



## A Macroanatomic and Subgross Study on the Structure of Heart in Chukar Partridges

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### ABSTRACT

This study was conducted to determine the macroanatomic properties of the heart in a chukar partridge (*Alectoris chukar*). In the literature, there is a need of conducting such study due to the limited number of studies conducted on partridge heart. In the study, 10 chukar partridges were used regardless of the sex. It was found that the heart of the chukar partridge was located between the second and fifth ribs in the thoracoabdominal region. It was seen that in chukar partridges, the heart was attached to sternum by sternopericardial ligaments. It was determined that apex cordis was completely formed by left ventricle in the heart of the partridge. While trabecula carnea were determined in left ventricle, their number was higher compared to right ventricle. The presence of the structures called as papillary muscles and tendinous cords was revealed in right ventricle. It was determined that left auricle in left atrium was more notched than right auricle in right atrium. The presence of a funnel-shaped enlargement was determined on the base of right atrium. Compared to the cavity of right atrium, the cavity of left atrium was smaller.

**Keywords:** Atrium, Heart, Partridge, Ventricle

### öz

### Kınalı Keklikte Kalbin Yapısı Üzerine Makroanatomik ve Subgross Bir Çalışma

Bu çalışma, kınalı keklikte (*Alectoris chukar*) kalbin makroanatomik özelliklerini belirlemek için yapıldı. Literatürde, keklik kalbi üzerinde yapılan çalışmaların azlığı nedeniyle bu yönlü bir çalışmanın yapılmasına ihtiyaç duyuldu. Yapılan araştırmada 10 adet cinsiyet ayrımı gözetmeksizin kınalı keklik kullanıldı. Kalbin, kınalı keklikte thoracoabdominal bölgede, ikinci ve beşinci kaburgalar arasında uzandığı tespit edildi. Keklikte kalbin ligamentum sternopericardiaca ile sternum'a bağlandığı görüldü. Keklik kalbinde apex cordis'in tamamen ventriculus sinister tarafından oluşturulduğu saptandı. Ventriculus sinister'de trabecula carnea'lar tespit edilirken; sayılarının ventriculus dexter'dekinden daha fazla olduğu saptandı. Ventriculus dexter'de mm. papillares ve chordae tendineae denilen yapıların varlığı ortaya konuldu. Atrium sinistrum'daki auricula sinistra'nın atrium dextrum'daki auricula dextra'dan daha fazla çentikli olduğu belirlendi. Atrium dextrum'un tabanında huni şeklinde bir genişlemenin varlığı saptandı. Atrium dextrum'a ait olan boşluğa nazaran atrium sinistrum'un boşluğunun daha küçük olduğu görüldü.

**Anahtar Kelimeler:** Atrium, Kalp, Keklik, Ventrikül

### INTRODUCTION

Chukar partridge is a species of *Alectoris chukar* belonging to the genus *Alectoris* from the *Perdiciinae* subfamily of the family *Phasianidae* of the order *Galliformes* in the class *aves* (Anonymous 2018). The origin of this partridge extends from the inner side of Western Himalayas to Nepal over Asia, Israel, Turkey, Afghanistan, India, and Pakistan (Rasmussen and Anderton 2005). The circulatory system is made of the heart and veins, which are the central organs in all mammals and birds (Dursun 1994; Dursun 2002).

The heart is a cone-shaped organ extending in the cranial part of the median line of the thoracoabdominal region in birds (Baumel 1968; Rigdon et al. 1970; Hodges 1974;

Aydınoğlu et al. 1998; Dursun 2002). In birds, the heart has sternal (cranioventral), hepatic (caudodorsal), and pulmonary surfaces (Baumel 1968; Hodges 1974; Dursun 2002). Heart of birds has a base, basis cordis, which is formed by the right and left atria, and an apex, apex cordis, (Dursun 2002). Additionally, an avian heart has a conical shape with a pointed end. Being located between the fifth and sixth ribs, an avian heart is tightly correlated with the cervical diverticula, clavícula, cranial thoracic air sacs (Nickel et al. 1977). Also it is attached to sternum by sternopericardial ligaments (Dursun 2002). The position of heart in thoracic cavity varies based on age, sex, species and general working condition of animal (Dursun 1994). The heart is made of three layers as endocardium, myocardium, and epicardium in birds and mammals

