and central reentrants are shallower than on the molars. Two labial cusps and parastyle are well developed; protocone is high and projected. The pre- and postprotocristae form an internally directed V. The anterior cingulum is slightly broader than the posterior cingulum. Upper molars with M² are very large with M³ slightly larger than M¹. M¹ and M² maintain similar dental morphology being subtriangular in form, and transversely expanded. Ectoloph is relatively long and recurved. Labial and central reentrant folds are slightly deep, and pre- and postparacristae are well developed. Paracone and metacone are nearly equivalent in size with labial wall slightly swollen. Preparacrista is distinct with a deep longitudinal groove lying between the parastyle and paracone. The postparacrista is indistinct. The parastyle is projected but a mesostyle and metastyle are absent. Cingula are similar to that of the P⁴ but the postcingulum is slightly expanded at the posterolingual base of the protocone. Hypocone and labial cingula are absent. Styles and secondary structures are absent on the loph. The M³ is triangular and lingually reduced to a nearly equivalent length and breadth. The labial wall is more projected than on the anterior dentition. The postparacrista is distinct but the postcingulum is not expanded on the lingual side.

The mandible is thin and long with a recurved lower margin of the ramus, which makes a gradual ascension anterior to the M¹ and attenuates to a thin anterior margin. The mandible is deepest beneath the M₂ with the anterior end nearly half the depth at the M₂. The coronoid process ascends close to the posterior margin of the M₂ and forms a nearly right angle intersection with the ramus. The condyle is relatively high and possibly small and flattened. The condyle projects slightly high and is positioned just above the line of the alveolae. The sulcus between the coronoid process and condyle is relatively shallow. The angular process is rather robust, extending posteroventrally to form a deep sulcus between it and the condyle. The masseteric fossa is large, shallow, and slightly quadrate in form. The masseteric ridge is strong, straight, and extends from the lateral side of the coronoid process to the lower region of the ramus. The condylar ridge is conspicuous and extends posteriorly to the ascending ramus. The symphysis is short with its posterior margin extending nearly anterior to the P₂. The mental foramen is indistinct on this specimen, but may lie beneath the P₂.

The incisors are broken but there may be three. Canines are small. Premolars are molariform. A diastema is absent. The anterior lower premolars are slightly flattened with a distinct labial longitudinal groove. The P₁ is small. The P₂ maintains two roots and approaches the size of the P₃ with a shallow groove on the labial wall. The P₃ is extended anteroposteriorly, and anterior to the principle cusp is a slightly low cusp both connected by a cristid. A lingual cusp is absent, but in the same manner as at the anterior there is a posterior cusp behind the principle cusp. The degree of molarization of the P₄ is low with a short trigonid composed of an anterolabial-posterolingually directed loph. The paraconid is low but the metaconid is high. The talonid basin is low with an anteroposterior directed loph. There is an extremely weak cusp within the talonid at its posterior end. Lower molars are biselenodont with anteroposteriorly reduced trigonids, unreduced anterior crests, and relatively long talonids. The paraconid on the M₁₋₂ is low and equivalent in height to the metaconid while positioned relatively close to the labial side of the tooth crown, or at the center anteriorly. A distinct paralophid is present. The metaconid is high and positioned on the lingual side. The protoconid is slightly lower than the metaconid and connected to it by a loph. The talonid is low with a selene-shaped loph, the anterior end of which

connects to the posterior trigonid wall at a point one-third from the labial margin. The entoconid is low, slightly lophate, situated near the center of the lingual margin of the talonid and extends slightly to the labial side of the crown but does not link to the cristid obliqua. The hypoconulid is situated at the center of the posterior margin of the tooth crown. The M₃ is similar to the preceding molars, but the hypoconulid has possibly formed the anteroposteriorly extended third lobe.

Table I. Upper dentition measurements (mm).

Upper dentition		<i>Asio- stylops spanios</i>	<i>Henricosbornia lophodonta</i>		<i>Noto- stylops muri- nus</i>	<i>Paleostylops iturus</i>	
			1	2		1*	2
p ₂	Length	^a 1.4	-	-	5.4	1.9	-
	Width	^a 1.6	-	-	7.0	1.5	-
p ₃	Length	2.5	5.0	4.9	7.6	1.9	-
	Width	2.5	^a 5.0	5.8	10.0	2.1	-
p ₄	Length	2.3	4.7	4.8	8.1	2.0	-
	Width	2.5	5.7	6.2	11.8	2.2	-
M ¹	Length	2.9	5.1	5.2	9.3	2.5	2.5
	Width	^a 3.0	6.1	6.3	12.0	2.9	2.7
M ²	Length	3.5	5.5	5.5	10.0	3.0	3.0
	Width	3.7	^a 6.5	6.7	12.4	3.3	3.3
M ³	Length	3.1	4.8	-	10.2	2.7	2.7
	Width	3.2	^a 6.0	-	12.1	3.2	3.1
M ¹ :M ² (Length)		82.8	92.7	94.5	93	83.3	83.3
P ² -M ³ Length		14.9	-	-	44.4	-	-

*Based upon estimated measurements of text plates.

