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Anatomical Features of Bones Directly Involved in the Act of Flying in the Homing Pigeon and in the Common Pigeon

Aurel DAMIAN[1)], Ioana CHIRILEAN[1)], Alexandru GUDEA[1)], Florin STAN[1)], Cristian DEZDROBITU[1)], Irina IRIMESCU[1)], Melania CRISAN[1)], Ştefan BURIAN[1)]

[1)]Faculty of Veterinary Medicine, Cluj Napoca, 3-5 Mănăştur Street, E-mail: damian56aurel@yahoo.com

Abstract. This study aims to identify distinct morphological features in the skeleton of both the homing pigeon and the common pigeon. The research comprised in this study is intended to enrich the currently existing general data referring to pigeon anatomy and to underline the differences of the two pigeon varieties, the homing one and the common one, regarding bones and their features and the way in which they influence body size, but also their importance in the act of flying. Our findings support the notion of common origins of the domestic pigeon and the homing pigeon. Through this study we have underlined the way in which distinct environmental conditions have led to the evolution of two pigeon varieties with different adaptations. The homing pigeon has adapted in time to progressively longer flights, due to continuously improving food, hygiene and housing conditions. The common pigeon, on the other side, has adapted to a restrictive environment (scarce food of inferior quality, improvised housing and medical conditions).

Keywords: act of flying, sternum, cranium, humerus, pigeon.

INTRODUCTION

Taking into consideration the breeding value which can be attained by a homing pigeon by winning competitions, studies regarding its anatomy, and those studies centered on the locomotor system anatomy in particular, have significant importance and can represent a starting point for further veterinary medical research in this field.

It must be noted that with the development of pigeon racing, there is an increase in the interest in pigeon anatomy, a scientific branch which forms the basis for a better knowledge of the pigeon’s origins and its performance influencing characteristics.

The choice of this theme was based on the interest in establishing correct criteria of selecting pigeons with a high flying potential, separating them from those lacking it.

MATERIALS AND METHODS

Research was carried out on two groups, one composed of 5 homing pigeons belonging to a private breeder and the other composed of 5 common pigeons. The homing pigeons used in this study belonged to different breed lines, but each subject had performed well in several endurance competitions. The common pigeons were captured 90 days prior to taking the measurements, during which they have been fed with the same food as the homing pigeons.

The health state of each pigeon was assessed by general clinical examination and vital sign examination.

The following body measurements were taken for each individual: body length, body mass, beak length, cranium length and width, wing length, wingspan, thoracic circumference, sternum length and width, tail length and leg length.

Body mass was determined with a digital scale, and total length, beak length, wingspan, thoracic circumference, tail length, wing length and leg length were determined with a measuring tape.

After the measuring, the subjects were euthanized to obtain the bones. The euthanized pigeons, which had been all fed with the same food, as mentioned above, were all one and a half years old and were all males. The age of the homing pigeons was easily established (it is imprinted on each bird's leg tag). The age of the common pigeons, however, was determined by assessing their feather shedding (they had a single secondary remex replaced) and their general appearance.

The anatomical pieces were prepared in the Comparative Anatomy Laboratory of the Faculty of Veterinary Medicine of Cluj-Napoca. The bones were obtained through the following steps: removing the muscular and ligament tissues, isolating each anatomical segment, thermal preparation by boiling, using detergent solutions and degreasing agents.

The general dimensions of the bones and the size of their features were determined with a digital caliper and expressed in millimeters.

RESULTS AND DISCUSSIONS

Before proceeding to this section, we wish to mention that the following results are strictly oriented on homing pigeon and common pigeon special features, with very little describing and discussing of features that are similar to other birds in general.

The cranium

Our observations show that the bones of the cranium are, for the most part, sutured together, forming a light but rigid structure which protects the brain. The orbits are large, due to the fact that sight is very important to the pigeon's orientation (Bonaţiu, 1985). The subjects present a short beak, with a thinner base that in chickens and with a sharp tip. The superior mandible, better developed is curbed downwards, surpassing and covering the tip of the inferior mandible. This last aspect is more pronounced in the common pigeon.

