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Gross Anatomical and Morphometrical Investigation on the Scapula of Indian Fox (*Vulpes bengalensis* (Shaw, 1800))

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ABSTRACT

The present study was conducted from March, 2023–July, 2024, at the College of Veterinary Science, Proddatur, Andhra Pradesh, India. The scapula bones were collected using the maceration technique to record the gross and morphometrical features. The gross morphological study on the scapula of the Indian fox revealed that it was a triangular bone with two surfaces, three borders, and three angles. The cranial border was thin, convex and showed an anteriorly projected process. The caudal border was thick and straight. The dorsal border was convex. The scapular spine was well developed, increasing in height from above downwards, and it terminated in the acromion process. The maximum length of the right and left scapulae in Indian foxes were 6.0 cm and 5.93 cm respectively. The average maximum width of the right and left scapulae was 3.55 cm. The length of the scapular spine was 5.8 cm. The acromion process consisted of hamate and suprahamate processes. The hamate process was quadrilateral with the blunt end and over-hanged the glenoid notch. The supra-hamate process was triangular and directed caudally. The ratio of supra and infraspinous fossae was approximately 1:1. The subscapular fossa was along the attached border of the spine on the costal surface. The costal surface presented three ridges and the nutrient foramen was observed near the scapular neck. The tuber scapula was not well defined but had a coracoid process towards its costal surface. The glenoid cavity was shallow and oval. The average length and the width of the glenoid cavity were 1.28cm and 0.80 cm respectively.

KEYWORDS: Hamate process, Indian fox, morphometry, scapula, subscapular fossa

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

The Indian fox was endemic to the Indian subcontinent from the Himalayan foothills and Terai of Nepal through southern India and from southern and eastern Pakistan to eastern India and southeastern Bangladesh (Jhala, 2016; Vanak, 2005). The Bengal fox was more daintily built than the red fox (*V. vulpes*) and can readily be recognized by its bushy, black-tipped tail, which was around 50-60% of the head and body length (Menon, 2014). The Indian foxes have a commonplace existence because of their omnivorous dietary requirements which do not involve any conflict with humans (Vanak et al., 2008). IUCN lists Indian foxes as Least Concern (Sillero-Zubiri et al., 2004). In India, they were listed under Schedule II of the Indian Wildlife (Protection) Act, which affords a lower degree of protection. Human activities such as hunting and habitat destruction have been suggested to cause the low population density of Indian foxes over most of their range (Johnsingh and Jhala, 2004).

The scapula was a flat bone whose lateral surface was divided by a scapular spine into two fossae (suprspinous and infraspinous). The medial surface of the scapula consisted of subscapular fossa. The scapula articulates distally with the proximal humerus at the glenoid cavity, above which was the constricted portion known as the scapular neck. The scapular morphology varies with species and arrived from the combination of phylogenetic history and functional requirements. The scapula provided a large surface area for insertion to the muscles connecting the forelimb to the body and a functional element of the forelimb, which was propulsive during locomotion. Furthermore, the differences in body size was expected to also influence scapular morphology, since body size plays a major role in determining the biomechanics of locomotion (Galvez-Lopez and Casinos, 2022). The Skeletal systems of carnivores such as dogs (Evans and de Lahunta, 2017), Civet cats (Sarma et al., 2017), wild carnivores such as Asiatic Lion (Pandey et al., 2004), Tigers (Lucy and Harshan, 2010, Mahapatra et al., 2016; Tomar et al., 2018), and Lions (Nzalak et al., 2010, Sohel et al., 2021) were studied in detail. The morphometrical features of the scapula in royal Bengal tigers were studied by Uddin et al. (2022). Comparative anatomical studies on the scapulae of the Bengal tiger and Indian leopard were carried out by Sarma et al. (2013). Macroanatomy of the scapula of sloth bear (Melursus ursinus) was studied by Kalita and Bhattacharya (2002). Rajput et al. (2022) studied the scapula of the Himalayan mongoose. Gross Anatomical Studies of the scapula in Leopard (Panthera pardus) was done by Sreeranjani et al. (2008). Onwuama et al. (2022) recorded the morphological and morphometrical features of the African lion (Panthera Leo Leo) pectoral limb. Comparative macro-anatomical observations of the forelimb bones of New Zealand rabbits (*Oryctolagus cuniculus*) and domestic cats (Felis domestica) were recorded by El-Ghazali and El-behery (2018). Microanatomy of the bones of the thoracic limb of an Asian elephant was studied by Ahsan et al. (2016). The skeletal features of domestic mammals were recorded by Konig and Liebich (2009). Indian fox was one of the least studied canids in the world. The paucity of literature on systematic information on characteristic anatomical features of the bones of Indian foxes leads us to go through this study. Keeping this fact in mind the present study had been planned to keep on record the gross anatomical and morphometrical study on the scapula of the Indian fox.

