The systematic position of Hoplitomerycidae (Ruminantia) revisited

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Supplementary materials

Table S1. Character-taxon matrix of the 121 morphological characters used for the cladistic analysis of the Hoplitomerycidae.

Table S2. Legend of characters included in the character-taxon matrix of Table S1.

Table S1. Character-taxon matrix of the 121 morphological characters used for the cladistic analysis of the Hoplitomerycidae (from Webb and Taylor, 1980; Janis and Scott, 1987; O'Leary and Geisler, 1999; Hassanin and Douzery, 2003; Geisler et al., 2007; Métais and Vislobokova, 2007).

	Character #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Praetragulidae		0	-	0	-	?	0	1	1	0	?	0	0	0	?	?	?	1	0	0	0	0	0	0	?	?	?	0	?	?	?	?
Hypertragulidae		0	-	0	-	0	0	1	1	0	0	0	0	0	1	?	0	1	0	0	0	0	0	0	0	2	1	0	0	0	?	0
Lophiomerycidae		0	-	1	1	?	0	0	?	?	1	0	?	?	?	?	?	0	0	1	?	?	0	1	?	0	1	0	1	?	?	?
Tragulidae		0	-	1	0	0	0	1	1	B	1	0	0	0	1	0	0	1	0	0	0	1	1	1	1	2	0	1	1	0	0	0
Archaeomerycidae		0	-	1	1	0	0	0	0	0	1	1	0	1	2	?	1	0	0	1	0	1	0	0	?	0	1	0	1	1	?	0
Leptomerycidae		0	-	1	1	0	0	1	1	0	1	1	0	1	2	?	1	0	0	0	0	0	0	?	0	1	0	0	1	1	?	0
Bachitheriidae		0	-	1	1	0	0	1	1	0	1	1	0	1	0	?	?	?	0	?	?	?	?	?	?	?	?	?	0	?	?	?
Gelocidae		0	-	1	1	0	0	1	1	0	1	1	0	1	0	?	?	1	1	0	0	2	?	?	0	?	?	0	0	?	?	?
Diacodexidae		0	-	0	-	0	0	?	?	0	1	0	0	0	0	?	?	?	0	0	1	-	?	?	1	?	?	0	1	0	1	0
Leptictidae		0	-	0	-	?	0	?	?	0	1	0	0	0	0	?	?	?	0	0	?	-	?	0	1	2	1	0	1	0	?	0
Palaeomerycidae		1	0	1	1	1	A	1	1	0	1	0	0	1	0	?	1	?	?	?	?	?	?	?	0	?	?	0	1	0	?	0
Bovidae		1	1	1	1	A	A	1	1	0	1	0	0	1	0	?	1	1	1	-	1	-	0	?	A	1	1	0	1	0	1	A
Antilocapridae		1	2	1	1	0	1	1	1	0	1	0	0	0	C	0	1	1	1	-	?	?	?	?	1	2	1	0	1	0	0	1
Giraffidae		1	0	1	1	0	0	1	1	0	1	0	0	0	0	0	1	1	1	-	0	1	?	?	1	1	1	0	2	0	0	0
Climacoceridae	*Canthumeryx*/*Zarafa*	1	5	1	1	1	0	1	1	0	1	0	0	?	?	?	?	?	?	?	?	?	?	?	1	?	?	0	2	?	0	1
Climacoceridae	*Climacoceras*/*Nyanzameryx*	1	4	1	1	?	0	1	1	0	1	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	2	?	0	?
Moschidae		1	7	1	1	A	A	1	1	0	1	1	0	1	2	0	1	1	1	-	0	2	?	?	1	1	1	0	0	0	1	1
Cervidae		1	3	1	1	1	1	1	1	0	1	0	0	1	0	0	1	1	1	-	?	?	0	?	A	2	1	0	1	0	1	1
Hoplitomerycidae		**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**?**	**1**	**1**	**1**	**0**	**2**	**0**	**1**	**?**

Table S1 (continued).

