**Comparative gross and biometrical studies on heart of Gaddi sheep and Gaddi goats**

**ABSTRACT**

This study presents a comparative gross and biometrical analysis of the heart in Gaddi sheep and Gaddi goats of Himachal Pradesh. Sixteen heart samples (eight from each species) were collected from healthy adult animals at a local abattoir. Gross anatomical observations revealed that in both species the heart was located ventrally within the mediastinum extending from the third to the sixth intercostal space. The heart of the goat appeared more conical compared to the relatively less tapered heart of the sheep. In both species the heart exhibited a triangular shape with a blunt apex entirely formed by the left ventricle. A considerable amount of epicardial fat observed on the surface of heart in both species. Biometric analysis demonstrated that the mean heart weight was 107.5 ± 2.54g in Gaddi sheep and 113.8 ± 2.85 g in Gaddi goats. The mean length of the anterior border (base to apex) measured 68.0 ± 4.4 mm in sheep and 72.7 ± 2.2 mm in goats. The mean heart diameter was recorded as 174.0 ± 17.6 mm in sheep and 176.0 ± 3.0 mm in goats. Additional parameters including circumference at the coronary groove, thicknesses of the ventricular walls and moderator band and external diameters of the aorta and vena cava were also assessed. The comparative data indicated that most biometrical parameters were greater in Gaddi goats than in Gaddi sheep highlighting species-specific anatomical differences that may have physiological and clinical relevance.

**Key words**: Biometery; Gaddi; goat; gross; heart; sheep.

**INTRODUCTION**

Sheep and goats were among the earliest domesticated ruminants and continue to play a vital role in livestock-based economies. In India, these species contribute significantly to agricultural productivity and contributes approximately 2–3% of global wool production and ranking among the top wool-producing countries. Additionally, sheep alone contribute about 7.68% to India’s total meat output emphasizing the economic importance of small ruminants in the country. As a vital component of the circulatory system, the heart functions as a muscular pump to maintain systemic and pulmonary circulation. Detailed anatomical and biometrical understanding of the heart is critical for identifying structural or functional disorders (Sisson & Grossman, 1975; Nickel et al., 1981). Several researchers have explored the cardiac anatomy in domestic animals and highlighted species-specific anatomical features like Panditrao (2014) in sheep, Sathapathy (2013) in goats, Gupta (2013) in buffaloes and Crick et al. (1998) in pig. Although similar data exist for other breeds but there is a distinct lack of published information on the heart morphology and biometrics in Gaddi sheep and goats. This lack of data hinders the ability to accurately recognize cardiac abnormalities and develop appropriate surgical treatment strategies. Therefore, a detailed investigation of the gross anatomical and biometric characteristics of the heart in Gaddi sheep and goats of Himachal Pradesh is both necessary and relevant.

**Materials and Methods**

The present study was conducted on a total of 16 heart specimens, comprising 8 Gaddi sheep and 8 Gaddi goats, irrespective of sex. All specimens were collected from apparently healthy adult animals slaughtered at local slaughter houses in the Palampur region of Himachal Pradesh. Immediately after collection, the hearts were thoroughly scrubbed and washed under running tap water to remove blood clots and tissue debris. Gross examination was performed to assess external features and morphological differences between the two species. For biometrical analysis, various instruments were employed, including a metric scale, a non-stretchable nylon thread for curved measurements and a digital Vernier caliper with a resolution of 0.01 mm and accuracy of ± 0.03 mm. The recorded measurements were subjected to routine statistical analysis. The data were expressed as Mean ± Standard Error (S.E.) for comparative evaluation between Gaddi sheep and goats.

