Journal of Avian Biology

JAV-00487
Smith, N. A. and Clarke, J. A. 2014. Systematics and evolution evolution of the Pan-Alcidae (Aves, Charadriiformes). – J. Avian Biol. doi: 10.1111/jav.00487

Supplementary material

Appendix 1 Supplementary Tables

Table A1. Taxon sampling and associated morphological character and sequence incompleteness (i.e., % missing data). Totals include molecular gaps and morphological characters not scored owing to absence. Extinct taxa denoted by "†". Supraspecific taxon terminal denoted by "SST".

Taxon	Morphological Data	Molecular Sequence Data	Combined Data
1. †*Aethia barnesi*	93.8	100	99.8
2. *Aethia cristatella*	24.9	38.3	37.9
3. *Aethia psittacula*	12.2	38.1	37.4
4. *Aethia pusilla*	11.3	37.5	36.8
5. *Aethia pygmaea*	24.4	37.5	37.1
6. †*Aethia storeri*	85.3	100	99.6
7. †*Alca ausonia*	84.1	100	99.6
8. †*Alca carolinensis*	62.9	100	98.9
9. †*Alca grandis*	70.5	100	99.2
10. †*Alca minor*	84.7	100	99.6
11. †*Alca olsoni*	71.4	100	99.6
12. *Alca torda*	2.8	36.4	35.5
13. †*Alca stewarti*	72.8	100	99.3
14. *Alle alle*	10.8	33.1	32.5
15. *Anous tenuirostris*	26.9	61.6	60.6
16. *Bartramia longicauda*	12.7	53.7	52.6
17. *Brachyramphus brevirostris*	24.6	37.8	37.5
18. †*Brachyramphus dunkeli*	84.7	100	99.6
19. *Brachyramphus marmoratus*	5.1	37.5	36.6
20. *Brachyramphus perdix*	25.8	41.6	41.2
21. †*Brachyramphus pliocenum*	85.3	100	99.6
22. †*Boutersemia belgica*	98.3	100	99.9
23. *Cepphus carbo*	24.9	41.7	41.2
24. *Cepphus columba*	3.1	29.1	28.4
25. *Cepphus grylle*	16.4	73.6	72.0
26. †*Cepphus olsoni*	84.7	100	99.6
27. †*Cerorhinca minor*	84.7	100	99.7
28. *Cerorhinca monocerata*	3.1	42.6	41.5
29. †*Cerorhinca reai*	84.9	100	99.6
30. †*Cerorhinca* sp.	83.9	100	99.6
31. *Charadrius vociferus*	11.3	15.2	15.1
32. *Charadrius wilsonia*	26.1	94.5	92.7
33. *Chlidonias leucopterus*	26.9	59.9	59.0
34. *Creagrus furcatus*	15.0	61.5	60.2

35. Cusorius temminckii	32.9	15.1	15.6
36. Fratercula arctica	2.8	11.8	11.6
37. Fratercula cirrhata	3.1	37.5	36.5
38. Fratercula corniculata	16.1	37.5	36.9
39. †Fratercula dowi	58.4	100	98.9
40. Glareola maldivarum	33.1	80.7	79.4
41. Gygis alba	16.9	58.9	57.8
42. Hydrophasianus chirurgus	28.0	56.6	55.8
43. †Laricola elegans	76.8	100	99.4
44. Larosterna inca	13.6	56.9	55.8
45. Larus argentatus	7.1	85.5	83.4
46. Larus marinus	23.8	51.1	50.4
47. †Mancallinae (SST)	47.3	100	98.6
48. †Miocepphus blowi	67.4	100	99.1
49. †Miocepphus bohaski	81.3	100	99.5
50. †Miocepphus mcclungi	89.2	100	99.7
51. †Miocepphus mergulellus	85.3	100	99.6
52. Numenius minutus	32.3	59.3	58.6
53. †Nupharanassa bulotorum	98.0	100	99.9
54. Pagophila eburnea	15.6	54.5	53.5
55. Phaetusa simplex	16.1	56.8	55.7
56. †Pinguinus alfrednewtoni	67.9	100.0	99.1
57. †Pinguinus impennis	25.5	82.4	80.9
58. †Pseudocepphus teres	87.8	100	99.7
59. Ptychoramphus aleuticus	4.5	38.3	37.4
60. Rhinoptilus chalcopterus	18.9	60.0	58.9
61. Rhodostethia rosea	15.6	55.3	54.2
62. Rissa tridactyla	12.5	15.3	15.1
63. Rynchops niger	7.9	15.1	15.0
64. Stercorarius longicaudus	11.6	53.6	52.5
65. Stercorarius skua	7.6	15.2	14.9
66. Sterna anaethetus	26.6	72.8	71.6
67. Sterna maxima	18.9	57.4	56.4
68. Sterna nilotica	8.8	51.3	50.1
69. Sternula superciliaris	30.9	59.4	58.6
70. Stiltia isabella	13.0	59.4	58.2
71. Synthliboramphus antiquus	3.9	24.0	23.5
72. Synthliboramphus craveri	24.4	41.7	41.2
73. Synthliboramphus hypoleucus	24.6	82.3	80.8
74. †Synthliboramphus rineyi	84.1	100.00	99.6
75. Synthliboramphus wumizusume	26.1	37.5	37.2
76. Tryngites subruficollis	14.2	54.3	53.2
77. Uria aalge	3.9	28.0	27.4
78. †Uria brodkorbi	75.6	100	99.3
79. Uria lomvia	16.9	33.3	32.8
80. Xema sabini	15.0	54.3	53.2

