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Macroanatomical Studies on the Neurocranium of Mallard Ducks (*Anas Platyrhynchos*)

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Abstract
In this study conducted to examine the mallard duck neurocranium, ten domestic duck skulls (five females and five males) obtained from manufacturers were used. The duck skulls were prepared for examination using maceration techniques. The neurocranium was observed to consist of the occipital bone, sphenoid bone, parietal bone, frontal bone, and temporal bone. The foramen magnum, located caudal to the occipital bone, was determined to be vertical and nuchal, and the occipital condyle, a single projection that articulates with the atlas, was located beneath this foramen. The parietal bones were observed to form the lateral aspect of the caudal portion of the skull roof. The dorsal surface of the parietal bone was convex. The frontal bone was long and thin. The surface area of the frontal bone was larger than the parietal bone. The fontanelle was found to have two foramina. The sphenoid bone had a triangular shape. The sphenoid bone, which participates in the formation of the ventral wall of the cranial cavity, was determined to consist of two parts: the parasphenoid bone and the basisphenoid bone. The nasal part of the frontal bone was well developed and had two prominences, the orbital process and the supraorbital process. The interparietal bone was absent, and the ethmoid bone was found to be part of the viscerocranium.
Consequently, the bones that make up the mallard duck neurocranium were examined in detail. It was concluded that the findings could be used to inform taxonomy and the field.

Keywords: Mallard Duck (*Anas Platyrhynchos*), Neurocranium, Anatomy

1. Introduction
Mallard ducks, a small type of poultry, are a type of poultry raised on small farms in many regions of Turkey (Especially in the northeastern regions) and are primarily a source of animal protein.
The bones that make up the skull are fused together by sutures and contain air spaces (Gültekin, 1966; Öktay, 1988) [8, 16]. The skull is examined as two parts: the neurocranium and the splanchnocranium (Öktay, 1988) [16]. The neurocranium is composed of the occipital bone, sphenoid bone, frontal bone, parietal bone, and temporal bone (Doğuer and Erencin, 1964) [5]. The occipital condyle is a single prominence (Çakır, 2001; Orhan *et al*., 2002; Koch and Rossa, 1973) [4, 15, 11]. The orbit constitutes a large part of the skull (Çakır, 2001; Dyce *et al*., 1964) [4, 7]. The largest bone of the skull is the frontal bone, located between the orbits (Çakır, 2001; Orhan *et al*., 2002) [4, 15]. The interparietal bone is not present in birds (Mcleod *et al*., 1964) [13]. Pneumatization of the skull bones is a factor that facilitates flight in birds (King and McLelland, 1984) [10].
This study was conducted to reveal the macro-anatomical features of domestic duck neurocranium bones, to shed light on taxonomy studies and to contribute to the knowledge in this field.

2. Materials and Methods
Ten domestic ducks (five females and five males) obtained from breeders were used in the study. Maceration of the skulls was performed according to methods described in the literature (Koch and Rossa, 1973; Taşbaş and Tecirlioğlu, 1996) [11, 20]. After boiling the duck skulls for sixty minutes, they were cleaned without damaging the bones. The cleaned skulls were then boiled with baking soda (Na2CO3) for approximately thirty minutes. Photographs were taken after macroanatomical examination of the skull bones. Nomenclature was based on the Nomina Anatomica Avium (Baumel *et al*., 1993) [2].

3. Results

The neurocranium bones of mallard ducks (*Anas platyrhynchos*) were determined to consist of the occipital bone, sphenoid bone, frontal bone, parietal bone, and temporal bone. While the ethmoid bone is included in the neurocranium in mammals, it was found to shift anteriorly under the influence of the orbit and become part of the viscerocranium in birds (Figures 1-2).

Fig 1: Caudal view of the mallard skull

Fig 2: Lateral view of the mallard skull.