Character #		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Praetragulidae		?	0	0	?	?	?	0	?	?	0	?	1	1	2	0	?	?	2	1	0	0	1	?	?	0	?	?	?	?	0	?
Hypertragulidae		?	0	0	0	1	1	0	0	0	0	?	2	1	1	0	?	?	2	1	0	0	0	0	?	0	1	0	0	?	0	0
Lophiomerycidae		?	0	1	0	0	2	1	0	1	0	?	2	0	0	0	?	?	?	0	0	0	1	1	0	1	1	0	0	0	0	0
Tragulidae		0	1	1	0	2	2	1	1	1	1	0	0	2	1	1	0	0	2	1	0	0	1	1	1	1	0	1	-	1	0	0
Archaeomerycidae		?	0	1	0	0	0	1	0	0	0	?	2	0	0	0	?	?	0	1	0	0	1	1	?	1	?	?	?	1	0	0
Leptomerycidae		?	?	1	1	2	1	1	1	1	0	?	0	1	?	1	?	?	2	1	0	2	1	2	1	1	0	1	-	?	0	0
Bachitheriidae		?	0	1	?	?	1	1	?	?	?	?	1	2	1	1	?	?	2	1	0	0	1	2	0	1	0	1	-	0	0	0
Gelocidae		?	1	1	1	2	1	1	0	?	?	?	2	2	?	?	?	?	2	1	0	B	1	2	0	1	A	0	0	1	0	0
Diacodexidae		0	0	?	0	?	?	0	0	0	0	0	?	?	?	0	?	0	?	0	0	0	0	0	?	0	?	?	?	-	0	0
Leptictidae		?	0	?	0	0	2	0	0	0	0	?	2	0	0	0	?	?	0	?	0	?	0	0	?	0	?	?	?	?	0	0
Palaeomerycidae		?	0	1	1	?	0	?	1	0	1	0	A	A	1	1	?	A	2	2	A	B	1	2	A	1	1	0	A	1	0	0
Bovidae		0	0	1	1	2	2	0	1	0	1	0	A	C	A	1	0	0	2	D	B	2	1	3	A	1	1	0	0	1	0	0
Antilocapridae		?	0	1	1	2	0	0	1	0	1	0	A	2	0	1	0	0	2	3	2	2	1	3	1	1	1	0	0	1	0	0
Giraffidae		0	0	1	1	2	0	0	1	0	1	0	1	2	1	1	0	0	2	3	0	2	1	3	1	1	1	0	0	1	0	0
Climacoceridae	*Canthumeryx*/*Zarafa*	?	0	1	?	2	?	?	1	?	?	0	?	?	?	?	?	?	2	3	0	2	1	3	1	1	0	0	0	1	0	0
Climacoceridae	*Climacoceras*/*Nyanzameryx*	?	0	1	?	?	?	?	1	?	?	0	?	?	?	?	?	?	2	3	0	2	1	3	1	1	0	0	0	1	0	0
Moschidae		0	0	1	1	2	0	0	1	0	1	0	1	1	0	1	0	0	2	2	0	B	1	3	1	1	1	0	A	A	0	0
Cervidae		0	0	1	1	2	0	0	1	0	1	0	A	A	1	1	0	A	2	D	A	B	1	3	1	1	1	0	0	1	0	0
Hoplitomerycidae		**0**	**0**	**?**	**?**	**?**	**0**	**0**	**1**	**0**	**1**	**0**	**A**	**2**	**1**	**1**	**0**	**0**	**2**	**2**	**A**	**2**	**1**	**3**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**

Table S1 (continued).

