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A MACROANATOMICAL, MORPHOMETRIC AND COMPARATIVE INVESTIGATION ON THE SKELETAL SYSTEM OF THE GEESE (*Anser anser*) RAISED IN THE KARS REGION I; SKELETON AXIALE

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Abstract. The aim of this study is to comparatively, morphometrically and macroanatomically investigate the skeleton axiale included in the formation of the skeletal system of the geese raised in the Kars region. A total of 24 goose cadavers were used; 20 for bones, 2 for latex application, and 2 for takilon application. The mean and standard deviation values of all measurements obtained were examined by gender in the SPSS (version 20.0) packaged software and the statistical data of the respective bones were revealed. It was aimed to detect the pneumatized bones with latex and takilon applications. It was detected that there were 17 vertebrae cervicales speciales and a distinct tuberculum ventrale in the geese. The number of vertebrae thoracicae was determined as 10. It was observed that the notarium was shaped between the 3rd and 6th vertebrae thoracicae, that there were 15 vertebrae synsacrales and 10 vertebrae caudales, that the pygostylus was formed with the unification of the last 3 vertebrae caudales and that there were 10 pairs of costae in the female and male geese. Processus uncinatus was not observed in the first and last three costae. While the average sternum length was measured as 138.45 ± 1.61 mm in the female geese, it was 148.53 ± 1.19 mm in the male geese. In conclusion, the morphological and morphometric values of all body bones of the mature geese were determined in the presented study, and a contribution was made towards addressing the lack of information in this area. It is thought that the findings obtained will contribute to scientific researches, sexual dimorphism evaluations, zooarchaeological studies and operations on poultry.

Keywords: *Anatomy, goose, Kars, poultry, skeletal system, skeleton axiale.*

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1. Introduction

One of the main problems of humanity today is the need for basic food sources. Foodstuffs of animal origin are of high importance within this need. The largest resource for increasing the species diversity in food production is poultry. Geese are at a different position among waterbirds with both the diversity they provide in production and their species that are raised for multiple purposes. Among the commercially and economically important yield components of geese are their meat, liver, fat, feathers and eggs (Aslan, 2013). Furthermore, according to a study (Kılıç *et al.*, 2018), intramedullary mature goose radius as the intramedullary pin was used in the treatment of femoral fractures in puppies and rabbits as organic osteosynthesis material. A new usage area for goose bones emerged with this application, which was found to be clinically, radiologically and histopathologically successful. Goose is the common name of the large species constituting the Anser strain of the Anatidae family from the Anseriformes tribe. In poultry, the locomotor system both contains the formations necessary for movement and body balance and reflects individual features. The skeleton constitutes the passive part of the locomotor system along with the joints and the skeletal muscles constitute the active part (Nickel *et al.*, 1977). The most important feature of poultry is that they have pneumatic bones. These bones participate in the respiratory system through air sacs (sacci pneumatici). Flightless birds do not have pneumatized bones. There are three types of poultry bones: morphologically compact bones, cancellous bones, and medullary bones (Hodges, 1974). In birds, the axial skeleton consists of columna vertebralis, costae, sternum and cranium. Columna vertebralis (vertebral column) consists of four parts: vertebrae cervicales speciales, vertebrae thoracicae, vertebrae synsacrales and vertebrae caudales. Saccus cervicalis surrounds the vertebrae and pneumatizes them (Dursun, 2007; N.A.A., 1993). In general, there are 7 costae (ribs). The first two are short and weak and named costae asternales for the fact that they cannot reach the sternum while the other five are strong and named costae sternales as they reach the sternum. Despite the fact that there are less costae in walking poultry and more in floating species, the number of costae is not related to locomotor condition (Tickle *et al.*, 2007). There is no cartilage in the ribs of domestic poultry. The sternal end of costae corresponds to the cartilago costalis of mammals (King & McLelland, 1975). Another feature of costae is the presence of processus (proc.) uncinatus. Proc. uncinatus has the task of demonstrating the necessary endurance in the thorax during severe diving flights. It also establishes the connection between muscles and ligaments (McLelland, 1990). Proc. uncinatus is also important as it makes it easier for the thorax to expand laterally when sternal swing is prevented. It is also thought to facilitate the movement of the bird during breathing (Codd *et al.*, 2005). Sternum (breast bone) is a large, flat bone that supports the body from below. Its front side resembles a wide boat (Gültekin, 1966). It consists of three parts: corpus (tabula) sterni, rostrum sterni and crista sterni (carina). Crista sterni, which extends from the front to the back in the ventromedial is surrounded by muscles that help in flying. Ossa cranii (cranium) have distinctive features in the taxonomy of birds (Demirsoy, 1995). Among all vertebrates, the skull base of poultry is the one that shows the most characteristics. That is because they have a skull base that is specialized for flying. The air voids between the bones (pneumatization) also contribute to flying (Nickel *et al.*, 1977). The number of cranium in poultry is higher compared to mammals, however, with increased age, unifications are observed between suturae (Mckibben & Harrison, 1986). As in mammals, poultry cranium are examined in 2 parts: neurocranium and splanchnocranium (Gültekin, 1966). The bones in the heads of poultry are pneumatized with the diverticulum originating from the nasal area and not with the lungs (Schepelmann, 1990). No pneumatized bone is observed the ossa cranii with the exception of neurocranium, os quadratum and partially mandibule (Hogg, 1984a). The neurocranium (neural skull) consists of a total of 9 bones; three of which are singular (os occipitale, os sphenoidale, os ethmoidale) and three in pairs (os parietale, os frontale, os temporale). Os ethmoidale is also included in the structure of the splanchnocranium. Unlike mammals, there is no os interparietale (Gültekin, 1966). Splanchnocranium (cranium viscerale) (visceral skull) is distinctly separated from the neurocranium through orbital gaps (Dursun, 2007; Gültekin, 1966; İlgün, 2016a). The width of the splanchnocranium depends on the development of rostrum (beak) and mandibula (Nickel *et al*., 1977). While os ethmoidale is included in both neurocranium and splanchocranium, other facial bones are os lacrimale, os nasale, os premaxillare, os maxillare, os zygomaticum, os palatinum, os pterygoideum, os vomer, os quadratum and mandibula (Dursun, 2007). In poultry, scleral ossicles located in each eye ring are among some of the several bones in the head (Mckibben & Harrison, 1986).