Along with rigidity and reduced weight, the bones of the cranium in pigeons have an aerodynamic structure which is very important during flight. The latter must pierce air currents without encountering a high resistance and in the same time create a slight lift which is maintained and increased by the following specialized structures (De Iuliis and Pulera, 2007). Thus, the cranium of the homing pigeon, thought larger than the one of the common pigeon, presents certain subtle differences which concur to create the flight posture. Differences between measurement results appear regarding the distance between the peak of the curve of the frontal bone and that of the angular bone, which is a lot shorter in homing pigeons, a fact which suggests better aerodynamics of the skull in this species (Table 1).

Table 1.
Skull dimensions in the homing pigeon and in the common pigeon.

Pigeon	Length	Height	Width	Length of the mandible
Homing	56	22.3	21.1	40.5
Common	52.2	22.2	20	32

The ribs

The ribs are arranged in seven pairs and present a vertebral segment and a sternal segment, with the exception of the first two pair of ribs, which lack the sternal segment and only present the vertebral one. (Damian *et al.*, 2001). For this reason, they are called floating ribs. This aspect is present in both the homing and the common pigeon. In both skeletons it is worthy of note the rigidity of the thoracic cage formed by the ribs due mainly to the uncinate processes, which are quite well developed.

The sternum

The sternum is completely osseous and differs from that of gallinaceae and palmipeds, because the pigeon is adapted to flight. On the border of the sternal body there are articular surfaces for the ribs, which have the appearance of incisures. On each sides of the cranial extremity of the sternum there are articular surfaces for the coracoid bones. On the lateral surfaces of the sternum there are also three pairs of well developed apophyses, smaller than those in la gallinaceae. The first pair is oriented dorso-cranially and it is called the costal apophyses pair. The next pair is oriented dorso-caudally and called the thoracic apophyses pair and the last pair is called the abdominal apophyses pair. The last two pairs form on each side two incisures: the lateral sternal notch, between the thoracic apophysis and the abdominal apophysis and the medial sternal notch between the abdominal apophysis and the xiphoid process (Fig.1).

The importance of the sternum for the act of flying is great, because this bone is the basis of insertion of the pectoral muscles, which represent a fourth of the total body weight. This ratio is rarely seen in birds and it is due to the rowing type of flight of pigeons. In seagulls, for example, the pectoral muscles/body weight ratio is 1:10.

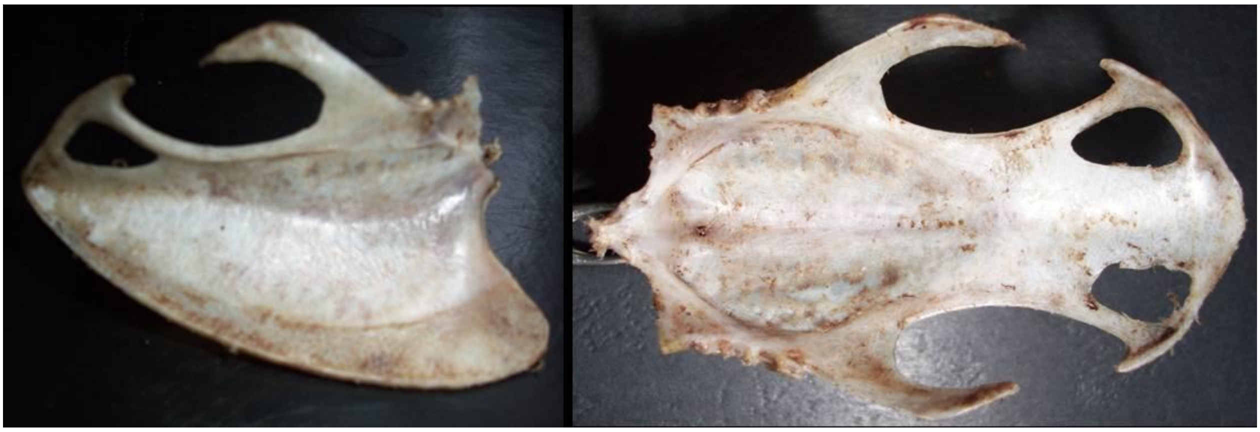

Fig.1. The sternum in the homing pigeon – lateral view, dorsal view.

