Original Article

Anatomy

The Skeleton of Domestic Fowl *(Gallus domesticus)*: a Comparative Morphologic Study

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ABSTRACT [ENGLISH/ANGLAIS]

Domestic fowls are probably the most numerous birds in the world largely because of their importance as a source of human food. Their skeleton can be used in teaching (anatomy) students, the skeletal features of Aves and comparative anatomical studies of the skeletal features of Aves and other vertebrae. The bird's skeleton was extracted after slitting the throat with a sharp knife; the feathers and flesh were systematically removed manually and with hot water, ammonia solution, hydrogen peroxide, forceps and lancets. The skeleton of the fowl was characterized by extensive fusion of its components and presented 40 vertebrae compared to man's 33. The Avian skeleton produced can be used to study avian morphology and make comparative analysis with other vertebrae.

Keywords: Domestic fowl, skeleton, comparative morphology

RÉSUMÉ [FRANÇAIS/FRENCH]

Volailles domestiques sont probablement les oiseaux les plus nombreux dans le monde en grande partie en raison de leur importance comme source de nourriture humaine. Leursquelette peut être utilisé dans l'enseignement (anatomie), les étudiants, les caractéristiques du squelette d'Aves et comparative des études anatomiques sur les caractéristiques du squelette d'Aves et autres vertèbres. Squelette de l'oiseau a étéextraite après tranchage de la gorge avec un couteau pointu; les plumes et la chair ont été systématiquement retirés manuellement et à l'eau chaude, une solution d'ammoniaque, le peroxyde d'hydrogène, des pinces et bistouris. Le squelette de la poule a été caractérisée par la fusion complète de ses composantes et a présenté 40 vertèbres par rapport àl'homme 33. Le squelette aviaire produite peut être utilisée pour étudier la morphologieaviaire et de faire une analyse comparative avec les autres vertèbres.

Mots-clés: Les volailles domestiques, le squelette, la morphologie comparative

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INTRODUCTION

Domestic fowls are probably the most numerous birds in the world largely because of their agricultural importance by serving as a source of protein for human consumption. In addition they are bred by some people for hobbies, for their beauty and even religious and traditional purposes.

As with many domestic animals, the origin of the present day domestic fowl is somewhat obscure. Four species of wild jungle fowls possibly contributed to the development of the domestic species we know today- The red jungle fowl (*Gallus gallus*), the Ceylonese jungle fowl (*Gallus lafeyetto*), the gray jungle fowl (*Gallus sonneratii*) and the black jungle fowl (*Gallus varius*). These wild ancestors are primarily found in southeastern India, Burma, Thailand, and Malay Peninsula, Ceylon, parts of China and Indonesia and Philippines. Gwin [1] reported that most available evidence points to Asia as the place of origin of the domestic fowls. These fowls were known to the ancient civilization of the Indus valley and were fully domesticated by 2000 BC. The domestic fowls spread rapidly over the ancient world and appeared in Egypt in the 15th century BC. The ability of hens to lay egg made her a symbol of fertility. A rooster and a hen were traditionally carried in front of Jewish couples. Cock fighting was practiced, apparently, long before the birth of Christ and it is possible that fowls were domesticated as fighting birds even before they were priced for meat and eggs.

According to Samuel et al. [2], the skeleton of the domestic fowl is the hard substance that forms the framework of its body. The bones are fit together and are held in place by strong bands of flexible tissues that tie the bones together to form joints. These skeletal features represent adaptations for flight and the entire skeleton is compact, lightweight but very strong. Many of the bones contain air-filled cavities connected to the respiratory system. The breast bone (sternum) has a keel-like structure for the attachment of powerful breast muscles used for flight [3]. However, the concept of flight as regards the domestic fowl is not an extreme quality because these birds do not have the ability to sustain flight for long distances- a possible adaptive feature of domestication.

Comparative studies of lower animals have aided increasing knowledge in the areas of developmental biology, evolutionary genetics and Comparative Anatomy and have also initiated studies in functional aspects of musculoskeletal biology among species. Therefore, this study will further create more understanding in the field of avian skeleton and its functional aspects as it relates to the Human Skeleton and developing knowledge in neglected areas of evolutionary biomechanics. Knowledge that may be gathered from this work could also be used to teach students aspects of avian skeleton in comparison to that of man for an improved understanding of comparative Human and Avian anatomy.