2. Materials and Methods

For this study, permission was obtained from Kars Provincial Directorate of Agriculture (dated 31.03.2017 and numbered E.791642) and Kafkas University Animal Experiments Local Ethics Committee (KAU-HADYEK/2017-047) /2017-047). The cadavers supplied by breeders who butcher for food were brought to the laboratory of Kafkas University Faculty of Veterinary Science Anatomy Department and the study was conducted there. A total of 24 goose cadavers (1 old); 12 female and 12 male with average weights of 3.25 ± 0.15 kg (female) – 3.92 ± 0.21 kg (male) were used in the study. The weights of the goose cadavers were recorded by means of digital precision balances (1g of non-confirmed sensitivity between 0-15 kg, and 2g between 15-30 kg, Baykon brand coded BCS21-6 MR). After the superficial muscles of 20 of the geese (10 female, 10 male) were dissected, the bones were revealed by maceration. After the superficial muscles of the geese were dissected, boiling was performed for two hours in the water in which 10-15% sodium bicarbonate ($NaHCO_3$) was added (Taşbaş & Tecirlioğlu, 1965). A wire was passed through the foramen (for.) vertebrale so that the normal vertebral row would not be disturbed. The vertebra of the atlas was pushed until the end of canalis vertebralis and columna vertebralis was detected. The bones were thoroughly cleaned after the cooling procedure and soaked in a 10% hydrogen peroxide (H_2O_2) solution for two hours to whiten. After the last of the bones were thoroughly washed, they were left to dry in the sun (Taşbaş & Tecirlioğlu, 1965; Mussa *et al.,* 2015). Measurements were taken from all goose bones by means of a digital caliper and a measuring tape in accordance with the method laid out by Driesh (1976). Denomination was made in accordance with Nomina Anatomica Avium (N.A.A., 1993). Tecirlioğlu's (1986) glossary of terms was used to translate the names of the bones into Turkish. The cranial width, caudal width, bone length, bone width, duct height from cranial and duct width of the vertebra cervicalis specialis and vertebra thoracica were measured with a digital caliper, referring to Tıpırdamaz & Yüksel (2012). The measurements of the vertebra lumbicalis and sacralis of os lumbosacrale were determined with a digital caliper in accordance with the method laid out by Driesh (1976). In order for the pneumatic bones to be determined, 1 female and 1 male goose were injected from the trachea with acrylic (takilon), and 1 female and 1 male goose were injected with a liquid rubber material (latex) colored with red fabric dye for the corrosion cast study. Each goose was injected with 120 ml of latex. Afterwards, they were soaked in a 10% formaldehyde solution and dissected. The muscles were dissected and the pneumatized bones reached by the latex through air sacs were detected. Each of goose was given 120 ml of an acrylic mixture containing 20% monomethyl-methacrylate and 80% polimetyl-methacrylate 'o' through the trachea. In order to ensure that this mixture solidified, the cadavers were soaked in tap water for 24-48 hours. Later, examinations were made after the cadavers were soaked in a 30% potassium hydroxide (KOH) solution at a temperature of 60°C until the tissues were melted and cleaned in order to make corrosion. Therefore, pneumatized bones were detected by means of both latex and acrylic. The mean and standard deviation values of all measurements and the differences between genders were determined with the "independent samples t" test in the SPSS (version 20.0) packaged software.

3. Results

Skeleton axiale (Axial skeleton): It was seen that the skeleton axiale in the geese was composed of columna vertebralis, costae, sternum and cranium.

3.1.Columna vertebralis (Vertebral column)

Columna vertebralis was examined in 4 parts as vertebrae cervicales speciales, vertebrae thoracicae, vertebrae synsacrales and vertebrae caudales.

3.1.1. Vertebrae cervicales speciales (Neck vertebrae): In the female and male geese, the pars cervicalis specialis of columna vertebralis was in the shape of the letter S formed by 17 vertebra. From C15-16 on, it was determined that the proc. carotici merged completely and transformed into the shape of proc. ventralis, which is a single protrusion. It was detected that the atlas was round, ring-shaped, and small in size. Tuberculum ventrale was shaped distinctly in the ventral of the atlas. The first vertebra cervicalis specialis (atlas) was not included in the measurements due to its shape and size that was different from the other vertebrae. An evaluation was made over a total of 16 vertebrae from the second vertebra cervicalis specialis (axis) to the last vertebra cervicalis specialis. At the end of the latex applications, it was seen that C12-C17 were pneumatized by the saccus cervicalis in the cadavers examined. It was determined as a result of the measurements that the cranial width of the vertebrae between C2-C14 was significantly different between the females and males, that the caudal width differences were significant except for the vertebrae C2, C11 and C13, and that the bone lengths of the vertebrae between C2-C17 were significantly higher in males than in females. It was observed as a result of the measurements taken on vertebra cervicalis specialis that the duct height of C6 and C17 and the duct width of C4 and C8 were significantly higher in males than in females.

3.1.2. Vertebrae thoracicae (Thoracic vertebrae): It was determined that there were 10 vertebra thoracica in the geese. It was seen that the proc. spinosus and proc. transversae of the vertebrae thoracicae were merged among themselves (Figure 1). The mergence between the proc. transversae was observed from T3 onwards. It was determined that the notarium was shaped between the vertebrae T3.-T6. Measurements of vertebrae throacicae were taken from each of the vertebrae between T1-T6. The vertebrae from T7 onwards were not evaluated due to non-disjunction and coalescence with the os lumbosacrale.

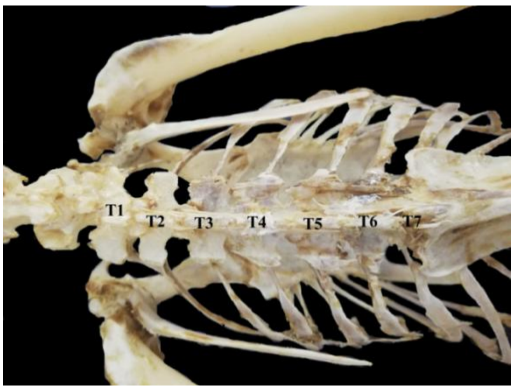

Figure 1. The view of vertebra thoracicae from the dorsal

It was detected that T1 and T2 were pneumatized by saccus cervicalis. It was determined according to the results of the measurements of vertebra thoracica that in males, bone length was higher in the vertebrae thoracicae other than T2 and bone width was higher in the vertebra T5 compared to females. It was detected that in T4, the duct height of the vertebra thoracicae was higher in males than in females and that there was no significant difference in duct width.