2. MATERIALS AND METHODS

The present study was conducted during March, 2023–July, 2024 on the scapulae of four adult Indian foxes in the Department of Veterinary Anatomy, College of Veterinary Science, Proddatur, Kadapa, Andhra Pradesh (516360), India. The bones were collected after maceration and observed for gross morphological features. Different biometrical parameters were measured with a thread, meter scale, and Vernier calipers. The following parameters like maximum length (dorsal border to the glenoid cavity), maximum width (cranial border to caudal angle), length of cranial border, Length of caudal border, Length of dorsal border, Length of scapular spine,Height of scapula spine from supraspinous fossa, Height of scapula spine from infraspinous fossa,Maximum width of supraspinous fossa, Maximum width of infraspinous fossa, Length of glenoid cavity, Width of glenoid cavity and Distance between the glenoid cavity and acromion process were measured.

3. RESULTS AND DISCUSSION

The maximum length of the right and left scapula in Indian foxes was 6.0 cm and 5.93 cm respectively. The maximum length of the scapula in royal Bengal tigers was 26.5 cm (Uddin et al., 2022). The average maximum width of the right and left scapulae was 3.55 cm. The maximum width of the right and left scapula in the royal Bengal tiger was 20 cm and 17.2 cm respectively (Uddin et al., 2022). The scapula of the rabbit and the cat was a near triangle in outline with a mean length measured 5.700±1.0055 and 6.430±.3831 in the rabbit and cat respectively (El-Ghazali and El-behery, 2018). Lucy and Harshan (2010) reported the scapular length and scapular width of the tiger as 25 cm and 17 cm respectively, whereas Sarma et al. (2013) recorded the tiger's scapular length and width as 24.82 cm and 21.11 respectively

The scapula of the Indian fox was placed on the lateral

aspect of the thorax, directed downwards and forward. The highest part of the scapula lies just below the level of the second thoracic vertebrae. The present observations tallied the earlier reports of Konig and Liebich (2009) in mammals, and Evans and de Lahunta (2017) in dogs. The scapula waa flat and imperfect triangular bone (Figure 1). The quadrangular shape of the scapula was mentioned in Badger (Johnson, 2015), in the civet cat by Sarma et al. (2017), and in the Indian tiger by Tomar et al. (2018).

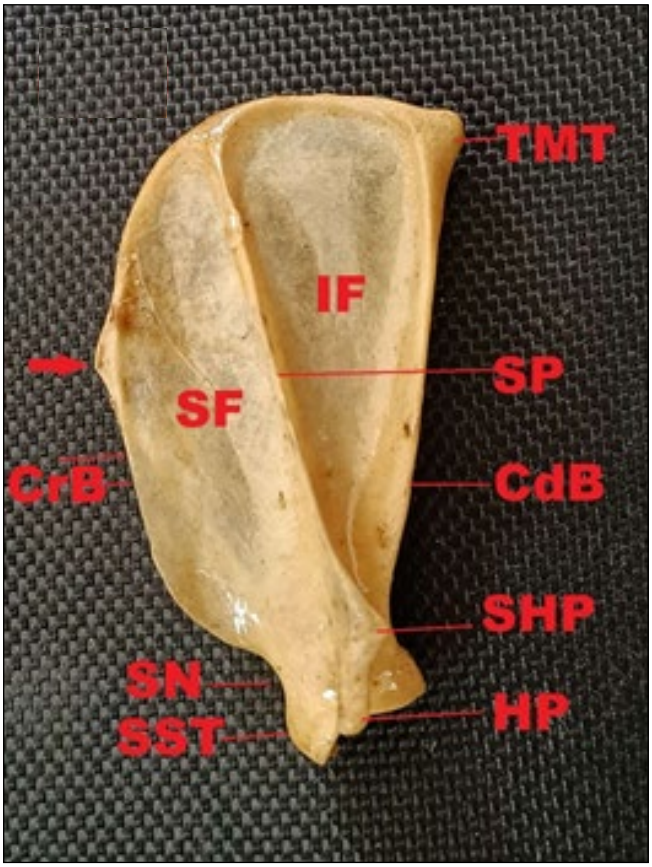

Figure 1: lateral aspect of left scapula of Indian fox showing suprspinous fossa (SF), infraspinous fossa (IF), scapular spine (SP), scapular notch (SN), supra glenoid tubercle (SST), hamate process (HPp, supra hamate process (SHP), caudal border (CdB), cranial border (CrB) and red arrow shows the projection present in the middle of cranial border