	Character #	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
Praetragulidae		?	2	0	0	?	1	?	?	?	B	2	?	1	?	0	1	1	0	0	?	?	?	1	2	0	0	?	1	?	?	?
Hypertragulidae		0	0	0	0	1	1	0	1	1	1	2	1	1	0	0	1	0	0	0	0	1	0	1	2	0	0	0	1	0	0	0
Lophiomerycidae		0	2	0	0	1	1	0	1	1	0	2	1	1	1	0	1	0	1	0	1	0	0	0	C	A	0	0	0	0	0	0
Tragulidae		0	0	0	1	1	A	0	A	1	0	2	1	1	1	0	1	B	0	0	-	1	0	1	2	1	0	0	A	0	0	0
Archaeomerycidae		0	2	0	0	1	1	1	1	1	0	2	1	0	2	0	1	0	0	0	1	1	0	1	2	0	0	1	0	0	0	0
Leptomerycidae		0	2	0	0	1	1	1	1	1	0	2	1	0	2	0	1	0	0	0	1	1	0	1	2	0	A	1	1	0	0	0
Bachitheriidae		0	2	0	0	1	1	0	1	1	0	2	1	1	1	0	1	0	0	0	-	1	0	1	2	A	A	0	1	0	0	0
Gelocidae		0	2	0	1	1	A	A	1	1	0	2	A	1	0	0	1	0	1	0	1	1	0	1	2	0	1	0	A	0	0	0
Diacodexidae		0	0	0	0	0	1	?	?	?	1	0	1	1	?	1	1	0	0	0	0	1	?	-	0	0	0	?	0	0	0	0
Leptictidae		?	2	0	0	0	2	?	?	?	1	0	1	1	-	1	1	0	0	0	0	1	?	-	0	0	0	?	0	0	0	0
Palaeomerycidae		1	B	0	0	1	1	A	1	A	1	2	A	1	1	0	1	A	1	A	1	0	1	1	2	0	1	0	1	0	0	0
Bovidae		0	2	0	1	1	1	1	1	1	1	2	1	A	1	0	1	1	1	A	1	0	0	1	2	0	1	0	1	0	0	0
Antilocapridae		0	2	0	1	1	1	1	1	1	1	2	1	1	1	0	1	1	1	1	1	0	0	1	2	0	A	A	1	0	0	0
Giraffidae		0	2	0	A	1	1	1	1	A	1	2	1	1	1	0	0	1	1	1	1	0	1	1	2	0	1	0	1	0	0	0
Climacoceridae	*Canthumeryx*/*Zarafa*	0	2	0	1	1	1	1	1	0	1	2	1	1	1	0	0	1	1	1	1	0	1	1	2	0	1	0	1	0	0	0
Climacoceridae	*Climacoceras*/*Nyanzameryx*	0	2	0	1	1	1	1	1	1	1	2	1	1	1	0	0	1	1	1	1	0	1	1	2	0	1	0	1	0	0	0
Moschidae		A	2	0	1	1	1	A	1	1	1	2	0	1	0	0	1	1	1	0	1	0	A	1	2	0	1	0	1	0	0	0
Cervidae		0	2	0	A	1	1	A	A	1	1	2	A	1	1	0	1	1	1	A	1	0	0	1	2	0	1	0	1	0	0	0
Hoplitomerycidae		**0**	**B**	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**2**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**A**	**1**	**2**	**0**	**1**	**A**	**1**	**0**	**0**	**0**

Table S1 (end).