Table A2. Genbank accession numbers and authorship of molecular sequences used in the phylogenetic analyses. Key to lowercase letters in parentheses following accession numbers which denote authorship of sequences: a, (Baker et al. 2007); b, (Pereira and Baker 2008); c, (Paton and Baker 2006); d, (Bridge et al. 2005); e, (Moum et al. 2002); f, (Whittingham et al. 2000); g, (Yamamoto et al. 2005); h, (Moum et al. 1994); i, (Hebert et al. 2004); j, (Kerr et al. 2007); k, (Friesen et al. 1996); l, (Liebers et al. 2004); m, (Cohen et al. 1997); n, (Fain and Houde 2007); o, (Paton et al. 2003); p, (Groth and Barrowclough 1999); *, unpublished sequence deposited in Genbank by Chen, X.-F. and Li, Q.-W., August 20, 2001.

Taxa	**ND2**	**ND5**	**ND6**	**CO1**
Aethia cristatella	EF373219 (a)	---	X73928 (h)	EF380315 (b)
Aethia psittacula	EF373235 (a)	---	X73925 (h)	EF380327 (b)
Aethia pusilla	EF380337 (b)	---	X73926 (h)	EF380316 (b)
Aethia pygmaea	EF380338 (b)	---	X73927 (h)	EF380317 (b)
Alca torda	EF373220 (a)	AJ242683 (e)	X73916 (h)	EF380318 (b)
Alle alle	EF373221 (a)	AJ242684 (e)	X73915 (h)	EF380319 (b)
Anous tenuirostris	EF373223 (a)	---	---	---
Bartramia longicauda	EF373226 (a)	---	---	AY666283 (i)
Brachyramphus brevirostris	EF373227 (a)	---	X73922 (h)	EF380321 (b)
Brachyramphus marmoratus	EF380340 (b)	---	X73923 (h)	EF380322 (b)
Brachyramphus perdix	EF380341 (b)	---	---	EF380323 (b)
Cepphus carbo	EF380342 (b)	---	---	EF380324 (b)
Cepphus columba	EF373229 (a)	---	X73918 (h)	EF380325 (b)
Cepphus grylle	---	AJ242688 (e)	X73917 (h)	DQ433470 (j)
Cerorhinca monocerata	EF373230 (a)	---	---	EF380326 (b)
Charadrius vociferous	DQ385082 (c)	DQ385150 (c)	---	DQ385167 (c)
Charadrius wilsonia	---	---	---	AY666175 (j)
Chlidonias leucopterus	EF373231 (a)	---	---	---
Creagrus furcatus	EF373234 (a)	---	---	---
Cursorius temminckii	DQ385090 (c)	DQ385158 (c)	---	DQ385175 (c)
Fratercula arctica	DQ385092 (c)	DQ385160 (c)	X73929 (h)	DQ385177 (c)
Fratercula cirrhata	EF380343 (b)	---	X73931 (h)	EF380329 (b)
Fratercula corniculata	EF380344 (b)	---	X73930 (h)	EF380328 (b)
Sterna nilotica	AY631383 (d)	---	---	DQ434167 (j)
Glareola maldivarum	EF373241 (a)	---	---	---
Gygis alba	EF373242 (a)	---	---	---
Hydrophasianus chirurgus	EF373243 (a)	AF146627 (f)	---	---
Larosterna inca	AY631364 (d)	---	---	---
Larus argentatus	---	---	---	DQ433743 (j)
Larus marinus	EF373246 (a)	---	---	DQ433757 (j)
Numenius minutus	EF373253 (a)	---	---	---

Table A2. (continued).

