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SUPPLEMENTARY DATA

New material of a ‘short-faced’ *Trogosus* (Mammalia, Tillodontia) from the Delmar Formation (Bridgerian), San Diego County, California, U.S.A.

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TABLE S1. Other comparative measurements (in mm) of cranium and dentary of *Trogosus* and *Tillodon*. * and ‘a’ indicate actual dimensions measured at broken portions and estimated dimensions, respectively. ‘g’ indicates the measurement from Gazin (1953). Average is cited here when the measurements on right and left sides are available. Measurements parentheses of *T. castoridens* and *Tillodon fodiens* are based on ANSP 10337 (holotype) and USNM 18164 (paratype), respectively.

	<i>T. castoridens</i> SDSNH 40819	<i>T. hyracoides</i> USNM 17886	<i>T. grangeri</i> AMNH 17008	<i>T. hillsii</i> USNM 17157	<i>Tillodon</i> <i>fodiens</i> YPM 11087
Cranium					
Length from posterior edge of I2 alveolus to posterior surface of postglenoid process	222.2	250.4	242.0	—	288.0g
Postglenoid length, from posterior surface of postglenoid to posteriormost projection of occipital condyle	25.7	—	22.8	22.2	30.6
Postpalatal length, from anteriormost point on posterior edge of palate to posteriormost projection of occipital condyle	117.8	—	132.6	135.0	150.6
Distance from posterior edge of I2 alveolus to lachrymal foramen	87.0	96.7	101.7	—	120.0g
Distance between lachrymal foramen and posterior surface of postglenoid process	138.7	157.8	147.3	142.0g	170.0g
Width of nasals at anterior border	12.9	18.4	25.4	20.0	28.1
Greatest width of nasals between maxillofrontal sutures	33.1	39.6	47.3	47.8	59.8

TABLE S1. (Continued)

Width of occiput, across nuchal crest	83.0a	—	121.5	99.0a	122.9a
Palate width between P3 alveoli, between M3 alveoli	32.7, 36.7	33.5, 35.4	38.8, 42.5	37.0, 35.4	40.2, 50.0
Width x height of foramen magnum	20.8 x 14.7	—	27.5 x 20.3	21.7 x 18.2	27.0 x 17.5
Height of skull, from palate at M3 to anterior extent of the sagittal crest	51.7*	97.8	120.3	82.8	104.2
Dentary					
Length from posterior margin of alveolus for i2 to posterior surface of condyle	—	217.0ag	230.0g	—	248.0g
Length from posterior margin of alveolus for i2 to posterior margin of angle	—	216.0ag	228.0g	—	—
Length of symphysis	70.5	75.0ag	76.8g	68.0g	91.0g
Distance between top of coronoid process and bottom of angle	124.7	136.0g	138.0g	—	(165.0ag)

TABLE S2. Tooth measurements (in mm) of SDSNH 40819, *Trogosus castoridens*. * and ‘alv’ indicate dimensions measured at broken portion of crown and at alveolus, respectively.

		Left	Right
Upper teeth			
I2	length	17.4	16.7
	width	14.8	13.9
I3	length	13.3alv	12.6
	width	9.8alv	8.9
C1	length	8.4	8.5
	width	6.2	6.0
P2	length	7.3alv	7.2alv
	width	5.7alv	5.4alv
P3	length	14.1	13.8
	width	15.3	14.8
P4	length	13.5	13.4
	width	22.1	22.2
M1	length	17.2	19.5*
	width	25.2	26.4*
M2	length	18.9	20.4
	width	30.0	33.1*
M3	length	16.6	16.6
	width	30.9	33.2*
I2 tip–M3	length	147.2	145.5
P2alv–M3	length	84.2	83.7
M1–3	length	51.5	52.0
I2–P2 distance		41.5alv	39.9alv
C1–P2 distance		6.9alv	6.6alv
Lower teeth			
m2	width of talonid	14.9	14.3
m3	length	27.9	27.2
	width of trigonid	16.4	16.3
	width of talonid	13.2	13.5
	width of third lobe	9.7	9.7

TABLE S3. Measurements of cervical vertebrae of SDSNH 40819, *Trogosus castoridens* and AMNH 17008, holotype of *Trogosus grangeri*. *, and ‘a’ indicate actual dimensions measured at broken margins and estimated dimensions of complete element, respectively. AP, L, and R mean anteroposterior, left, and right, respectively.