Character #		94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121
Praetragulidae		?	?	?	?	0	0	?	1	1	0	?	0	0	?	?	?	0	?	0	0	0	0	0	1	0	0	0	?
Hypertragulidae		0	0	0	-	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Lophiomerycidae		0	0	0	-	1	0	1	0	?	1	0	0	0	?	0	1	0	1	0	0	0	0	1	0	-	1	0	0
Tragulidae		0	0	0	-	0	0	0	0	0	1	1	B	1	1	D	1	1	1	E	0	0	0	1	1	1	0	0	0
Archaeomerycidae		0	0	0	-	0	0	1	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	2	0	-	0	0	0
Leptomerycidae		0	0	0	-	0	0	1	0	1	1	1	0	1	1	2	0	1	2	1	0	1	0	2	1	0	1	0	0
Bachitheriidae		0	0	0	-	1	0	1	0	?	1	1	0	?	1	2	0	1	2	1	0	0	0	2	1	0	1	0	0
Gelocidae		0	0	0	-	1	0	?	0	0	1	1	B	1	1	2	0	1	2	G	0	0	0	2	1	0	1	0	0
Diacodexidae		0	0	0	-	0	0	0	0	?	0	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	1	?
Leptictidae		1	0	0	-	?	0	?	0	?	?	0	0	0	0	0	-	0	0	0	0	0	0	-	0	0	0	1	?
Palaeomerycidae		0	0	A	0	1	0	1	0	0	?	?	2	1	1	2	0	2	2	H	1	1	A	2	1	1	1	0	3
Bovidae		0	0	0	-	1	0	1	0	0	1	1	2	1	1	2	0	2	2	G	1	1	0	2	1	1	1	0	1
Antilocapridae		0	0	0	-	1	0	1	0	0	1	1	2	1	1	2	0	2	2	F	1	C	0	2	1	1	1	0	3
Giraffidae		0	0	A	0	1	0	1	0	0	1	1	2	1	1	2	0	2	2	G	1	1	0	2	1	1	1	0	A
Climacoceridae	*Canthumeryx*/*Zarafa*	0	0	1	?	1	0	?	?	?	?	?	?	?	?	?	?	?	?	G	1	1	0	?	?	?	1	0	1
Climacoceridae	*Climacoceras*/*Nyanzameryx*	0	0	0	-	1	0	?	?	?	?	?	?	?	?	?	?	?	?	G	1	1	0	?	?	?	1	0	1
Moschidae		0	0	A	0	1	0	1	0	0	1	1	2	1	1	2	0	2	2	C	1	C	A	2	1	1	1	0	3
Cervidae		0	0	0	-	1	0	1	0	0	1	1	2	1	1	2	0	2	2	H	1	C	1	2	1	1	1	0	3
Hoplitomerycidae		**0**	**0**	**1**	**A**	**1**	**0**	**1**	**0**	**0**	**?**	**?**	**2**	**1**	**1**	**?**	**0**	**2**	**2**	**2**	**1**	**?**	**0**	**2**	**?**	**1**	**0**	**0**	**3**

Table S2. Legend of characters included in the character-taxon matrix of Table S1.

Characters		**Character states**								
Cranial characters										
1	cranial appendages	absent (0)	present (1)							
2	characters of cranial appendages (Janis and Scott, 1987):	unbranched ossicones preformed in cartilage (nondeciduous) (0)	unbranched horns (nondeciduous) with unbranched (?) nondeciduous keratin sheath (1)	branched or unbranched non-deciduous appendages with deciduous branched or unbranched keratin sheath (2)	branched deciduous antlers on top of nondeciduous pedicle (3)	branched appendages of uncertain developmental origin (nondeciduous) (4)	unbranched appendages of uncertain developmental origin (nondeciduous) (5)	appendages formed with fusion of dermal elements with skull (6)	cranial appendages supposedly secondarily lost (7)	presence of median occipital cranial appendages (8)
3	postorbital bar (Métais and Vislobokova, 2007):	open (0)	close (1)							
4	postorbital formed by (Métais and Vislobokova, 2007):	mostly jugal (0)	mostly frontal (1)	both (half-half) (2)						
5	lacrimal fossa (Janis and Scott, 1987):	absent (0)	present (1)							
6	lacrimal orifice(s) on dorsal rim of orbit (Janis and Scott, 1987):	single (0)	double (1)							
7	lacrimal (Métais and Vislobokova, 2007):	small facial and orbital parts (0)	expanded facial exposure (1)							
8	jugal (Métais and Vislobokova, 2007):	lowly situated, weakly extended anteriorly, with a long posterior spine (0)	higher situated, strongly extended anteriorly, with a short posterior spine (1)							
9	contact premaxillar-nasal (Métais and Vislobokova, 2007):	present (0)	absent (1)							
10	amastoid condition of skull (Janis and Scott, 1987):	absent (0)	present (1)							