MATERIALS AND METHODS

Preparation of Skeleton of Domestic Fowl

The fowl was sacrificed with a sharp knife-cut through the throat, severing the carotid artery and the trachea. Hot water was poured on the bird to facilitate the removal of the feathers from all parts of the body. De-fleshing was done using a pair of scissors, forceps and knife. The abdominal and thoracic cavities were cut open using the pair of scissors and forceps followed by the removal of GIT, respiratory, urinary and reproductive organs by inserting the hand deep into the cavities and severing them from their point of attachments.

A soap solution was made by dissolving 150 mls of ammonia solution, 12 g of potassium nitrate and 75 g of local soap in 200 mls of distilled water. The solution was shaken constantly until all the soap was dissolved. The solution was diluted with distilled water in the ratio of 1:25. The remnants of the flesh and ligaments were put into a big pot of water and the soap solution added. The contents of the pot was boiled and stirred continuously for five (5) minutes. After the boiling, the carcass was placed on a dissecting board and the remaining pieces of flesh (which were then soft) were carefully removed with the aid of forceps. The completely de-fleshed fowl was put in a bowl of cold water and allowed to rot for 48 hours. After which it was carefully washed in tap water.

On drying the skeleton was soaked in 50% xylene and 50% chloroform in order to de-fat the bones. Subsequently, the bones were degreased and bleached with hydrogen peroxide solution (10%) by using a fine-toothed brush. The skeleton was then rinsed with clean tap water to remove the hydrogen peroxide. Any flesh not removed from after the entire process was removed mechanically with forceps. Finally, the skeleton was sundried for 12 days.

The skeleton was then mounted in a glass case using props where necessary to support the skeleton and confer a fixed shape on the bony structure. Mothballs (camphor) were added to the box to scare insects from devouring the bones and to prevent fungal growth.

Ethical Approval

Ethical approval for the study was obtained from the ethics/research committee of the Faculty of Basic Medical Sciences, Anambra State University, Uli, Nigeria. This is in line with ethical guidelines for the use experimental animals [4].

RESULTS

Table 1 shows that the vertebral arrangement of the domestic fowl is patterned so that the cervical vertebrae has the largest number of bones (14) followed by the lumbar vertebrae and then the thoracic and sacral vertebrae respectively. These totaled 40 vertebrae as compared to man's 33 vertebrae.

DISCUSSION

The endoskeleton of the domestic fowl is a bony framework that supports the body mass, protects delicate internal organs, provides surface for muscle attachment and gives rigidity and shape to the bird [5]. These bones are light weight with numerous air spaces unlike those of man, which are compact and heavy [6]. This is probably an adaptation to flight. Guttman [5] further stated that the lightweight bones are heavier than those of other birds because they are more stoutly built and may account for the short distances domestic fowls can fly.

The study has evinced that the skull of the fowl is made up of thin hollow bones which are generally fused and providing protection for the brain [6]. The skull is extremely light in proportion to the rest of the body due to the absence of a heavy jaw, jaw muscles and teeth as confirmed by Ashkharad [5]. The shape of the skull, being pointed directs lateral oriented mode of vision. It constitutes less than one percent of the total body weight of the domestic fowl [5].

Table 1: This table shows the different skeleton of the domestic fowl

Vertebrae	Location	Number of bones
Cervical	Neck	14
Thoracic	Thorax	7
Lumbar	Upper abdomen	9
Sacral	Lower abdomen	6
Caudal	Tail	4
	Total	40

Table 2: This table shows comparisons between the vertebrae of Man and domestic fowl

Vertebrae	Man	Domestic Fowl
Cervical	Less mobility and flexibility of the neck because of the 7 bones	Very high mobility/flexibility because of the 14 bones
Thoracic	A total 12 bones not fused together	A total of seven fused bones
Lumbar	A total of 5 bones not fused together	A total 9 fused bones
Sacral	Made of 5 progressively smaller sacral vertebrae with costal elements fused together	Made of 6 bones fused together. They also fuse with the caudal bones to form the syngacrum
Caudal	Formed by the fusion of 4 rudimentary coccygeal vertebrae	Made up of 4 bones that fuse together to form the pygostyle.

