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SUPPLEMENTARY ONLINE MATERIAL FOR

**A new fossil from the London Clay documents the convergent origin of a  
“mousebird-like” tarsometatarsus in an early Eocene near-passerine bird**

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**Supplementary Online Material**

**SOM 1.** Character descriptions.

**SOM 2.** Character matrix used in the phylogenetic analysis.

**SOM 1.** Character descriptions.

1. Skull, largely or completely ossified septum nasale: absent (0), present (1).
2. Beak with well-defined cere surrounding narial openings (feathered in some Psittacidae): no (0), yes (1).
3. Skull, os lacrimale with well-developed, caudally projecting processus supraorbitales: absent (0), present (1).
4. Palatinum, crista ventralis: absent (0), present (1).
5. Well-developed processus basipterygoidei, which articulate with the ossa pterygoidea: yes (0), no (1).
6. Mandible, large, ovate fenestra caudalis mandibulae: absent (0), present (1).
7. Mandible, rami dorsoventrally deep across the entire mandibular length: no (0), yes (1).
8. Mandible, area of pars symphysialis with rectangular cross section: absent (0), present (1).
9. Mandible, well-developed processus retroarticularis: absent (0), present (1).
10. Columella with large, hollow, bulbous basal and footplate area which exhibits a large fenestra on one side: no (0), yes (1).
11. Quadrate, condylus medialis with concave lateral articular surface: no (0), yes (1).
12. Quadrate, tip of processus oticus, caudal surface with large pneumatic foramina: no (0), yes (1).
13. Number of praesacral vertebrae: 20 or more (0), 18 or 19 (1).
14. Fourth cervical vertebra, osseous bridge connecting the processus transversus with the processus articularis caudalis: absent (0), present (1).
15. Fourth cervical vertebra, processus spinosus long and well defined: no (0), yes (1).  
Scoring of this character was corrected for *Tynskya*.
16. Fourth cervical vertebra, processus ventralis long and well defined: no (0), yes (1).
17. Corpus of thoracic vertebrae pleurocoelous, that is, with distinct ovate fossae on lateral surfaces: no (0), yes (1).
18. Caudal thoracic vertebrae: heterocoelous (0), platycoelous (1), opisthocoelous (2).
19. Pygostyle with large, shield-like discus pygostyli with sharply defined, ridge-like lateral margins: no (0), yes (1).
20. Furcula, extremitas omalis plate-like and of subtriangular shape: no (0), yes (1).
21. Furcula, extremitas omalis with distinct, laterally protruding facies articularis acrocoracoidea: no (0), yes (1).
22. Furcula with well-developed apophysis furculae: no (0), yes (1).

23. Coracoid, facies articularis scapularis deeply excavated and cup-like, i.e., forming a cotyla scapularis: yes (0), no (1).
24. Coracoid, foramen nervi supracoracoidei: present (0), absent (1).
25. Coracoid, extremitas sternalis with notch in the margo medialis: no (0), yes (1).
26. Coracoid, tip of processus acrocoracoideus broadly rounded: no (0), yes (1).
27. Coracoid, processus lateralis well-developed, with dorsal portion of facies articularis sternalis extending well beyond lateral margin of shaft of bone: yes (0), no (1).
28. Scapula, acromion distinctly bifurcate, i.e. with an additional dorsal process: no (0), yes (1).
29. Sternum, apex carinae strongly cranially protruding: no (0), yes (1).
30. Sternum, well-developed spina externa: absent (0), present (1).
31. Sternum, spina externa: blade-like (0), bifurcated (1). This character was scored as non-comparable (–) in taxa without a well-developed spina externa.
32. Caudal margin of sternum: with four notches/fenestrae (0), with two notches/fenestrae (1).
33. Humerus long and slender, with small proximal end: yes (0), no (1).
34. Humerus, processus flexorius prominent and reaching distally well beyond distal margin of condylus ventralis: no (0), yes (1).
35. Humerus, fossa pneumotricipitalis with pneumatic openings: yes (0), no (1).
36. Humerus, processus supracondylaris dorsalis: absent or only small tubercle (0), forming a well-defined, dorsally directed process (1), strongly developed and proximodorsally projected (2).
37. Ulna exceeding humerus in length: no (0), yes (1).
38. Ulna, cotyla ventralis greatly enlarged, extending into olecranon: no (0), yes (1).
39. Ulna, oblique mediodistal ridge extending distally from cotyla dorsalis: absent (0), present (1).
40. Ulna, olecranon very long, narrow, and pointed; tuberculum ligamenti collateralis ventralis strongly protruding: no (0), yes (1).
41. Radius, distal end, tuberculum aponeurosis ventralis strongly developed and distoventrally protruding: no (0), yes (1).
42. Radius, distal end, dorsal portion forming a proximally directed hook: no (0), yes (1).
43. Carpometacarpus, distinctly exceeding coracoid in length: no (0), yes (1).
44. Carpometacarpus, os metacarpale minus distinctly bowed, spatium intermetacarpale very wide: no (0), yes (1).

