

that aid blood-feeding<sup>8</sup>. By so doing, they also promote the transmission of arthropod-borne pathogens<sup>10,11</sup>.

**Hui Wang, Guido C. Paesen,**

**Patricia A. Nuttall**

*NERC Institute of Virology & Environmental Microbiology,*

*Mansfield Road, Oxford, OX1 3SR, UK*

*e-mail: pan@mail.nerc-oxford.ac.uk*

**Alan G. Barbour**

*Departments of Microbiology & Molecular Genetics and Medicine, University of California, Irvine, California 92697-4025, USA*

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## Theropod–bird link reconsidered

Norell *et al.*<sup>1</sup> describe a *Velociraptor* ‘wishbone’ which they interpret as a new piece of evidence for the theropod origin of birds. The bone fits a pattern of furcula-like structures that have been discovered in certain late Cretaceous theropods, including *Oviraptor*, *Ingenia* and possibly others<sup>2</sup>, some of which possess clavicles — usually not fused. But this interpretation gives rise to problems of chronology, structure and function.

First there is the temporal paradox: the earliest-known bird, *Archaeopteryx*, occurred 75–80 million years earlier than the *Velociraptor* and other late Cretaceous theropods that had ‘wishbones’. Supposed Jurassic examples are from carnosaurs, a group generally thought to be distant from birds — although the cladistic analysis of Thulborn<sup>3</sup> places *Tyrannosaurus* closer to modern birds than to *Archaeopteryx*.

Second, the furcula-like structure in the specimen of *Velociraptor* has a round cross-section<sup>1</sup>, while that of the primitive Mesozoic birds — *Archaeopteryx*, *Confuciusornis* and the enantiornithines — is dissimilar, being grooved postero-dorsally along almost its entire length<sup>4</sup>.

Also, the articulation of the arms of *Velociraptor*’s furcula-like structure along the entire margin of the coracoid (Fig. 1 of ref. 1) is unlike the articular relationship of the furcula in birds. However, it is similar to the relationship of the interclavicle bone to the coracoids found in primitive diapsids<sup>5</sup>. This

raises the possibility that the *Velociraptor* and theropod ‘furculae’ are nonhomologous to that of birds — the view of Bryant and Russell<sup>2</sup>. Fig. 1 of ref. 1 does not show an avian articulation of the ‘wishbone’ to the rest of the shoulder girdle and resembles the restoration of Barsbold for *Oviraptor* and the mounted specimen of *Ingenia*.

Third, in most flightless birds the furcula degenerates into two clavicular splints<sup>6</sup>, similar to the clavicles reported in some dinosaurs<sup>2</sup>. This strongly indicates that flight arose as an original function in birds, not as a modification of a structure already present before flight evolved<sup>1</sup>.

Fourth, the presence of a furcula-like structure in *Longisquama*<sup>6</sup>, a primitive Triassic archosaur with long feather-like scales and postulated arboreal habits, indicates that structures of this type have developed more than once in the archosauromorphs, which means they are weak evidence for a bird link to theropods.

**Alan Feduccia**

*Department of Biology, University of North Carolina, Chapel Hill, North Carolina 27514, USA*

**Larry D. Martin**

*Museum of Natural History, University of Kansas, Lawrence, Kansas 66045, USA*

Norell *et al. reply* — First, maniraptoran theropods, and theropods with furculae, are known from the Late Jurassic period<sup>7,8</sup>, significantly closing the ‘gap’ discussed above. We did not say in our Scientific Correspondence<sup>1</sup> that *Velociraptor* was a direct ancestor, only that dromaeosaurs are related to birds. How do Feduccia and Martin explain the presence of primitive living mammals such as monotremes and marsupials 100 million years after they split from the line leading to ourselves?

Second, exact similarity is not a requirement for homology — take, for example, the forelimb variation among the living orders of mammals. Bat wings, whale flippers and human arms are very different but homologous. The furculae of living birds are highly variable<sup>6</sup> and often different from the furcula of *Archaeopteryx*, yet Feduccia and Martin do not question the homology between these two groups. These authors identify this element as a possible interclavicle, a bone that is extremely different in crocodylomorphs and not present in any ornithodiran<sup>9</sup>.

We do not think Feduccia and Martin can, from a small photograph, say with confidence that the furcula is articulated along the entire margin of the coracoid. Examination of the actual specimen shows that the furcula attaches to the scapula just as it does in modern birds. We discussed this feature in our Scientific Correspondence<sup>1</sup>: “...the proximal process of the furcula tapers to a point where it contacts the scapulocoracoid”.