**Results and discussion**

**Topography and External Morphology of the Heart**

The heart was positioned in the lower ventral part of the middle mediastinal space between the third and sixth intercostal spaces in both Gaddi sheep and goats. It was characterised by a wide base that was orientated dorsally and a sharply pointed apex that was positioned just above the terminal part of the sternum and directed caudoventrally. These findings were in agreement with those reported by Panditrao (2014) in sheep, Gumansing (2015) in goats and Bhasin (2017) in buffalo. The hearts of Gaddi sheep were observed to be reddish-brown while those of goats appeared dark brown, aligning with the findings of Shahida et al. (2007) in water buffalo. In contrast to the present findings Martin et al. (2009) reported a red-colored heart in the Western Grey kangaroo emphasizing species-specific variations. A broader lateromedial width was observed in Gaddi sheep whereas Gaddi goats exhibited a greater anteroposterior width at the base of the heart. In both species heart was found to possess distinct right and left surfaces along with anterior and posterior borders. The right surface was mainly formed by the right ventricle with a smaller portion from the left ventricle while the left surface consisted of about one-third right ventricle and two-thirds left ventricle. The anterior border was prominently convex whereas the posterior border was convex near its origin and became straight distally aligning itself with the anterior edge of the sixth rib in both species. These structural characteristics were in line with the findings reported by Archana (2010) and Panditrao (2014) in sheep, Gumansing (2015) in goat, Bhasin (2017) in buffalo and Sandhu (2021) in sheep. Both species exhibited a triangular-shaped heart with a distinctly pointed apex which was consistent with the observations of Archana (2010) in sheep. In comparison cattle, pigs and kangaroos were reported to have cone-shaped, valentine-shaped and globe-shaped hearts respectively as documented by Raghavan (1964), Dyce (1996), Crick et al. (1998) and Martin et al. (2009), highlighting the morphological variations across different species. In both species a prominent transverse coronary groove encircling the hearts and separating the atria from the ventricles and contained fat and coronary vessels. This observation aligns with the findings of Malik et al. (1978), Schummer et al. (1981), Panditrao (2014), Bhasin et al. (2017), Sisson (1975), and Dyce (1996). The circumference of the coronary groove was comparatively greater in Gaddi goats (72.0 ± 1.0 mm) compared to sheep (67.4 ± 1.8 mm). Three longitudinal grooves (right, left and intermediate) were identified in both species. Among these the left longitudinal groove was most prominent in Gaddi goats. The right groove originated from the coronary groove beneath the posterior vena cava whereas the intermediate groove appeared shallow and short, extending along the left posterior border. These observations were aligned with those of Dyce et al. (1996) and Pasquini et al. (2007).

**Internal Cardiac Architecture**: The right atrium located anteriorly at the base of heart consisted of the sinus venarum and auricle and received openings of the cranial and caudal venae cavae as well as the coronary sinus. The cranial and caudal venae cavae were observed entering at the level of the fourth and fifth ribs, forming acute angles measuring 125.4±1.8° in sheep and 127.8±1.02° in goats, deviating from the right-angle configuration reported by Crick et al. (1998) in pigs. The coronary sinus was found opening just beneath the posterior vena cava, consistent with Bari (2013) in sheep. A meshwork of pectinate muscles was observed on the wall of the right atrium, similar to the findings by Getty (1975). The right atrioventricular orifice guarded by crescent-shaped fibrous tricuspid valves (anterior posterior and medial) opened into the right ventricle in both species and was consistent with the observations of Archana (2010), Bhasin (2017) and Sandhu (2021). The wall thickness of the pulmonary artery was measured at 3.2±0.2 mm in Gaddi sheep and 3.3±0.15 mm in Gaddi goats. Within the right ventricle, trabeculae carneae, papillary muscles and chordae tendineae were evident along with a prominent moderator band in Gaddi goat. Semilunar valves located at the origin of the pulmonary artery in both species found preventing backflow of blood. These observations were in agreement as reported by Raghavan (1964), Getty (1975), Dyce et al. (2002) and Ghosh (2006). The interventricular septum which constituted the posterior wall of the right ventricle showed a slight concavity towards the left and had a thickness similar to that of the left ventricle. The thickness of interventricular septum measured 13.4±0.3 mm in Gaddi sheep and 15.2±0.3 mm in Gaddi goats. The left atrium situated caudodorsally behind the aorta and pulmonary artery and superior to the left ventricle, received four pulmonary veins in both species and communicated with the left ventricle via a triangular atrioventricular opening guarded by a bicuspid (mitral) valve. The mitral valve in both species were larger than the right-sided valve corroborating the observations of Archana (2010) and Sandhu (2021) in sheep, although Bari (2013) documented a smaller left opening in sheep. The left ventricle formed the caudal region of the heart near the sixth intercostal space was observed to have a thicker wall than the right and extended from the transverse groove to the apex in both species. The left ventricle of the Gaddi goat showed more prominent trabeculae carneae and thicker chordae tendineae.