	<i>T. castoridens</i> SDSNH 40819	<i>T. grangeri</i> AMNH 17008
Atlas, AP length of body	35.6	33.4
height	36.0	40.8
width	87.3	97.9
maximum articular width for condyle	46.82	52.6
maximum articular width for axis	45.3	46.5
transverse foramen	4.5 x 3.1L, 3.5 x 2.5R	12.0 x 6.8L, 10.8 x 7.5R
Fifth cervical, AP maximum length of body	28.6	
height	50.3	
width	50.8*, 55.4a	
length and width of centrum	16.4, 27.1	
Sixth cervical, AP maximum length of body	27.1	
height	49.7	
width	58.9*, 63.7a	
length and width of centrum	15.1, 26.7	
Seventh cervical, AP maximum length of body	23.3	
height	47.7	
width	57.7*, 63.4a	
length and width of centrum	12.7, 27.8	

APPENDIX S1. Characters and character states used in the phylogenetic analysis. Descriptions and character coding for characters 1–27 and 29–32 (dental and mandibular characters) are taken directly from the characters 1–27 and 28–31 in Miyata (2007). Characters 9 and 20 are modified with the varieties of P4 size and I2–P2 distance, respectively. See also comments and references for dental and mandibular characters in Supplementary Data in Miyata (2007), although those are omitted here. Character 28 is newly subsumed based on the examinations of the present study. Unless otherwise noted, the character coding for skull and atlas are basically based on the examinations for the following specimens: ingroup taxa: *Trogosus castoridens* (SDSNH 40819), *T. hyracoides* (USNM 17886), *T. grangeri* (AMNH 17008, holotype), *T. hillsii* (USNM 17175, holotype), *Tillodon fodiens* (YPM 11087, holotype); outgroup taxa: *Azygonyx ancylion* (UM 68511, holotype; see Gingerich and Gunnell, 1979), *Esthonyx acutidens* (USNM 18202; see Gazin, 1953).

Upper dental characters

1. P2 root(s).
 - (0) Two roots.
 - (1) Single root.
2. P3 parastyle.
 - (0) Low crest-like cusp on the anterior slope of paracone.
 - (1) Diminutive (much reduced) or lost.
 - (2) Large and cusp-like parastyle, separating from paracone by a notch.
3. P3 paracone.
 - (0) Intermediately or slightly anteriorly positioned paracone, without a labial enamel extension to root.
 - (1) Anteriorly positioned paracone, with a labial enamel extension to root.
4. P3 metastyle.
 - (0) Low and obtuse cusp, showing a symmetric aspect with parastyle.
 - (1) Posteriorly expanded, developed crest-like cusp, forming a broad ectoflexus.
5. Precingulum (anterolingual cingulum) on P4–M3.
 - (0) Present, as a defined shelf- or crest-like structure.
 - (1) Reduced or lost.
6. Styler shelf and ectocingulum (labial cingulum between parastyle and metastyle) on P4–M3.
 - (0) Present, as shelf-like structure (styler shelf).
 - (1) No shelf-like structure, but sometimes with weak and discontinuous cingulum.
7. Lingual crests (preprotocrista and postprotocrista) from P4 protocone, and position of P4 paracone.
 - (0) Symmetric (V-shaped crests), and mid-positioned paracone.

APPENDIX S1. (Continued)

- (1) Slightly asymmetric with relatively expanded postprotocrista, and anteriorly positioned paracone.
 - (2) Distinctly asymmetric with well-expanded postprotocrista and reduced preprotocrista, anteriorly positioned paracone, and anteriorly swelling lingual wall of P4.
8. Hypoconal crest (posterolingual cingulum, postcingulum) on P4.
- (0) Present, a shelf- or crest-like structure.
 - (1) Reduced as a small enamel pit or lost.
9. M1 size relative to P4: ratio of M1/P4 in crown area (length x width).
- (0) Moderately larger than P4: approximate range = 1.10–1.45.
 - (1) Much larger than P4: approximate range = 1.60–1.90.
10. Hypoconal crest (posterolingual cingulum, postcingulum) on M1–2.
- (0) Cingulum or crest-like structure, less developed than pre- and postprotocristae.
 - (1) Expanded hypoconal crest, a shelf-like structure with a square posterolingual edge, as developed as pre- and postprotocristae.
11. M3 size relative to M2: ratio of M3/M2 in crown area (length x width).
- (0) Smaller than M2: approximate range = 0.74–0.97 (average 0.83).
 - (1) Larger than M2: approximate range = 1.18–1.32.
12. “Enamel loop” (Gazin, 1953:66) in trigon basin of M1–3.
- (0) Absent.
 - (1) Present.
13. Mesostyle on M1–3.
- (0) Absent.
 - (1) Present.
- Lower dental characters**
14. i1.
- (0) Present.
 - (1) Absent.
15. i2 (I2) morphology.
- (0) Rooted, with oval cross section.
 - (1) Rootless, with posteriorly elongated dentine and labial enamel layer extending to the basal end.
16. A longitudinal groove on i2 labial enamel surface.