Discussion and Comparison: Simpson (1934) recognized three families within the suborder Notioptogonia: the Arctostylopidae, Notostylopidae, and Henricosborniidae, the latter two families being known only from South America.

The specimens described above maintain dental characters typical of the Notioptogonia, particularly in their biselenodont lower molar morphology. Further obvious comparisons may be made between these specimens, the Henricosborniidae, and early species of the Arctostylopidae through features such as brachydont dentition, projection of the ectoloph, advanced development of the parastyle, the short trigonid of the lower molars, an anteroposterior extended selene-shaped cristid obliqua of the talonid, the slightly lophate shape of the entoconid, and the position of the base of the zygomatic arch, which is situated above the anterior molars. However, it may also be noted that these characters being anapomorphic are more primitive than on the other notioptogoniid species known. Unquestionably, this represents a new and significant taxon of the Notioptogonia.

Simpson (1948) believed the Henricosborniidae to be the most primitive group of the Notioptogonia, as exemplified by the genus *Henricosbornia* maintaining a complete brachydont dentition, triangularly shaped premolars, upper molars with a weak crochet, absence of cristae; and a nearly lophate entoconid on the lower molars. This tooth morphology resembles that of the Notostylopidae but is not as derived. Although the Jiangxi specimens compare to *Henricosbornia* through such characters as upper premolar and lower molar talonid morphology, the Chinese specimens are smaller, extremely low crowned, P₄ lacks a conically shaped entoconid, lower molars with a relatively distinct paraconid, hypoconid absent on upper molars and lack derived

features such as secondary structures (anterior spurs). These characters are clearly sufficient to distinguish the Chinese material from *Henricosbornia*. In spite of both preserving distinctly primitive molar morphology, *Henricosbornia* maintains apomorphic characters such as upper molars with a hypocone, molariform P3-4 lower molars with a reduced paraconid, and other relatively derived characters shared with South American notoungulates. This clearly indicates the phylogenetic relationship of the family Henricosborniidae to be more derived than the Asiostylopinae.

Table II. Lower Dentition measurements (mm).

Lower Dentition		<i>Askiostylops spanios</i>	<i>Henricosbornia lophodonta</i> (1) (2)		<i>Notostylops murinus</i>	<i>Paleostylops iturus</i>	<i>Arctostylops steini</i> *
P1	Length	1.5	-	-	-	-	-
	Width	0.5	-	-	-	-	-
P2	Length	2.5	-	-	4.7	-	-
	Width	^a 0.7	-	-	3.5	-	-
P3	Length	2.4	5.0	-	7.2	1.9	3.0
	Width	1.0	3.5	-	5.5	1.0	-
P4	Length	2.6	5.3	5.1	7.8	2.3	3.3
	Width	1.1	3.9	3.9	6.3	1.1	-
M1	Length	2.8	5.9	5.6	8.7	2.7	4.0
	Width	1.4	4.3	4.1	6.1	1.2	-
M2	Length	3.0	-	5.9	9.4	3.8	3.8
	Width	1.6	-	4.6	6.4	1.8	-
M3	Length	^a 4.0	-	6.8	12.4	3.5	3.7
	Width	1.6	-	3.8	6.3	1.1	-
M1:M2 (Length)		93.3	-	94.9	94	71.1	79.4
P4-M3 Length		12.5	-	^a 23.4	38.3	13.1	^a 14.3

*Based upon estimated measurements of text plates.