Third, we disagree with Feduccia and

Martin’s implication that preconceived process dictates the interpretation of pattern. Science is about discovery; by assuming less, we discover more. Feduccia and Martin believe that furculae cannot exist in the non-avian Maniraptora because they did not fly, but this view precludes the possibility of furculae ever being discovered in these animals.

Fourth, *Longisquama* is a poor-quality fossil, and the interpretation of single elements is controversial. *Longisquama* lacks other characters — present in non-avian Maniraptora — that would ally it with birds. Single features do not overturn a hypothesis that is strongly supported by a plethora of character evidence.

Ironically, if one does use Feduccia and Martin’s reasoning that *Longisquama* is a close bird ‘ancestor’ as advocated elsewhere<sup>10</sup>, the temporal paradox increases. *Longisquama* comes from rocks about 220 million years old, creating a fossil-free gap of more than 80 million years before the appearance of *Archaeopteryx*. Any empirical measure of stratigraphic fit<sup>11</sup> will prefer a hypothesis of maniraptoran relationships over this one.

**Mark A. Norell, Peter Makovicky**

*Department of Vertebrate Paleontology, American Museum of Natural History, New York, New York 10024, USA*

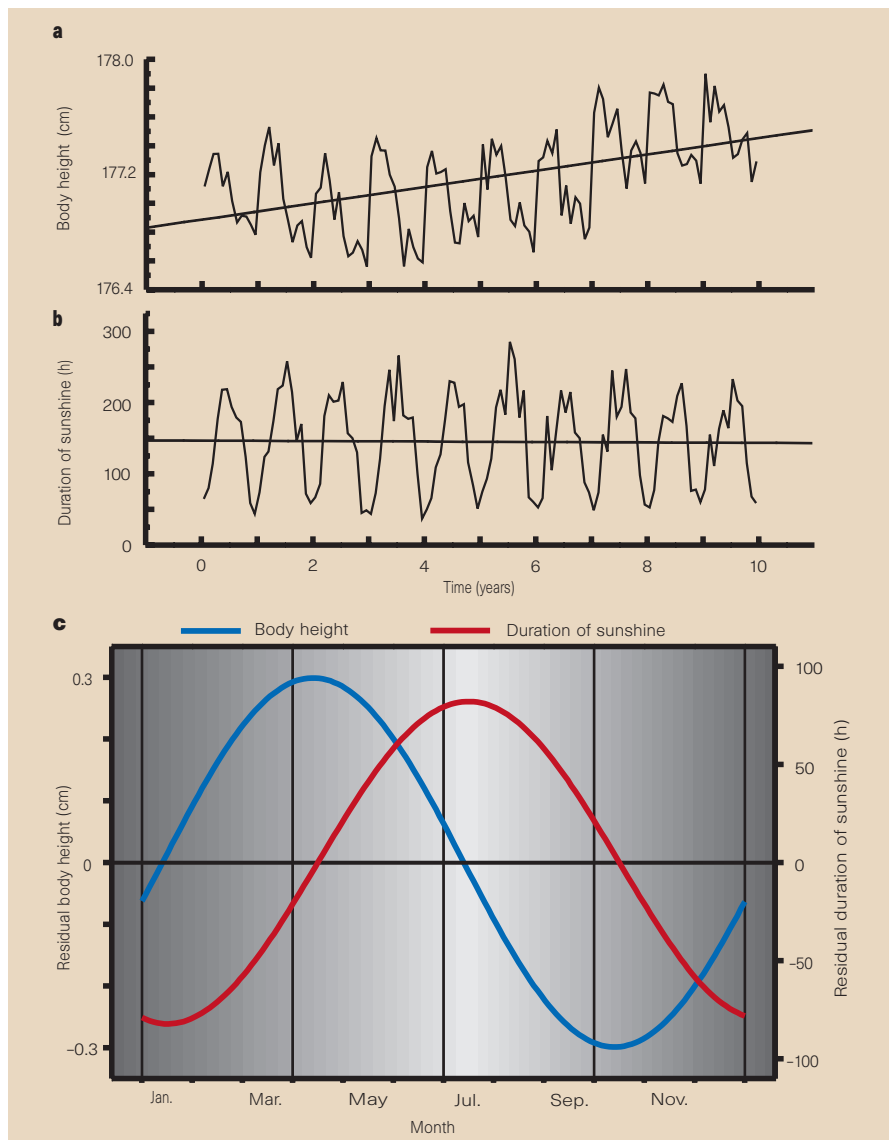
**James A. Clark**

*Department of Biological Sciences, George Washington University, Washington, DC 20052, USA*