The cervical vertebrae are more in number than most mammals [7] having a total of 14 bones, which are important for maintenance of neck shape and eye sight. The long cervical vertebrae makes the neck flexible aiding an extensive area of movements to create an advantage for head movements and focusing on objects at various distances, preen their feathers and see danger from varying distances and directions and also catch prey [8]. This extreme neck mobility due to the large number of cervical vertebrae creates a balance with the other rigid components of the rest of the vertebrae.

The domestic fowl has seven (7) fused thoracic vertebrae. These bones form part of the rib cage and connect the back with the sternum. Overlying flaps projecting off the ribs called the uncinate processes connect each rib to the adjourning ribs. They add strength to the rib cage to avoid collapse during powerful strokes required for flight [9]. The fused thoracic vertebrae may also provide a high degree of rigidity and planar balance necessary for stability in air during flight. In contrast, the twelve (12) thoracic vertebrae of Man that are not fused allow a certain degree of movement that initiate different biomechanical orientations necessary for the sustained erectness during bipedalic motion and other deviations without loss of planar stability in load bearing situations.

The pectoral girdle was found to be made up of sternum, coracoids and scapula. The sternum is a highly modified breast bone which is positioned under the body of the fowl. It is fused to a deep keel that provides an anchor for the powerful flight muscles [10]. Guttman [6] stated that the deeper the keel, the more powerful the flight and flightless birds such as ostriches have a sternum without a keel. The broad sternum seen may also have a responsibility of providing a broad area for expansion during the mechanical phase of respiration. Comparatively, it covers a wider surface area than that of man and may aid the planar orientation in air during flight of the bird. The clavicle fuses together at their base to form the furcula or wishbone [11]. It provides a flexible attachment site for the breast muscles and along with the coracoids acts as struts that resist pressure created by the wing strokes during flight.

The study also revealed that the lumbar vertebrae are fused as well as the bones of the pelvic girdle (sacrum and hip bones) forming a light but strong plate that rests on the thigh bones and supports the fowl when it is on the ground [3]. This extensive fusion of the bones of the pelvic region provides stiff support for the legs in order to deal with the stress of takeoff and landing. The syngacrum is a fusion of the pelvic and caudal vertebrae. At the end of the spinal column is the pygostyle, a fusion of the final few caudal vertebrae. The pygostyle supports the tail feathers and musculature.

The forelimb of the domestic fowl is modified to form the wings. It contains the usual arm bones of reptiles and

mammals but in a highly modified form [9]. The humerus is rather short compared to the total length of the wing as it must withstand the pull by the flight muscles, which depress and elevate the wings. The radius and ulna form support for the mid wing. The outer wing or hand bones are fused for strength and feather support. The first digit (pollex) supports the alula, a small feather used to control air flow around the wing [5]. However, the digitized outer wing is in conformity with the evolutional inclination of flight as a characteristic of flying birds.

The hind limb of the domestic fowl was also observed to have the same basic structure, though modified, as reptiles and mammals. The upper leg is composed of a fairly standard femur, but the lower leg is characterized by fusion of bones [8]. The tarsometatarsus of the fowl is an extended fusion of the foot bones. These lengthening add extra leverage for running, landing and take-off during flight [12].

This study has triggered an extension into the frontiers of anatomical knowledge to ensure continuous study of the anatomical inclinations of our local animal breed. It should initiate a guidepost in the frontline of comparative anatomy within our environment and more of such studies will place our local animal breeds on their true state in the dynamics of evolutionary biology without forgetting its benefits in the teaching and organization of environmental biology.

This study has conclusively established some structural similarities and differences in the bony skeleton of the domestic fowl and man showing that most bones in the skeleton of the domestic fowl are patterned to initiate and aid flight while those of man are patterned to sustain the benefits of bipedalism in human locomotion. The study has also established the local and cheaper pattern of preparation of the fowl for the study which didn't involve lots of laboratory chemicals.

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CONFLICT OF INTEREST

No conflict of interests was declared by authors