45. Carpometacarpus, fossa between processus pisiformis and caudal end of os metacarpale minus; no (0), yes (1).
46. Carpometacarpus, well-developed protuberantia metacarpalis: absent (0), present (1).
47. Carpometacarpus, cranially directed process at proximal end of sulcus tendinosus: absent (0), present (1).
48. Carpometacarpus, distinct, narrow fossa supratrochlearis running across dorsal portion of trochlea carpalis: no (0); yes (1).
49. Carpometacarpus, processus intermetacarpalis: absent or small (0), well-developed, reaching os metacarpale minus (1), absent, but tendon of musculus extensor carpi ulnaris inserts on the os metacarpale minus as it does in taxa with a processus intermetacarpalis (2).
50. Carpometacarpus, ventral portion of trochlea carpalis cranio-caudally narrow and proximodistally elongated: no (0), yes (1).
51. Carpometacarpus, os metacarpale minus distinctly exceeding os metacarpale majus in length: no (0), yes (1).
52. Os carpi radiale, proximodistally wide, with well-defined, narrow sulcus for the tendon of musculus extensor longus alulae: no (0), yes (1).
53. Phalanx proximalis digiti majoris, proximal end with large, proximally directing process: no (0), yes (1).
54. Pelvis, ilia co-ossified with synsacrum: yes (0), no (1).
55. Pelvis, crista dorsolateralis ilii strongly developed, overhanging a pronounced concavitas infracristalis and convexly bowed in dorsal view; praeacetabular part much longer than postacetabular part, spina dorsolateralis ilii reduced: no (0), yes (1).
56. Pelvis, processus terminalis ischii very narrow and slender, touching pubis at an angle of 45°-90°, fenestra ischiopubica very wide: no (0), yes (1).
57. Femur, pneumatic foramen on cranial surface of proximal end: absent (0), present (1).
58. Femur, distal end widened, tuberculum musculi gastrocnemialis lateralis large: no (0), yes (1).
59. Tibiotarsus, both cristae cnemiales and crista patellaris forming a ridge, which circumscribes a groove on the cranial side of the bone: no (0), yes (1).
60. Tibiotarsus, medial aspect of proximal end: not as follows (0), low ridge opposite to crista fibularis (1), crista cnemialis cranialis continuous with a marked crest opposite to crista fibularis (2).
61. Tibiotarsus, crista cnemialis lateralis distinctly hooked: no (0), yes (1).

