Form, Function, and the Flight of the Pterosaur

A. W. A. KELLNER AND D. A. CAMPOS ("THE function of the cranial crest and jaws of a unique pterosaur from the Early Cretaceous of Brazil," Reports, 19 July, p. 389) suggest that the huge cranial crest of a newly discovered pterosaur might have had multiple functions, including mating display and thermoregulation, but they say it might have interfered with flight.

The authors compare the pterosaur with a modern bird less than one-fifth its size, speculating that the pterosaur might have caught fish by flying low over water with its lower jaw partially submerged.

The relatively massive lower jaw of the analogous modern bird, drawn in the authors' Fig. 3, suggests that the pterosaur could not have maintained flight against water resistance with its entire lower jaw submerged, but must have skimmed with the distal third or so, where the greatest lateral compression is shown to occur.

Not discussed by the authors is that the pterosaur probably needed its crest to balance its long jaws, the attitude of the head changing somewhat depending on locomotion on land, flying speed, or submergence of the lower jaw while flying over water.

A crest inflatable with blood and possibly variable in air resistance (like a hand-held fan) would have helped the pterosaur adjust the long-term attitude of its head, reducing the need for heavy, powerful neck muscles, at the cost of requiring a little more forward thrust while skimming. The force of air against an extended crest would balance the force of water on the jaw, keeping the head from being rotated toward the water.

Far from interfering with flight, an inflatable crest might have made longer flights possible. The spermaceti reservoir in the head of the sperm whale is supposed to have a similar function, allowing the whale to use blood flow to adjust the temperature and thus the buoyancy provided by the spermaceti.

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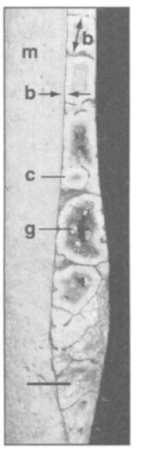
Response

WORKING WITH EXTINCT ORGANISMS IS always a challenge, particularly when it comes to the interpretation of the function of previously unknown structures. In our report, we described a skull and lower jaw of a new pterosaur (*Thalassodromeus sethi*) from Early Cretaceous deposits of Brazil, which bears a gigantic bony crest never before recorded in any animal (fossil or recent). We listed several possible functions of this oversized structure, focusing primarily on its effect in signaling (e.g., species recognition) and on its possible use to control body temperature. Despite noting that it had to have an aerodynamic effect (due to its large size), we did not discuss this function in detail, as correctly pointed out by Williams. He further suggests that in *Thalassodromeus*, this crest might have been inflatable and acted to balance the force of water on the jaw in a similar function of the spermaceti reservoir in the head of the sperm whale that is supposed to adjust buoyancy. We reject the "inflatable crest hypothesis" on the basis of the reasons discussed below.

The oversized cranial structure in *Thalassodromeus* is made up of two thin layers of bone connected on the sagittal plane by a well-developed system of trabeculae (see the figure). It is difficult to imagine that such a laterally compressed structure could be substantially "inflated" (even by soft tissue present on the lateral side) to have a strong aerodynamic effect that could not have been achieved otherwise (e.g., simple lateral movement of the head). The analogy with a supposed buoyancy adjustment of the spermaceti organ in sperm whales does not make much sense in a flying animal that had other perhaps more effective mechanisms to "float" in the air (e.g., wings). Furthermore, the spermaceti is mostly regarded as having other functions ranging from aggression (discarded for this pterosaur because of the fragility of the crest) to a sonar [e.g., (*1*)]. On the basis of the large occipital region and muscle scars, *Thalassodromeus* did have strong neck muscles that (in conjunction with the flying apparatus) kept the head from being rotated toward the water during fishing.

The main problem regarding the aerodynamic influence of the crest is empirically establishing the range of those effects considering all variables (e.g., angles and wind speed). The idea of this crest being used as a forward rudder, for example, is very tempting, and there seems to be little doubt that any lateral movement of the head would allow this animal to change direction during flight. Even during fishing, fast changes of the trajectory might have increased the capacity of *Thalassodromeus* to catch a prey—particularly when skimming the water surface.



