PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

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Cherrie D. Bramwell and G. R. Whitfield

Phil. Trans. R. Soc. Lond. B 1974 **267**, 587-589
doi: 10.1098/rstb.1974.0009

Phil. Trans. R. Soc. Lond. B. **267**, 587–589 (1974) [587]
Printed in Great Britain

D. M. S. WATSON'S NOTES ON PTEROSAURS

By Cherrie D. Bramwell and G. R. Whitfield

(*Communicated by F. R. Parrington, F.R.S.* – *Received* 13 *September* 1973)

This is a collection of notes, drawings and calculations made by D. M. S. Watson on pterosaurs. None of the work is dated with the year, but some notes have been made on the back of examination timetables for 1929. The most striking item is a general essay on pterosaurs. This is not complete but shows clearly that Watson thought of pterosaurs in a way similar to our own. We chose to study *Pteranodon* because, as a large flying animal, its design would be dependent to a great extent on aerodynamic demands; and that these would show up clearly in the structure. Watson puts forward this concept very plainly, writing: 'Flying animals live a life so difficult in many ways, in the actual flight, in take-off and landing, in feeding and in the production and rearing of their young, that they are necessarily highly efficient mechanisms, and their structure must conform to rigid and to a great extent determinable limits.' It is these limits we have tried to determine for *Pteranodon*, and we fully agree with Watson as he continues 'the pterodactyl gives us a unique opportunity of testing our powers of interpretation of an animal's structure in terms of function, because, owing to the urgent need of economizing weight, we can be sure that very little of the skeleton can be without definite and important function'. Watson concludes the introduction to his essay by mentioning that 'any investigation of a pterodactyl must begin by an attempt to reconstruct the animal'. This has been exactly our own approach.

The fine engineering aspects of the skeleton had not escaped Watson. Writing of *Pteranodon* itself he mentions that 'the cylinders of bone were no thicker than a visiting card, prevented from collapse only by a system of tie-bars, bony rods as thick as a pin passing across the cavity, with their expanded ends continuous with the wall'. On one scrap of paper Watson has scribbled his measurements of a bone, presumably a humerus, as 'of thickness of bone just below deltoid crest 0.52 mm. Diameter of shaft 16.5 mm, length 110 mm'. As well as measuring bones in this way to determine the bone thickness and wing spread, Watson examined the articulations, using the same bones as we have for this purpose, the uncrushed 'English specimens in Cambridge and the Isle of Wight'. He writes that 'the actual articular surfaces fit with the perfection of good machinery, and there is no difficulty in determining by trial what movements were possible'.

Watson's aerodynamic work was done mostly on species of *Pterodactylus*, *Rhamphorhynchus* and *Dimorphodon*. Among the notes are several drawings of these in plan with the wing outstretched, to determine the wing-span and wing area (figure 1). Also treated in this way are *Archaeopteryx* and a 'pterodactyl' aeroplane.† These drawings are really the dorsal and lateral engineering views of these animals. Having found the wing areas, Watson wished to know the mass. He did this mostly by referring to birds; for example, one note reads '*Diomedea exulans* 12700 g, area 17800'. A paper by E. Banks, 'Relation of weight to wing area in the flight of animals' is among his papers. In one sketch of *Rhamphorhynchus* Watson has applied a geometrical

† This R.A.F. plane, the Westland-Hill Pterodactyl, used to fly at the air show at Hendon during the thirties.

method of his own to find the mass. The details are not clear, but the animal has been divided into large segments and is surrounded by geometrical sums. The conclusion was that *Rhamphorhynchus gemmingi* had a wing loading of 1.2 lbf ft^{-2} (5.9 kgf m^{-2}). Watson then plotted the wing loading against body length for various pterodactyls, but the purpose of this is not clear. He was clearly having trouble with his aerodynamics; for example, he tries to calculate the drag from the surface area of the animal, although the draft shows that he realized that the shape also matters. We believe it is significant that his paper stops at this point.