APPENDIX S1. (Continued)

- (0) Absent, flattened or smooth surface.
- (1) Present.

17. i3.

- (0) Present, smaller than i1 and than c1.
- (1) Much vestigial or possibly lost, because of no space between i2 and c1.
- (2) Lost, despite enough space (long diastema) between i2 and c1.

18. c1.

- (0) As large as, or slightly smaller than i2.
- (1) Reduced, apparently smaller than i2, almost the same size as i3 or p2.

19. p2 root(s).

- (0) Two roots.
- (1) Single root.

20. i2–p3 distance (diastemata anterior to p3) or I2–P2 distance: ratio of length from i2 posterior edge to p3 anterior edge with the diastemata / length of lower cheek teeth (p3–m3), or ratio of length from I2 posterior edge to P2 anterior edge with the diastemata / length of lower cheek teeth (P3–M3).

- (0) Moderately long: approximate range = 0.30–0.35 (0.59–0.61 in upper dentition).
- (1) Shorter: approximate range = 0.22–0.27 (0.50–0.54 in upper dentition).
- (2) Longer: approximate range = 0.37–0.41 (0.65–0.71 in upper dentition).

Comment: This character is closely related with the length of the snout. The diastema between p2 and p3 (longer one among lower diastemata) and that between C and P2 (longer one among upper diastemata, but not in *T. hillsii*) are also correlative.

21. Unilateral hypsodonty of lower cheek teeth: ratio of labial enamel expansion of the tooth / the tooth length (m1 or m2, preferable).

- (0) Less hypsodont: less than 0.4 (approximate range = 0.28–0.38).
- (1) Moderately hypsodont: approximate range = 0.41–0.48.
- (2) Greatly hypsodont: over 0.57 (approximate range = 0.58–0.72).

22. Metaconids of lower molars.

- (0) Relatively conical and slender, with no strong posterior projection over protocristid.
- (1) Elongated anteroposteriorly, with flat lingual wall and defined posterior projection.

23. Anterolingual connection of cristid obliqua in lower molars.

- (0) Almost at the middle of protocristid.
- (1) At lingual position of protocristid, close to metaconid (posterolabial side of metaconid).

APPENDIX S1. (Continued)

24. Size of m2 relative to m1: ratio of m2/m1 in crown area (length x width).
(0) Slightly larger than m1: approximate range = 1.06–1.22.
(1) Moderately larger than m1: approximate range = 1.22–1.52.
(2) Much larger than m1: approximate range = 1.60–1.65.
25. m2 hypoconulid and entoconid.
(0) No basin structure, with a conical or weak crest-like hypoconulid and a conical entoconid.
(1) No basin structure, with a lingually positioned crest-like hypoconulid and a conical entoconid.
(2) Basin-shaped (lingually positioned hypoconulid-entoconid basin), with connection between a crest-like hypoconulid and a conical entoconid by a low enamel ridge.
26. m3 metastylid.
(0) Single, weak or prominent.
(1) Double (twinned) and weak.
(2) Much reduced (possibly absent).
27. m3 third lobe (m3 hypoconulid basin).
(0) No basin structure and no posthypocristid: a conical hypoconulid and a small crest-like entoconid.
(1) Basin-shaped, with a weak posthypocristid.
(2) Basin-shaped, with a distinct posthypocristid
28. Groove on lingual surface of m3 talonid (lingual extension of occlusal notch between entoconid and third lobe (= hypoconulid)).
(0) Absent
(1) Present

Mandibular characters

29. Mandibular depth: ratio of the maximum depth of mandible / m2 size in the natural logarithmic crown area (Ln length x width).
(0) Shallow: less than 7 (approximate range = 4.19–6.85).
(1) Moderate: approximate range = 8.08–8.97.
(2) Deep: over 10 (approximate range = 10.12–11.27).
30. Lateral shape of mandible.
(0) Depth decreasing anteriorly from m3.
(1) Depth decreasing anteriorly from p3.
31. Mandibular symphysis.
(0) Unfused

APPENDIX S1. (Continued)

- (1) Fused, with posterior expansion under p3 or more anterior
- (2) Well-fused, further posteriorly extending at least under p4 talonid

32. Thickness (robustness) of mandibular ramus and depth of masseteric fossa.

- (0) Thin to moderate thickness with a shallow masseteric fossa.
- (1) Very thick (massive) with a deep masseteric fossa.

Cranial characters

Premaxilla + Maxilla

33. Rostral depth relative to palatal length (ratio of rostral depth / palatal length, Table 1).

- (0) Shallow: approximate range = 0.27–0.29.
- (1) Moderate: approximate range = 0.33–0.35.
- (2) Deep: approximate range = 0.38–0.41.