62. Tibiotarsus, distal end mediolaterally wide and craniocaudally compressed, trochlea cariliginis tibialis shallow: no (0), yes (1).
63. Tarsometatarsus, not as follows (0), short and stocky, with distal width of bone measuring about one third of its length or more (1), greatly elongated, distinctly exceeding humerus in length (2).
64. Tarsometatarsus, crista plantaris lateralis: absent (0), present (1).
65. Tarsometatarsus, hypotarsus passing into a well-developed crista medianoplantaris: no (0), yes (1).
66. Tarsometatarsus, fossa parahypotarsalis medialis marked and proximal part of margo medialis forming a sharp ridge: no (0), yes (1).
67. Tarsometatarsus, medial portion of cotyla medialis forming a proximally projecting lip: no (0), yes (1).
68. Tarsometatarsus, foramina vascularia proximalia widely separated, with lateral foramen situated farther proximally than medial one: no (0), yes (1).
69. Tarsometatarsus, hypotarsus, with closed, or nearly closed, canal for tendon of musculus flexor digitorum longus: no (0), yes (1), condition in Trogonidae, with common canal for tendons of musculus flexor digitorum longus, m. flexor perforatus digiti 2, and m. flexor perforans et perforatus digiti 2 (2). Scoring of this character was corrected for the Galbulae.
70. Tarsometatarsus, hypotarsus: not as follows (0), with marked, plantarly open furrow for tendon of musculus flexor hallucis longus (1), with closed canal for tendon of musculus flexor hallucis longus (2). This character was coded as additive.
71. Tarsometatarsus, arcus extensorius (ossified retinaculum extensorium tarsometatarsi): absent (0), present (1).
72. Tarsometatarsus, tuberositas musculi tibialis cranialis large and situated at medial margin of bone: no (0), yes (1).
73. Tarsometatarsus, canalis interosseus distalis: present (0), absent (1).
74. Tarsometatarsus, dorsally open sulcus between foramen vasculare distale and incisura intertrochlearis lateralis: no (0), yes (1).
75. Tarsometatarsus, incisurae intertrochleares very short: no (0); yes (1).
76. Tarsometatarsus, trochlea metatarsi II: not as follows (0), enlarged, of subcylindrical shape, and with marked sulcus on plantar surface (1), as before, but sulcus extending on medial surface of trochlea (2), with well-developed plantarly directed projection (3).

77. Tarsometatarsus, trochlea metatarsi III much wider in mediolateral than in dorsoplantar direction, its dorsal surface not being significantly raised above the dorsal surface of the shaft: no (0), yes (1).
78. Tarsometatarsus, trochlea metatarsi III with a deeply incised groove between the trochlear rims: no (0), yes (1).
79. Tarsometatarsus, trochlea metatarsi III with marked tubercle on lateral side: no (0), yes (1).
80. Tarsometatarsus, distinct fossa immediately proximal to trochlea metatarsi III, on dorsal surface of bone: no (0), yes (1).
81. Tarsometatarsus, trochlea metatarsi IV: not as follows (0), with plantarly-directed wing-like flange (1), with large trochlea accessoria that is not separated by a furrow from the main trochlea (2), with large trochlea accessoria that is separated by a furrow from the main trochlea (3). This character was coded as additive.
82. Tarsometatarsus, trochlea metatarsi IV with a laterally slanted distal margin, which forms an angle of about 45° relative to the longitudinal axis of the tarsometatarsus: no (0), yes (1). This character was newly added.
83. Hallux, first phalanx with proximal end greatly widened: no (0), yes (1).
84. Third and fourth toe coalescent at least over length of basal phalanx of third toe: no (0), yes (1).
85. Second toe, proximal phalanx abbreviated, measuring half the length of penultimate phalanx or less: no (0), yes (1).
86. Fourth toe, proximal phalanx greatly widened: no (0), yes (1). This character was newly added.
87. Fourth toe, proximal three phalanges abbreviated, measuring less than half the length of fourth phalanx: no (0), yes (1).
88. Ungual pedal phalanges, sulcus neurovascularis closed to form a canal that opens next to the tuberculum flexorium: no (0), yes (1).
89. Ungual phalanx of third toe with longitudinal ridge along medial surface: no (0), yes (1).
90. Musculus ambiens: present (0), absent (1).
91. Musculus flexor hallucis longus, origin with three heads, iliofibularis tendon passes lateral to lateral head: no (0), yes (1).
92. Musculus flexor hallucis longus, tendon supplying hallux: no (0), yes (1).
93. Tendon of musculus extensor digitorum longus sending branch to hallux: no (0), yes (1).
94. Phallus: present (0), absent (1).

95. Nestling, tip of upper beak forming marked, ventrally decurved hook: no (0), yes (1).

96. Freshly hatched nestling, mandible exceeding upper beak in length: no (0), yes (1).

**SOM 2.** Character matrix used in the phylogenetic analysis. The anseriform Anhimidae were specified as the outgroup taxon; extinct taxa are indicated by a dagger. The matrix is based on Mayr and Kitchener (in press), newly added taxa and characters, as well as revised character scorings, are highlighted in bold.