The pectoral muscles have the role of flexing the wing against the body, and the dimensions of the sternum offer relevant clues regarding their capacity and efficiency. The most important and conclusive results of this study are offered by the measurements of this osseous piece. Same as the other bones, because of the differences in weight, the sternum of the homing pigeon is larger than that of the common pigeon. However, it is obvious that the difference in length between the keel of the homing pigeon and that of the common pigeon is far larger than the differences between sizes of other bones of structures that have no significant importance in the act of flying. In contrast to this difference, the depth of the sternum has a smaller value in the homing pigeon (Table 2).

These differences suggest that the homing pigeon has a much larger basis of insertion for the pectoral muscles, but in the same time is retains a more efficient aerodynamic shape due to a smaller distance between the ventral border of the keel and the back of the pigeon. Furthermore, the thoracic circumference of the homing pigeon is 13.1% larger than that of the common pigeon, which proves a better development of the pectoral muscles in the former.

The higher value of the keel's length compared to other bone structures is also explained by the fact that in the homing pigeon this length is 9.33% larger than the distance between the manubrium and the xiphoid process, while in the common pigeon, this length is only 2.63% larger than the other one (Table 2).

These special features have been shaped over time through natural selection in the case of the common pigeon, aiming at the functionality and robustness of this osseous structure, and through human selection in the case of the homing pigeon, aimed at increased performance.

It is worthy of note that certain nest faults and nutritional deficiencies can cause sternal keel deflection palpable in the adult pigeon, with consequences on its potential.

Table 2.

Dimensions of the sternum in the homing pigeon and in the common pigeon.

Pigeon	Length	Depth	Width – lateral notches	Width - medial notches	Manubrium – xiphoid process length
Homing	78.5	31.6	19.5	104	71.8
Common	66.1	32.3	17.6	8.5	64.1

Thoracic girdle and the thoracic limb

In the pigeon the thoracic girdle is complete, containing three separate bones: the scapula the coracoid and the clavicle (Gheţie *et al.*, 1976).

The scapula is shaped like the blade of a knife and is almost horizontally oriented. Its dorsal border is convex, with a more pronounced curve than its ventral border.

The coracoid is a long bone, which presents on its proximal end an articular surface for the scapula. Its distal extremity is wider and has an articular surface for the sternum.

The clavicle is a thin bone with a slightly flattened body and an arch which articulates with the scapula. The bodies of both clavicles are sutured together, and the dorso-cranially oriented arches give it a "V" shaped appearance, a feature also common to gallinaceae. In pigeons, the proximal extremity is more flattened and the distal extremity is less prominent than in gallinaceae (Fig.2). The joint system between the scapula, the coracoid and the clavicle forms a space called the triosseal canal (*foramen triosseum)* which is present in pigeons at the proximal epiphysis of the coracoid (Kent and Carr, 2001).

In the homing pigeon, the curve of the dorsal border of the scapula is more prominent that in the common pigeon. The coracoid is longer and has a wider diaphysis. The clavicles are also longer and thicker, and the articular surfaces of the epiphyses more prominent.

Fig.2. The clavicle in the homing pigeon (left) and common pigeon (right).

Following the examination of the bones, we noticed that the humerus is a long bone with a well developed diaphysis and with prominent features on the epiphyses. The proximal epiphysis presents a well defined large tubercle. There is only one simple intertubercular groove. The distal epiphysis presents a lateral condyle and a trochlea with a median position (Fig.3).

The dimensions of the humerus in general, the width of is diaphysis in particular, are extremely important due to the presence at this level of the axillary diverticulum of the interclavicular air-sac. Considering the ration between the size of the humerus and that of other pneumatic bones, we view as relevant the association between the girth of the diaphysis and the respiratory capacity of the pigeon. Thus, a wider humeral diaphysis means a larger volume of the interclavicular air-sac and a higher respiratory capacity.

The subjects of this study present a total length of the humerus which is 3.7% only larger in the homing pigeon, while the width of the diaphysis is 118% larger (Table 3). This difference suggests the existence of a much larger osseous chamber in the homing pigeon, which implies the existence of a bigger air-sac.