(Hodges 1974; Banks 1993). Endocardium is the inner layer. Myocardium is a muscular layer in structure and it is partially similar to striated muscles and partially to the unstriated muscles (Banks 1993). Pericardium is formed of serous and fibrous layers (Nickel et al. 1981; Dursun 2002). The heart is composed of four ventricles called as right atrium and left atrium, which are separated from each other by interatrial septum, and the right ventricle and left ventricle, which are separated from each other by interventricular septum, in birds and mammals (Nickel et al. 1981; Dursun 1994; Dursun 2002). Due to the limited number of macroanatomic studies conducted on the heart in birds, it was decided to conduct this study. The present study presented anatomical data related to the heart of the chukar partridge. Also, recent advancements in the poultry sector have brought such an experimental study into question. We believe that the presence of a macroanatomic and subgross study on partridge heart would shed light on veterinarians, scientific researchers, and those engaged in poultry sector. It is also thought that this study would constitute a basis for different future anatomical studies on birds.

## MATERIALS and METHODS

In the study, 10 chukar partridges (*Alectoris chukar*) were used regardless of the sex. Live material was obtained from partridges reared by the Van Yüzüncü Yıl University Directorate of Wildlife Conservation and Rehabilitation Center for release to nature.

Materials such as scissors, injector, lancet, costotome, needle holder, glass stirrer, catheter, dissection microscope (stereomicroscope) (Nicon- SM7-ZT) that are present at the Department of Anatomy were used for the dissection technique to be used in this study.

The partridges were anesthetized by making an intramuscular injection of 0.5 ml rompun and 0.5 ml ketamine (6 mg/kg). Thus, they were taken under sedative effect for 2 hours (Allen and Oosterhuis 1986; Ali et al. 1987, Gonder and Barnes 1989). In order to prevent coagulation after premedication, 5 mg/kg heparin 1-1.5 ml together with 0.9% normal saline were injected from axillary vein that is a branch of subclavian vein and is formed by the combination of brachial veins and basilic veins from the upper limb veins (Baumel et al. 1993). In order to determine the location and the connections of the heart, an 8-10 cm long incision was done over the linea alba and the thoracoabdominal area was incised. The animals were laid on their right side and the skin and muscle sections on the left ribs were dissected after the incision from linea alba. When seeing from the outside, the thoracic cavity and the heart were brought into a visible situation, and the location and the connections of the heart between which ribs were specified in situ. Additionally, the position of the heart within the thoracic cavity was determined. Cranial vena cava, caudal vena cava, and aorta were ligatured, these veins were cut under the ligatures and the heart was resected from the thoracic cavity together with ascending aorta, cranial vena cava, caudal vena cava, and trachea. Lungs were left in the thoracic cavity. Thoracic artery was removed. In order to prevent the extravasation of the stained latex, left and right brachiocephalic arteries were ligatured without damaging the vein wall (Aksoy 2000; Cakmak 2007).

The hearts of the chukar partridges were photographed by using a Canon 350D DIGITAL model camera.

## RESULTS

In this study, it was observed that the heart of the partridge had a dark red color. The heart had a basis cordis and an apex cordis. Apex cordis had a shape of a pointed cone (Figure 1). It was determined that the average weight of the heart in the partridge was 2.80 gr. It was specified that the average length of the heart was 2.2 cm and its average width was 1.7 cm. Mean weight of the partridges was 550-650 gr.

The heart of the chukar partridge was transversally located between the second and fifth ribs (Figure 2). It was seen that the heart was attached to vertebral column via aorta in thoracoabdominal cavity (Figure 3), to aperture of thorax via cranial vena cava, to the air sacs via caudal vena cava, to the lungs via pulmonary trunk and to the sternum by sternopericardial ligaments.

It was determined that the heart had three faces as hepatic surface (caudodorsal surface), sternal surface (cranioventral surface) and pulmonary surface (base of heart). It was seen that pulmonary surface was formed by right and left atria. The heart had two sides as left and right ventricular margins (Figure 4).

