International Journal of Multidisciplinary Research And Studies

Available online at https://ijmras.com/

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND STUDIES
ISSN: 2640 7272
Volume:03; Issue:05 (2020)

EVOLUTIONARY HISTORY OF VERTEBRATES AND IT'S SKELETAL MORPHOLOGY

RITA JAISWAL
M.Phil., Roll No.: 150685 Session-2015-16
Department of Zoology, B.R.A. Bihar University, Muzaffarpur, India
E-mail: khushboja003@gmail.com

ABSTRACT

The vertebral column, sometimes known as the backbone, is one of the most distinguishing characteristics of vertebrates. This structure is made up of a number of tiny bones known as vertebrae. These vertebrae are joined to one another by joints, and the space between them is occupied by discs that are both soft and flexible. Because of this, vertebrates are able to quickly digest information and respond to stimuli in a coordinated manner. In order to efficiently ventilate these lungs by the movements of the cranial ribs, these tejus have developed a posthepatic septum from the embryonic septum transversum and the cranial mesosalpinx. This prevents the intestines from being sucked into the cranial body cavity during strong inspirations. Certain species of tiny lizards exhibit an additional kind of differentiation of their paired unicameral lungs by generating caudal dilatations that are not associated with respiration. During normal breathing, these dilatations are compressed, but they become inflated in defensive situations by taking in the maximum amount of air possible. For instance, several members of the iguanid genus Sauromalus do this so that they may anchor themselves in rock crevices. In lizards belonging to a number of different families that have a discernible extension of the trunk, the lungs have more or less extended caudal non-respiratory dilatations that are, for the most part, formed asymmetrically. These dilatations result in a significant increase in the volume of the lungs and, as a consequence, the total capacity of the body cavity. This results in increased cross-sectional dimensions of the trunk and the ribs, which in turn results in improved mobility of the trunk.

Keywords: Evolutionary , History , Vertebrates, Skeletal , Morphology

INTRODUCTION

Vertebrates

The vertebral column, sometimes known as the backbone, is one of the most distinguishing characteristics of vertebrates. This structure is made up of a number of tiny bones known as vertebrae. These vertebrae are joined to one another by joints, and the space between them is occupied by discs that are both soft and flexible. The vertebral column acts as a support framework for the body and protects the spinal cord, which travels through a hollow area in the core of the vertebrae. The spinal cord is protected by the vertebral column.

The skulls of vertebrates are another significant aspect of their anatomy. The skull is a bony structure that encases and protects not just the brain but also various sensory organs including the eyes, ears, and nose. The brain is contained within the skull. The form and size of the skull can vary greatly from one vertebrate species to another, which is a reflection of how they have adapted to their respective surroundings and ways of existence.

Vertebrates, on the other hand, have a highly developed nervous system that consists of a brain in addition to a nerve network that is spread out over their entire bodies. This enables vertebrates to digest information and react to stimuli in a quick and coordinated way, which gives them an evolutionary advantage.

Major Groups Of Vertebrates

The traits of different vertebrates, as well as the evolutionary connections among them, allow for the taxonomy of these animals into a number of distinct primary groupings. The five primary classes of vertebrates are as follows::

1. Fish: Fish are animals that live in water and are characterised by having gills for breathing and fins for swimming. It is possible to further subdivide them into many

classes, such as jawless fish, cartilaginous fish (like sharks and rays), and bony fish (such as salmon and tuna).

2. Amphibians: Amphibians are a group of animals that are able to subsist in both terrestrial and aquatic environments. In most cases, they go through a transformation that takes them from a larval stage in which they have gills to an adult stage in which they have lungs. There are many different kinds of amphibians, such as frogs, salamanders, and toads..
3. Reptiles: Reptiles are classified as vertebrates because they have scaly skin and lungs that allow them to breathe air. They are what is known as cold-blooded, which means that their body temperature is controlled by the environment in which they live. There are many different kinds of reptiles, such as turtles, lizards, and snakes..
4. Birds: Birds are vertebrates with a warm blood circulation with feathers and wings. They produce eggs, have a beak or bill, and have a very lightweight skeleton. Birds have evolved to be able to fly, and many species have developed specialised beaks and feet to accommodate their unique eating and perching behaviours..