Comparisons between the Asian and North American arctostylopids suggest *Asiostylops* to closer approach the arctostylopids rather than the South American taxa. With the exception of the Early Eocene taxa, shared characters include: small brachydont dentition; simplified premolars; upper molars with well-developed parastyle, relatively lengthened ectoloph, and undeveloped secondary structures on the tooth crown; lower molars with a shortened trigonid, talonid extended and lophiform. As these characters are clearly distinct from those of the South American taxa, it is more appropriate to include the Asiostylopinae within the Arctostylopidae. Additionally, this new genus appears both more primitive and archaic than any other taxon in the family Arctostylopidae, as exemplified by the presence of the triangular upper molar that is transversely expanded, the lack of a hypocone, lower anterior premolars relatively simple, the unreduced anterior crests on the trigonid of the lower molars, and the slightly lophate entoconid within the talonid unconnected to the posterolabial crescentic-shaped cristid obliqua, which are obviously characters typical of the ancestor to the family Arctostylopidae. It is evident that based upon tooth morphology, the new material from China undoubtedly represents the most primitive taxon of this family found to date from either North America or Asia. Additionally, within the phylogenetic evolution of the suborder Notioptarion, this material occupies a relatively significant and exceptional position. Finally, with regard to taxonomic origins, it is believed here that at the very least this material represents a new subfamily of the Arctostylopidae.

Arctostylopinæ subfam. nov

Diagnosis: Molars brachydont to slightly hypsodont. M^{1-2} quadrate to subquadrate in form with a precipitous and flat lateral wall and flat and even ectoloph. The two transverse lophs do not connect lingually, or else are separated by a shallow sulcus. Pericone may be present or absent. The M^3 is triangular to subtriangular, occasionally with a metaloph. The two anterior crests of the trigonid are extremely reduced and the talonid is even more lengthened. The entoconid is extremely lophate and generally connects to the cristid obliqua.

Allostylops gen. nov

Type Genus: *Allostylops periconotus* sp. nov.

Genus Diagnosis: Size approaching the notioprogonid *Paleostylops*. Molars brachydont, slightly broad and equivalent in length and width. Upper premolars simple, but P^4 submolariform. Upper molars with projected anterior crista. A deep groove lies between the parastyle and paracone on the labial wall of the crown. Pericone is well developed and conical in shape. Pre- and postcingula unconnected lingually. Ectocingula undeveloped. M^3 triangular in shape with a distinct metaloph.

Allostylops periconotus sp. nov.

(Plate I, fig. 2; Text fig. 3)

Type: A complete skull with incomplete and damaged dentition on both sides. Specimen #V5043.

Species Diagnosis: As for genus.

Locality and Stratigraphic Position: IVPP Locality 73041, 1/2 kilometer southeast of Wangwucun, Dayu, Jiangxi. Late Paleocene upper member of Chijiang Fm. (Wangwu member).

Description: Skull short and broad, widest at the frontals. Facial region short and deep. Well-developed supraorbital projections and robust zygomatic arches. Infraorbital foramen slightly large, elliptically formed and situated above the P^4 . This specimen resembles *Notostylops* in skull morphology.



Figure 3. Occlusal view of *Allostylops periconotus* right P^2 - M^3

Dentition on both sides of skull are poorly preserved with most teeth broken. Observations of the alveolae and damaged dentition indicate the size of the canine to be equivalent to the P^1 . Anterior premolars are reduced with P^1 single rooted, and P^2 larger than P^1 with paired roots. The P^3 is subtriangular with three roots. Anterolabial side of crown is slightly expanded

anteriorly, while at the posterolingual side there is an incipient cusp. The P⁴ is slightly quadrate, submolariform, and slightly smaller than the molars, with a metaloph slightly smaller than the paraloph. A longitudinal groove is present at the lingual aspect and a posterolingual cusp may be present.

Upper molars are not excessively lengthened anteroposteriorly. The M² is largest of the molars and M¹ is slightly smaller than M³. M¹ and M² morphology are similar, being quadrate with equivalent length and breadth. The labial wall is high, level, and straight. Parastyle is extremely well developed and precrista is well projected. A noticeable longitudinal groove is present at the anterolabial side of the crown. The posterolabial wall is relatively flat and level. The metastyle is weak. The paraloph is inclined anterolingually. The metaloph is extended lingually from the metacone and is nearly the length of the paraloph. The hypocone is slightly lower than the protocone which is well projected, and a shallow trough lies between the two. A well-developed and projected pericone is present at the anterolingual side of the protocone and separated from it by a trough. The precingulum is well developed but restricted to the center of the anterior margin of the crown. The postcingulum is low and narrow, terminating at the base of the hypocone. An ectocingulum is not well developed with only a slight vestige of it at the anterolabial side of the crown. The M³ is subtriangular with a slightly small pericone. There is a distinct metastyle, and the metaloph extends from the protocone to the posterolabial side of the crown to connect with the metastyle. The postcingulum is slightly expanded at the lingual base.