The dimensions of the radius and of the ulna are proportionally bigger in the homing pigeon, mentioning that in the case of the ulna the width of its diaphysis is also 79% larger in the homing pigeon with the same explanation and meaning as for the humerus (Fig.4). It is also worthy of notice the presence on the caudal border of the ulna of five button elements called remigial papillae, which are present in both the homing and the common pigeon.

In *Columbidae*, the carpal bones are sutured, with the exception of two bones, the ulnar carpal bone and the radial carpal bone (Silverman and Tell, 2010). These are smaller in the homing pigeon. The phalanges are proportionally bigger in the homing pigeon.

Tab.3.

Dimensions of the humerus in the homing pigeon and in the common pigeon.

Pigeon	Humerus length	Maximal width of the diaphysis - humerus	Minimal width of the diaphysis - humerus
Homing	47.2	10.9	4.6
Common	45.5	5	3.9

Fig.3. The humerus in the homing pigeon (right) and in the common pigeon (left).

Fig.4. The ulna in the homing pigeon (left) and in the common pigeon (right).

Body size in homing pigeons and in common pigeons

Based on the measurements of body regions and of bones directly involved in the act of flying, we have made two charts which underline several features that directly influence flight performances. When the two graph lines representing the homing pigeon and the common pigeon draw away from each other, the differences between the measured regions or bones are more significant. It is noticeable that the two lines draw apart past the points representing the measurements relevant to the act of flying.

In the first chart, obvious differences are seen in the width of the humerus' diaphysis and in the sternum's length. In the second chart, there is a bigger difference regarding wingspan and thoracic circumference between the homing pigeon and the common pigeon.

The bone dimensions and the averages of the measurements in the homing pigeon presented in the charts 1 and 2 have been modified by increasing each value by 20% , aiming to obtain a bigger distance between the two graph lines, in order to better observe the differences, without interfering with their interpretation. In the second graph, each value represents the arithmetic mean of the measurements of each of the pigeons belonging to each group.

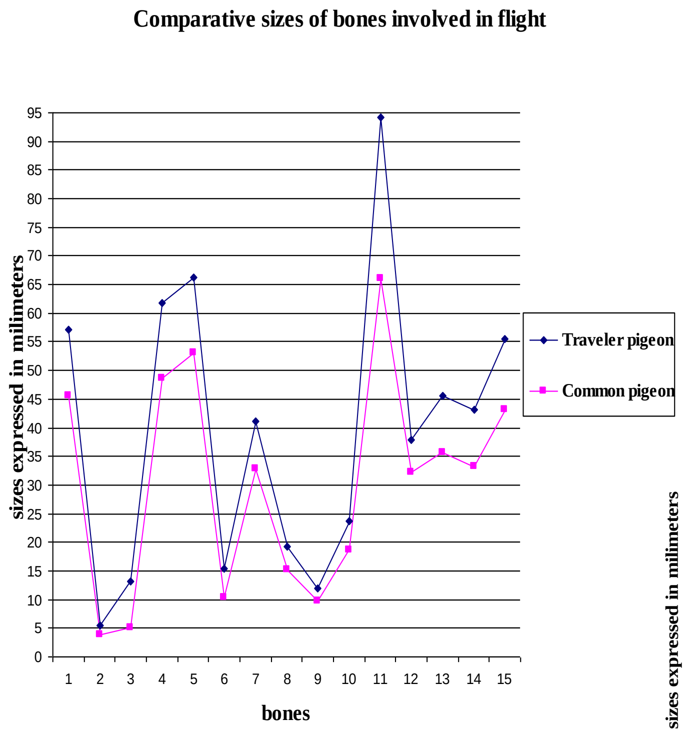

Chart 1.

1. Humerus length; 2. Minimum thickness of the humerus shaft; 3. Maximum thickness of the humerus shaft; 4. Radius length; 5. Ulna length; 6. phalanx length 1,2 of the first digit; 7. Carpometacarpal length; 8. The length of phalanx 1 of the second digit; 9. The length of phalanx 1 of the third digit; 10. Length of phalanx 2 of the second digit; 11. Sternum length; 12. Sternum depth; 13. Coracoid length; 14. Length of clavicle; 15. Length of the Scapula.