Taxa	**cyt *b***	**12S rDNA**	**16S rDNA**	**RAG-1**
Aethia cristatella	U37087 (k)	EF373064 (b)	EF380278 (b)	EF373165 (a)
Aethia psittacula	U37296 (k)	EF373077 (a)	EF380290 (b)	EF373179 (a)
Aethia pusilla	U37104 (k)	EF380303 (b)	EF380279 (b)	EF380266 (b)
Aethia pygmaea	U37286 (k)	EF380304 (b)	EF380280 (b)	EF380267 (b)
Alca torda	U37288 (k)	EF373065 (a)	EF380281 (b)	AY228788 (o)
Alle alle	U37287 (k)	AJ242684 (e)	EF380282 (b)	EF373166 (a)
Anous tenuirostris	EF373119 (a)	EF373066 (a)	---	EF373168 (a)
Bartramia longicauda	EF373122 (a)	EF373069 (a)	---	EF373171 (a)
Brachyramphus brevirostris	U37289 (k)	EF380306 (b)	EF380284 (b)	EF373172 (a)
Brachyramphus marmoratus	U37290 (k)	EF380306 (b)	EF380285 (b)	EF380269 (b)
Brachyramphus perdix	U37291 (k)	EF380307 (b)	EF380286 (b)	EF380270 (b)
Cepphus carbo	U37292 (k)	EF380308 (b)	EF380287 (b)	EF380271 (b)
Cepphus columba	U37293 (k)	X76349 (h)	DQ674610 (n)	EF373173 (a)
Cepphus grylle	U37294 (k)	AJ242688 (e)	---	---
Cerorhinca monocerata	U37295 (k)	EF373072 (a)	EF380289 (b)	EF373174 (a)
Charadrius vociferous	DQ385218 (c)	DQ385269 (c)	DQ385286 (c)	AF143736 (p)
Charadrius wilsonia	---	---	---	---
Chlidonias leucopterus	EF373124 (a)	EF373073 (a)	---	EF373175 (a)
Creagrus furcatus	EF373127 (a)	EF373076 (a)	---	EF373178 (a)
Cursorius temminckii	DQ385226 (c)	DQ385277 (c)	DQ385294 (c)	AY228780 (o)
Fratercula arctica	U37297 (k)	DQ385279 (c)	DQ385296 (c)	AY228787 (o)
Fratercula cirrhata	U37298 (k)	EF380309 (b)	EF380291 (b)	EF380273 (b)
Fratercula corniculata	U37299 (k)	EF380310 (b)	EF380292 (b)	EF380272 (b)
Sterna nilotica	AY631311 (d)	AY631347 (d)	---	EF373184 (a)
Glareola maldivarum	EF373133 (a)	EF373083 (a)	---	---
Gygis alba	AY631290 (d)	EF373084 (a)	---	EF373185 (a)
Hydrophasianus chirurgis	EF373135 (a)	EF373085 (a)	---	EF373186 (a)
Larosterna inca	AY631292 (d)	AY631328 (d)	---	EF373190 (a)
Larus argentatus	AJ508101 (l)	---	---	---
Larus marinus	AJ508140 (l)	EF373088 (a)	---	AY228799 (o)
Numenius minutus	EF373145 (a)	EF373095 (a)	---	EF373195 (a)

Table A2. (continued)