Table 3. Dentition measurements (mm):

V5043	p ⁴	M ¹	M ²	M ³	p ² -p ⁴	M ¹ -M ³
Length	^a 2.1	2.3	2.5	2.5	^a 6.8	^a 7.3
Width	^a 2.3	2.5	2.6	2.5	-	-
W:L	109.5	108.7	104	100	-	-

Discussion: With the exception of *Asiostylops* described above, the family Arctostylopidae includes several derived or specialized taxa, the most typical being *Palaeostylops* and *Arctostylops*. These two taxa clearly display more derived dental morphologies such as being generally more hypsodont, having many or several molariform premolars, anterior molars generally quadrate, hypocone present, trigonid further constricted, anterior crests on lower molars further reduced, and the entoconid completely lophate and connected to the cristid obliqua. These features amply reflect that the systematic development of these taxa formed different evolutionary lineages. Therefore, these taxa are hereby included in the separate subfamily the Arctostylopinae, distinguished from the subfamily Asiostylopinae.

There is no doubt that based upon the analysis of characters enumerated above, the material from Jiangxi belongs to the subfamily Arctostylopinae, as the dental structure is extremely different from the Asiostylopinae. *Allostylops* and *Paleostylops* most closely approach each other based upon the morphology of the anterior molars, molars with a high, straight and even ectoloph, labial wall of the crown relatively flat and even, and the presence of a distinct pericone and metastyle. *Allostylops* differs from *Palaeostylops* in that its degree of P³⁻⁴ molarization is more strongly advanced, but the last molar is not as reduced as *Palaeostylops*. Additionally, the pre- and postcingula are not united lingually to form a continuous cingulum, and the pericone is universally well developed (see Table 3 for a detailed comparison of the two genera). Although there are distinct differences between the two genera, the fundamental characters of the tooth crowns are basically comparable. Consequently, they probably lie at the same evolutionary level. In addition, in spite of the difficulties in comparing the Jiangxi material to the North American Early Eocene Arctostylops (only mandibles); *Palaeostylops* may possibly be a more derived taxon than *Allostylops* as inferred from such characters as the height of the tooth crown, large dentition, a

more reduced trigonid, and other features. The same characters may be observed in the relatively early *Anatolestylops dubius* Zhai* from the Eocene of the Xinjiang Autonomous region, which also displays relative hypsodonty, molars anteroposteriorly lengthened and not very transversely broadened, and M² larger than M³. In summary, the advanced evolutionary level reflected by the dental morphology of each taxon in the subfamily Arctostylopinae is distinct and diagnostic for a separate lineage. The Asiostylopinae is intimately related to the origin of this subfamily.

II The Phylogenetic Status of *Asiostylops*

Taxonomically, the Notioprogoniaie may represent the most archaic group of notoungulates. Although in the past several notioprogoniids were found in Early Tertiary sediments of Asia, North America, and South America, from the perspective of tooth morphology, they were not considered an evolutionary ancestral group. Hence, various controversies erupted regarding the origin and systematics of these animals. Some workers believed the Notoungulates originated in the northern hemisphere (Matthew, 1925; Patterson, 1958), while others believed that if the origin of these animals was not in South America, then their genesis must have occurred in North America (Patterson et al., 1968). These hypotheses have yet to be sufficiently verified. Most recently, due to the continuous discoveries of new material in China, there is both sufficient and verifiable evidence to reconsider these problems.

Asiostylops is the oldest and most primitive form found outside the South American continent to date. Its dental characters closely resemble those exhibited in the South American Late Paleocene Rio Chican taxa, such as the toxodont family Isotemiidae; the tyothere family, Oldfieldthomasiidae, and the notioprogoniid family Henricosborniidae. These taxa all display brachydont dentition, triangular upper premolars, and biselenodont lower molars with low lophate entoconids, or symplesiomorphies that suggest the primitive nature of these taxa, and which may also express the presence of a common ancestor shared between them. A comparison with the other taxa within the Notioprogoniaie suggests that the Asiostylopinae from Asia truly possess archaic characters, including simple premolars, upper molars triangular and lacking a hypocone, uncomplicated lophodont morphology, and unreduced anterior crests of the trigonid. The asiostylopines undoubtedly retain certain characters attributable to primitive placental mammals. It is therefore evident that phylogenetically, *Asiostylops* is an ancestor to the South American taxa. Simpson (1948) stated the notoungulate family Henricosborniidae from the Early Eocene Casamayoran and the Late Paleocene Rio Chican stages of South America was more or less primitive. However, he recognized that this family certainly was not a genuine ancestral group but were conservative descendants. Additionally, he later stated that all the Notoungulate taxa from the aforementioned stages were primitive but essentially similar (Simpson, 1967). These observations are sufficient to confirm that although the Early Tertiary South American Notoungulates maintained a low standard of development, they diversified to a relatively large extent. The discovery of *Asiostylops* adds an additional element of clear evidence that the South American forms do not represent an ancestral stock but are merely a diversification of Late Paleocene to Early Eocene side branches. In summary, as quite a few primitive notoungulate fossils have been recovered from the early stages of the Chinese Early Tertiary, there is sufficient evidence to suggest that Asia, and particularly South China, is very possibly the center of origin for this group of animals.