Characters and character states																										
Taxa	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	
Anhimidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Strigidae	1	1	01	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	01	0	1	0	0
Psittacidae	1	1	0	1	1	0	1	0		0	0	1	0	1	0	0	2	0	0	0	0	0	1	1	0	0
Coliidae	1	01	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	1	0	1	1	1	1	0	0
Leptosomidae	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Alcedinidae	1	0	01	1	1	0	0	0	0	1	0	1	1	1	1	0	0	0	0	1	0	0	1	1	1	1
Meropidae	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	1	0	0
Momotidae	1	0	0	1	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
Coraciidae	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Upupidae	1	0	0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	1	0	0	0	1	1	0	0
Bucerotidae	1	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	1	0	0
Passeriformes	0	0	0	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	01	0
Pici	01	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	0	1	1	1	1
Galbulae	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1	1
Trogonidae	1	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	1	1	1	1
† <i>Zygodactylus</i>	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	0	1	0	?	1	1	0
† <i>Primoscens</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	1	1	1	1
† <i>Primozygodactylus</i>	0	?	0	?	?	0	0	0	0	?	0	1	?	?	?	?	1	?	0	1	0	1	1	1	0	0
† <i>Minutornis</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	1	1	1	?
† <i>Pumiliornis</i>	0	?	0	?	?	?	0	0	?	?	?	?	0	?	?	?	1	?	0	0	0	1	1	1	?	0
† <i>Psittacopes</i>	0	?	0	?	?	1	0	0	?	?	?	0	0	?	?	?	1	?	0	?	?	1	1	1	0	0
† <i>Parapsittacopes</i>	0	?	0	?	?	0	0	0	0	?	1	1	?	0	?	?	1	?	?	?	?	1	1	1	0	0
† <i>Psittacomimus</i>	0	?	?	?	?	0	0	0	?	?	?	1	?	?	?	?	1	?	?	0	0	1	1	1	0	0
† <i>Eofringillirostrum</i>	1	?	0	?	?	0	0	0	1	?	?	?	?	?	?	?	1	?	0	0	0	?	1	?	?	?
† <i>Vastanavis</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	1	0
† <i>Quercypsitta</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	1	0
† <i>Pseudasturides</i>	?	?	1	?	1	0	0	0	0	?	?	0	?	?	?	?	1	?	0	0	?	0	1	0	0	0
† <i>Cyrilavis</i>	0	?	1	?	?	0	0	0	0	?	?	?	1	?	?	?	1	?	0	0	0	0	0	0	0	0
† <i>Serudaptus</i>	?	?	?	?	?	0	0	0	0	?	?	?	?	?	?	?	?	?	?	?	0	0	0	?	?	0
† <i>Avolatavis</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?
† <i>Eurofluvioviridavis</i>	?	?	?	?	?	0	0	0	0	?	?	0	?	?	?	?	?	?	?	0	?	?	?	?	0	?
† <i>Sandcoleidae</i>	0	?	0	?	1	0	0	0	<b>01</b>	?	?	0	?	?	?	?	0	?	0	0	0	0	1	0	0	0
† <i>Messelastur</i>	?	?	1	?	?	0	1	0	0	?	?	?	?	?	?	?	?	?	?	0	0	0	0	0	0	0
† <i>Tynskya</i>	?	?	?	?	?	?	1	0	?	?	1	0	?	1	<b>0</b>	1	1	1	?	0	0	0	0	0	0	0
† <i>Morsoravis</i>	0	?	0	?	?	1	0	0	1	?	?	0	0	?	?	?	1	?	?	?	?	?	?	?	?	?
† <i>Eocuculus</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	1	0	1	?	1	0
† <i>Sororavis</i>	?	?	?	?	?	?	<b>0</b>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	<b>0</b>	<b>1</b>	<b>0</b>	0