3.1.3. Vertebrae synsacrales (Conjoined rump vertebrae): It was determined that from T7 on, a total of 15 vertebra in the geese; vertebrae thoracicae (3), all vertebrae lumbicales (3), all vertebrae sacrales (8), and the first vertebra caudalis, merged and formed the synsacrum (os lumbosacrale). Forked bone spurs were observed in the caudal of the dorsal side of the proc. transversae of the vertebrae synsacrales. It was determined that the vertebrae synsacrales were pneumatized.

3.1.4. Vertebrae caudales (Tail vertebrae): There were 10 vertebra caudalis in the geese. It was determined that the first vertebra caudalis was included in the formation of the synsacrum, that the 2nd-7th vertebrae were free and that the last three vertebrae were included in the formation of the pygostylus. The pygostylus, which was shaped by the mergence of the last three vertebrae caudales, was larger than the others and in the shape of a triangular wedge. It was determined that the proc. haemales located in the ventral of the last three vertebrae caudales before the pygostylus were distinctive and that the vertebrae caudales were not pneumatized.

3.2. Costae (Ribs)

10 pairs of costae were detected in the female and male geese. As shown in Figure 2, it was observed that the first pair of costae had the shortest height and did not possess the proc. uncinatus, and that the heights of the costae increased from the first costa to the last. It was determined that the first two pairs of costae were free and did not joint with the sternum (floating costa), that the 3rd, 4th, 5th, 6th and 7th costae were stronger, that the 8th, 9th and 10th pairs of costae were thinner, and that the last pair of costae (10th) did not directly joint with the sternum and merged with the previous pair (9th) of costae. There was no proc. uncinati in the 1st pair and the last 3 pairs. It was determined that the last 4 pairs of costae were located in the ventral of the vertebrae of the os lumbosacrale. Only vertebral measurements were taken as the 1st and 2nd pairs had the vertebral part but not the sternal part.

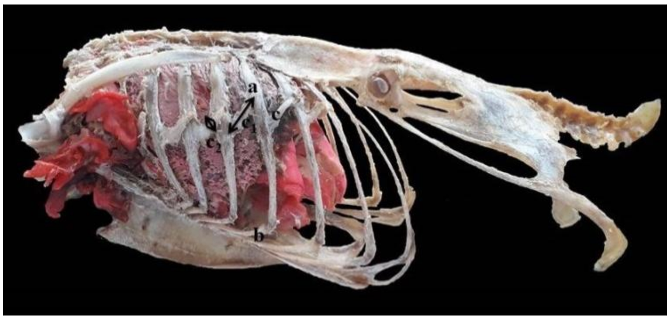

Figure 2: The measurements taken on the costae and proc. uncinatus
a: Vertebral ribs, **b:** Sternal ribs, **c:** Proc. uncinatus, **c_1:** Proc. uncinatus's length, **c_2:** Proc. uncinatus's width

Table 1. The comparison of the length and width of the proc. uncinatus in the male and female geese

Costa	Proc. uncinatus's length (Mean ± S.E.)			Proc. uncinatus's width (Mean ± S.E.)		
	Female (n = 10)	Male (n = 10)	P value	Female (n = 10)	Male (n = 10)	P value
2.	9.41 ± 0.10	11.44 ± 0.07	< 0.001	4.48 ± 0.08	4.65 ± 0.05	0.084
3.	17.38 ± 0.09	19.70 ± 0.07	< 0.001	4.45 ± 0.09	5.30 ± 0.04	< 0.001
4.	17.14 ± 0.16	21.70 ± 0.10	< 0.001	4.89 ± 0.14	5.63 ± 0.05	< 0.001
5.	19.15 ± 0.04	20.18 ± 0.02	< 0.001	4.63 ± 0.02	4.77 ± 0.01	< 0.001
6.	17.72 ± 0,06	18.72 ± 0,05	< 0.001	3.12 ± 0.03	3.46 ± 0.02	< 0.001
7.	8.73 ± 0.03	11.81 ± 0.08	< 0.001	2.82 ± 0.03	3.38 ± 0.03	< 0.001

As seen in Table 1, which was generated in accordance with the measurements taken from the locations shown in Figure 2, it was determined that the proc. uncinatus length was significantly higher in males than in females, and that the proc. uncinatus width was significant except for the 2nd costa.

The vertebral and sternal costae lengths were measured. It was detected that the vertebral and sternal lengths of the costae were significantly higher in males than in females.

3.3. Sternum (Breast bone)

Sternum is a flat bone located in the ventral of the torso. Crista sterni is located in its ventromedial, expanding from the front to the back. Crista sterni has a wavy skew in the middle and then flattens again. While incisura ovalis was present in 3 of the female geese and for.ovale was in 7 of them, incisura ovalis was present in 4 of the male geese and for.ovale was in 6 of them. It was detected that proc. lateralis cranialis and proc. lateralis caudalis were present but proc. thoracicus was not. It was observed that the saccus clavicularis pneaumatized the sternum.

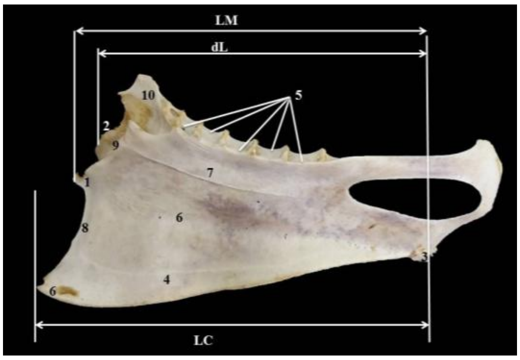

Figure 3: The view of the sternum from the lateral
1: Manubrium sterni, **2:** Labium ventrale, **3:** Metasternum, trabecula mediana, **4:** Crista sterni, **5:** İncisura intercostales, **6:** Apex carinae, **7:** Linea intermuscularis, **8:** Crista lateralis carinae, **9:** Sulcus carinae, tuberculum labri externum, **LM:** From the cranial point of the manubrium sterni to the caudal border of the metasternum in the median plane, **dL:** From the cranial point of the labium dorsale or internum to the caudal border of the metasternum in the median plane, **LC:** From the apex cristae sterni to the caudal border of the metasternum in the median plane.

Table 2. The comparison of some of the parameters taken from the sternum in the female and male geese

Parameters	Female (n = 10)	Male (n = 10)	P value
LM	138.45 ± 1.61	148.53 ± 1.19	< 0.001
dL	131.84 ± 1.98	140.05 ± 1.20	0.002
LC	143.10 ± 2.13	152.56 ± 1.98	0.004
SBF	62.32 ± 0.89	66.20 ± 0.70	0.003

LM: From the cranial point of the manubrium sterni to the caudal border of the metasternum in the median plane, **dL:** From the cranial point of the labium dorsale or internum to the caudal border of the metasternum in the median plane, **LC:** From the apex cristae sterni to the caudal border of the metasternum in the median plane, **SBF:** Smallest breadth between the facets fort he costo-sternal articulations, measured at the narrowest part.