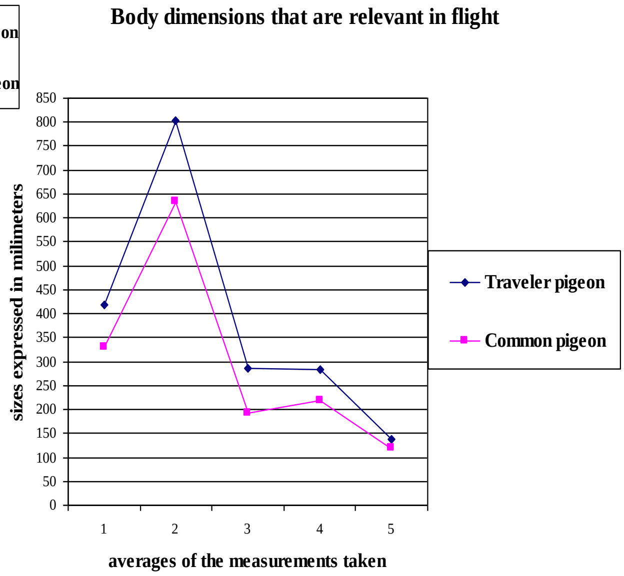

Chart 2.

1. Total length; 2. Wingspan; 3. Chest perimeter; 4. Wing length; 5. Tail length.

CONCLUSIONS

- The pigeon's skeleton presents several special features closely related with its flying type. Bone weight is much reduced and its rigidity is high. The sternum is better developed than in other birds due to the weight factor of pectoral muscle mass in the total body mass.
- The homing pigeon shows several adaptations selected in time by pigeon fanciers through competitions, which correspond to body size and bone features. The aerodynamic shape is improved, the respiratory capacity is higher, and the basis of pectoral muscle insertion is better developed.
- Common pigeons have a smaller average body weight than the homing pigeons, as they have adapted to poor feeding and sheltering conditions, and to short distance flights.
- The similarities of the skeleton between the two varieties considered in this study support the theory of their common origins.
- Homing pigeons with good performances usually have a fine build, but there is no relevant correlation between outer body dimensions and flight performances. Elements making this difference are more pronounced with regards to the development of the bones involved in the act of flying.

REFERENCES

1. Baumel, J. J., A. S. King, J. E. Breazile, H. E. Evans and J. C. Vanden Berge (1993). Handbook of Avian Anatomy: Nomina Anatomica Avium, 2nd edition, Publications of the Nuttal Ornithological Club 23, Cambridge, MA.
2. Bonaţiu, F. (1985). Rasele de porumbei din România, Editura Ceres, Bucureşti.
3. Chiasson, R. (1966). Laboratory Anatomy of the Pigeon, Wm. C. Brown Publishers, Dubuque.
4. Damian, A., N. Popovici and I. Chirilean (2001). Anatomie comparată – Sistemul de susţinere şi mişcare; Editura AcademicPres, Cluj-Napoca.
5. De Iuliis, G. and D. Pulera (2007). The Dissection of Vertebrates - A Laboratory Manual; Ed. Academic Press, Elsevier Inc.
6. Fishbeck, D.W. and A. Sebastiani (2001). Comparative Anatomy: Manual of Vertebrate Dissection, Morton Publishing Company, Englewood.
7. Gheţie, V. and A. Hilebrand (1971). Anatomia animalelor domestice, Aparatul locomotor, Editura Academiei, Bucureşti.
8. Gheţie, V., Şt. Chiţescu, V. Coţofan and A. Hillebrand (1976). Atlas de anatomie a păsărilor domestice; Editura Academiei Republicii Socialiste România; Bucureşti.
9. Kent, G.C. and R. K. Carr (2001). Comparative anatomy of the Vertebrates, 9th edition, McGraw-Hill Higher Education, Boston.
10. Silverman, S. and A. L. Tell (2010). Radiology of Birds, Elsevier Inc, St. Louis, Missouri.