Additional Features

The following are some other characteristics that are shared by all vertebrates::

1. Endoskeleton: The internal skeleton of vertebrates is typically composed of either bone or cartilage. This offers support and protection for the internal organs of the body, in addition to serving as a framework for the attachment of the muscles..
2. Closed circulatory system: All vertebrates, including humans, have a heart and a network of blood veins that enable them to pump blood throughout their bodies. This makes it possible for oxygen and nutrients to be delivered to cells efficiently, as well as for waste products to be removed..
3. Bilateral symmetry: The bodies of vertebrates have a bilateral symmetry, which means that they may be split into two parts that are mirror images of one another along a vertical plane..

4. Digestive system: The digestive systems of vertebrates are quite sophisticated, allowing them to break down their food and extract the nutrients they need..

5. Respiration: Lungs, gills, and skin are all forms of respiration that have independently developed in vertebrates throughout the course of their evolutionary history..

6. Reproduction: Vertebrates are animals that reproduce sexually and have a number of different reproductive techniques, some of which include live birth, internal fertilisation, and external fertilisation..

The history of vertebrates' evolution as well as their ties to other animal groups.

The phylogenetic tree is an essential tool that may be used to better understand the links that exist between various species. A phylogenetic tree is a branching diagram that displays the evolutionary relationships between various creatures based on similar features. Phylogenetic trees may be found in biology and evolutionary biology textbooks. The nodes of the tree symbolise the species' ancestors, while the branches of the tree indicate the many lineages or groupings of organisms that exist.

Phylogenetic trees are always in the process of being updated as new information is discovered. For instance, the finding of new fossil species can give significant insights on the evolution of vertebrates and the relationships between different vertebrate groups. In a similar vein, developments in the tools used for DNA sequencing have resulted in new understandings of the evolutionary history of vertebrates and the connections between them and other creatures.

It is essential, for a number of different reasons, to have a solid grasp on the evolutionary connections that exist between various species. Scientists are able to trace the origins of certain features and discover the genetic and physiological systems that are responsible for them because to this ability. In addition to this, it sheds light on the myriad forms of life that have evolved on Earth and the forces that have influenced their evolution over time.

Lastly, it is essential for conservation efforts to have a solid grasp of the evolutionary connections that exist between various species. Scientists are able to devise plans for the protection of imperilled species and the conservation of their ecosystems if they first identify the species that are in danger and comprehend the connections between them and other living things. This is very necessary in order to preserve the variety of life on Earth and to ensure the continued existence of vertebrates and other species over the long term.

OBJECTIVES OF THE STUDY

1. To study on Evolutionary history of vertebrates and their relationships to other animals.
2. To study on Vertebrates additional features

RESEARCH METHOD

Skeletal Morphology

Skeletal remains from one hundred different bird species, spanning all of the major taxa and orders, were used to compile the data (see Appendix in supplementary material). In order to determine whether or not the within-species variance in the length of the uncinate process on various ribs was significantly different, the lengths of the processes were measured on 10 adult barnacle geese skeletons belonging to the species Branta leucopsis. After then, birds were classified according to the principal style of mobility that they are specialised in. (1) Walking, which includes birds that are either flightless (such as the cassowary) or incapable of sustained flight (such as the capercallie); (2) diving, which includes all birds that actively forage under water by either plunge (such as the kingfisher) or sustained, deep diving (such as the penguin); and (3) nonspecialists, which includes all other birds flying or swimming that are not facultative diving or walking birds.

We took measurements of the length of the vertebral ribs, the length of the sternal ribs, the length of the uncinate processes, and the width of the uncinate processes. In addition, sternal morphology was investigated by measuring the entire length of the sternum as well as its depth (height of keel). When it comes to birds, adjusting for body size can be difficult since many species have disproportionally long necks. Because of this, the conventional snout–vent measures that are used to scale for size are not an option. As a result, all of the data that were obtained were adjusted to account for changes in body size. This was accomplished by dividing the overall length by the length of the vertebral column that encompassed the thoracic ribs. With a Mayr digital calliper (16EX 150•mm, Product No: 4102400, Mayr GmbH), all of the data was gathered from the left side of the skeleton.)

Statistical analysis

Canonical variate analysis, also known as CVA, was used to identify the relationships between the groups. This method maximises the amount of variation that exists between groups in comparison to the variation that exists within groups (Campbell and Atchley, 1981). The following values were utilised in the construction of the CVA: uncinate length and breadth at the base, the midpoint, and the tip; sternal width, length, and depth; and vertebral and sternal rib length. To determine whether or not the mean uncinate length differs depending on the mode of locomotion, a one-way analysis of variance (ANOVA) was performed, followed by a Tukey post-hoc test. Using a repeated-measures ANOVA with Bonferroni comparisons, we looked at the relationship between sternal length and depth, as well as the comparison of uncinate lengths within the same species. The statistical programme known as SPSS (version 13.0; SPSS Ltd., Chicago, Illinois, USA) was used for all of the analyses that were carried out.).

