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COMMENTS & REPLIES

The dodo was not so slim: leg dimensions and scaling to body mass

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Recently Angst et al. (2011) proposed a new mean body mass estimate for the dodo (*Raphus cucullatus*), of Mauritius Island, 10.2 kg, which is at the lower end of previous estimated intervals such as Kitchener's (1993). We question both their methods and results and propose a revised estimated interval.

Angst et al. (2011) used the lengths of the hindlimb three long bones and regression equations, based on a sample of living birds, between these lengths and body mass (Zeffer et al. 2003). But contra Angst et al. (2011), tibiotarsus and tarsometatarsus lengths cannot be used to estimate body mass. This is because different bird species of the same weight can show considerable differences in the lengths of these two bones, hence in leg length, across families and orders, generally in adaptation to particular locomotory habits (terrestriality, running, perching, aeriality, swimming, wading …), mode of predation (e.g. ornithophagy) and others, with particular causes in insular contexts (e.g. Campbell and Marcus 1992; Zeffer et al. 2003; Louchart 2005 and references therein). This is visible in the relatively low R^2 (coefficient correlation squares), considering the log–log scaling, for tibiotarsi and even more for tarsometatarsi (0.66) in Zeffer et al. (2003). In contrast, the femur length scales tightly with body mass (Campbell and Marcus 1992) and hardly participates in leg length, the femur being essentially horizontal in life in birds (except for the graviportal extinct birds of several hundred kilograms) and incorporated inside the avian body. Incidentally, Zeffer et al. (2003) themselves had emphasized that leg length–i.e. essentially tibiotarsus and tarsometatarsus lengths–varies with ecomorphology rather than with body mass. In addition, the composite 'mean' of 10.2 kg in Angst et al. (2011) derives from an artificial averaging of different mean estimates obtained using: femur, tibiotarsus and tarsometatarsus lengths, and sum of these lengths. This averaging is flawed as it incorporates twice the unreliable estimates from the tibiotarsus and tarsometatarsus lengths. Indeed, the dodo deviates from an average bird in terms of leg inter-segment proportions. Both tibiotarsus- and tarsometatarsus- based estimates strongly depart from the femur-based estimate, and the former two bones appear proportionately short.

The estimates from individual femur lengths in Angst et al. (2011) can be considered representative of real body mass. They yielded 12.8–17.8 kg (mean, 15.7 kg, for 24 femurs of 15 individuals, the Lyon left femur excluded because its anomalously low length appears to be an error compared

We dedicate this short note to Bradley C. Livezey, ornithologist devoted to research on avian evolution and ecomorphology–which included studies on the dodo and solitaire–who died prematurely in February 2011.

This is a comment on Angst et al. (2011) The end of the fat dodo? A new mass estimate for *Raphus cucullatus*. Naturwissenschaften 98: 233–236.

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with the right one; D. Berthet, pers. com.). Campbell and Marcus (1992), not cited by Angst et al., have provided the most efficient regressions between skeletal measurements and body mass with the largest sample of birds, based on femur and tibiotarsus shaft least circumferences. The R^2 of these regressions, 0.958 (based on species means) and 0.961 (based on individuals) for femurs vs. weight with their complete sample of birds ('all birds'), are much higher than those in Zeffer et al. (2003), for instance. Those for ecomorphological subgroups such as HB (heavy bodied terrestrial, which includes pigeons, galliformes, etc.) are even higher. Campbell and Marcus (1992) found 13.2–16.4 kg for the dodo with three femurs, using the 'all birds' equation. With three femurs (Milne-Edwards 1866; Janoo 1997, 2005) and the same method, we find 11.7–15.4 kg using 'all birds' and 9.5–12.3 kg using 'HB'. Kitchener (1993) found 10.6–17.5 kg using several independent and congruent scaling methods with leg bones and others, on a wide dodo sample.

Hence, the most reliable known methods concur to confirm that 10.2 kg is too low for a mean. A reasonable range interval for the dodo is ca. 9.5–18 kg, very close to that already proposed by Kitchener (1993). The interval is rather wide, which may result from an important sexual size dimorphism and/or individual variation (Livezey 1993).

References

Angst D, Buffetaut E, Abourachid A (2011) The end of the fat dodo? A new mass estimate for *Raphus cucullatus*. Naturwissenschaften 98:233–236

Campbell KE Jr, Marcus L (1992) The relationship of hindlimb bone dimensions to body weight in birds. Nat Hist Mus Los Angeles Cnty Sci Ser 36:395–412

Janoo A (1997) La Position Phylogénétique du Dodo (*Raphus cucullatus* L.) et du Solitaire (*Pezophaps solitaria* Gm.). PhD dissertation, Mus Natl Hist Nat Paris

Janoo A (2005) Discovery of isolated dodo bones [*Raphus cucullatus* (L.), Aves, Columbiformes] from Mauritius cave shelters highlights human predation, with a comment on the status of the family Raphidae Wetmore, 1930. Ann Paléontol 91:167–180

Kitchener A (1993) On the external appearance of the dodo, *Raphus cucullatus* (L., 1758). Arch Nat Hist 20:279–301

Livezey B (1993) An ecomorphological review of the dodo (*Raphus cucullatus*) and solitaire (*Pezophaps solitaria*), flightless Columbiformes of the Mascarene Islands. J Zool 230:247–292

Louchart A (2005) Integrating the fossil record in the study of insular body size evolution: example of owls (Aves, Strigiformes). Monogr Soc Hist Nat Balears 12:155–174

Milne-Edwards A (1866) Remarques sur des ossements de Dronte (*Didus ineptus*) nouvellement recueillis à l'île Maurice. Ann Sci Nat Zool 5ème Ser 5:355–380

Zeffer A, Johansson LC, Marmebro Å (2003) Functional correlation between habitat use and leg morphology in birds (Aves). Biol J Linn Soc 79:461–484