Eggs of extinct aepyornithids (Aves: Aepyornithidae) of Madagascar: size and taxonomic identity

Vejce vyhynulých madagaskarských epyornisů (Aves: Aepyornithidae): velikost a taxonomická příslušnost

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Mlíkovský J. 2003: Eggs of extinct aepyornithids (Aves: Aepyornithidae) of Madagascar: size and taxonomic identity. *Sylvia 39: 133–138.*

The fossil record of extinct aepyornithids (Aepyornithidae) known from the late Quaternary comprises, apart from osteological material, a number of eggshells. Almost 50 complete eggs have been delivered from Madagascar to Europe and the USA. For 43 eggs, the measurements of which were available, statistical evaluation has revealed that (1) all the eggs are referable to a single aepyornithid species *Aepyornis maximus* Geoffroy-Saint-Hilaire, 1851, (2) average egg measurements of the species are 302,7 × 223,6 mm, (3) egg length ranges between 264–340 mm and (4) egg width ranges between 194–245 mm.

Vyhynulí epyornisové (Aepyornithidae), známí pouze z mladších čtvrtohor Madagaskaru, po sobě kromě kosterních pozůstatků zanechali řadu vaječných skořápek. Téměř padesát vajec se zachovalo v celku a bylo vyvezeno do Evropy a USA. Pro 43 z nich se podařilo získat rozměry, jejichž statistická analýza ukázala, že (1) všechna tato vejce patří pouze jedinému druhu, pro který zřejmě platí jméno Aepyornis maximus *Geoffroy-Saint-Hilaire, 1851, (2) průměrné rozměry vajec tohoto druhu jsou 302,7× 223,6 mm, (3) délka vajec kolísá v rozmezí 264–340 mm a (4) šířka vajec kolísá v rozmezí 194–245 mm.*

Keywords: Aepyornithidae, eggs, biometry, taxonomy, Madagascar

INTRODUCTION

Aepyornithids (Aepyornithidae Bonaparte, 1854) were large, flightless birds, endemic to the island of Madagascar. Their fossil record is restricted to the late Quaternary, probably only to the Holocene (Lambrecht 1933, Brodkorb 1963, Feduccia 1996). The last aepyornithids possibly survived in the 17th century (cf. Flacourt 1658). Aepyornithid bones were described by several researchers (e. g. Monnier 1931, Lambrecht 1933, Lamberton 1934), but no modern osteological revision of this group is available.

Aepyornithid eggshells have been known since the 1830s (Gervais 1841). The first complete eggshells arrived in Europe in the early 1850s (Geoffroy-

Saint-Hilaire 1851, 1854, 1855, 1856). Overall, almost 50 aepyornithid eggs have been delivered from Madagascar to Europe (e. g. Joly 1867, Rowley 1867, Capellini 1889, 1900, Lydekker 1891, Sclater 1892, Krause 1900, 1907, Meyer & Heller 1901, Diederichs 1906, Fischer-Sigwarth 1915, Neviani 1926, Cauderay 1931, Lambrecht 1933, Boxberger 1949, Astro 1951, Henrici 1957, Schönwetter 1960) and the USA (Eastman 1898, Bradbury 1919, Anonymous 2003). No data are available on eggs which are possibly deposited in private or institutional collections in Madagascar and in the rest of the world.

In the present paper, available data on the size of aepyornithid eggs are gathered in order to study their metrical variability, and to clarify their taxonomic identity.

MATERIAL AND METHODS

This study is based on the list of egg dimensions presented by Cauderay (1931), supplemented with and/or corrected by the data presented by Eastman (1898), Bradbury (1919), Lambrecht (1933), Boxberger (1949), Astro (1951), Henrici (1957), Schönwetter (1960), and Anonymous (2003). Standard statistical techniques were used to evaluate the measurements (e. g. Sokal & Rohlf 1995).

RESULTS AND DISCUSSION

Variability

Statistical distributions of both the length and width of known aepyornithid eggs are unimodal (Figs. 1–2), and both fit with the normal distribution (Kolmogorov-Smirnov's D = 0.0978 for length and 0.105 for width; $p < 0.01$ in both cases). This allows treating all these eggs as a single statistical unit.