11	mastoid exposure (Métais and Vislobokova, 2007):	lateral (0)	occipital (1)		exposed externally on posterior face of braincase as a triangle between lambdoidal crest of the squamosal dorso-laterally, the exoccipital ventrally, and the supraoccipital medially (0)	not exposed posteriorly, lambdoidal crest of squamosal in continuous contact with exoccipital and supraoccipital (1)				
12	mastoid foramen (O'Leary and Geisler, 1999):	present, skull in posterior view (0)	absent (1)							
13	position of the mastoid foramen (Métais and Vislobokova, 2007):	lateral (0)	posterodorsal (1)							
14	size of the mastoid foramen (Métais and Vislobokova, 2007):	small (0)	moderate (1)	large (2)						
15	stylomastoid foramen (O'Leary and Geisler, 1999):	complete, ectotympanic contacts tympanohyal laterally and petrosal medially, in some cases ectotympanic separated from petrosal by a narrow (< 1 mm) fissure (0)	incomplete, ectotympanic does not contact the petrosal either anterior or posterior to the fenestra rotunda, medial side of foramen open (1)							
16	tympanohyal vagina (Métais and Vislobokova, 2007):	small, posterolateral (0)	moderate, subcentral (1)							
17	fenestra vestibuli (Métais and Vislobokova, 2007):	small (0)	large (1)							
18	promontorium on petrosal (Janis and Scott, 1987):	present (0)	lost (1)							
19	promontory sulcus (Métais and Vislobokova, 2007):	present (0)	absent (1)							

20	subarcuate (floccular) fossa (O'Leary and Geisler, 1999):	present (0)	absent (1)							
21	state of subarcuate (floccular) fossa (Métais and Vislobokova, 2007):	deep (0)	moderately deep (1)	shallow (2)						
22	fossa for stapedial muscle (Métais and Vislobokova, 2007):	narrow, and posteriorly situated (behind fenestra vestibuli) (0)	displaced anteriorly to the level of the fenestra vestibuli (1)							
23	lateral wall of epitympanic recess (Métais and Vislobokova, 2007):	mostly formed by the petrosal (0)	mostly formed by the squamosal (1)							
24	ectotympanic (O'Leary and Geisler, 1999):	simple ring, no bulla formation (0);	medial edge expanded into bulla (1)							
25	stylohyoid vagina (Métais and Vislobokova, 2007):	shallow, broadly open posteriorly, and situated between the auditory bulla and tube (0)	deeper, encroached on bulla, with sharp lateral border (1)	deeper, narrower, encroached on bulla and enclosed posteriorly (2)						
26	optic foramen (Métais and Vislobokova, 2007):	fused (0)	separate (1)							
27	postglenoid process (Métais and Vislobokova, 2007):	present (0)	absent (1)							
28	postglenoid foramen (Métais and Vislobokova, 2007):	enclosed in the auditory bulla (0)	laterally open (1)	completely enclosed by postglenoid process (2)						
29	shape of foramen ovale (Métais and Vislobokova, 2007):	small, ovate (0)	slitlike (1)							
30	position of foramen ovale (O'Leary and Geisler, 1999):	anterior to glenoid fossa, posterior wall formed by alisphenoid (0)	medial to glenoid fossa, posterior wall formed by alisphenoid (1)	medial to glenoid fossa, posterior wall formed by petrosal (2)	posterior to glenoid fossa (3)					
31	ethmoidal fissure (Métais and Vislobokova, 2007):	absent or small (0)	well developed (1)							