Taxa	ND2	ND5	ND6	CO1
Pagophila eburnea	EF373255 (a)	---	---	DQ433862 (j)
Phaetusa simplex	AY631365 (d)	---	---	---
†*Pinguinus impennis*	---	AJ242685 (e)	---	---
Ptychoramphus aleuticus	EF373261 (a)	---	X73924 (h)	EF380330 (b)
Rhinoptilus chalcopterus	EF373263 (a)	---	---	---
Rhodostethia rosea	EF373264 (a)	---	---	DQ434048 (j)
Rissa tridactyla	DQ385093 (c)	DQ385161 (c)	---	DQ385178 (c)
Rynchops niger	DQ385094 (c)	DQ385162 (c)	---	DQ385179 (c)
Stercorarius longicaudus	EF373267 (a)	---	---	DQ434147 (j)
Stercorarius skua	DQ385091 (c)	DQ385159 (c)	---	DQ385176 (c)
Sterna anaethetus	AY631368 (d)	---	---	DQ433203 (j)
Sterna maxima	AY631381 (d)	---	---	DQ434165 (j)
Sternula superciliaris	AY631388 (d)	---	---	---
Stiltia isabella	EF373268 (a)	---	---	---
Synthliboramphus antiquus	EF373269 (a)	AP009042 (g)	X73920 (h)	EF380331 (b)
Synthliboramphus craveri	EF380345 (b)	---	---	EF380332 (b)
Synthliboramphus hypoleucus	---	---	X73921 (h)	DQ434184 (j)
Synthliboramphus wumizusume	EF380346 (b)	---	X73919 (h)	EF380333 (b)
Tryngites subruficollis	EF373272 (a)	---	---	AY666178 (i)
Uria aalge	EF380348 (b)	AJ242686 (e)	X73913 (h)	EF380334 (b)
Uria lomvia	EF373273 (a)	AJ242687 (e)	X73914 (h)	EF380336 (b)
Xema sabini	EF373275 (a)	---	---	---

Table A2. (continued).

Taxa	cyt *b*	12S rDNA	16S rDNA	RAG-1
Pagophila eburnea	EF373147 (a)	EF373097 (a)	---	EF373198 (a)
Phaetusa simplex	AY631293 (d)	AY631329 (d)	---	EF373200 (a)
†*Pinguinus impennis*	AJ242685 (e)	AJ242685 (e)	---	---
Ptychoramphus aleuticus	U37302 (k)	EF373103 (a)	EF380293 (b)	EF373204 (a)
Rhinoptilus chalcopterus	EF373154 (a)	EF373105 (a)	---	EF373205 (a)
Rhodostethia rosea	EF373155 (a)	EF373106 (a)	---	EF373206 (a)
Rissa tridactyla	DQ385229 (c)	DQ385280 (c)	DQ385297 (c)	AY228785 (o)
Rynchops niger	DQ385230 (c)	DQ385281 (c)	DQ385298 (c)	AY228784 (o)
Stercorarius longicaudus	U76820 (m)	EF373109 (a)	---	EF373208 (a)
Stercorarius skua	DQ385227 (c)	DQ385278 (c)	DQ385295 (c)	AY228783 (o)
Sterna anaethetus	AY631296 (d)	AY631332 (d)	---	---
Sterna maxima	AY631309 (d)	DQ674571 (n)	DQ674609 (n)	---
Sternula superciliaris	AY631316 (d)	AY631352 (d)	---	EF373210 (a)
Stiltia isabella	EF373159 (a)	EF373110 (a)	---	EF373211 (a)
Synthliboramphus antiquus	U37303 (k)	EF373111 (a)	EF380294 (b)	EF373212 (a)
Synthliboramphus craveri	U37304 (k)	EF380311 (b)	EF380295 (b)	EF380274 (b)
Synthliboramphus hypoleucus	U37305 (k)	---	---	---
Synthliboramphus wumizusume	U37306 (k)	EF380312 (b)	EF380296 (b)	EF380275 (b)
Tryngites subruficollis	EF373162 (a)	EF373114 (a)	---	EF373215 (a)
Uria aalge	U37307 (k)	DQ485794 (n)	DQ485832 (n)	EF380276 (b)
Uria lomvia	U37308 (k)	AJ242687 (e)	EF380299 (b)	EF373216 (a)
Xema sabini	EF373164 (a)	EF373116 (a)	---	EF373217 (a)