Comment: Rostral depth / palatal length values are as follows: *T. castoridens* (SDSNH 40819), 0.27; *Esthonyx*, 0.29; *Tillodon fodiens*, 0.33; *Azygonyx*, 0.34; *T. hyracoides*, 0.35; *T. grangeri*, 0.41. The skull of *T. hillsii* lacks the anterior part of the rostrum (as preserved palatal length = 128.2 mm, ratio: 0.42). The complete palatal length was clearly shorter than that of *T. grangeri* (149.2 mm) as evidenced by the short dental diastemata anterior to P2 in *T. hillsii*. The ratio, if applied to the same palatal length of *T. grangeri*, becomes 0.36, which should be less than the expected ratio of *T. hillsii* and is greater than that of *T. hyracoides*. The deformed rostrum of SDSNH 40819 yields an approximate minimum rostral depth of 37.7 and a ratio of 0.27.

Premaxilla + Maxilla

34. Pattern of premaxilla-maxilla suture on lateral surface of rostrum.

- (0) Gently extending posteriorly with a faint inflection above the level of the infraorbital foramen.
- (1) Weak sigmoid contact with a right-angled flexure slightly above the level of infraorbital foramen.
- (2) Sigmoid contact with an intricate sub-vertical flexure above the level of the infraorbital foramen, between C1 and P2.

Comment: Based on the incomplete rostrum of USNM 18202 (*E. actidens*), *Esthonyx* appears to possess either states 0 or 1. The rostrum of *Tillodon fodiens* preserves a sigmoid pattern of the suture on left lateral side (the right side is damaged) (Fig. 7H).

Premaxilla + Maxilla

35. Narrowness of posterodorsal process of premaxilla (measured as the angle between the premaxilla-nasal and premaxilla-maxilla sutures).

- (0) Broad: approximate range = 57–64°.
- (1) Narrow: approximate range = 33–48°.

Comment: Angular measurements for various tillodont taxa are as follows: *T. castoridens* (SDSNH 40819) = 33.5°; *T. hyracoides* = 47.2°; *Tillodon fodiens* = 57.2°; *T. grangeri* = 62.5°; and *T. hillsii* = 63.1°.

APPENDIX S1. (Continued)

Premaxilla

36. Posterior extension of palatine process of premaxilla, or the anterior edge of palatine junction with maxilla.

- (0) Midpoint of I3 alveolus or more anterior.
- (1) Posterior margin of I3 alveolus.
- (2) Between I3 and C1.

Premaxilla

37. Anterior parts of premaxillae along the external nares.

- (0) Weak, not projected.
- (1) Stout ridge-like projection.

Nasal

38. Alignment of lateral margins of paired nasals between premaxillae.

- (0) Nearly parallel lateral margins of nasals (not anteriorly convergent).
- (1) Slightly narrower anteriorly, or slightly anteriorly convergent.

Comments: Although the anterior portions of the nasals in both *T. hillsii* and *Tillodon fodiens* are incomplete, the lateral margins of the paired nasals are nearly parallel (1), unlike in *T. hyracoides*.

Nasal

39. Posterior margin of paired nasals intrusion into frontals at the midline (computed as ratio of the anteroposterior length of nasal from maxilla-frontal suture to the posterior-most end of nasal / total nasal length).

- (0) Shallow: approximate range = 0.20–0.24.
- (1) Deep: approximate range = 0.30–0.32.

Comment: The ratio for various tillodont taxa are as follows: *T. hillsii* = 0.20 (estimated); *T. grangeri* = 0.23; *Tillodon fodiens* = 0.24 (estimated); *T. hyracoides* = 0.30; *T. castoridens* (SDSNH 40819) = 0.31.

Nasal

40. Shape of posterior border of paired nasals (frontonasal sutures).

- (0) V-shaped.
- (1) Rectangular.

Nasal

41. Lateral intrusion of nasals between maxilla and frontal (into maxilla-frontal suture).

- (0) Absent.
- (1) Weak.
- (2) Deep.

Nasal + Maxilla

APPENDIX S1. (Continued)

42. Length of maxilla-nasal contact (ratio of the anteroposterior length of maxilla-nasal contact / total nasal length).

(0) Moderate: approximate range = 0.10–0.14.

(1) Long: > 0.20.

(2) No maxilla-nasal suture (point-like contact with maxilla).

Comment: The ratio for various tillodont taxa are as follows: *T. grangeri* = 0.11; *T. hyracoides* = 0.12; *Tillodon fodiens* = 0.14; *T. hillsii* = 0.22 (estimated).

Maxilla

43. Shape of infraorbital foramen (ratio of W/H)

(0) Nearly circular: approximate range = 1.0–1.3.