It was observed in the measurements conducted that the Lm, dL, LC (Figure 3) and SBF values were statistically different in the female and male geese (P<0.001; P=0.002; P=0.004; P=0.003). Namely, it was determined that these parameters higher in length in males (Table 2).

3.4. Ossa cranii (Cranium)

The cranium in the geese were examined in two parts as ossa cranii (neurocranium) and ossa faciei (splanchnocranium). In Table 3, which was generated as a result of the measurements conducted, it was determined that only the GL parameter was significantly different in males and that the other parameters were not significant.

Table 3. The comparison of some of the parameters taken through the cranium in the female and male geese

Parameters	Female (n = 10)	Male (n = 10)	P value
GL	133.34 ± 1.60	144.07 ± 0.82	< 0.001
CBL	124.92 ± 2.55	132.91 ± 1.14	0.10
GB	45.26 ± 1.83	47.31 ± 0.48	0.292
GBP	45.82 ± 2.35	47.14 ± 0.51	0.590
SBO	19.60 ± 1.95	20.34 ± 1.13	0.749
GH	47.75 ± 2.63	48.13 ± 0.58	0.888
LP	62.18 ± 1.89	60.40 ± 1.07	0.424
LI	79.21 ± 2,83	84.30 ± 1.31	0.120

GL: Greatest length: Protuberantia occipitalis externa-apex premaxillaris, **CBL:** Condylobasal length: aboral border of the occipital condyle-apex premaxillaris, **GB:** Greast breadth: wherever it is to be found, usually across the processus postfrontales, **GBP:** Greatest breadth across the processus postfrontalis, **SBO:** Smallest breadth between the orbits on the dorsal side: smallest breadth of the pars nasalis of the frontale, **GH:** Greatest height in the median plane, **LP:** Length from the protuberantia occipitalis externa to the most aboral points of the processus frontales of the incisivum in the median plane, **LI:** Greatest length of the incisivum.

3.4.1. Neurocranium (Neural skull): It was seen that the neurocranium was composed of a total of 9 bones: three singular bones (os occipitale, os sphenoidale, os ethmoidale), and three in pairs (os parietale, os frontale, os squamosum). It was detected that the os ethmoidale was also involved in the formation of the splanchnocranium.

3.4.2. Splanchnocranium (Cranium viscerale) (Visceral skull): The splanchnocranium consisted of the bones located around the orbital, nasal and oral gaps. It was seen that the bones that formed the splanchnocranium were os lacrimale, os nasale, os premaxillare, os maxillare, os zygomaticum, os palatinum, os pterygoideum, os vomer, os quadratum and mandibula. It was detected that os ethmoidale was involved in both the neurocranium and splanchocranium. When mandibula was viewed from the dorsal, it was seen that the two mandibulae were in the shape of the letter V. Symphysis mandibularis was located in the commissure of the letter V. It was formed by 4 bones: Mandibula os dentale, os angulare, os articulare and os supraangulare. The proc. retroarticularis of os angulare expanded towards the caudal and ended sharp. Proc. articularis was shaped strongly in the geese.

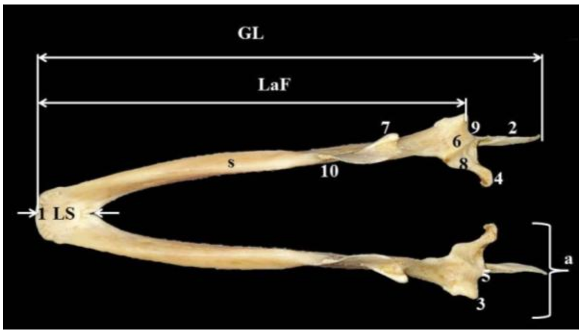

Figure 4. Measurements taken on mandibula

LS: Os dentale, **s:** Os supraangulare, **a:** Os articulare, **1:** Apex, **2:** Os angulare's proc. angulare, retroarticularis, **3:** Os articulare, cotyla lateralis, **4:** Proc. medialis mandibulae, **5:** Cotyla caudalis, **6:** Crista intercotylare, **7:** Proc. pseudocoronoidei mandibulae, **8:** Cotyla medialis, **9:** Fossa articularisquadratica, **10:** Fossa aditus canalis mandibulae, **7-10:** Os supraangulare, **GL:** Greatest length of one-half of the mandibula: Apex to the most aboral point of the mandibula, **LaF:** Length from the most aboral point of the facies articularis on one side to the apex, **LS:** Length of the symphysis mandibulae

Table 4. The comparison of some of the parameters in the female and male geese mandibula

Parameters	Female (n = 10)	Male (n = 10)	P value
GL	116.28 ± 0.99	127.48 ± 1.25	< 0.001
LaF	103.97 ± 1.39	114.09 ± 1.40	< 0.001
LS	14.35 ± 0.61	14.73 ± 0.36	0.593

GL: The biggest length of the mandibula between the apex and proc. aboralis, **LaF:** The distance between the apex and the proc. lateralis of the mandibula, **LS:** The length of the symphysis mandibulae

It was detected as a result of the measurements taken (Figure 4) that the GL and LaF values were statistically different in the female and male geese ($P<0.001$), and that the parameters regarding the males had higher lengths compared to the females. Also, it was determined that there was no significant difference in the LS value ($P=0.593$) between genders (Table 4).

It was seen that apparatus hyolingualis (Os hyoideum, hyoid bone) was a weak bone (Figure 5). Os hyoideum was composed of the basihyoideum (corpus) located in the middle, the ramus hyoideum connected to the corpus from two sides, the urohyale expanding towards the caudal, and the os entoglossum located in the front end of the corpus (Figure 5). The length of the os entoglossum (EGU) was determined to be 33.07 ± 1.1 mm in the female geese and 38.05 ± 0.6 mm in the male geese. The length of urohyale (UB) was measured as 2.3 ± 0.8 mm in the female geese and 14.5 ± 0.5 mm in the male geese. It was determined that the spur located on the basihyoideum was singular. The length of this spur was determined to be 16.23 ± 0.3 mm in the female geese and 17.7 ± 0.4 mm in the male geese.