Table A3. Fossil calibrations used in the divergence time analysis. Ages represent the minimum age applied (i.e., offset of lognormal distributions). See Smith (in press) for additional details of dating methods for specific fossil taxa (e.g., radiometric or biostratigraphic) and support for systematic position. Institutional Abbreviations: California Academy of Sciences, San Francisco, CA, USA (CASG); Duke Lemur Center, Division of Fossil Primates, Durham, North Carolina, USA (DPC); Georgia College and State University Vertebrate Paleontology Collection, Milledgeville, GA, USA (GCVP); Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China (IVPP); Los Angeles County Museum of Natural History, Los Angeles, California, USA (LACM); Museum National d'Histoire Naturelle, Paris, France (MNHN); San Diego Museum of Natural History, San Diego, California, USA (SDSNH); University of California Museum of Paleontology, Berkeley, CA, USA (UCMP); Smithsonian Institution, National Museum of Natural History, Washington, DC, USA (USNM).

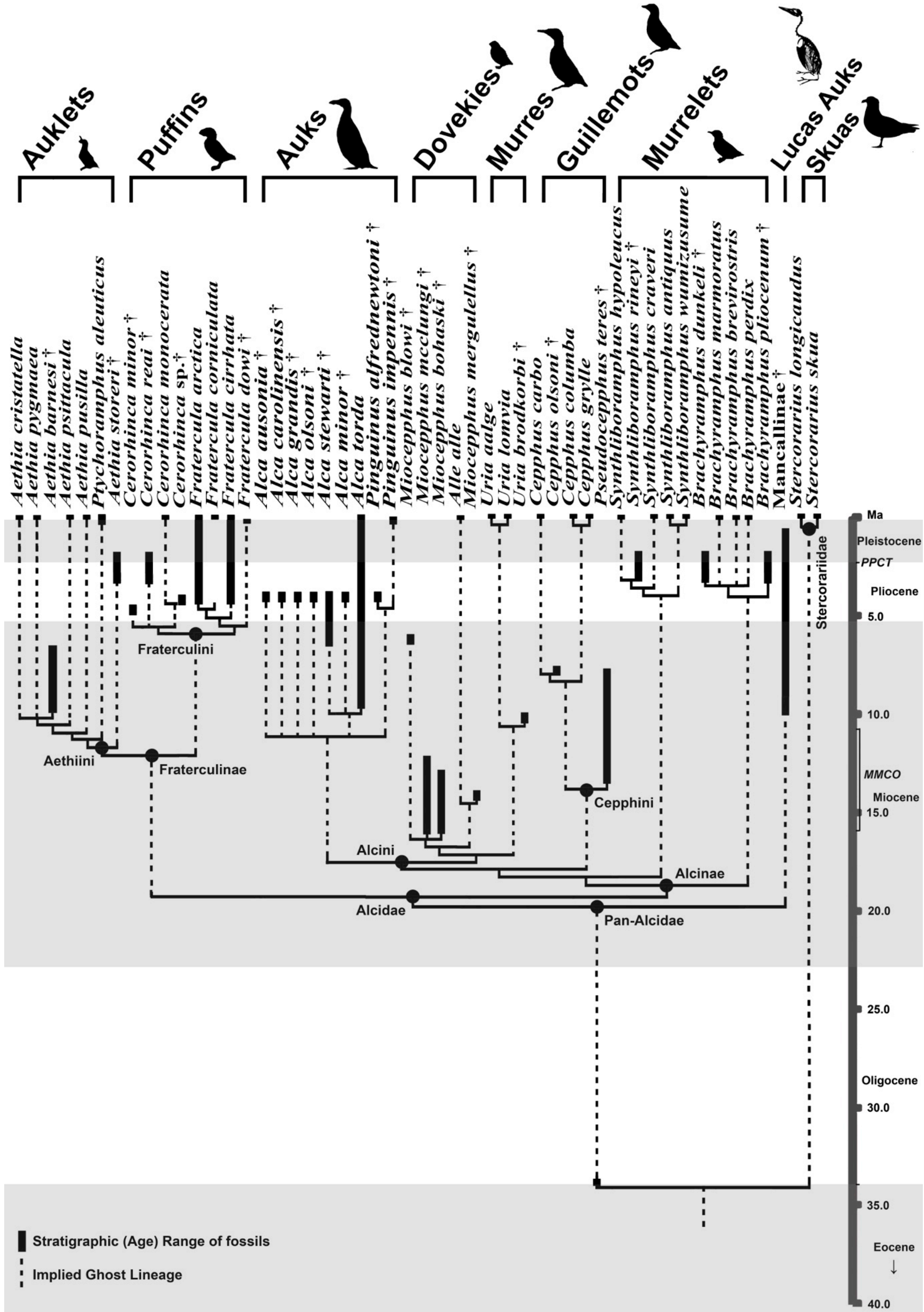
Taxon and specimen #	Split Calibrated	Age (Ma)	Reference
†*Brachyramphus dunkeli* (SDSNH 24573)	*B. marmoratus* x *B. brevirostris*	1.5	Chandler 1990
†*Synthliboramphus rineyi* (UCMP 61590)	*S. craveri* x *S. hypoleucus*	1.5	Chandler 1990
Fratercula aff. *arctica* (USNM 490887)	*F. arctica* x *F. corniculata*	4.2	Olson and Rasmussen 2001; Smith et al. 2007
Uria lomvia (CASG 71892)	*Uria lomvia* x *Uria aalge*	2.6	Olson 2013
†*Aethia barnesi* (LACM 107031)	Aethiini x Fraterculini	6.7	Smith 2014
†*Cepphus olsoni* (LACM 107032)	*C. carbo* x *C. grylle* + *C. columba*	6.7	Howard 1982
Alca cf. *torda* (e.g., USNM 237157)	*Alca torda* x †*Pinguinus impennis*	7.2	Wijnker and Olson 2009, Smith and Clarke 2011
†*Miocepphus bohaski* (USNM 237270)	*Alle alle* x *Uria*	15.97	Wijnker and Olson 2009; Smith and Clarke 2011
†*Laricola elegans* (MNHN Av.4134)	Laridae, Sternidae, Rynchopidae	23.6	De Pietri et al. 2011
†*Nupharanassa bulotorum* (DPC 3848)	Jacanidae x other Scolopaci	30.0	Rasmussen et al. 1987
Pan-Alcidae incertae sedis (GCVP 5690)	Pan-Alcidae x Stercorariidae	34.2	Chandler and Parmley 2002
†*Jiliniornis huadianensis* (IVPP V.8323)	Charadrii x Scolopaci + Lari	41.3	Hou and Ericson 2002