It was observed that the heart consisted of the epicardium, myocardium and endocardium layers. While lamina visceralis of pericardium serosum shaped the epicardium, the thickest layer was myocardium. Being the thinnest layer, endocardium was tightly bound to myocardium. The presence of three sulci on the external surface of the heart was determined. The groove that was separating atria and ventricles in outer side, surrounding the heart and forming the base of ventricles was sulcus coronaries. It was specified that this groove was full of subepicardial fat mass (Figure 4). However in the partridge, it was remarkable that this fat layer was not so dense. It was determined that the groove beginning from coronary sulcus and continuing to the apex cordis was paraconal interventricular groove. Also it was observed that subsinuosal interventricular groove continued on the right side of the heart and descended to the apex cordis by originating from coronary sulcus. Also it was determined that subsinuosal interventricular groove descended to the apex cordis by continuing on the right side of the heart and originating from coronary sulcus.

It was determined that the heart of partridge was formed by ventricles and atria. It was observed that right and left atria are separated from each other by the interatrial septum. (Figure 5). The volume of left atrium was smaller than the volume of right atrium. Left auricle in left atrium was more notched than right auricle in right atrium. The presence of a funnel-shaped enlargement was determined on the base of right atrium.

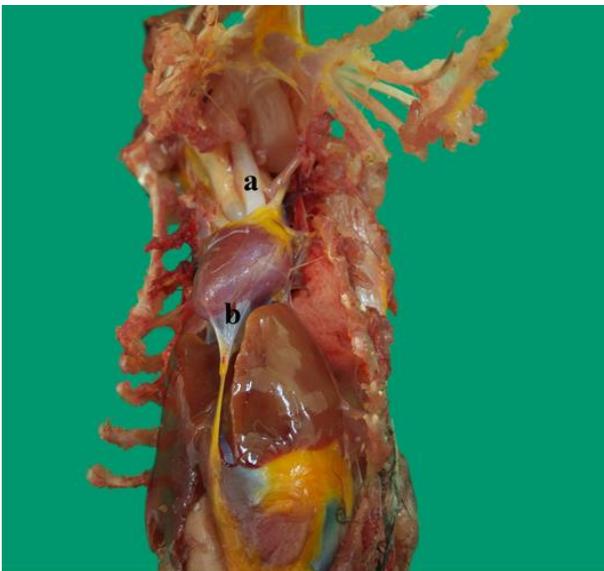
The presence of the structures called as papillary muscles and tendinous cords in right ventricle could not be revealed. It was determined that tendinous cords and papillary muscles were present in left ventricle. Also papillary muscles in left ventricle were stronger muscular masses (Figure 6).



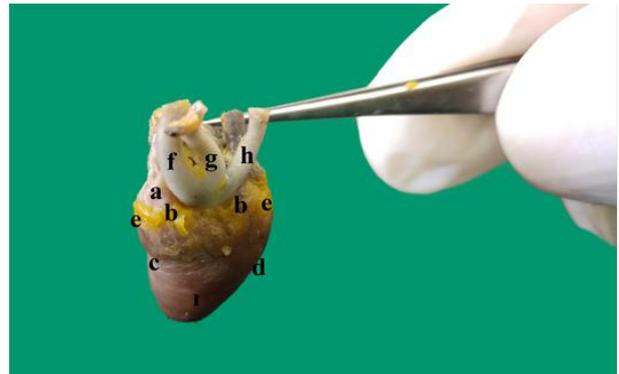
**Figure 1.** The appearance of the partridge heart  
**a.** Apex cordis, **b.** Pulmonal root, **c.** Trachea



**Figure 2.** Position of the heart in the partridge  
**a.** Hearth, **b.** Second rib, **c.** Fifth rib

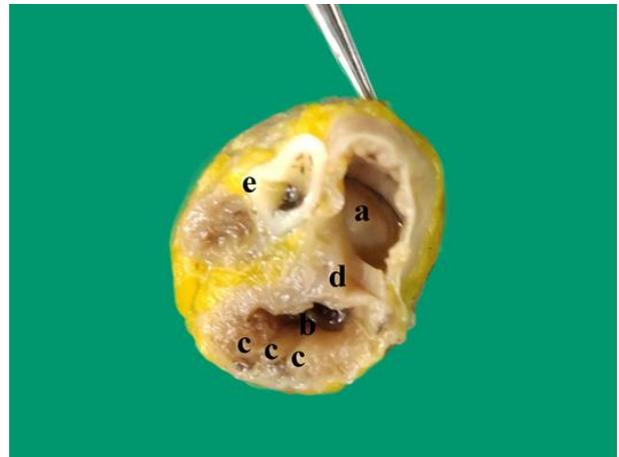


**Figure 3.** The partridge heart is located in the thoracoabdominalis of the cavum and the pericardium  
**a.** Cavum thoracoabdominalis, **b.** Pericardium, lig. sternopericardiaca