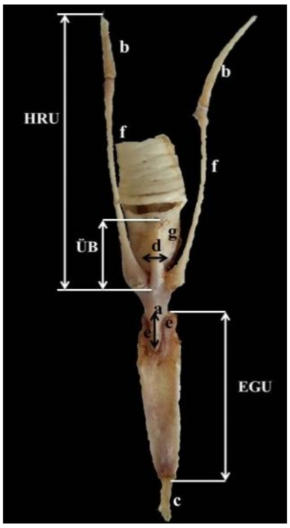

Figure 5: Measurements taken on os hyoideum

HRU: Ramus hyoideus length, cornu branchiale (b + f: Ramus hyoideus), **UB:** Urohyale's length, **EGU:** Os entoglossum (paraglossum) length, **a:** Basihyoideum, **b:** Os epibranchiale (caudobranchial segment), **c:** Cartilage at the end of the os entoglossum, **d:** Urohyale's width, **e:** Os basihyoideum's protrusion (proc. parahyalis), **f:** Os ceratobranchiale (basibranchial segment), **g:** Larynx cranialis

Table 5. The comparison of some of the parameters of os hyoideum in the female and male geese

Parameters	Female (n = 10)	Male (n = 10)	P value
EGU	33.07 ± 1.12	38.06 ± 0.58	0.001
BU	16.24 ± 0.30	17.69 ± 0.45	0.015
HRU	47.21 ± 1.92	48.49 ± 0.55	0.528
ÜB	13.49 ± 0.40	14.54 ± 0.52	0.126
UE	2.31 ± 0.08	2.57 ± 0.07	0.027

EGU: Os entoglossum length**, BU:** Basihyoideum length**, HRU:** Os hyoideum's ramus length**, UB:** Urohyale's length**, UE:** Urohyale's width

It was seen in the measurements (Table 5) that the EGU, BU and UE values were statistically different (P<0.001; P=0.015; P=0.027) in the female and male geese. Namely, it was detected that these parameters were higher in length in the males compared to the females. Also, it was determined that there was no significant difference (P=0.528; P=0.126) between genders in the HRU and UB values (Table 5).

4. Discussion and Conclusions

Columna vertebralis was examined in 4 parts as vertebrae cervicales speciales, vertebrae thoracicae, vertebrae synsacrales and vertebrae caudales. While the number of vertebrae cervicales was reported as 15 in ducks (Çevik Demirkan, 2002), 13 in rock partridges and pheasants (Tıpırdamaz & Yüksel, 2012), 12 in pigeons, 14 in chickens (Bahadır & Yıldız 2014), and 17 in geese (Nickel *et al.*, 1977), it was detected as 17 in the female and male geese. While it was reported that the tuberculum ventrale of the atlas was not shaped in ducks (Çevik Demirkan, 2002), a distinctive tuberculum ventrale was detected in geese. While the caudal articular surface of the vertebrae cervicales speciales was reported to be wider and more protruding than the cranial (McLelland, 1990), it was observed that the cranial width in the geese was higher than the caudal. It was reported that the vertebrae were pneumatized in the blue-headed parrot (Mckibben & Harrison, 1986), that saccus cervicalis pneumatized the vertebrae from the atlas to the first 2 vertebrae thoracicae (Gety, 1975; N.A.A., 1993), all vertebrae cervicales speciales in the japanese quail (Çevik Demirkan *et al.*, 2006) and all vertebrae cervicales speciales except the atlas and axis in the Denizli rooster (Taşbaş *et al.*, 1994) and geese (Onuk, 2008). It was seen in this study that C12-C17 were pneumatized by saccus cervicalis. While the finding regarding the pneumatization of the vertebrae from the atlas to the first 2 vertebra thoracicae (Getty, 1975; N.A.A., 1993) shared similarities with the part that was pneumatized from C12 to T2 in the presented study, the pneumatization of the bones before C12 showed differences.

While the number of vertebrae thoracicae was reported as 7 in chicken and pigeons (Tıpırdamaz & Yüksel, 2012), 8 in the budgerigar (Mckibben & Harrison, 1986), 5 in gold tail starred chicks, 9 in ducks and geese (Dursun, 2007; Nickel *et al.*, 1977), 6 in rock partridges and pheasants (Tıpırdamaz & Yüksel, 2012), and 10 in the cattle egret (Rezk, 2015a), it was determined to be 10 in geese in this study. While notarium was reported to be present only in chicken and pigeons among domesticated birds (König *et al.*, 2016), it was seen to be present in domesticated geese as well. While N.A.A. (1993) reports that the notarium is shaped between the 2nd and 6th vertebrae thoracicae and McLelland (1990) reports that it is shaped between the last vertebra cervicalis specialis and the first 3 vertebrae thoracicae, it was determined that it is shaped between the 3rd and 6th thoracal vertebrae in geese. While the diverticula vertebralia of the saccus cervicalis was reported to pneumatize only T12 in the Denizli rooster (Taşbaş *et al.*, 1994), it was determined that it pneumatized T1 and T2 in geese. The finding in this study contradicted the finding of Taşbaş et al. (1994).

While 15-16 vertebrae are included in the formation of the synsacrum in chicken, the number varies between 9 and 22 in other species (König *et al.*, 2016). Synsacrum is formed by the mergence of 14 vertebra lumbicalis and vertebra sacralis in rock partridges and pheasants (Tıpırdamaz & Yüksel, 2012), 8 in the budgerigar (Mckibben & Harrison, 1986) 15 in gold tail starred chicks (Hogg, 1984a), and 13 in ducks (Bahadır *et al.*, 1993), it is formed by the mergence of the last 3 thoracal and all lumbical and sacral vertebrae in ducks according to another study (Çevik Demirkan, 2002). It was seen that a total of 15 vertebrae, including the vertebrae throacicae from T7 onwards, all vertebrae lumbicales, vertebrea sacrales, and the first vertebra caudalis merged and formed the synsacrus (os lumbosacrale). It was determined that while the numbers of the vertebrae synsacrales in chicken (König *et al.,* 2016), rock partridges, pheasants (Tıpırdamaz & Yüksel, 2012) and gold tail starred chicks (Hogg, 1984a) were similar with geese, they were different in other poultry.

While the number of vertebrae caudales was reported as 6 in chicken (McLelland, 1990), 10 in ducks (Çevik Demirkan, 2002), and a total of 12 in geese, 5 of which participate in the synsacrum formation, and 7 of which are free (Bahadır *et al.,* 1993), it was determined in the presented study that the number was 10 in geese, as in ducks. As in ducks, vertebrae caudales were not pneumatized in geese either (Çevik Demirkan, 2002).