32	foramen rotundum (O'Leary and Geisler, 1999):	absent, maxillary division of trigeminal nerve exits skull through sphenorbital fissure (0)	present (1)							
33	infraorbital canal (Métais and Vislobokova, 2007):	lowly situated and small (0)	higher situated and large (1)							
34	medial concavity of posterior edge of palate (Métais and Vislobokova, 2007):	accentuated (0)	reduced (1)							
35	position of the posterior opening of the infraorbital canal (Métais and Vislobokova, 2007):	higher than the sphenopalatine foramen (0)	opposite or lower than the sphenopalatine foramen (1)							
36	infraorbital canal opens in (Métais and Vislobokova, 2007):	maxilla (0)	on the suture separating the lacrimal and maxilla (1)	on the triple point where the lacrimal, palatine, and maxilla connect (2)						
37	palatine foramina situated (Métais and Vislobokova, 2007):	anteriorly (0)	medially (1)	both locations on the palatine (2)						
38	jugular foramen (Métais and Vislobokova, 2007):	not confluent with the posterior lacerate foramen (0)	confluent with the posterior lacerate foramen (1)							
39	basioccipital (Métais and Vislobokova, 2007):	elongated, poorly expanded posteriorly (0)	shorter, expanded posteriorly (1)							
40	basisphenoid (Métais and Vislobokova, 2007):	elongated, poorly expanded posteriorly, and strongly convex ventrally (0)	shorter, expanded posteriorly, and weakly convex or flat ventrally (1)							
41	alisphenoid (Métais and Vislobokova, 2007):	poorly expanded laterally (0)	expanded laterally (1)							

42	preglenoid process (O'Leary and Geisler, 1999):	absent (0)	present, forms transverse, ventrally projecting ridge at anterior edge of glenoid fossa (1)							
43	ventral border of the mandible (Métais and Vislobokova, 2007):	convex (0)	flattened (1)	convex anteriorly and concave posteriorly (2)						
44	angular process of the mandible (Métais and Vislobokova, 2007):	strongly convex posteriorly (0)	moderately convex posteriorly (1)	weakly convex posteriorly (2)						
45	coronoid process of the mandible (Métais and Vislobokova, 2007):	high with oblique anterior border (0)	high with subvertical anterior border (1)	high with vertical and sightly convex anterior border (2)						
46	articular process of the mandible (Métais and Vislobokova, 2007):	low (0)	high (1)							
47	mandibular foramen (O'Leary and Geisler, 1999):	small, maximum height of opening < 25% the height of the mandible at m3 (0)	large, continuous with a large posterior fossa, maximum height > 50% the height of the mandible at m3 (1)							
48	angle of dentary (O'Leary and Geisler, 1999):	distal end at same level as ventral edge of dentary below molars (0)	forms distinct flange that projects posteroventrally well below ventral edge of dentary (1)							
Dental characters										
49	upper incisors (Métais and Vislobokova, 2007):	present (0)	vestigial (1)	absent (2)						
50	upper canines (Janis and Scott, 1987):	small (0)	moderately elongated ("traguloid" type) (1)	sabrelike ("moschid" type) (2)	secondarily reduced or lost (3)					
51	height of crown (Janis and Scott, 1987):	brachydont (0)	mesodont (1)	hypsodont (2)						