**Biometrical Comparison of the Heart**:

The average heart weight was recorded 107.5±2.54 g in Gaddi sheep and 113.8±2.85 g in goats. These values were comparable to those of Archana et al. (2010) in sheep and were lower than those reported in deer by Malik et al. (2000). Hussain and Qureshi (2007) documented weights of heart 160.6±53.86 g in juvenile and 256.1±71.57 g in adult Nili-Ravi buffalo. The anterior border measured 72.7±2.2 mm in Gaddi goats and 68.0±4.4 mm in Gaddi sheep. Lengths of posterior border were 61.25±3.0 mm in Gaddi goats and 56.6±3.0 mm in Gaddi sheep. These findings were consistent with reports by Bari (2013 in sheep and Shahida et al. (2007) in buffalo. The circumference at the coronary groove was greater in Gaddi goats (72.0±1.0 mm) than in Gaddi sheep (67.4±1.8 mm), in accordance with data from Sathapathy (2013) in goats and Shahida et al. (2007 in buffalo. Slightly larger heart diameters were observed in Gaddi goats (176.0±3.0 mm) compared to Gaddi sheep (174.0±6.0 mm), supported the findings of Archana et al. (2010) and Bari (2013). Lateromedial width was greater in Gaddi sheep (93.4±4.0 mm) whereas Gaddi goats showed a greater antero-posterior width (83.0±3.0 mm), corroborating Archana et al. (2010) and Bari (2013). The right atrial wall thickness was 7.3±0.4 mm in Gaddi sheep and 7.9±0.3 mm in Gaddi goats. Higher values were reported in Nili-Ravi buffalo by Hussain and Qureshi (2007), while Bari (2013) found lower values in sheep. Left atrial wall thickness was 7.1±0.4 mm in Gaddi sheep and 7.7±0.2 mm in Gaddi goats. This was in parallelism with higher values documented in sheep and buffalo by Bari (2013) and Hussain and Qureshi (2007) respectively. Right ventricular wall thickness was recorded as 8.7±0.5 mm in Gaddi sheep and 7.9±0.3 mm in Gaddi goats which was in agreement with Archana et al. (2010) and Bari (2013) in sheep. Left ventricular wall thickness was 16.0±0.8 mm in Gaddi sheep and 17.7±0.03 mm in Gaddi goats, aligning with prior studies. The interventricular septum thickness was measured as 13.4±0.5 mm in Gaddi sheep and 15.2±0.3 mm in Gaddi goats, comparable to the 15.0 mm reported in deer by Malik et al. (2000). Aortic circumference was 32.5±1.0 mm in Gaddi sheep and 35.3±1.66 mm in Gaddi goats, and aortic wall thicknesses were 3.3±0.1 mm and 4.0±0.1 mm, respectivelym and found consistent with Archana et al. (2010) and Bari (2013) in sheep. Moderator band length was 25.9±1.0 mm in Gaddi sheep and 26.6±0.6 mm in Gaddi goats, while thickness of moderator band measured 5.2±0.3 mm and 5.678±0.3 mm respectively. The angle between the anterior and posterior vena cava was 125.4±1.8° in Gaddi sheep and 127.8±1.02° in Gaddi goats, aligning with Archana et al. (2010) and Bari (2013) in sheep. Simon et al. (1998) reported a right angle between the anterior and posterior vena cava in pigs and a straight line in humans. Circumference of Pulmonary artery was 34.3±0.7 mm in sheep and 35.6±0.7 mm in Gaddi goats, while wall thicknesses of pulmonary artery reported 3.2±0.2 mm and 3.3±0.1 mm respectively. This was in correspondence with the findings of Archana et al. (2010) and Bari (2013) in sheep.