While it was reported that there were 5-6 pairs of costae in chicken (McLelland, 1990), 6 pairs in ostriches (Predoi *et al.,* 2009), and merlins (John *et al.,* 2014), 7 pairs in cattle egrets (Rezk, 2015a), 3 pairs in some pigeons, 9 pairs in geese (Kuru, 1987), 9 pairs in teals (Can *et al.*, 2010), 10 pairs, and 9 pairs in another source (Nickel *et al.*, 1977), in domesticated ducks (Bahadır *et al.,* 1993; Çevik Demirkan, 2002) and domesticated geese (Bahadır *et al.,* 1993), 10 pairs of costae were detected in the female and male geese raised in the Kars region. While this finding is the same as the finding of Bahadır *et al.,* (1993), it is different from other compared literatures. While it was reported that proc. uncinatus was not present in the last three pairs of costae in teal (Can *et al.*, 2010) and geese (Bahadır *et al,*. 1993) and the last 4 pairs in peking ducks, proc. uncinatus was not observed in the geese in the first and last three pairs of costae in the study conducted. The finding that there were no proc. uncinati in the last three pairs of costae was in accordance with the finding of Bahadır *et al.,* (1993). In Broiler chicken, proc. uncinatus was detected in the 2nd-5th costae (Tickle *et al.*, 2014). While the average length of proc. uncinatus in Barnacle geese was reported to be 7.21 ± 0.43 mm (Tickle *et al.,* 2007); it was measured in this study that it belonged to the 5th longest pair of costae in the female geese (19.15 ± 0.04 mm) and the 4th longest pair of costae in the male geese (21.70 ± 0.10 mm). It was detected that there were proc. uncinati belonging to the 2nd shortest pair of costae (9.41 ± 0.10 mm – 11.44 ± 0.07 mm) in the female and male geese. When the levels found in this study were compared, it was seen that even the shortest proc. uncinatus length was higher than the average of the Barnacle geese. While it was reported that the 1st pair of costae was free in ducks (Çevik Demirkan, 2002), it was observed that the first 2 pairs of costae were free in geese. The finding in this study that the first 2 pairs of costae were free is the same as the findings of Bahadır *et al.,* (1993). It was reported that the costae were pneumatized in the blue-headed parrot (Mckibben & Harrison, 1986). It was reported that saccus cervicalis pneumatized the 1st costa in the Denizli rooster (Taşbaş *et al.,* 1994), that saccus abdominalis pneumatized the last 3 costae in the mallard, and that saccus thoracicus cranialis pneumatized the 2nd-7th costa sternales (Çevik Demirkan *et al.*, 2006). It was reported that in geese, saccus abdominalis pneumatized the last 2 costae from costae 1 to 8 of the diverticula sternalia of the saccus clavicularis (Onuk, 2008). Contrary to the literature, pneumatization in costae was not observed in this study.

The average sternum length was reported as 67.3 mm in pigeons, 60.2 mm in crows, 46.9 mm in owls (John *et al.,* 2014a), 42 mm in moorhen, 109.61 ± 1.8 mm in female ducks and 112.32 ± 1.04 mm in male ducks (Çevik Demirkan, 2002). These lengths were measured as 138.45 ± 1.61 mm in the female geese and 148.53 ± 1.19 mm in the male geese. It was detected that the sternum length was numerically closer to that of ducks (Çevik Demirkan, 2002). As reported in the literature (Onuk, 2008), it was determined that saccus clavicularis pneumatized the sternum in geese.

There are various studies on the head of poultry (Gündemir, 2019; Gündemir *et al.*, 2020).The biggest head length was calculated as 39.23 ± 0.06 mm in male quails, 39.76 ± 0.09 mm in female quails (Özkan, 2002a), 115.83 ± 5.46 mm in geese, 129.67 ± 5.73 mm in ducks (Dayan *et al.*, 2014), and 127.5 ± 9.62 mm in seagulls (Gezer İnce *et al.*, 2018). The comparative morphometrical study conducted between female and male turkeys revealed that the male turkey head was bigger (Süzer *et al.*, 2018). In the study, this length was measured as 133.34 ± 1.60 mm in female geese and 144.07 ± 0.82 mm in male geese. Higher levels were found compared to other studies. It was stated in the osteometric measurements carried out on the cranium that the average cranium height was higher in male quails than in female quails, and that the average cranium length was higher in female quails than in male quails (Özkan, 2002a). The average cranium height in seagulls was measured as 31.9 ± 2.12 mm (Gezer İnce *et al.*,2018). In this study, cranium height was determined as 47.75 ± 2.63 mm in the female geese and as 48.13 ±0.58 mm in the male geese. While for. magnum was oval-shaped in turkeys (Süzer *et al.*, 2018), it was seen to resemble an upright lemon in geese.

As reported in the literature (Nickel *et al.*, 1977), proc. articularis was seen to be strong in geese. The mandibula length was measured as 116.28 ± 0.99 mm in the female geese and as 108.12 ± 7.65 mm in the male geese. It was reported to be 108.12 ± 7.65 mm in seagulls (Gezer İnce *et al.*, 2018), 340 mm in the Dalmatian pelican (İlgün *et al.*, 2017), 30.36 ± 0.08 mm in male quails and 30.80 ± 0.06 mm in female quails (Özkan, 2002a). While mandibula length was at maximum in the Dalmatian pelican, it was seen that the lengths closest to geese were in seagulls. The symphysis mandibulae length was measured as 5.82 ± 0.07 mm in male quails, 5.73 ± 0.08 mm in female quails (Özkan, 2002a), 14.35 ± 0.61 mm in male geese and 14.73 ± 0.36 mm in female geese. The pars symphysialis mandibulae was reported to correspond to 1/3 of the overall mandibula length in woodpeckers (Donatelli, 2012) and 1/10 in frigatebirds (Carlos *et al.*, 2017). It was observed that the symphysis mandibulae length was 1/7 of the total corpus mandibulae in geese. It was stated that mandibula in the red-green Ara bird is in the shape of a horse's foot and that the ramus mandibulae were found to be vertical, wide and thick (İndu *et al.*, 2013). It was seen that the two mandibulae were in the shape of the letter V, and that ramus mandibulae were shorter and thinner.