(1) Dorsoventrally elongated, or ovoid: > 1.8.

Comment: The ratio for various tillodont taxa are as follows: *Azygonyx* = 1.0; *Esthonyx* = 1.1; *Tillodon fodiens* = 1.2; *T. hyracoides* = 1.3; *T. hillsii* = 1.8; *T. grangeri* = 2.0. Because of the deformed rostrum of SDSNH 40819, *T. castoridens* is scored as unknown (?). This deformation is largely the result of dorsoventral compression, but the infraorbital foramen was probably nearly circular with an approximate diameter = 5.6 mm.

Maxilla

44. Position of paired palatine foramina on palatal processes with anteriorly-directed sulci (Gazin, 1953).

(0) Anteromedial or medial to P3.

(1) Medial to P2.

Comment: The presence of the palatine foramina in *T. hillsii* and *Azygonyx* is obscure owing to poor preservation.

Maxilla

45. Lateral constriction of rostrum, showing lateral concavity of the alveolar process of the maxilla between C1 and P2.

(0) Weak.

(1) Distinct.

Comments: The character seems to vary in *T. hyracoides*; the concavity is distinct (1) in YPM 11084 (holotype), but weak (0) in USNM 17886.

Palatine

46. Position of anterior margin of choanae (or posterior margin of horizontal process of palatine).

(0) At level close to posterior margin of M3 crown.

(1) Almost at level of M3 paracone.

Palatine

47. Posterior palatine sulcus, continuing to the saddle-shaped flexion between the horizontal and

APPENDIX S1. (Continued)

perpendicular processes.

(0) Broad.

(1) Narrow.

Palate (Premaxilla + Maxilla + Palatine)

48. Palatal length, ratio of palatal length / condylobasal length (related to basicranial length).

(0) Palate < basicranium (slightly longer basicranium): < 0.48.

(1) Palate > basicranium (slightly longer palate): approximate range = 0.52–0.57.

Comment: Trogonine tillodonts generally possess basicrania that are shorter than palatal length.

The ratios for various tillodont taxa are as follows: *Azygonyx* = 0.48; *T. hyracoides* = 0.53 (estimated); *T. grangeri* = 0.53; *T. hillsii* > 0.53 (estimated); *T. castoridens* (SDSNH 40819) = 0.54; *Tillodon fodiens* = 0.56.

Lacrimal

49. Facial process and anterior orbital rim.

(0) Narrow facial process, anterior to a saddle-shape curvature partially forming the orbital rim.

(1) Concave facial process with anterior border partially delimitating the orbital rim (not anteriorly extending beyond the orbital rim).

Lacrimal

50. Position of lacrimal foramen.

(0) Almost on anterior orbital rim.

(1) Anterior to orbital rim, on the facial process of lacrimal.

(2) Posterior to orbital rim.

Lacrimal

51. Lacrimal tubercle

(0) Absent.

(1) Present, faint.

(2) Present, strong.

Jugal + Maxilla

52. Masseteric margin of jugal and zygomatic process of maxilla.

(0) Narrow jugal with acute masseteric margin (ventral ridge) above M3 and shallow depression between zygomatic and alveolar processes of maxilla above M2–3.

(1) Robust jugal with rounded masseteric margin, with no depression between zygomatic and alveolar processes of maxilla

Zygomatic Arch

53. Lateral expansion of zygomatic arch, ratio of distance between zygion and sagittal crest / anteroposterior length of orbitotemporal fossa.

APPENDIX S1. (Continued)

- (0) Weakly expanded: < 0.75 .
- (1) Moderately expanded: approximate range = 1.00–1.06.
- (2) Well expanded: > 1.26 .

Comment: The ratios for various tillodont taxa are as follows: *Azygonyx* = 0.75 (estimated); *T. hillsii* = 1.00 (estimated); *T. hyracoides* = 1.00; *T. castoridens* (SDSNH 40819) = 1.06; *T. grangeri* = 1.30; *Tillodon fodiens* = 1.26 (estimated).

Zygomatic Arch

54. Position of the zygion, for anteroposterior length of orbitotemporal fossa.

- (0) Anteriorly positioned (about mid-position along length of fossa), on the contact of jugal with the zygomatic process of squamosal: approximate range = 0.51–0.58.
- (1) Posteriorly positioned (posterior one third to one fifth), on the zygomatic process of squamosal: approximate range = 0.70–0.85.

Comment: The ratios for various tillodont taxa are as follows: *T. grangeri* = 0.51; *Azygonyx* = 0.58 (estimated); *T. castoridens* (SDSNH) = 0.70; *T. hillsii* = 0.75; *T. hyracoides* = 0.81; *Tillodon fodiens* = 0.85 (estimated).