Statistical distribution of the egg length is characterized by the following parameters: arithmetic mean = 302.7 ± 2.62 mm, range = 264–340 mm, variance = 302.7 mm, standard deviation = 17.2, coefficient of variation = 5.68 %, skewness = 0.30 ± 0.36, kurtosis = –0.0089 ± 0.71.

Statistical distribution of the egg width is characterized by the following

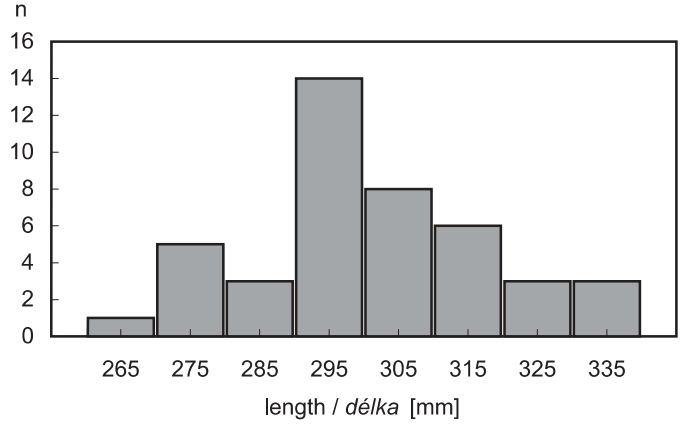

Fig. 1. Statistical distribution of the length of aepyornithid eggs from Madagascar.
Obr. 1. *Statistické rozdělení délky vajec epyornisů z Madagaskaru.*

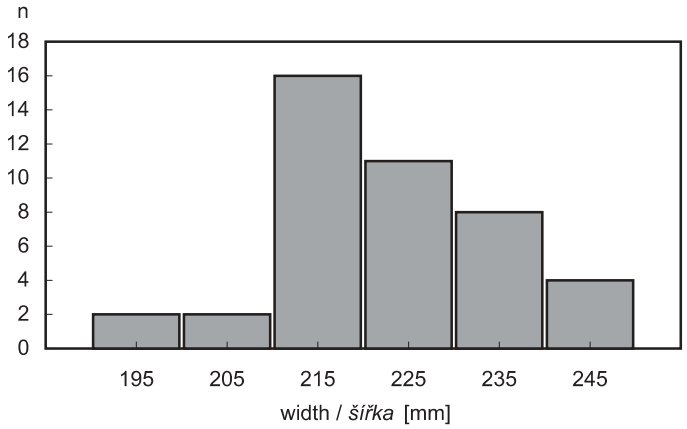

Fig. 2. Statistical distribution of the width of aepyornithid eggs from Madagascar.
Obr. 2. *Statistické rozdělení šířky vajec epyornisů z Madagaskaru.*

parameters: arithmetic mean = 223.6 ± 1.82 mm, range = 194–245 mm, variance = 142.6 mm, standard deviation = 11.9, coefficient of variation = 5.34 %, skewness = –0,17 ± 0.35, kurtosis = –0.28 ± 0.71.

Relation between the width and length of aepyornithid eggs is described by the following linear regression: *width* = 56.1 + 0.55 *length*. Correlation r = 0.80 ($p < 0.01$) – see Fig. 3.

Taxonomic identity

Aepyornithid eggs were either referred to the genus *Aepyornis* Geoffroy-Saint-Hilaire, 1851 without reference to a species (most authors) or attributed to

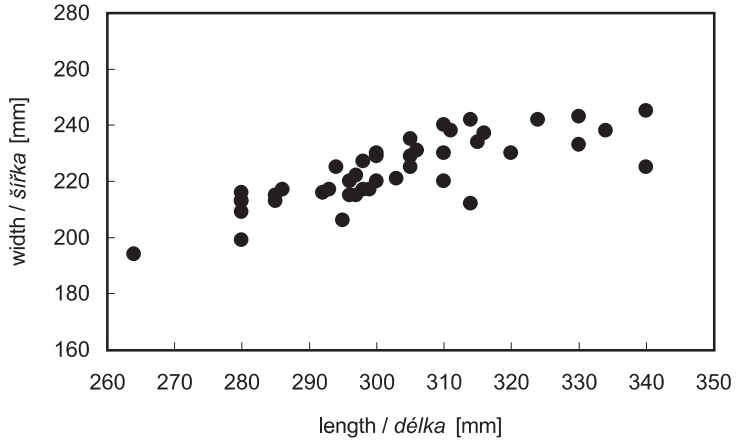

Fig. 3. Relation between the length and width of aepyornithid eggs. See Appendix for the data.
Obr. 3. *Vztah mezi délkou a šířkou vajec epyornisů. Data jsou uvedena v příloze.*