Table A4. Age range of pan-alcid species based on published fossil material. Extant species appear in **bold font** and extinct taxa are denoted by "†". Note, that species such as †*Cerorhinca reai* and other taxa known exclusively from the San Diego Formation of southern California are not known to have definitively crossed the Pliocene-Pleistocene boundary. Rather, the stratigraphic occurrence of pan-alcid taxa within the San Diego Fm. are poorly constrained.

Taxon	Age Range	Reference
Aethia cristatella	~2.5 ka - present	Friedmann 1934
Aethia pygmaea	no fossil record	
Aethia psittacula	~1.5 ka - present	Friedmann 1941
Aethia pusilla	~2.0 ka - present	Friedmann 1941
†*Aethia storeri*	1.8-3.6 Ma	Smith 2014
†*Aethia barnesi*	6.7-10.0 Ma	Smith 2014
Ptychoramphus aleuticus	~25.0 ka - present	Howard 1949, Guthrie 1992
†*Cerorhinca minor*	~5.0 Ma	Howard 1971, Addicot 1972
Cerorhinca monocerata	~2.0 ka - present	Friedmann 1937
†*Cerorhinca* sp.	4.4 Ma	Smith et al. 2007
†*Cerorhinca reai*	1.8-3.6 Ma	Chandler 1990, Wagner et al. 2001
Fratercula arctica	4.4 Ma - present	Olson and Rasmussen 2001
Fratercula corniculata	~15.0 ka - present	Friedmann 1941
Fratercula cirrhata	4.4 Ma - present	Olson and Rasmussen 2001
†*Fratercula dowi*	46.0 - 31.0 ka	Guthrie et al. 1999
†*Alca ausonia*	4.4 Ma	Olson and Rasmussen 2001
†*Alca carolinensis*	4.4 Ma	Smith and Clarke 2011
†*Alca stewarti*	7.0 - 4.4 Ma	Wijnker and Olson 2009
†*Alca minor*	4.4 Ma	Smith and Clarke 2011
Alca torda	10.0 Ma - present	Wijnker and Olson 2009
†*Alca olsoni*	4.4 Ma	Smith and Clarke 2011
†*Alca grandis*	4.4 Ma	Olson and Rasmussen 2001
†*Pinguinus alfrednewtoni*	4.4 Ma	Olson and Rasmussen 2001
†*Pinguinus impennis*	500.0 ka - 1844	Harrison and Stewart 1999
Alle alle	34.0 ka - present	Stewart 2002
†*Miocepphus mergulellus*	14.0 Ma	Wijnker and Olson 2009
†*Miocepphus blowi*	~6.5 Ma	Wijnker and Olson 2009
†*Miocepphus bohaski*	16.0 - 12.0 Ma	Wijnker and Olson 2009
†*Miocepphus mcclungi*	16.0 - 13.0 Ma	Wijnker and Olson 2009
Uria aalge	~25.0 ka - present	Guthrie 1992
Uria lomvia	~2.6 Ma - present	Olson 2013
†*Uria brodkorbi*	~10.0 Ma	Howard 1981
Cepphus carbo	no fossil record	