DATA ANALYSIS

Rib Cage Morphology

Although there is not necessarily a correlation between the number of ribs and the style of locomotion, in general, walking animals tend to have the fewest ribs, whereas diving species tend to have the most. Just two of the birds that were employed in this research had ten ribs, whereas eight of them had six, 43 had seven, 25 had eight, 22 had nine, and the remaining two had ten (see Appendix in supplementary material). Our adjustment for body size will have the effect of making comparisons look more similar, rather than more dissimilar. A within-species comparison of relative uncinate process length (mean standard error of the mean) for 10 barnacle geese Branta leucopsis indicated that the general morphology of the rib cage was the same in all of the birds that were analysed. This was determined by examining the rib cages of the birds. Sternal ribs are the ribs that link the vertebral ribs to the sternum. As one proceeds down the vertebral column, these sternal ribs get progressively thin and longer. The first rib is the only exception to this rule. Using one-way ANOVA and Tukey post-hoc tests, we determined that the mean length (standard error) of the uncinate processes is significantly shorter on the first (0.160.02) and last (0.140.02) ribs on which they occur. This result was found by comparing the lengths of all of the ribs that contain uncinate processes. As a result, the data collected during these operations were not included in the canonical analysis. There is not a significant difference in the length of the processes on the remaining ribs (rib 2: 0.220.03, rib 3: 0.230.02, rib 4: 0.220.02, and rib 5: 0.210.03). Because of this, the average duration of processes 2–5 was taken into account in all future studies..

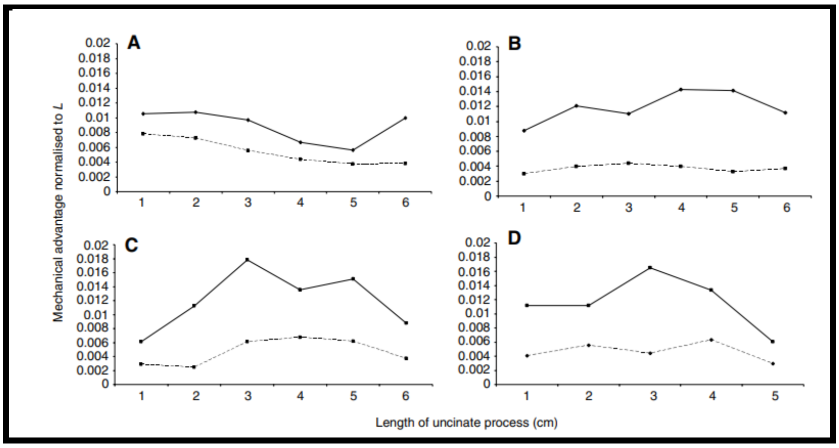

Figure 1 Calculations of the mechanical advantage (adjusted for the length of the muscle, L) for representative species were performed both with (solid line) and without (broken line) the uncinate processes. (A) A bird that dives, the razorbill (Alca torda); (B,C) birds that are not specialists, the barnacle goose (Branta leucopsis) and the kestrel (Falco tinnunculus); and (D) a bird that walks, the red-legged partridge (Alectoris rufa)..

Table 1 The measurements of the uncinate process on the anterior rib that extends back a perpendicular distance (Q), the distance between the ribs (D), the distance of the posterior insertion (P), and the rib angle () of the ribs in bird species that are representative of different types of locomotion are presented here.

	Barnacle goose	Razorbill	Kestrel	Red-legged partridge
D (mm)	14.9±0.59	7.94±0.44	7.51±1.57	7.6±1.99
P (mm)	4.54±0.43	13.08±1.29	3.79±1.91	3.81±1.13
Q (mm)	7.21±0.43	10.50±1.3	4.50±0.36	3.87±0.50
θ (degrees)	71.19±1.88	64.79±6.77	76.85±3.66	74.26±0.41

Species include the diving razorbill *Alca torda*; the non-specialists kestrel *Falco tinnunculus* and barnacle goose *Branta leucopsis*; and the walking red-legged partridge *Alectoris rufa*.
Values are means ± s.e.m. (*N*=6–10).