one or more species recognized within the genus (e. g. Boxberger 1949, Schönwetter 1960). Statistical evaluation of the egg size of available aepyornithid eggs has revealed that all of them are referable to a single aepyornithid species: (1) statistical distribution of the egg length (Fig. 2) and width (Fig. 3) is unimodal; (2) metrical variability of egg dimensions is small (coefficient of variation = 5.3–5.7 %), which is well within the limits for a single species (see Mlíkovský 2002).

Altogether, 15 nominal species of aepyornithids were described from Madagascar in 1851–1913 (Brodkorb 1963, Mlíkovský in press). Findings of the eggs support the idea that only a single aepyornithid species inhabited Madagascar in the late Quaternary, for which the name *Aepyornis maximus* Geoffroy-Saint-Hilaire, 1851 is available (see Mlíkovský in press). Taxonomic identity of individual nominal species of Madagascar aepyornithids will be evaluated elsewhere (Mlíkovský in press).

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Received September 1, 2003; accepted September 25, 2003.
Došlo 1. září 2003, přijato 25. září 2003.

Appendix. Dimensions of aepyornithid eggs [in mm]. Numbering in the present paper is supplemented by egg numbering after Schönwetter 1960 (S), Henrici 1957 (H) and Cauderay (C).
Příloha. *Rozměry vajec epyornisů [v mm]. Číslování vajec v tomto článku je doplněno číslováním použitém u Schönwettera 1960 (S), Henricibo 1957 (H) a Cauderaye (C).*

no. /*č.*	S	H	C	length *délka*	width *šířka*	reference *autor*
1		1		264	194	Astro 1951
2	1	2		280	199	Schönwetter 1960
3		3	28	280	209	Cauderay 1931
4	6		30	280	213	Schönwetter 1960
5	2	4	29	280	213	Schönwetter 1960
6		9		280	216[1]	Henrici 1957
7	3	5		285	213	Schönwetter 1960
8	4	7	26	285	215	Schönwetter 1960
9	5	8		286	217	Schönwetter 1960
10				292	216	Anonymous 2003
11			25	293	217	Cauderay 1931
12			27	294	225	Lambrecht 1933
13		6		295	206	Schönwetter 1960
14	8	11		296	215	Schönwetter 1960
15		13		296	220	Schönwetter 1960
16	7	10		297	215	Schönwetter 1960
17	11	14		297	222	Schönwetter 1960
18	9	12	23	298	217	Schönwetter 1960
19	13	16		298	227	Schönwetter 1960
20			24	299	217	Cauderay 1931
21			22	300	220	Cauderay 1931
22			20	300	229	Cauderay 1931
23			19	300	230	Cauderay 1931
24	12	18		303	221	Schönwetter 1960
25		15		305	225	Henrici 1957
26	14	19	16	305	229	Schönwetter 1960
27				305	235	Boxberger 1949
28	15	20	18	306	231	Schönwetter 1960
29				310	220	Eastman 1898
30	16	21	13	310	230	Schönwetter 1960
31	22	23	34	310	240	Schönwetter 1960
32			11	311	238	Cauderay 1931
33	10	17	12	314	212	Schönwetter 1960
34	20	25	10	314	242	Schönwetter 1960
35	18	22	9	315	234	Schönwetter 1960
36	19	24	8	316	237	Schönwetter 1960
37			7	320	230	Cauderay 1931
38	21	26	5	324	242	Schönwetter 1960
39			4	330	233	Cauderay 1931
40				330	243	Bradbury 1919
41			3	334	238	Cauderay 1931
42	17	27	2	340	225	Cauderay 1931
43	23	28	1	40	245	Schönwetter 1960

[1] Henrici (1957) gave 230 mm as the width of this egg, but comparison with the circumference showed that this is a misprint for 216 mm. The latter value is used here.