

## Comment

**Palaeobiology of the  
Cretaceous bird  
*Confuciusornis*: a  
comment on Peters &  
Peters (2009)**

The Chinese Early Cretaceous bird *Confuciusornis sanctus* is notable because among the many well-preserved specimens, some exhibit a pair of remarkably long, blade-like tail feathers absent in other specimens. The Peters & Peters (2009) study provides confirmation of the main conclusion of Chiappe *et al.* (2008), namely that there is no statistical correlation between size (limb bone lengths) and presence/absence of the long tail feathers of *C. sanctus*. Peters & Peters (2009) also concluded that the two distinct size classes identified by Chiappe *et al.* (2008)—each containing long-tailed specimens—were the expression of sexual size dimorphism, in which the large class was interpreted as females. We argue that such a conclusion is not substantiated by the available data and that interpretations of the size variability of *C. sanctus* may involve other biological or taphonomic phenomena.

Chiappe *et al.* (2008) presented four plausible explanations that, individually or together, may account for the observed size classes within the 106 analysed specimens: (i) two species, (ii) sexual dimorphism, (iii) attritional deaths, and (iv) a particular growth pattern. By adding a few new specimens to the original data, Peters & Peters (2009) embraced only one of these explanations: sexual size dimorphism. Peters & Peters supported their deduction by interpreting what is essentially the same size distribution of Chiappe *et al.* (2008)—a few smaller specimens and two clusters of larger and distinctly sized individuals—through the lens of considering the growth pattern of *C. sanctus* as comparable to that of modern birds (individuals reaching adult size within months). This assumption was based on De Ricqlès *et al.* (2003), who, subjectively using bone depositional rates of 10 µm per day (comparable to rates of some modern birds), deduced that *C. sanctus* developed adult size in 20 weeks. However, these calculations are questionable. Firstly, given that the cortical bone of *C. sanctus* consists of different types of tissue deposited at different rates, growth through maturity cannot be accurately represented by a single depositional rate. Secondly, De Ricqlès *et al.*'s estimations cannot accurately account for the bone formed during the early ontogenetic stages of their studied specimen, which was erased by resorption during medullary expansion.

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Thirdly, De Ricqlès *et al.* failed to account for the actual duration of pauses in growth implied by the presence of lines of arrested growth that interrupt the deposition of bone tissue in *C. sanctus*. Thus, the assumption that growth in *C. sanctus* was comparable to that of its living counterparts is not well supported. In fact, it is more reasonable to assume that depositional rates in *C. sanctus* were lower than those of modern birds and that skeletal maturity was reached after several years of growth, a condition inferred for other Mesozoic pre-modern birds (Chinsamy-Turan 2005; Erickson *et al.* 2009) and determined in some basal living birds (Bourdon *et al.* 2009). The latter assumption is at least consistent with the interpretation of the size distribution of the sample analysed by Chiappe *et al.* (2008) as a growth series. The Peters & Peters (2009) hypothesis is additionally weakened by not entirely being supported by their own statistics. In contrast to what was proposed by Chiappe *et al.* (2008), Peters & Peters (2009) argue that the scaling of the long bones of *C. sanctus* is not isometric and that the smallest specimens constitute a distinct cluster with wing bones that are relatively longer than in larger individuals (i.e. allometric growth). Such an argument is puzzling, however, given that the confidence intervals computed by Peters & Peters (2009) included the smallest individuals on their lower limit, which indicates that all values can be fitted to a single regression line whose slope is virtually 1 (i.e. reduced major axis on the log-transformed variables of the entire sample fits lines with a slope range of 1.03–1.07). Consequently, the diverging slopes of Peters & Peters (2009, figs 1a,b,c,e) for the smallest individuals in the studied sample are statistically unjustifiable. Thus, their argument that the smallest individuals are the only juveniles in the sample (the two larger clusters corresponding to adults of different sexes) cannot be sustained, let alone their claim that the larger cluster is composed of females. It is worth noting that the second dimension of the principal component analysis of Chiappe *et al.* (2008) indicates that the variability of limb proportions (wings versus legs) is the same throughout the entire sample. Consequently, outliers of small, middle and large size indicate that examples of individuals with relative longer wing bones are not restricted to the smallest sizes. A greater understanding of the morphological diversity of *C. sanctus* may be reached using shape analysis (geometric morphometrics), but the taphonomic distortion of all known specimens puts a caveat on this approach.

Given the above, it is evident that Peters & Peters (2009) have provided a rather inadequate solution, compounded by questionable ideas about growth patterns and *ad hoc* statistics, to a far more complex situation. The exceptional preservation and large sample of available specimens of *C. sanctus* offer an unprecedented opportunity for studying the variation, development and life history of early Mesozoic birds. The elongated rectrices of this bird may have played a reproductive role, but if so, determining this would likely be masked by factors such as molting and differential preservation (Chiappe *et al.* 1999). Deciphering this 125-Ma-old conundrum may require interpretations that allow the interplay of multiple biological explanations as proposed by Chiappe *et al.* (2008).

L. M. Chiappe<sup>1,\*</sup>, J. Marugán-Lobón<sup>1,2</sup> and  
A. Chinsamy<sup>3</sup>

<sup>1</sup>Dinosaur Institute, Natural History Museum of  
Los Angeles County, 900 Exposition Boulevard,  
Los Angeles, CA 90007, USA

<sup>2</sup>Departamento de Biología, Universidad Autónoma de  
Madrid, Cantoblanco 28049, Madrid, Spain

<sup>3</sup>Zoology Department, University of Cape Town,  
Private Bag, Rondebosch 7701,  
South Africa

\*chiappe@nhm.org

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