 Rita Jaiswal*, *University Department of Education: B.R.A. Bihar University, Muzaffarpur*

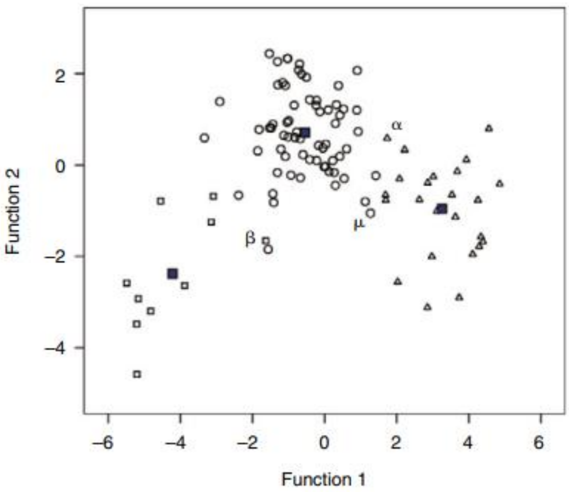

Figure 2 Analysis of the canonical variates (CVA) of the skeletal morphology in birds. In the case of strolling species (squares, N=10), non-specialists (circles, N=66), and diving birds (triangles, N=24), function 1 was compared to function 2. The relative length and width of the uncinate, as well as the rib length, were the primary determinants of function 1 and function 2, respectively. The solid black squares reflect the distinct group centroids that are significantly important. The following species are considered to be on the verge of being classified into their respective groups: the fulmar, the green woodpecker, and the swallow ().

Canonical variate analysis

There was clear clustering in the data that corresponded to the locomotor mode, and there were significant variations between the means of the different groups (Wilks' Lambda = 0.82, P 0.001). There is a degree of overlap, which suggests that there are species that are just on the cusp of our taxonomy. The first canonical discriminant function accounts for 80.2% of the variation, whereas the second canonical discriminant function accounts for 19.8% of the variation. The relative length and width of the uncinate, as well as the rib length, were the primary determinants of function 1 and function 2, respectively..

Uncinate morphology

It was shown that birds that utilised the same way of locomotion had uncinate processes with lengths that were more comparable to one another. They were the shortest in the walking species (0.110.02, N=10, P0.01), the intermediate length in the non-specialist species

(0.170.01, N=66, P0.01), and the longest in the diving species (0.230.01, N=24, P0.01). In most cases, the processes of walking birds extend almost halfway across to the rib that comes after them. In non-specialists, the processes have a distinctive morphology that looks like an L, and they extend all the way to the rib that comes after them. The uncinate processes of diving species are often quite long, very narrow, and gradually taper off as they approach the end (Fig. 1C), and they may overlap the rib that comes next. The relative uncinate length of deep (0.210.01, N=8) and shallow (0.190.02, N=16, P=0.32 for a two-sample t-test) divers does not differ significantly from one another statistically speaking.).

Sternal morphology

Walking birds had a considerably lower relative ratio of sternal length to depth than other types of birds (1.120.44, N=10, P 0.01). compared to those of those who are not specialists (2.16 0.07, N = 66, P 0.01). as well as species that dive (2.75 0.20, N = 24, P 0.01)).

Determination Of Locomotor Modes

The modes of locomotion that were included in the morphometric analysis were, in a general sense, classified as either walking, diving, or non-specialist birds. Although within each group there remain potentially significant differences between the birds, such as foot propelled divers and wing propelled divers, these modes can be considered to be representative because there are broad mechanical differences between specialisation for running versus diving and/or non-specialists (all other birds). There are no examples of birds that swim but are unable to fly, hence there was no need to classify swimming birds as a different subgroup. According to the findings of the CVA research, there are species that either overlap or are located quite close to the boundary between the locomotor groups. These species are examples of birds that have a morphology that falls somewhere in the middle, such as the fulmar (Figure). 5µ), which is considered to be a species that dives is an excellent flier, which may help explain why it is on the boundary between the expert and non-specialist groups. The green woodpecker (Fig.• 5µ), which clusters near to the walking species and can be considered an uncommon bird since it has substantial widening of the vertebral ribs as an adaptation to head banging as a result of its head banging (Kirby, 1980). A flock of swallows (Fig.• 5µ) have bodies that are extremely streamlined, which may help to explain why they congregate so closely with diving animals.