Os Occipitale

The foramen magnum was observed to be surrounded by the supraoccipital, basioccipital, and exoccipital segments of the occipital bone. The foramen magnum was found to be vertical and nuchal in the mallard. Beneath it, a single prominence, the occipital condyle, was identified (Fig 1).

The occipital condyle resembled a perfect sphere. The fontanelle, located between the parietal and supraoccipital bones, had two foramina, one on each side (Fig 2).

The subcondylar fossa was observed beneath the occipital condyle. The hypoglossal foramen nerve was found to be two small foramina on either side of the foramen magnum. The presence of the foramen nervi vagi was noted oromedially, and the presence of the carotic canal and external ophthalmic canal ostiums were noted lateral to these foramina. The carotic foramen, jugular foramen, and foramen nervi vagi and glossopharyngeal foramen were observed on the lateralis (Fig 2).

The supraoccipital os was found to be separated from the parietal os superiorly by the sagittal nuchae crista and laterally by the transverse nuchae crista, which runs vertically from the temporal os and posteriorly borders the temporal fossa. Two external occipital vein foramina were present on the supraoccipital bone.

Os Sphenoidale

The sphenoid bone comprised most of the floor of the cranial cavity. The sphenoid bone had a triangular shape. The sphenoid bone is divided into two parts: the presphenoid bone and the basis phenoid bone. The basis phenoid bone was observed to be larger than the parasphenoid bone (Fig 2).

The basis phenoid bone was formed by the body and the temporal ala on either side (Fig 2).

The presphenoid bone was composed of the body and the orbital ala. The orbital alae were observed to unite anteriorly and, with a portion of the ethmoid bone, form the interorbital septum. It was determined that the foramina at the dorsal end of the same septum were for the olfactory nerve, while the large foramina at the caudal end were for the optic nerve. The body of the sphenoid bone was observed to connect to the dorsal end of the pterygoid bone via a joint (Fig 2).

The pharyngeal ostium, belonging to the auditory tube, was located on the medial side of the sphenoid bone, and the external carotid foramen was seen lateral to this opening (Fig 2).

The foramen ovale was located at the junction between the temporal bone and the sphenoid bone. The hypophysial fossa was observed near the center of the anterior surface (Fig 2).

Os Parietale

The caudolateral portion of the skull roof was formed by the parietal bone. The dorsal surface of the parietal bone was smooth and convex. The dorsal half of the parietal bone was slightly wider than the ventral half (Fig 2).

Os Temporale

The temporal bone, formed by the union of the otic and squamosum bones, was observed to have right and left sides and to be located lateral to the cranial cavity.

The os oticum consisted of three bones: the epicotic, prootic, and opisthotic. Located between the exoccipital, parietal, and phenotypic bone, the os oticum was observed to extend medially into the cranium (Fig 2).

The external acoustic porus was prominent. The pars squamosum, which forms the temporal fossa, formed the lateral wall of the cranium. The pars squamosum contained an articular fossa and a formation called the otic process. An articular process, the aboral process, was observed on the anterior aspect of the otic process, and a second process, the zygomatic process, was observed connecting this process. Rostrodorsal to the junction of the otic process with the quadrate bone, was the maxillomandibular foramen. The tympanic membrane and mastoid process were absent (Fig 2).

Os Frontale

The frontal bone, one of the paired bones of the neurocranium, was determined to be a very large bone, forming the nasal cavity, cranial cavity, and orbit. The dorsal portion of the frontal bone was observed to be flat and widen caudally in a triangular shape. The nuchal transverse crest was determined to be located between the parietal and supraoccipital crests (Fig 2).

The frontal bone was observed to consist of three parts: the pars nasalis, pars frontalis, and pars orbitalis.

The fossa on the pars nasalis and the groove in the center of the frontal bone were prominent. The nasalis bore prominences called the orbital and supraorbital processes. The prefrontal bone was found to be located on either side of the anterior end of the frontal bone. It is believed that the supraorbital process, located within the prefrontal bone, protects the ocular bulb.