It was reported that basihyoideum was rod-shaped in chicken, domesticated poultry, roosters and pigeons (Koch & Rossa 1973), flat in ducks and geese (Nickel *et al.*,1977), and shaft-shaped in penguins (Taşbaş *et al.*, 1986). It was determined that basihyoideum was in the shape of a sharp stick in geese. There was a distinct pit on the ventral side of basihyoideum in parrots and this area was shaped convexly (Özkan, 2002b) in budgerigars. A distinct pit was observed in geese as well. In parrots, two protrusions were located on the basihyoideum with an average length of 3.6 mm with open ends, whereas in budgerigars, they were in a triangular shape with average edge lengths of 3.8 mm with conjoined ends (Özkan, 2002b). In this study, it was seen that this protrusion was singular in the female and male geese. The length of the protrusion was detected to be 16.23 ± 0.3 mm in the female geese and 17.7 ± 0.4 mm in the male geese. While it was reported that the os entoglossum length was 5.7 mm in parrots, 3.6 mm in budgerigars (Özkan, 2002b), 3.60 ± 0.40 mm in guinea fowls, and 6.65 ± 0.31 mm in turkeys (İlgün *et al.*, 2015) it was determined as 33.07 ± 1.1 mm in the female geese, and 38.05 ± 0.6 mm in the male geese. It was observed that os entoglossum was longer in geese than the compared poultry.

The goose (*Anser anser domesticus*) is one of the most exemplary animals in veterinary anatomy teaching. It is also the geographical sign of our region. For this reason, all body bones (skeleton axiale) of adult geese were examined in our study. As a result, the morphometric values and pneumatized bones of all body bones (skeleton axiale) of the adult female and male geese were determined and a contribution was made towards addressing the lack of information in this area. It is thought that the findings obtained will contribute to future scientific researches, sexual dimorphism evaluations, zooarchaeological studies and operations on poultry based on gender and species.

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References

Aslan, C. (2013). *Goose Nutrition and Breeding*. 2nd edition, Medipres Publishing, 30-35.

Bahadır, A., Yıldız, B., Serbest, A. & Yılmaz, O. (1993). Comparative macroanatomical studies on the skeletons of domestic goose, domestic duck and pekin duck from domestic waterfowl. *Uludag University Journal of Veterinary Medicine*, 12, 1-12 (in Turkish).

Bahadır, A.& Yıldız, H. (2014). *Veterinary Anatomy, Locomotor system & Internal organs.* Ezgi bookstore, expanded 5. Edition, Bursa,Turkey, 94-111.

Can, M., Özdemir, D. & Özüdoğru, Z. (2010). Macro-Anatomical Investigations on Skeletons of Teal (Anas crecca) I. Skeleton Axiale. *Fırat University Veterinary Journal of Health Sciences,* 24, 123-127 (in Turkish).

Carlos, C.J., Alvarenga, J.G. & Mazzochi, M.S. (2017). Osteology of the feeding apparatus of magnificent frigatebird Fregata magnificens and brown booby sula leucogaster (*aves:suliformes*). *Papéis Avulsos de Zoologia*, 57, 265-274. http://dx.doi.org/10.11606/0031-1049.2017.57.20.

Codd, J.R., Boggs, D.F., Perry, S.F. & Carrier, D.R. (2005). Activity of three muscles associated with the uncinate processes of the giant canada goose Branta canadensis maximus. *Experimental Biology and Medicine (Maywood),* 208, 849-857. doi:10.1242/jeb.01489.

Çevik Demirkan, A., Kürtül, İ.& Hazıroğlu, R.M. (2006). Gross morphological features of the lung and air sac in the Japanese quail. *Journal of Veterinary Medical Science,* 68, 909-913. https://doi.org/10.1292/jvms.68.909.

Çevik Demirkan, A. (2002). *The Skeletal System of the Duck*. Ankara University, Institute of Health Sciences, PhD thesis, Ankara, Turkey (in Turkish).

Dayan, M.O., Demiraslan, Y., Akbulut, Y., Duymuş, M. & Akosman, M.S. (2014). The morphometric values of the native duck and gooses' heads: A computed tomography study. *Journal of Veterinary Medicine and Animal Sciences, 2,* 175-178. doı: 10.11648/j.avs.20140206.13

Demirsoy, A. (1995). *Basic Rules of Life. Vertebrates / Amniota (Reptiles, Birds and Mammals).* Vol. 3, Chapter 2, Meteksan Publishing, Ankara, 205-290 (in Turkish).

Donatelli, J.R. (2012).*Cranial Osteology of Meiglyptini (Aves: Piciformes: Picidae).* Hindawi Pub Corp Anat Res Int, Article ID 951836.

Driesch, V.D.A. (1976). *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum Bulletin I. Cambridge M.A. Harvard University, 103-130.

Dursun, N. (2007). *Anatomy of Domestic Birds.* Medisan Publishing, 11. Edition, Ankara, 1-29.

Getty, R., Sisson & Grossman's. (1975). *The Anatomy of the Domestic Animals*. Philadelphia, WB Saunders Company, pp 1883-1891.

Gezer İnce, N., Demircioğlu, İ., Yılmaz, B., Ağyar, A.& Dusak, A. (2018). Three-Dimensional Modeling of Cranium in Seagulls (Laridae spp.). *Harran University Journal of Veterinary Faculty, 7*, 98-101. https://dx.doi.org/10.31196/huvfd.470973 (in Russian).

Gültekin, M. (1966). *Comparative Osteologia of Domestic Mammals and Poultry.* Ankara University Press, pp 288-306 (in Turkish).

Gündemir, O., Pazvant, G. & Gezer İnce, N. (2020). The Morphometric Examination of Head Area of Black Headed Gulls (*Larus Ridibundus*) from Marmara Region. *Journal of Research in Veterinary Medicine, 39*(1), 49-53. DOI:10.30782/jrvm.634404

Gündemir, O. (2019). A Comparative Study of the Cockatiel (Agapornis roseicollis) and Lovebird (Psephotellus pulcherrimus) Neurocranium. *Harran University Journal of Veterinary Faculty, 8*(1), 81-84

Hodges, R.D. (1974). *The Histology of the Fowl*. Academic Press Inc, London, New York, 273 - 293.

Hogg, D.A. (1984). The development of pneumatisation in the postcranial skeleton of the domestic fowl. *Journal of Anatomy, 139*, 105-113.

İlgün, R., Kuru, N. & Özkan, Z.E. (2015). Comparative Macro-Anatomical Investigations on Oshyoideum in Guinea fowls (*Numida meleagridis*) and turkeys (*Meleagridis gallapova*). *Journal of Faculty of Veterinary Medicine, Erciyes University, 12*(3), 191-194 (in Turkish).

İlgün, R., Özkan, Z.E. & Akbulut, Y. (2017). Macroanatomical investigations on neurocranium and splanchnocranium in dalmatian pelican (*Pelecanus crispus*). *Van Veterinary Journal, 28,* 5-10.

