Scientists create new functional morphology index to understand how ancestors of modern birds used their wings

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Scientists develop new index to understand how ancestors of modern birds used their wings based on the strength of the coracoid bone (shown in red) and the animal's body mass. Credit: Reiko Matsushita

Scientists at Nagoya University in Japan have developed an index to estimate how a bird uses its wings for flight or other locomotion by

measuring the strength of the coracoid bone and the animal's body mass. It should improve our understanding of how extinct animals used their wings and the different patterns of wing-propelled locomotion that emerged as birds evolved. Their findings were published in the *Journal of Anatomy*.

The presence of a wing alone does not tell us whether an animal can fly. For example, penguins evolved wings to propel them through water whereas feathered dinosaurs may have used their wings for other purposes, such as thermoregulation and intraspecific display. Therefore, to better understand how animals evolved the ability to fly, an index must take into account both the presence of wings and the ability to perform powerful wing-beats.

"We wanted to create a new index because people think that if an animal has wings, then it can fly," said the study's second author, Assistant Professor Shin-ichi Fujiwara. "But this is not always true. An animal can also use its wings for other purposes, such as thermal insulation in flightless animals.

"Our research team focused on how changes in skeletal morphology can lead to changes in locomotion. Subsequently, these changes can lead to major ecological transitions such as a shift in lifestyle from a terrestrial environment to an aerial, aquatic, arboreal, or subterranean environment.

"The origin of flight in birds has been an important topic in this field. We, therefore, needed to develop an alternative index, based on biomechanics, to determine the flapping ability of birds and which we could also use to measure skeletal remains."

To create this index, the researchers used the avian coracoid bone. The coracoid bone acts as a strut to prevent the thoracic skeleton from deforming when an animal's powerful flight muscles, which connect the

wings to the sternum, contract.

Doctoral student Takumi Akeda of the Department of Earth and Planetary Sciences, Graduate School of Environmental Studies, at Nagoya University, and Fujiwara of the Nagoya University Museum, measured the size of a cross section of the coracoid bone in relation to the body mass of 220 bird specimens. Their sample of 209 species included extinct birds such as the dodo and the great auk.

The researchers then divided the birds into four groups based on how they used their wings. These groups were those that used flapping flight (e.g., pigeons); those that used wing-propelled diving (e.g., penguins); those that were flightless with no flapping ability (e.g., ostriches); and those that used thermal and dynamic soaring (e.g., albatrosses and vultures). Based on the strength of the coracoid bone and flapping ability, the researchers could create a new index to analyze flight patterns.

They found that the strength of the coracoid in relation to body mass may reflect the force exerted by the flight muscles, which counteract the lifting force on the wings. This helps to estimate how a bird uses propulsion. Soaring birds had increased coracoid strength, probably to enable them to withstand the greater bending forces caused by the contraction of the flapping muscles. In contrast, non-flapping birds had lower coracoid strength. These findings show that coracoid strength in relation to body mass reflects the lifting force on the wings, therefore, it is a useful tool for reconstructing the type of propulsion used by the animal.

Akeda and Fujiwara's index should allow future researchers to assess the flight styles and flapping abilities of not only extinct birds but also other flying animals, including the Pteranodon and Quetzalcoatlus of "Jurassic World" fame. The index could also allow them to estimate the origin of

flight in winged theropods, the ancestors of birds.

"The use of coracoid strength is a powerful theoretical framework for reconstructing the origins of pre-flight flapping ability and powered flight," said Fujiwara. "It seems appropriate to first apply our new index to the extinct taxa in the theropod bird lineage, which includes feathered dinosaurs such as Archaeopteryx and Confuciusornis. We also believe that coracoid bones of Pteranodon and Quetzalcoatlus functioned as struts against the contraction of the flapping muscles. Therefore, our index can potentially reconstruct their flight ability and help answer controversial questions such as whether Quetzalcoatlus could flap its wings to fly."

More information: Takumi Akeda et al, Coracoid strength as an indicator of wing-beat propulsion in birds, *Journal of Anatomy* (2022). DOI: 10.1111/joa.13788

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