Perpendicular (coronal) section of the upper portion of the cranial crest of the pterosaur *Thalassodromeus sethi*. The gray area on the left-hand side is the matrix (m) that originally involves the bone (removed from the right side); the white substance is calcium carbonate (c) that occasionally forms geodes with the growth of calcite crystals (g). The actual bone (b) is very thin, forming the external part of the crest (two arrows) and the thin trabeculae inside the crest (double arrow). This configuration demonstrates the hollow nature of the crest. Scale bar, 5 mm.

To properly study the aerodynamics of *Thalassodromeus*, however, there is a need for information from different sources starting with the fossils but including notions of biomechanics (e.g., muscle power and stress capacity of different biological tissues) and flight mechanics. Only a project with such an interdisciplinary approach, to which we would like to contribute, could empirically establish the limitations and effects of such an oversized cranial structure, including any effect that an extended crest might have had as a counterbalance to the forces of the water on the jaws, also suggested by Williams.

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Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

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Humility in Observational Studies

THE WOMEN'S HEALTH INITIATIVE HORMONE replacement therapy (HRT) study has shaken medical practice and left many women puzzling, as reflected in Martin Enserink's article "The vanishing promises of hormone replacement" (News Focus, 19 July, p. 325). Although many previous observational studies found substantial cardio-protection with HRT (*1*), two large, well-conducted clinical trials found no such "protection" (*2*, *3*). Why were these earlier studies wrong? In all likelihood, although the observational studies "controlled" for a plethora of variables, they all suffered the same "selection bias"—women using HRT were healthier in other ways those studies didn't or couldn't address well.

Beyond HRT itself, however, the studies are a wake-up call for a range of disciplines including sociology, demography, epidemiology, and econometrics that often rely on such observational methods and attempt to "control" for variables statistically. For example, education is associated with positive social attributes including economic status, voter participation, lower cardiovascular disease, lower infant mortality, and lower fertility. So education is advocated for those benefits. But investigators seldom pursue how people who achieve higher education might be different (e.g., in motivation, intelligence, work ethic, aspirations, social connections, and so forth) and thus confound the effect of education. Rather this entire Gordion knot of explanatory factors is often lumped together as years of schooling.

No single study design is a panacea. We must continue to use such observational methodologies. But we must implement them more carefully and interpret them more humbly.

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The Difficulties of Double Blinding

THE RECENT PUBLICATION OF RESULTS FROM the Women's Health Initiative (WHI) study of hormone replacement therapy (HRT) suggests that the health risks of taking HRT may outweigh the benefits ("The vanishing promises of hormone replacement," M. Enserink, News Focus, 19 July, p. 325). One interesting thing to note about HRT studies like the WHI is the strong possibility that the treatment and placebo groups can guess their assignments at a better than chance level. Beginning HRT can cause physical changes that may well be detected by women, such as a sudden reduction in hot flashes, an increase in vaginal lubrication, and mild acne. Women's guesses about their group assignment can affect their compliance with the program, as well as their choice of other treatments. It is possible that women who believe they are in the treatment group and expect HRT to help cardiovascular problems might be less likely to use the small doses of aspirin that are recommended to reduce clotting, while

Recent findings about hormone replacement therapy have left patients and doctors shaken.

others whose continuing symptoms suggest that they are in the placebo group may seek a variety of "natural" remedies for their symptoms such as soy products. A systematic effect is hard to predict, but we should keep in mind that a real double-blind design may not be possible here.

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Science and Technology Centers and Education

JEFFREY MERVIS'S DESCRIPTION OF THE SCIence and technology center (STC) program supported by the National Science Foundation (NSF) ("Science with an agenda: NSF expands centers program," News Focus, 26 July, p. 506) presents a view of the program that is not universally shared by all of the STCs. The nature of our mission, which is broad and includes not only research but also education and knowledge transfer, is demanding, but there are sufficient resources to make STCs a success. The nature of the support, up to $20 million for 5 years, with a second 5-year period of funding, allows members of our STC and others to pursue cutting-edge research that is not only high-risk but whose payoff may be years away. In coupling this commitment to education and knowledge transfer, the STCs are able to explore a complete array of science-related activities.

The article also seems to portray K-12 education as an unwelcome burden placed on the STCs by the NSF. It is suggested that individuals who direct K-12 education efforts should be drawn from the scientist pool of the university—Ramon Lopez of the Center for Integrated Space Modeling is quoted as saying "It is a mistake to put an educator in charge."

On the contrary, at the inception of the Nanobiotechnology Center (NBTC), we

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