**Conclusion**
The present study revealed the comparable gross anatomical and biometrical features of the heart between Gaddi sheep and goats with evident significant morphometric differences. The goat heart was consistently larger across most parameters, indicating possible physiological variations between the two species. These findings offer valuable comparative anatomical information with potential implications for species-specific clinical and veterinary practices.

**Table 1. Statistical analysis of the biometrical observations of various parameters of the heart of Gaddi sheep and goat (values in mm except weight in gm and angle in degrees)**

| **Sr. No.** | **Parameters** | **Gaddi Sheep (Mean ± SE)** | **Gaddi Goat (Mean ± SE)** |
| --- | --- | --- | --- |
| 1. | Weight of heart (gm) | 107.5 ± 2.54 | 113.8 ± 2.85 |
| 2. | Length of anterior border from base to apex (mm) | 68.0 ± 4.4 | 72.7 ± 2.2 |
| 3. | Length of posterior border from base to apex (mm) | 56.6 ± 3.0 | 61.25 ± 3.0 |
| 4. | Circumference at coronary groove (mm) | 67.4 ± 1.8 | 72.0 ± 1.0 |
| 5. | Diameter of heart (mm) | 174.0 ± 6.0 | 176.0 ± 3.0 |
| 6. | Latero-medial width (mm) | 93.4 ± 4.0 | 83.0 ± 2.9 |
| 7. | Antero-posterior width (mm) | 77.2 ± 2.0 | 83.0 ± 3.0 |
| 8. | Wall thickness of right atrium (mm) | 7.3 ± 4.4 | 7.9 ± 0.3 |
| 9. | Wall thickness of right ventricle (mm) | 8.7 ± 0.5 | 7.3 ± 0.3 |
| 10. | Wall thickness of left atrium (mm) | 7.12 ± 0.4 | 7.7 ± 0.2 |
| 11. | Wall thickness of left ventricle (mm) | 16.0 ± 0.8 | 17.7 ± 0.3 |
| 12. | Thickness of interventricular septum (mm) | 13.4 ± 0.5 | 15.2 ± 0.3 |
| 13. | Circumference of aorta (mm) | 32.5 ± 1.0 | 35.3 ± 1.66 |
| 14. | Wall thickness of aorta (mm) | 3.3 ± 0.1 | 4.0 ± 0.1 |
| 15. | Length of moderator band (mm) | 25.9 ± 1.0 | 26.6 ± 0.6 |
| 16. | Thickness of moderator band (mm) | 5.2 ± 0.3 | 5.7 ± 0.3 |
| 17. | Angle between anterior and posterior vena cava (°) | 125.4 ± 1.8 | 127.8 ± 1.02 |
| 18. | Circumference of pulmonary artery (mm) | 34.3 ± 0.7 | 35.6 ± 0.7 |
| 19. | Wall thickness of pulmonary artery (mm) | 3.2 ± 0.2 | 3.3 ± 0.15 |

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| **Plate 1:** Photograph of the Goat heart showing **A**. base of heart. **B.** left ventricle **C.** apex of heart. | **Plate 2**: Photograph of Goat heart showing **A.** right atrium **B.** cups **C.** chordae tendineae **D**. papillary muscle **E.** thick wall of left ventricle |
| **Plate 3**: Showing the weight of the goat heart. | **Plate 4:** Showing measurement of length of the sheep heart. |
| **Plate 5:** Showing the circumference of sheep heart measured with thread and scale. | **Plate 6:** Showing the measurement of wall thickness of left ventricle of goat heart. |
| **Plate 7**: Showing measurement of thickness of aorta of goat heart. | **Plate 8:** Photograph of the sheep heart showing moderator band (**arrow**) of right ventricle.  |

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