In the orbital pars: There were holes named foramen nervi olfactorii, foramen opticum, foramen nervi trochlearis, foramen nervi oculomotorii, foramen nervi ophtalmici and foramen nervi abducenti.

4. Discussion

It has been reported that the sutures between the bones that make up the cranium disappear with age in poultry (Orhan *et al*., 2002; Özkan, 2002) [15, 18]. Because the mallard ducks used as material were adults, it was determined that the sutures between the bones that make up the neurocranium had disappeared.

The foramen magnum was reported to be dorsoventrally flattened in the quail (Özkan, 2002) [18], rounded, horizontal and located basally in the long-legged buzzard (Can *et al*., 2010; Orhan *et al*., 2002; Özdemir *et al*., 2009) [3, 15, 17], triangular in the chicken (McLelland, 1990) [12], oblique with respect to the long axis of the skull in the bald ibis (Çakır, 2001) [4]. Nickel *et al*. and Tan and Özdemir reported that it was located vertically and nuchal in the duck and goose, intermediate in the chicken, and horizontally and basally in the pigeon. In this study, the foramen magnum was observed to be in the vertical and nuchal regions.

McLelland reported that the fontanella is present between the parietal bone and the supraoccipital bone in all young generations. Jollie reported that this formation is a single, small opening in the pigeon, while Özdemir *et al*. reported two openings in the bittern and long-legged buzzard. Orhan *et al*. reported that the fontanella was present as two small openings between the supraoccipital bone and the parietal bone in the long-legged buzzard. Jollie reported that the external occipital vein was present on the supraoccipital os in many bird species. Çakır, however, found that the fontanella was absent in the bald ibis, but there are two external occipital veins on the supraoccipital bone, which Jollie noted was present in many bird species. In this study, the fontanella was found to be two openings.

Özdemir *et al*. reported that the frontal bone was long and thin in the bittern and broad in the long-legged buzzard, while Can *et al*. reported that the dorsal surface of the frontal bone was convex and broad in the teal. Orhan *et al*. reported that the flat dorsal surface of the frontal bone in the long-legged buzzard widens posteriorly into a triangular shape, and that a crista nuchae was located between the parietal and supraoccipital bones. The frontal bone has been reported to be dorsal in the grey heron (Atalgın *et al*., 2014) [1]. Dursun reported that the frontal bone in the guinea fowl bears a median ridge composed of spongiosum tissue, while this same ridge was not evident in domestic waterfowl. In this study, the frontal bone was found to be long and thin.

Koch reported that the parietal bone was wider than the frontal bone in birds of prey. Çakır noted that in the bald ibis, the skull roof was entirely formed by the frontal bone, and the parietal bone was located in the nuchal region. In the mallard duck, the frontal bone was determined to be wider than the parietal bone.

Orhan *et al*. reported that in the long-legged buzzard, the otic process was located dorsolateral to the tympanic cavity, and the maxillomandibular foramen was located craniodorsal to this process. Çakır reported that in the bald ibis, the zygomatic process was located dorsolateral to the tympanic cavity, the parotic process was located caudolaterally, and the maxillomandibular foramen was located craniodorsal to the tympanic cavity. The study observed that the squamosum has an articular fossa and the otic process for articulation with the quadratum. Furthermore, an articular process, the aboral process, and a second process, the zygomatic process, which joins this process, were observed. This process was determined to be long in the mallard duck.

In the mallard duck, the ethmoidale bone was found in the viscerocranium group, while the interparietal bone was absent. These findings were consistent with reports in the literature (Can *et al*., 2010 [3]; Doğuer and Erençin, 1964 [5]; Dursun, 2014 [6]; Gültekin, 1957; McLelland, 1990 [12]; Orhan *et al*., 2002 [15]; Özdemir *et al*., 2009; [17]).

As a result, different features of mallard duck neurocranium bones that can be used in taxonomy were revealed and it was concluded that the study would contribute to the knowledge in this field.

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