Frontal

55. Dorsal aspect of frontal (ratio of maximum L/W on vertex).

- (0) Moderate: approximate range = 0.9–1.0.
- (1) Short: approximate range = 0.7–0.8.

Comment: The ratio is following; *T. grangeri* = 0.7; *T. hillsii* = 0.8; *Tillodon fodiens* = 0.9; *T. castoridens* = 0.9; *T. hyracoides* = 1.0. Although the sutural position is obscure in *Azygonyx* skull, *Azygonyx* potentially has a ratio greater than state 0 (more than 1.2).

Frontal

56. Supraorbital rim, distance between lacrimal foramen and postorbital process.

- (0) Moderate.
- (1) Short.
- (2) Long.

Comment: The comparative measurements of trogosines are shown in the Table 1. The supraorbital rim in *Azygonyx* seems to be moderately long.

Frontal

57. Postorbital process.

- (0) Blunt.
- (1) Distinct.

Frontal

58. Postorbital constriction.

- (0) Present.
- (1) Absent.

APPENDIX S1. (Continued)

Parietal

59. Dorsolateral surface of parietal, comprising side walls of braincase.

(0) Dorsolaterally bulged with prominent swelling.

(1) Posteriorly narrow without bulging.

Comment: *Azygonyx* has the dorsolaterally bulged parietal comprising the braincase, but its relatively longer parietal is constricted anterior to the braincase unlike in trogosines (character 58(0)). *Tillodon fodiens*, tentatively scored as 1, has a broader parietal than in *T. hyracoides* and *T. castoridens*, but has no distinct bulging unlike in *T. grangeri* and *T. hillsii*.

Parietal

60. Coronal narrowness of parietals between squamosals in dorsal view, ratio of narrowest width of paired parietal / greatest width of occiput.

(0) Narrow: approximate range = 0.19–0.24.

(1) Wide: approximate range = 0.32–0.36.

Comment: The ratios for various tillodont taxa are as follows: *T. hyracoides* = 0.19; *Azygonyx* = 0.22; *T. castoridens* (SDSNH) = 0.24; *Tillodon fodiens* = 0.32; *T. grangeri* = 0.35; *T. hillsii* = 0.36.

Parietal

61. Sagittal crest, ratio of sagittal crest length / skull length; depth of sagittal crest

(0) Long: approximate ratio = 0.45; shallow.

(1) Short: approximate range = 0.34–0.37; shallow.

(2) Short: approximate range = 0.34–0.37; deep (well-developed).

Pterygoid Plate (perpendicular Palatine + Alisphenoid + Pterygoid)

62. Ventral outline of the pterygoid plate in lateral view, from the perpendicular process of palatine to pterygoid.

(0) Straight (gradually descends posteriorly), with shallow pterygoid.

(1) Concave, with downwardly developed pterygoid.

Comment: This character is related to the depth of the pterygoid, rather than to the shortness of pterygoid plate. The state in *T. hillsii* is unknown because of the poor preservation of the holotype skull.

Alisphenoid

63. Size and position of posterior opening of alisphenoid canal.

(0) Smaller than the foramen ovale and positioned close to the latter with a weak depression between the two.

(1) As large as the foramen ovale and connected to the latter by a distinct, short channel.

(2) Approximately as large as the foramen ovale and connected to the latter by a long channel.

APPENDIX S1. (Continued)

Basisphenoid

64. Midline crest (ventral keel).

- (0) Absent, or very weakly developed.
- (1) Present, strongly developed.

Squamosal

65. Suprameatal crest of squamosal.

- (0) Undeveloped, or forming no continuous crest uniting the nuchal crest and dorsal crest of the zygomatic process.
- (1) Developed, or forming continuous crest between the nuchal crest and dorsal crest of the zygomatic process (formation of a concave triangular shelf of the squamosal in dorsal view).

Squamosal

66. Postglenoid process

- (0) Tab-like, or transversely narrow projection with a short lateral process (expanded less than half of glenoid fossa).
- (1) Transversely wide with a long lateral process extending close to the lateral end of the glenoid fossa.

Squamosal

67. Glenoid fossa.

- (0) Expanded anteromedially.
- (1) Narrow anteroposteriorly.

Squamosal + Parietal

68. Nuchal crest near midline.

- (0) Anteriorly turned (upturned).
- (1) Posterodorsally projected.

Auditory Region + Occipital

69. Occipitomastoid process

- (0) Knob-like (bulbous).
- (1) Anteroposteriorly compressed.

Occipital

70. Occipital shield.

- (0) Concave shield, with apparent dorsal condyloid fossa, exoccipital crests, and swelling at the center.
- (1) Relatively flattened shield, with faint dorsal condyloid fossa and weak exoccipital crests.