52	cingulum on upper molars (Janis and Scott, 1987):	present (0)	reduced (1)	absent (2)						
53	P1 (Métais and Vislobokova, 2007):	present (0)	absent (1)							
54	P2 (Métais and Vislobokova, 2007):	subconical (0)	three labial cusps, no lingual cusp (1)	three labial cusps, and lingual extension (2)	two labial cusps, two lingual cusps (3)					
55	P3 (Janis and Scott, 1987):	posteriorly situated and directed (0)	centrally situated and lingually directed (1)							
56	premolar row (Métais and Vislobokova, 2007):	shortened (0)	elongated (1)							
57	entostyle (Janis and Scott, 1987):	small, incipient (0)	more prominent (1)							
58	metastyle (Janis and Scott, 1987):	present (0)	absent (1)							
59	metastyle (Janis and Scott, 1987):	large (0)	small (1)							
60	labial rib of metacone in upper premolars	weak to absent (0)	strong (1)							
61	P4 protocone (O'Leary and Geisler, 1999):	present (0)	absent (1)							
62	size of P4 paracone (O'Leary and Geisler, 1999):	equal or subequal to height of paracone of M1 (0)	greater than twice the height of M1 paracone (1)							
63	size of P4 metacone (Janis and Scott, 1987):	large (0)	small (1)							
64	M1 parastyle (O'Leary and Geisler, 1999):	absent (0)	weak (1)	moderate to strong (2)						
65	M2 metacone (O'Leary and Geisler, 1999):	distinct cusp, subequal to paracone (0)	distinct cusp approximately half the size of the paracone (1)	highly reduced, indistinct from paracone (2)						
66	lingual cingulum on M2 (O'Leary and Geisler, 1999):	present (0)	absent (1)							
67	ectocingula (O'Leary and Geisler, 1999):	present (0)	absent (1)							

68	M3 size (O'Leary and Geisler, 1999):	present, larger than M2 (0)	present, approximately equal to M2 (1)	present, small, maximum mesiodistal length < 60% of the length of M2 (2)	absent (3)					
69	M3 metaconule (Janis and Scott, 1987):	small (0)	large (1)							
70	bifurcated posterior wing of protocone on molars (Janis and Scott, 1987):	present (0)	absent (1)							
71	bifurcated posterior wing of metaconule on molars (Janis and Scott, 1987):	present (0)	absent (1)							
72	mesostyle on upper molars (Métais and Vislobokova, 2007):	present (0)	absent (1)							
73	upper molar paraconule (Métais and Vislobokova, 2007):	well developed (0)	vestigial (1)	absent (2)						
74	"Palaeomeryx fold" (Janis and Scott, 1987):	present (0)	absent (1)							
75	i1-i3	procumbent (0)	nonprocumbent (1)							
76	i1	spatulate (0)	fan shaped (1)	enlarged, procumbent (2)						
77	lower canine (Métais and Vislobokova, 2007):	incisiform (0)	caniniform (1)							
78	bilobed lower canine (Janis and Scott, 1987):	present (0)	absent (1)							
79	p1 (Métais and Vislobokova, 2007):	present (0)	absent (1)							
80	p3 metaconid (O'Leary and Geisler, 1999):	absent (0)	present (1)							
81	paraconid on p4 forming lingual wall to tooth (Janis and Scott, 1987):	absent (0)	present (1)							

82	p4 metaconid (Métais and Vislobokova, 2007):	absent (0)	present (1)							
83	lower premolars with small metaconid, without posterior extension of metaconid forming posterolingual wall to tooth (Janis and Scott, 1987):	present (0)	absent (1)							
84	vertical groove on posterolingual region of p4 (Janis and Scott, 1987):	absent (0)	present (1)							
85	trigonid on lower molars (Métais and Vislobokova, 2007):	open mesiolingually (0)	closed (1)							
86	lower molar paraconid (Métais and Vislobokova, 2007):	present (0)	vestigial (1)	absent (2)						
87	lower molar Dorcatherium fold (Métais and Vislobokova, 2007):	absent (0)	present (1)							
88	lower molar metastylid (Métais and Vislobokova, 2007):	absent (0)	present (1)							
89	ectostylids in lower molars (Janis and Scott, 1987):	present (0)	absent (1)							
90	lower molar postentocristid (Métais and Vislobokova, 2007):	absent (0)	present (1)							
91	m1 metaconid (O'Leary and Geisler, 1999):	present, forms distinct cusp (0)	absent or occasionally present as swelling on lingual side of protoconid (1)							
92	m2 metaconid (O'Leary and Geisler, 1999):	present, forms distinct cusp (0)	absent or occasionally present as swelling on lingual side of protoconid (1)							