CONCLUSION

The evolution of body cavity subdivisions, in conjunction with the development of non-respiratory lung dilatations in the various kinds of unicameral or multichambered lungs, made it possible for very specific designs of the locomotory apparatus in the various orders of reptiles, ultimately resulting in a great multiplicity of form and function. The development of the respiratory system in vertebrates reached its pinnacle in birds with their volume constant parabronchial lungs and their very compliant air sacs with a low-pressure ventilation, which allowed them to maintain flapping flight throughout their lives. In contrast, the broncho-alveolar lungs of mammals, which are required to have high-pressure ventilation and can undergo significant volume changes, enabled the development of a highly mobile trunk, which is necessary for activities such as high-speed running by predators or deep-sea diving by whales that hunt. The distinctive path that each respiratory system takes throughout embryonic development has a direct bearing on the form and function of both respiratory systems. In addition to these interrelationships, oviparity in birds places a limit on the possibilities for brain evolution, whereas viviparity in mammals enabled cerebralization to expand by several higher orders of magnitude. As a result, humans owe their ability to communicate and participate in cultural activities to this enormous development..

REFERENCES

[1] Burggren, W.W., 1989. Lung structure and function. Amphibians. In: Wood, S.C. (Ed.), Comparative Pulmonary Physiology. Current Concepts. Lung Biology in Health and Disease, vol. 39. Marcel Dekker, New York, pp. 153–192.

[2] Xu, X., Norell, M. A., Kuang, X., Wang, X., Zhao, Q. and Jia, C. (2004). Basal tyrannosauroids from China and evidence for protofeathers in tyrannosauroids. Nature 431, 680-684. (doi: 10.1038/nature02855)

[3] Norell, M. A., Clark, J. M., Chiappe, L. M. and Dashzeveg, D. (1995) A nesting dinosaur. Nature 378, 774-776 (doi: 10.1038/378774a0)

[4] Padian, K. and Chiappe, L. M. (1998) The origin and early evolution of birds. Biol. Rev. 73, 1-42.

[5] Codd, J. R., Manning, P. L., Norell, M. A. and Perry, S. F. (2008). Avianlike breathing mechanics in maniraptoran dinosaurs. P. Roy. Soc. B 275, 157- 161. (doi: 10.1098/rspb.2007.1233)

[6] Chinsamy, A., Chiappe, L. M. and Dodson, P. (1995). Mesozoic avian bone microstructure: physiological implications. Paleobiology 21, 561-574.

[7] Erickson, G. M., Rogers, K. C., Varricchio, D. J., Norell, M. A. and Xu, X. (2007) Growth patterns in brooding dinosaurs reveals the timing of sexual maturity in non-avian dinosaurs and genesis of the avian condition. Biol. Lett. 3, 558-561. (doi: 10.1098/rsbl.2007.0254)

[8] Erickson, G. M., Rauhut, O. W. M., Zhou, Z., Turner, A. H., Inouye, B. D., Hu, D. and Norell, M. A. (2009). Was dinosaurian physiology inherited by birds? Reconciling slow growth in Archaeopteryx. PLoS ONE 4, e7390. (doi: 10.1371/journal.pone.0007390)

[9] Powell, F. L. (2000) Respiration. n Avian Physiology 5th Edition (ed. Causey Whitlow, G.) pp. 233-264. Academic Press, New York.

[10] Zimmer, K. (1935). Beitrage zur Mechanik der Atmung bei den Vögeln in Stand und Flug. Aufgrund anatomischer-physiologisher und experimenteller Studien. Zoologica 88, 1-69

[11] Claessens, L. P. A. M. (2008). The skeletal kinematics of lung ventilation in three basal bird taxa (emu, tinamou, and guinea fowl). J. Exp. Zool. A 311, 586- 599. (doi: 10.1002/jez.501)

[12] Kardong, K. (2006) The respiratory system. In Vertebrates, Comparative Anatomy, Function, Evolution, pp. 430-433. McGraw-Hill Publishing, New York.

[13] Codd, J. R., Boggs, D. F., Perry, S. F. and Carrier, D. R. (2005). Activity of three muscles associated with the uncinate processes of the giant Canada goose Branta canadensis maximus. J. Exp. Biol. 208, 849-857. (doi: 10.1242/jeb.01489)

[14] Schufeldt, R. W. (1890) The musculature of the trunk. In The Myology of the Raven, pp.300-301. London MacMillan and Co.