APPENDIX S1. (Continued)

Basioccipital

71. Narrowness of width between occipital condyles, ratio of anteroposterior length of condyle / width between the condyles (related to the anteroposterior oblateness of condyles, or to the width of odontoid notch)

(0) Broad width (approximate range = 0.23–0.34) and laterally expanded (i.e., anteroposteriorly compressed) occipital condyles.

(1) Narrow width (> 0.47) and posterolaterally faced occipital condyles.

Comment: The ratios for various tillodont taxa are as follows: *Azygonyx* = 0.24; *T. grangeri* = 0.32; *T. hillsii* = 0.33; *Tillodon fodiens* = 0.34; *T. castoridens* (SDSNH) = 0.48. This character is potentially correlated with the width of ventral condyloid fossa (0, narrow; 1, broad).

Basioccipital

72. Shape of basioccipital in ventral view

(0) Quadrate with parasagittally oriented margins (medial edge of the channel-like depression, continuing to jugular foramen from ventral condyloid fossa).

(1) Ventrolaterally-facing lateral wall on each side (i.e., V-shaped bottom in coronal plane) and no channel-like depression continuing to jugular foramen.

Comment: *Azygonyx* probably has state 0 based on a faint channel-like depression from ventral condyloid fossa, although the basioccipital is damaged.

Postcranial characters

Atlas

73. Transverse process

(0) Short, with small transverse foramen.

(1) Posterodorsally expanded, with large and oval transverse foramen.

Atlas

74. Position of neural spine

(0) Anterior margin of neural arch.

(1) Middle of neural arch.

Atlas

75. Groove (sulcus) on caudal surface between neural arch and articular facet for axis.

(0) Deep, continuous to the transverse foramen.

(1) No distinct groove.

APPENDX S2. Data matrix of character states used in the phylogenetic analysis. Data for the characters 1–27 and 29–32 (dental and dentary characters) are derived from characters 1–27 and 28–31 in Miyata (2007). Characters 28 and 33–75 are briefly described in Appendix S1. ‘?’ indicates unknown state. A, B, and C are multiple indicates 0+1, 1+2, and 0/1(= 0 or 1), respectively. Note that there are two taxon codings for *Trogosus castoridens*, one representing the holotype specimen (ANSP 10337) only and a second representing the holotype plus SDSNH 40819. Two analyses were run, one with ANSP 10337 and SDSNH 40819 as separate OTUs and another with ANSP and SDSNH 40819 combined as a single OTU (see text). Character numbering: 1–10, 11–20, 21–30, 31–40, 41–50, 51–60, 61–70, 71–75.

<i>Azygonyx</i> (outgroup)				
0000000000	000000A0AA	00000A0000	001???????	??0?000000
?000?00000	00?0000000	00000		
<i>Esthonyx</i> (outgroup)				
A00000000A	00000000A0	A000000000	1001?0????	??000000???
?0????????	????????????	?????		
<i>Megalesthyonyx hopsoni</i>				
?20001????	?010000100	1011?0?001	10????????	????????????
??????????	????????????	?????		
<i>Adapidium huanghoense</i>				
????011001	?01????????	111?11000?	?0????????	????????????
??????????	????????????	?????		
<i>Kuanchuanianus shantunensis</i>				
??????????	???0110110	101?102011	20????????	????????????
??????????	????????????	?????		
<i>T. castoridens</i> (ANSP 10337 only)				
??????????	???0101111	1??1?????11	21????????	????????????
??????????	????????????	?????		
Delmar <i>Trogosus</i> (SDSNH 40819)				
1011111101	010?1?????1	101?10C11?	?101100110	02?0001100
0011020110	1010111100	10011		
<i>T. castoridens</i> (ANSP 10337 + SDSNH 40819)				
1011111101	0100101111	101110C111	2101100110	02?0001100
0011020110	1010111100	10011		
<i>T. hyracoides</i>				
1211111101	1100100110	1011?01021	2111110110	0000A00112
0011021110	201?111???	?????		
<i>T. grangeri</i>				
1???111?01	1100100112	1011?02021	2120011001	1010110100
2120101101	2101101111	01101		
<i>T. hillsii</i>				
10?111????	01001001?1	???1?????11	21200??001	111?010100
1111100101	1?0?101110	01???		
<i>T. latidens</i>				

APPENDIX S2. (Continued)

	?1111121?1	?10010?112	B011B020??	2??????????	????????????
	????????????	????????????	??????		
<i>T. gazini</i>					
	?111112101	110?1001??	10122020??	????????????	????????????
	????????????	????????????	??????		
<i>Tillodon fodiens</i>					
	1211112111	0101102112	101222?021	2112020000	2001100101
	0021010111	2020101?01	01???		