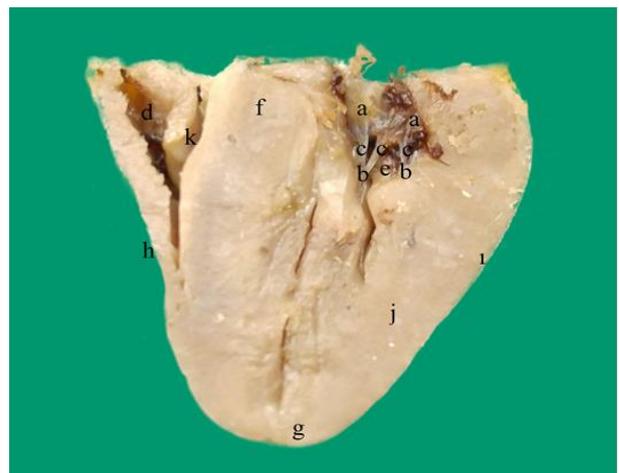
**Figure 4.** The edges of the partridge heart and the auricula sinistra

**a.** Auricula sinistra, **b.** Sulcus coronaries, **c.** Margo ventricularis dexter, **d.** Margo ventricularis sinister, **e.** Subepicardial fat tissue filling the sulcus coronaries, **f.** Aorta ascendens, **g.** A. brachiocephalicus sinistra, **h.** A. brachiocephalicus dextra, **i.** Facies sternalis



**Figure 5.** The atria, the mm. pectinati, and the septum interatriale in the partridge

**a.** Atrium dextrum, **b.** Atrium sinisterum, **c.** Mm. pectinate, **d.** Septum interatriale, **e.** Aorta



**Figure 6.** The cusps, the mm. papillaris, the chordae tendineae in the heart of the partridge

**a.** Cuspis (cuspis of the ostium atrioventriculare sinister), **b.** Mm. papillares, **c.** Chordae tendineae, **d.** Ventriculus dexter, **e.** Ventriculus sinister, **f.** Septum interventriculare, **g.** Apex cordis, **h.** Margo ventriculus dexter, **i.** Margo ventriculus sinister, **j.** Myocardium, **k.** Endocardium

## DISCUSSION AND CONCLUSION

It is reported that the apex cordis has a shape of a pointed cone in the goat, cattle, and sheep (Nickel et al., 1981; Tipirdamaz 1987; Dursun 1994) and a circular cone in buffalo (Tecirlioglu et al. 1977) and cat (Nickel et al. 1981; Dursun 1994; Aksoy 2000). It is expressed that the apex cordis in the rabbit has a pointed shape like sheep, cattle, and goat and is blunt in the cat like the buffalo heart (Aksoy 2000). While apex cordis of human heart is reported to be cone-shaped (Arinci and Elhan 1995), the shape of heart is spherical in dogs, cone-like in pigs, cone-like in goat, and a pointed cone-like in cattle (Nickel et al. 1981). In chicken, the apex cordis has a shape of a long pointed cone (Baumel 1975). In a turkey study, it is determined that the heart had a shape of a pointed cone (Cakmak 2007). In this study, it was determined that the heart of the chukar partridge was in the shape of a sharp cone like the heart of turkey and chicken.

It is reported that the heart of the birds extends in the frontal side of thoracoabdominal cavity and the heart of poultry is located in the medial line in the thoracic cavity (Nickel et al. 1977). An avian heart is located in the thoracoabdominal cavity and on the cranial line of this cavity (Dursun 2002). Arinci and Elhan (1995) reported that the human heart was located above the diaphragm between two lungs in the thoracic cavity. Cakmak (2007) specified that the heart of a turkey was in the position oriented towards caudoventral in thoracoabdominal cavity. In this study, it was observed that the position of the heart was similar to the literature related to the birds.

The heart is located between fifth and sixth ribs in domesticated birds (Nickel et al. 1977; Dursun 2002; Bartyzel et al. 2004), and between fourth and sixth ribs in turkeys (Cakmak 2007). In the study conducted on chukar partridges, it was determined that the heart was located between the second and fifth ribs.