Figure A2. Chronogram of extant charadriiform relationships inferred from the Bayesian divergence time analysis showing nodes that were calibrated with fossils (stars), posterior

Figure A2. (continued from previous page) probabilities (nodes with PP = 1.0 not shown; PP < 1.0 shown above nodes in *italics*), 95% HPD (blue error bars) and estimated mean node ages (in or alongside error bars). All nodes have been assigned labels (e.g., B2) corresponding to those in Table A4. Note that only extant taxa (with the exception of † *P. impennis* for which sequence data was available) were included as terminals in the divergence analysis and only extant taxa are represented in the resulting molecular based topology. Also note that the divergence time estimates for all cladogenetic events pre-date the minimum implied divergences based on the fossil record or are within the stratigraphic range of extinct taxa used as calibrations in the divergence time analysis (also see Figure A3). For example, because the youngest possible age of †*Aethia barnesi* (6.7 Ma) was used as a hard minimum bound on the divergence between Aethiini and Fraterculini (in concordance with the criteria outlined by Parham et al., 2012), the age of divergences nested within Aethiini were not constrained (see Smith, 2014 for discussion of the age and systematic position of †*A. barnesi*).



Auklets
Puffins
Auks
Dovekies
Murres
Guillemots
Murrelets
Lucas Auks
Skuas
Aethia cristatella
Aethia pygmaea
Aethia barnesi †
Aethia psittacula
Aethia pusilla
Ptychoramphus aleuticus
Aethia storeri †
Cerorhinca minor †
Cerorhinca reai †
Cerorhinca monocerata
Cerorhinca sp. †
Fratercula arctica
Fratercula corniculata
Fratercula cirrhata
Fratercula dowi †
Alca ausonia †
Alca carolinensis †
Alca grandis †
Alca olsoni †
Alca stewarti †
Alca minor †
Alca torda
Pinguinus alfrednewtoni †
Pinguinus impennis †
Miocepphus blowi †
Miocepphus mcclungi †
Miocepphus bohaski †
Alle alle
Miocepphus mergulellus †
Uria aalge
Uria lomvia
Uria brodkorbi †
Cepphus carbo
Cepphus olsoni †
Cepphus columba
Cepphus grylle
Pseudocepphus teres †
Synthliboramphus hypoleucus
Synthliboramphus rineyi †
Synthliboramphus craveri
Synthliboramphus antiquus
Synthliboramphus wumizusume
Brachyramphus dunkeli †
Brachyramphus marmoratus
Brachyramphus brevirostris
Brachyramphus perdix
Brachyramphus pliocenum †
Mancallinae †
Stercorarius longicaudus
Stercorarius skua
Fraterculini
Aethiini
Fraterculinae
Alcini
Cepphini
Alcinae
Alcidae
Pan-Alcidae
Stercorariidae
Ma
Pleistocene
PPCT
Pliocene
5.0
10.0
MMCO
Miocene
15.0
20.0
25.0
Oligocene
30.0
35.0
Eocene
40.0
Stratigraphic (Age) Range of fossils
Implied Ghost Lineage

Figure A3 (previous page). Minimum fit cladogram based on the fossil record of Pan-Alcidae and the results of the parsimony based phylogenetic analysis (dotted lines represent implied ghost lineages). See Table A4 for age ranges (i.e., stratigraphic ranges) of pan-alcid fossils.

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