APPENDX S3. All character states shared at each node and each terminal taxon, generated by PAUP analysis using all craniodental and postcranial characters (1–75), under the assumption that the Delmar *Trogosus* (SDSNH 40819) belongs to *T. castoridens* (see also Fig. 19C). Character followed by ‘a’ and ‘d’ means as supported only by ACCTRAN and only by DELTRAN, respectively. The number between parentheses and the arrow indicate the character state and the direction of character change, respectively. Unambiguous character state designated by the PAUP analysis is shown in bold. Character without underline has a C.I. value of 1.0.

Outgroups: *Azygonyx*: **31(1→0)**; *Esthonyx*: 33(1→0)

Node A (all ingroups): 1a(0→1), **6(0→1)**, **7(0→1)**, **10(0→1)**, **18(0→1)**, **21(0→1)**, **23(0→1)**, **24(0→1)**, **25(0→1)**, **30(0→1)**, 36a(0→1), 48a(0→1), 53a(0→1), 54a(0→1), 58a(0→1), 59a(0→1), 61a(0→2), 65a(0→1), 67a(0→1), 68a(0→1), 75a(0→1)

Node B (*M. hopsoni* + *Ad. huanghoense*): 2a(0→2), **13(0→1)**

M. hopsoni: 2d(0→2)

Ad. huanghoense: **22(0→1)**, **26(0→1)**

Node C (Trogosinae): 3a(0→1), 4a(0→1), 5a(0→1), 8a(0→1), 12a(0→1), **15(0→1)**, **19(0→1)**, **27(0→2)**, 29a(0→1), **31(1→2)**

K. shantunensis: **16(0→1)**, 29d(0→1)

Node D (North American trogosines): 1d(0→1), 3d(0→1), 4d(0→1), 5d(0→1), 8d(0→1), 12d(0→1), 29a(1→2), 29d(0→2), **32(0→1)**, 48d(0→1), 54d(0→1), 58d(0→1), 61d(0→2), 65d(0→1), 67d(0→1), 68d(0→1), 75d(0→1)

Node E (*T. castoridens* + *T. hyracoides*): **27(2→1)**, **35(0→1)**, **38(0→1)**, **39(0→1)**, 53d(0→1), **56(0→2)**, 59d(0→1), **63(0→1)**, **66(0→1)**, 71a(0→1), 74a(0→1)

T. hyracoides: 2(0→2), 11(0→1), 36d(0→1), **49(0→1)**, **50(0→2)**, 57(0→1)

T. castoridens: **17(0→1)**, 20(0→1), **28(0→1)**, 29(2→1), 33(1→0), 36a(1→0), **42(0→2)**, **47(0→1)**, 61(2→1), 71d(0→1), 74d(0→1)

Node F ((*T. hillsii* + *T. grangeri*) + (*T. latidens* + (*T. gazini* + *Tillodon fodiens*))): 20(0→2), 25a(1→2), 34a(1→0), 41a(0→1), 45a(0→1), 53a(1→2), 53d(0→2), **60(0→1)**, 70a(0→1), **72(0→1)**, 73a(0→1)

Node G (*T. hillsii* + *T. grangeri*): 33(1→2), 34d(1→0), 37a(0→1), **40(0→1)**, 41d(0→1), **43(0→1)**, **46(0→1)**, 51a(0→1), **52(0→1)**, **55(0→1)**, 59a(1→0), 62a(0→1), 64a(0→1), **69(0→1)**

T. grangeri: 11(0→1), 36d(0→1), 37d(0→1), 45d(0→1), **51(1→2)**, 54(1→0), 57(0→1), 62d(0→1), 64d(0→1), 70d(0→1), 73d(0→1)

T. hillsii: 20(2→1), 29(2→1), **42(0→1)**, 45a(1→0), 51d(0→1), 53(2→1), 61(2→1), 70a(1→0)

Node H (*T. latidens* + (*T. gazini* + *Tillodon fodiens*)): 2(0→1), **7(1→2)**, 34a(0→2), 36a(1→2), 41a(1→2), 44a(0→1), 50a(0→1), 56a(0→1), 63a(0→2)

Node I (*T. gazini* + *Tillodon fodiens*): 14a(0→1), **24(1→2)**, 25d(1→2)

T. gazini: 11(0→1)

Tillodon fodiens: 2(1→2), **9(0→1)**, 14d(0→1), **17(0→2)**, **26(0→2)**, 34d(1→2), 36d(0→2), 41d(0→2), 44d(0→1), 45d(0→1), 50d(0→1), 56d(0→1), 59d(0→1), 63d(0→2), 70d(0→1)

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