It is reported that the heart is surrounded with pericardium in human (Moore 1992; Banks 1993; Arinci and Elhan 1995), domesticated mammals (Tecirlioglu et al. 1977; Dursun 1979; Nickel et al. 1981; Karadag and Soyguder 1989; Dursun 1994; Aksoy 2000) and turkeys (Cakmak 2007). It was observed that the heart in chukar partridges was surrounded with a slippery, transparent structure called as pericardium.

The heart is attached to the sternum by phrenicopericardial and sternopericardial ligaments in carnivore, by sternopericardial ligaments in horses (Nickel et al. 1981; Dursun 1994), by sternopericardial ligament (Nickel et al. 1977) in birds (Baumel 1975) and domesticated birds, and by sternopericardial ligament in turkeys (Cakmak and Karadag 2008). In this study, it was specified that the heart in partridge was attached to the sternum by sternopericardial ligament.

It is revealed that the heart walls consist of three layers named as endocardium, myocardium and pericardium from the inside to the outside in the domesticated mammals (Chakravathy and Sastry 1979; Nickel et al. 1981; Dursun 1994), human (Moore 1992; Dellmann 1993), poultry (Hodges 1974), birds (Baumel 1975), domesticated birds (Nickel et al. 1977) and the thickest layer of the heart is myocardium in equide, ruminant and carnivore (Nickel et al. 1981), pigs (Dursun 1994), human (Dellmann 1993; Arinci and Elhan 1995), rabbit and cat (Aksoy 2000), turkey (Cakmak and Karadag 2008), poultry (Hodges 1974; Baumel 1975; Nickel et al. 1977). In the

present study, it was determined that the thickest layer of the heart was myocardium.

In domesticated mammals, three grooves on the surface of the heart are specified and these grooves are coronary groove, paraconal interventricular groove and subsinuosal interventricular groove (Nickel et al. 1981). In this study, the presence of coronary groove, paraconal interventricular groove, and subsinuosal interventricular groove was also determined.

It is stated that the heart is surrounded with coronary sulcus in domesticated mammals (Nickel et al. 1981) and in human (Moore 1992; Dellmann 1993; Arinci and Elhan 1995), ostrich (Bezuidenhout 1984), domesticated birds (Nickel et al. 1977), birds (Baumel 1975), and turkey (Cakmak and Karadag 2008). The results of this study are compatible with the information in the literature.

Paraconal interventricular groove and subsinuosal interventricular groove are located on left and right surfaces of heart, respectively and these grooves continued from coronary sulcus to apex of heart in domesticated mammals (Nickel et al. 1981; Dursun 1994), human (Moore 1992; Arinci and Elhan 1995), and birds (Hodges 1974; Baumel 1975; Nickel et al. 1977; Dursun 2002). This result is similar to results of this study.

In cat, dog, pig, horse, and cattle (Nickel et al. 1981; Dursun 1994), rabbit (Aksoy 2000), domesticated birds and birds (Baumel 1975; Nickel 1977), the cavity of right atrium is wider than the cavity of left atrium. The results of the study on heart of chukar partridge support the literature data.

The presence of papillary muscles and tendinous cords in right ventricle has been revealed in domesticated mammals (Dursun 1994). While one end of tendinous cords is attached to right atrioventricular valve in mammals (Dursun 1994), the absence of papillary muscles and tendinous cords in right ventricle has been stated in studies conducted on birds (Baumel 1975; Yildiz et al. 2004; Alsafy et al. 2009; Figueroa et al. 2009), domesticated birds (Nickel et al. 1977), turkey (Cakmak 2007) and various birds (Ates et al. 2010). This study did not reveal the presence of papillary muscles and tendinous cords in right ventricle.

Consequently, the heart of the partridge is located between the 2<sup>nd</sup> and 5<sup>th</sup> ribs. The heart turns towards caudoventral in thoracoabdominal cavity and located in the left side of the median line. The heart is covered by the pericardium. The heart is attached to the sternum by sternopericardial ligament. It is originated from four tendinous cords in the left ventricle from the end of papillary muscles and from three tendinous cords in the right ventricle. The wall structure of right ventricle is thinner than the wall structure of left ventricle. The cavity of left ventricle is smaller than the cavity of right ventricle. Right auricle is less notched than left auricle. Apex cordis in the heart of the chukar partridge is formed by left ventricle.

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