Characters and character states

Taxa	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
Anhimidae	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
Falconidae	0	0	0	0	1	0	1	0	0	0	0	1	02	0	1	0	0	0	0	0	0	0	0	0	0	0
Strigidae	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	01	0	0	0	0	
Psittacidae	0	0	0	0	0	0	0	0	0	1	0	1	01	0	0	0	0	0	1	2	0	1	1	0	0	
Coliidae	1	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	
Leptosomidae	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	2	0	0	0	0	0	
Alcedinidae	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	1	0	0	
Meropidae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	1	0	0	
Momotidae	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1	1	0	0	
Coraciidae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	
Upupidae	1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	1	2	1	0	1	0	1	
Bucerotidae	1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	1	2	0	0	1	0	1	
Passeriformes	1	0	0	0	0	01	0	0	0	1	1	0	2	1	0	0	0	0	1	2	1	0	1	0	0	
Pici	1	1	1	0	0	1	0	0	1	1	0	0	0	0	0	01	0	0	1	0	01	1	1	0	0	
Galbulae	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	
Trogonidae	1	0	0	0	0	01	0	0	0	0	0	1	0	0	1	0	0	0	2	02	0	1	1	0	0	
†Zygodactylus	0	0	0	?	?	?	?	?	0	0	1	0	2	1	0	0	?	?	1	2	0	?	1	0	0	
†Primoscens	0	?	0	?	?	?	0	0	?	?	?	?	2	0	0	0	1	0	1	1	0	0	1	0	0	
†Primozygodactylus	0	0	0	0	?	1	0	0	0	0	1	0	2	1	0	0	1	0	1	2	0	0	1	0	0	
†Minutornis	0	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
†Pumiliornis	0	?	0	?	?	?	?	?	0	1	1	1	0	0	0	0	1	?	?	?	0	1	?	0	0	
†Psittacopes	0	?	0	?	?	?	?	?	0	?	1	0	0	0	0	0	0	?	?	?	0	1	?	1	0	
†Parapsittacopes	?	?	0	1	0	?	?	?	0	1	?	0	?	?	?	?	0	?	?	?	?	?	?	?	?	
†Psittacomimus	0	?	0	?	0	0	0	0	?	?	?	0	0	0	0	0	0	1	1	1	0	1	1	1	0	
†Eofringillirostrum	0	?	0	?	0	?	?	?	?	?	?	1	0	0	0	0	?	?	?	?	?	?	?	?	0	
†Vastanavis	0	?	0	?	?	?	?	0	?	?	?	1	1	0	0	0	0	1	1	1	0	1	0	0	0	
†Quercypsitta	?	?	?	?	?	?	?	?	?	?	?	1	0	0	0	0	?	1	1	2	0	1	1	0	0	
†Pseudasturides	0	?	0	?	0	?	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	1	1	0	
†Cyrilavis	0	0	0	?	0	0	?	0	0	?	0	1	0	0	1	0	0	?	0	0	0	1	1	1	0	
†Serudaptus	0	?	0	?	0	0	?	?	0	1	0	?	1	0	?	0	?	?	?	?	?	?	?	?	0	
†Avolatavis	?	?	?	?	?	0	?	?	0	?	?	1	1	0	0	0	?	1	?	1	?	?	?	?	0	
†Eurofluvioidavis	0	?	0	?	0	0	?	?	?	?	?	1	1	0	0	0	?	?	?	12	?	?	?	?	0	
†Sandcoleidae	0	0	0	?	0	1	0	1	1	2	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	
†Messelastur	0	0	0	?	?	?	0	?	0	0	0	1	0	0	1	0	0	?	0	0	0	1	?	?	0	
†Tynskya	0	0	0	?	?	?	0	?	0	0	0	?	0	0	1	0	0	1	0	0	0	1	?	1	0	
†Morsoravis	?	?	?	1	0	0	0	0	0	1	1	0	0	?	?	?	1	0	?	?	0	?	?	?	0	
†Eocuculus	0	0	0	?	0	0	?	0	0	0	0	0	0	0	0	0	0	0	?	?	0	1	?	1	0	
†Sororavis	?	?	?	?	?	?	?	?	?	?	?	0	0	0	0	0	1	0	0	1	0	1	?	0	0	