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## Height depends on month of birth

Using a large human male population of 507,125, we find clear evidence for a dependence of body height at age 18 on birth month. Over 10 years there is a sinusoidal variation with a period of 1.0 year with maxima in spring and minima in autumn differing by 0.6 cm. Although global environmental factors<sup>1</sup> are small and can be studied only with the help of sophisticated methods on very large sample sizes, they might offer insights into still undiscovered mechanisms of human development. This may provide empirical facts for clinical



**Figure 1** Relationship between body height and birth month. **a**, Monthly averages of height at age 18 (birth cohorts 1966–75). **b**, Duration of sunshine (1984–93). In both graphs, linear interpolations indicate trends<sup>†</sup>. Mean and standard deviation for height, 177.2±0.33 cm with 0.057 cm yr<sup>-1</sup> secular trend; for sunshine duration in the same interval, 144±65 h with a trend of -0.69 h yr<sup>-1</sup>. **c**, Variation in height and sunshine duration residuals, as determined by the inverse Fourier transform of the signal with the largest amplitude ( $P < 0.001$ ), during one year. The next largest amplitude ( $P < 0.04$ ) with a period of 10 years is 0.12 cm. Maximum height is reached in April, minimum in October. Maximum duration of sunshine is in July, minimum in January.

research on the pineal gland and melatonin<sup>2</sup>. The body heights of the entire male population of ten 1-year birth cohorts of Austria were measured by the Austrian Federal Army and recorded (in millimetres and rounded to the nearest centimetre) throughout the whole year in five conscription centres. Not only is there a difference between the ‘January to June’ and ‘July to December’ cohorts (an effect that Breiting<sup>3</sup> has already noted) but also a sinusoidal fluctuation over the year. We also compared this fluctuation with the monthly variation in sunshine duration in Austria<sup>4</sup> during the same interval (Fig. 1a, b).

To demonstrate the periodic nature of the observed variations, we linearly interpolated both data sets (body height and sunshine

level) to find — and then subtract — the long-term linear trends. We analysed the resulting residuals in two different ways: by generating a Fourier spectrum and by producing a Lomb–Scargle<sup>5</sup> periodogram. We found the amplitudes, the periods and the phase difference between the two data sets by Fourier analysis and tested the assumption of periodicity by calculating the Lomb–Scargle normalized periodogram, which can reveal the existence and the frequencies of periodic signals and their statistical significance in seemingly random, unevenly sampled data in the presence of some degree of (gaussian) noise. The body heights vary periodically (amplitude ±0.3 cm) with a 365-day period, as does the duration of sunshine. There is also a constant phase shift of +89 (or

-276) days between the maximum body height and the maximum light level from the Sun (Fig. 1c).

We cannot offer definitive explanations of why body height depends on the month of birth with such a pronounced cycle. Yet all proposed hypotheses must consider the clear annual rhythm, which is a strong indicator of a synchronization with extraterrestrial conditions, and the nonlinear growth curves during the prenatal and early postnatal period for humans. Growth is fastest during the three months before and after birth, so we postulate that the periodicity is due to influences extending from the time of late pregnancy to the first postnatal year. Furthermore, because seasonal photic input is known to regulate both various body functions and growth in mammals, we infer a phylogenetic remnant in humans.

The underlying physiological mechanism might involve the light-dependent activity of the pineal gland. The magnitude of the melatonin concentration is related to the intensity, as well as the wavelength, of light incident on the optical apparatus. Melatonin is active during the prenatal period by transplacental passage<sup>6</sup>, and its cyclic production in the newborn is already established by 9–15 weeks after birth<sup>2</sup>. Some authors postulate effects of melatonin on growth hormones<sup>7</sup>; others are convinced of an association of growth with blindness<sup>8</sup>.

In rhesus macaques, chimpanzees and humans, during the later part of fetal life and for a short time after birth, the arcuate nuclei in the middle hypothalamus have an important role in growth. Recent studies suggest effects of the arcuate nuclei on the growth hormone<sup>9</sup> as well as the binding of melatonin in that hypothalamic structure<sup>10</sup>. Perhaps our observed periodicity in body height will provide impetus to further discussion on mechanisms of human growth.

**Gerhard W. Weber, Hermann Prossinger, Horst Seidler**

*Institute of Human Biology, University of Vienna  
Althanstrasse 14, A1090 Vienna, Austria  
e-mail: gerhard.weber@univie.ac.at*

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