93	m3 metaconid (O'Leary and Geisler, 1999):	present, forms distinct cusp (0)	absent or occasionally present as swelling on lingual side of protoconid (1)							
94	m1-m2 hypoconulid (O'Leary and Geisler, 1999):	absent (0)	present (1)							
95	m3 hypoconulid (O'Leary and Geisler, 1999):	long, protrudes as separate distal lobe (0)	short, does not protrude substantially beyond rest of talonid (1)	absent (2)						
96	lobe on m3	formed only by hypoconulid (0)	formed by hypoconulid and entoconulid (1)							
97	double posterior lobe on m3 (Janis and Scott, 1987):	closed posteriorly (0)	open posteriorly (1)							
98	anterior cingulum on lower molars (Janis and Scott, 1987):	absent (0)	present (1)							
99	lingual cingulid on lower molars (O'Leary and Geisler, 1999):	poorly defined or absent (0)	continuous from mesial to distal extreme (1)							
Postcranial characters										
100	axis with odontoid process possessing high dorsal crest with high anterior articulatory surfaces (Janis and Scott, 1987):	absent (0)	present (1)							
101	radius and ulna (Métais and Vislobokova, 2007):	separate (0)	partly fused (1)							
102	facet for the triquetrum (pyramidal bone) on the distal articular surface of the radius (Métais and Vislobokova, 2007):	present (0)	absent (1)							

103	trapezoid and magnum (Métais and Vislobokova, 2007):	separate (0)	fused (1)							
104	trapezium (Métais and Vislobokova, 2007):	present (0)	absent (1)							
105	metacarpals III and IV (Métais and Vislobokova, 2007):	separate (0)	partly fused (1)	fully fused (2)						
106	metacarpals II and V (Métais and Vislobokova, 2007):	nonreduced (0)	reduced (1)							
107	metacarpal I (Métais and Vislobokova, 2007):	present (0)	absent (1)							
108	tibia and fibula (Métais and Vislobokova, 2007):	separate (0)	partly fused (1)	reduced to a malleolar bone (2)						
109	fibular facet on the calcaneum (Métais and Vislobokova, 2007):	present (0)	absent (1)							
110	metatarsals III and IV (Métais and Vislobokova, 2007):	separate (0)	partly fused (1)	fully fused (2)						
111	metatarsals II and V (Métais and Vislobokova, 2007):	slightly reduced (0)	strongly reduced (1)	lost (2)						
112	fusion of metapodials (Janis and Scott, 1987):	unfused (0)	fused with open gully (1) 28A	fused with closed gully (2) 28B	fused with secondarily open gully (from closed gully) (3) 28C	fused and elongated over traguloid condition (metacarpals similar length to metatarsals) (4) 28D				
113	distal metapodial keels (Janis and Scott, 1987):	incomplete (0)	complete (1)							
114	side toes (Janis and Scott, 1987):	complete and retained (0)	partially lost (proximal or distal ends) (1)	completely lost, metapodials further elongated (2)						

115	posterior tuberosity on metatarsus (Janis and Scott, 1987):	absent (0)	present (1)							
116	shape of the fibular facet on calcaneum (Métais and Vislobokova, 2007):	large and convex (0)	concave (1)	large proximal convexity and small distal concavity (2)						
117	cuneiforms II and III (Métais and Vislobokova, 2007):	separate (0)	fused (1)							
118	ectomesocuneiform and cubonavicular (Métais and Vislobokova, 2007):	separate (0)	fused (1)							
119	trochlea of astragalus (Métais and Vislobokova, 2007):	nonaligned (0)	aligned (1)							
120	cuboid and navicular (Métais and Vislobokova, 2007):	fused (0)	separate (1)							
121	cubonavicular facet on proximal metatarsus (Janis and Scott, 1987):	high and pointed (0)	very flat and broad (1)	somewhat flattened (2)	raised, but not as sharply as in 136 new (0) (3)					

Supplementary references

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