İlgün, R. (2016).). Comparative Macro-Anatomical Investigations on Oshyoideum in Guinea fowls (*Numida meleagridis*) and turkeys (*Meleagridis gallapova*). *Fırat University Journal of Health Sciences, 30,* 171-175 (in Turkish).

İndu, V.R., Lucy, K.M., Sreeranjini, A.R., Maya, S., Ashok, N & Chungat, J.J. (2013). Gross anatomy of the splanchnocranium in green-winged macaw. *Tamilnadu J. Veterinary & Animal Sciences, 9*, 213-220.

John, M.A., Sasan, J.S., Ahmed, K., Tomar, M.P.S., Ahmad, A. & Singh, A.D. (2014). Morphometry of sternum of pigeon, crow and owl. *Indian Veterinary Journal, 91*, 40-41.

Kılıç, E., Yayla, S., Ermutlu, C.Ş., Aydın, U. & Yıldız, U. (2018). The use of goose radius for the treatment of diaphyseal femur fracture in puppies. V. International Multidisciplinary Congress of Eurasia, Barcelona-Spain, 24 - 26 July, 257-258 (in Turkish).

King, A.S. & McLelland, J. (1975*). Outlines of Avian anatomy*. Bailliere Tindal, London, 1-22.

Koch, T. & Rossa, E. (1973). *Anatomy of the Chicken and Domestic Birds*. The Iowa State University press, Iowa, pp. 234-256.

König, H.E., Korbel, R. & Liebich, H.G. (2016). *Avian Anatomy Textbook and Colour Atlas*. 5m publishing, 2. Edition, 17-65.

Kuru, M. (1987). *Vertebrate Animals.* Ataturk University Publications, Erzurum, Turkey, 382-386 (in Turkish).

Mc Kibben, J.S. & Harrison, G.J. (1986). *Clinical Anatomy with Emphasis on the Amazon Parrot. Clinical Avian Medicine and Surgery*. WB Saunders, Philadelphia, pp 37-43.

Mclelland, J. (1990). *A Colour Atlas of Avian Anatomy*. Wolfe Publishing Ltd, Aylesbury England, pp 35 - 43.

Mussa, M.T., Kamal, M.M., Mahmud, M.A.A., Sarker,B.K., Jalil,M.A. & Das,S.K. (2015). Evaluation of a rapid and efficient method for preparation of skeletons of rabbit and goose. *Bangladesh Journal of Veterinary Medicine, 13*, 27-31.

N.A.A (1993). International Committe on Avian Anatomical Nomenclature: Nomina Anatomica Avium. 2nd ed., World Association of Veterinary Anatomist, Cambridge, Massachusetts, pp.109-173.

Nickel, R., Schummer, A. & Seiferle, E. (1977). *Anatomy of the Domestic Birds*. Berlin: Verlag Paul Parey, 1-25.

Onuk, B. (2008). Anatomy of the Respiratory System of the Goose (*Anser Anser Domesticus*). PhD thesis, University of Ondokuz Mayıs Samsun, Turkey (in Turkish).

Özkan, Z.E. (2002a). Macroanatomical and osteometric investigations on the cranium in male and female quails (Coturnix coturnix). *Kafkas University Journal of Veterinary Medicine*, 8, 147-151 (in Turkish).

Özkan, Z.E. (2002b). Comparative macro-anatomical investigations on os hyoideum in parrots (Agapornis personata) and budgerigars (Melopsittacus undulatus).). *Kafkas University Journal of Veterinary Medicine, 8*, 143-145 (in Turkish).

Predoi, G., Belu, C., Dumitrescu I, Georgescu, B., Şeicaru, A., Roşu,P., Carmen, B. & Dumitrescu, F. (2009). Comparative researches regarding the sternum in ostrich (*Sruthio camelus*) and Nandu (*Rhea americana*). *Lucrărı Ştıınlıfice Medıcınă Veterınară, 43*, 2.

Rezk, H.M. (2015). Anatomical investigation on the axial skeleton of the cattle egret, Bubulcus ibis. *Journal of Experimental and Clinical Anatomy, 61*, 145.

Schepelmann, K. (1990). Erythropoietic bone marrow in the pigeon: development of its distribution and volume during growth and pneumatization of bones. *Journal of Morphology, 203,* 21-34.

Singh, N.S., Bamon, I., Dixit, A.S. & Sougrakpam, R. (2015). Structural variations and their adaptive significances in the bones of some migratory and resident birds. *The Journal of Basic & Applied Zoology, 70,* 33-40. http://dx.doi.org/10.1016/j.jobaz.2015.06.003

Süzer, B., Serbest, A., Arıcan, İ., Yonkova, P. & Yılmaz, B. (2018). A morphometric study on the skull of the turkeys (*Meleagris gallopavo). Journal of Uludag University Faculty of Veterinary Medicine,* 37, 93-100. https://dx.doi.org/10.30782/uluvfd.427228.

Taşbaş, M., Hazıroğlu, R.M., Çakır, A. & Özer, M. (1994). Morphological investigations of the respiratory system of the Denizli cock. III. The lungs and air sacs *Journal of Ankara University Faculty of Veterinary Medicine,* 41,154-168 (in Turkish).

Taşbaş, M., Özcan, Z. & Hazıroğlu, M. (1986). A study on anatomical and histological structures of tonguc and the upper respiratory passages (Iarynx cranialis, trachea, syrinx) in the penguin. *Journal of Ankara University Faculty of Veterinary Medicine,* 33, 240-261 (in Turkish).

Taşbaş, M. & Tecirlioğlu, S. (1965). Research on maceration technique. *Journal of Ankara University Faculty of Veterinary Medicine,* 12, 324-330 (in Turkish).

Tecirlioğlu, S. (1986). *Comparative Anatomy Terms*. Ankara University Press, Ankara, 1-100 (in Turkish).

Tıpırdamaz, S. & Yüksel, M.F. (2012). Morphometric investigations on the vertebral column of the rock partridges (*Alectoris graeca*) and pheasants (*Phasianus colchicus*). *Eurasian Journal of Veterinary Sciences,* 28, 5-9.

Tickle, P.G., Ennos, A.R., Lennox, L.E., Perry, S.F. & Codd, J.R. (2007). Functional significance of the uncinate processes in birds. *Journal of Experimental Biology,* 210, 3955-3961. doi:10.1242/jeb.008953

Tickle, P.G., Rankin, J.W., Hutchinson, J.R. & Codd, J.R. (2014). Anatomical and biomechanical traits of broiler chickens across ontogeny. Part I. Anatomy of the musculoskeletal respiratory apparatus and changes inorgan size. *Peer of Journal*, July. doi: 10.7717/peerj.432.