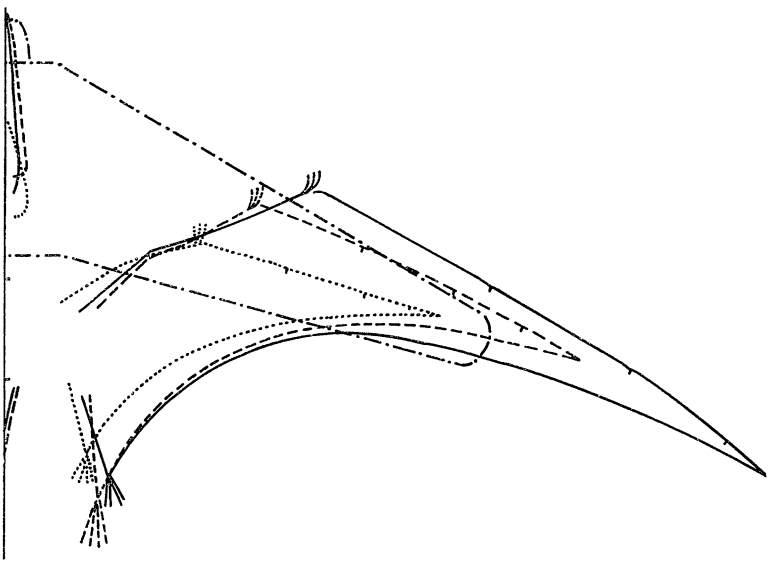

FIGURE 1. *P. brevirostris*, ..., 2.9 cm; *P. kochi*, – – –, 7.9 cm; *Nyctodactylus*, ——, 13.6 cm; pterodactyl aeroplane, – · –, 70 cm.

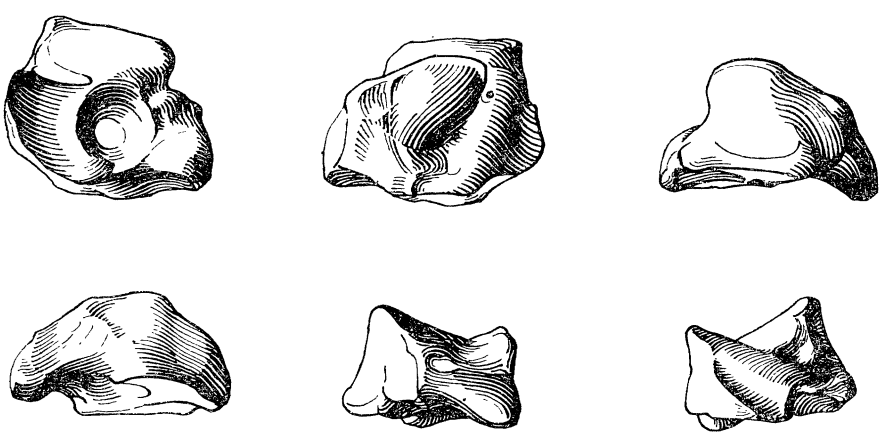

FIGURE 2. Bone drawings by D. M. S. Watson.

He was obviously interested in the power output of pterodactyls and to what extent they could flap their wings. He went to considerable trouble to find power-output figures for muscle, a task that must have been even harder then than today. Included in the notes is a letter from R. H. Burne of the Royal College of Surgeons. Watson had obviously written to him for information on the power of muscle and received references and figures in response. There is a sketch which shows he was trying to estimate the size of the pectoral muscle of an unnamed

pterodactyl and several mysterious mentions of large cat muscles; for example: 'lion, 56 cm^2, 560 kg = 896 lb.' These studies must have led Watson to believe, as he states in his essay, that 'in general, pterodactyls soared like albatrosses and had only a slow flapping gait'.

The final items of interest are many good bone drawings, inked in on board. They are mostly articular ends of bones, especially wrist bones, and some are clearly Cambridge Greensand specimens.

It is both fascinating and tantalizing to suddenly have this collection of pterodactyl notes just as we have finished our paper. They resemble very strongly the collection of rough pieces of paper resulting from our own work. It is a great pity that D. M. S. Watson did not continue with this line of research, because the trend of all the notes shows that a 'Biomechanics of *Pterodactylus* and *Rhamphorhynchus*' could have been the end result, anticipating our work by 40 years. Now we will never know how much farther his thought went on these matters, even while knowing that the concept of pterodactyls 'as living aeroplanes' was clear in his mind.

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