Currently, a good portion of Asian notoungulates may be assigned to the arctostylopid subfamilies Asiostylopinae and Arctostylopinae based upon dental morphology. As previously stated the arctostylopines display more specialized and derived characters than the asiostylopines, as exemplified by the lower molars of *Arctostylops* from North America which are both higher and

* Renjie Zhai, 1978: The Mammalian Fauna of the Shisanfang Formation and its Significance toward Paleobiogeographic Studies. Monograph #14, Series I, Institute of Vertebrate Paleontology, Paleoanthropology, Academia Sinica.

narrower with a reduced and shortened trigonid, the height of their anterior crests is reduced, and their talonid basin lengthened. Matthew (1915) considered them a highly specialized form. In addition, Asia's Late Paleocene *Paleostylops* slightly resembles a primitive *Arctostylops* but in the same manner is a comparatively derived form in that the tooth crown is slightly hypsodont, the upper molar is quadrate and possesses a hypocone, the anterior crests on the lower molar trigonid are also very reduced, the lophate entoconid is derived one step further with its posterolabial attachment to the cristid obliqua, and the lower third molar lacks an entoconid. These features are also apparently present among the other arctostylopinines such as *Allostylops* and *Anatostylops* from Jiangxi and Xinjiang. Therefore, it is very possible that members of the subfamily Arctostylopininae descended directly from a member of the subfamily Asiostylopininae as did *Asiostylops*.

Bibliography

- Jepsen, G.L. and Woodburne, M.O., 1969, Paleocene Hyracothere from Polecat Bench Formation, Wyoming. *Science*, 164 (3879), 543-547.
- Lavacot, R., 1958, Notoungulata. *Traite De Paleontologie* 6, 60-120.
- Matthew, W.D., 1915, A revision of the Lower Eocene Wasatch and Wind River faunas. part IV. *Bull. Amer. Mus. Nat. Hist.* 34, 429-483.
- Matthew, W.D., Granger, W. and Simpson, G.G., 1929, Addition to the fauna of the Gashato Formation of Mongolia. *Ibid* (376), 1-12.
- McKenna, M.C., 1969, The origin and early differentiation of therian mammals. *Amer. N. Y. Acad. Sci.*, 167, 217-240.
- Patterson, B., 1934, Upper premolar-molar structure in the notoungulata with notes on taxonomy. *Field Mus. Nat. Hist., Geo. Ser.* 6(6), 91-111.
- Paula Couto, C. De, 1954, On a notostyloid from the Paleocene of Itaborai, Brazil. *Amer. Mus. Novitates* (1963), 1-5.
- Riggs, E.S. and Patterson, B.V., 1935, Description of some Notoungulates from the Casamayor (*Notostylops*) beds of Patagonia. *Proc. Amer. Philos. Soc.*, 75(2), 163-215.
- Schlosser, M., 1923, Grundzuge der Palaontologie. II. Abteilung: Vertebrata von Karly A. V. Zittle., 603-619.
- Simpson, G.G., 1934, Provisional classification of extinct South American hoofed mammals. *Amer. Mus. Novitates* (750), 1-21.
- Simpson, G.G., 1935, Description of the oldest known South American Mammals from the Rio Chico Formation. *Amer. Mus. Novitates* (793), 1-25.
- Simpson, G.G., 1948, The beginning of the age of mammals in South America. Part I. Introduction-systematics: Edentata, Condylarthra, Litopterna, and Notioprogonia. *Bull. Amer. Mus. Nat. Hist.* 91, 1-232.
- Simpson, G.G., 1948, The beginning of the age of mammals in South America. Part II. *Bull. Amer. Mus. Nat. Hist.* 137, 1-259.
- Szalay, F.S. and McKenna, M.C., 1971, Beginning of the age of mammals in Asia: the Late Paleocene Gashato fauna, Mongolia. *Bull. Amer. Mus. Nat. Hist.* 144, 273-317.
- Tang, Yingjun; and Yan, Defa, 1976, Paleocene mammalian fossils from Xuancheng, Qianshan, Anwei. *Vertebrata PalAsiatica*, 14(2), 91-99 (in Chinese).