The cranial, dorsal (vertebral), and caudal (axillary) borders were measured as 6.55 cm, 3.8 cm, and 5.8 cm respectively (Table 1). The dorsal border was convex and thick. The cranial border of the scapula was thin, and strongly convex, that extended from the scapular notch (incisura scapulae) to the cranial angle (anguluscranialis). The cranial border has an anteriorly directed projection in the middle (Figure 1, Figure 2). The scapular notch was observed in dogs (Evans and de Lahunta, 2017), and tigers (Tomar et al., 2018). The thick caudal border was smooth and straight. The distal

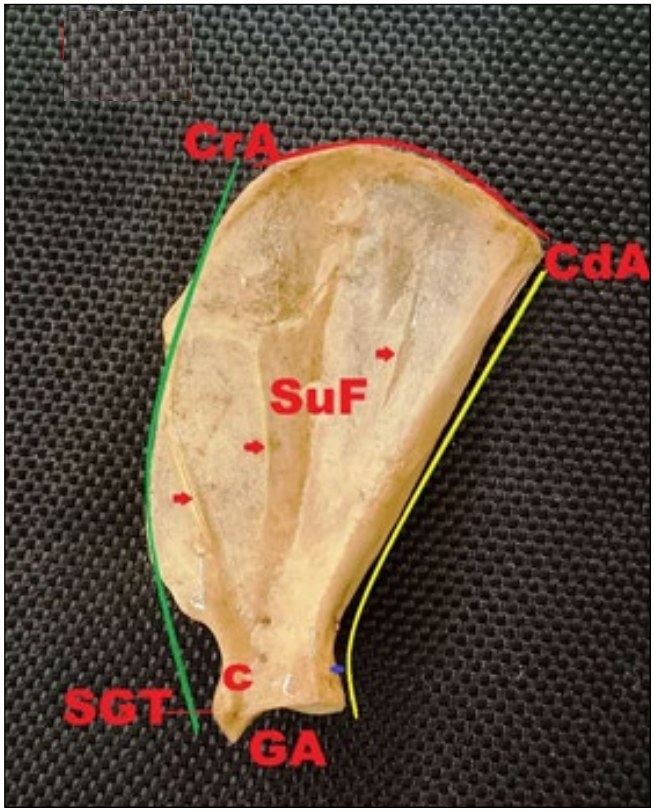

Figure 2: Medial aspect of the right scapula of Indian fox showing subscapular fossa (SuF), supraglenoid tubercle (SGT), coracoid process (C), Cranial angle (CrA)Caudal angle (CdA), glenoid angle (GA), red arrows represent the muscular line, red line (Dorsal border), green line (cranial border) and yellow line (caudal border)

aspect of the posterior border slightly toward the costal side bears a small infra-glenoid tubercle (Figure 2).

The dorsocaudal angle was thick, bears the teres major process, and was pointed backward (Figure 1). The presence of the teres major process relates to an enlarged m. teres major with a long moment arm and, thus, to the powerful limb retraction required for digging with the forelimbs (Galvez-Lopez and Casinos, 2022). The cranial angle was thin and not well-defined. The inferior angle consists of an articular glenoid cavity. The glenoid cavity was shallow oval and its rim shows anteromedially a glenoid notch (Figure 3). The supraglenoid tubercle was not well marked but bears on its coastal surface a small coracoid process (Figure 2, Figure 3). A hook-like coracoid process was mentioned in the scapula of the tiger (Tomar et al., 2018) whereas, the supraglenoid tubercle (tuberculum supraglenoidalis) was absent in Lions (Sohel et al., 2021)

The lateral surface was divided by the scapular spine into almost equal supraspinous fossa and infraspinous fossa. The supraspinous fossa was undulating i.e., concave anteriorly then became convex and finally concave towards the spine

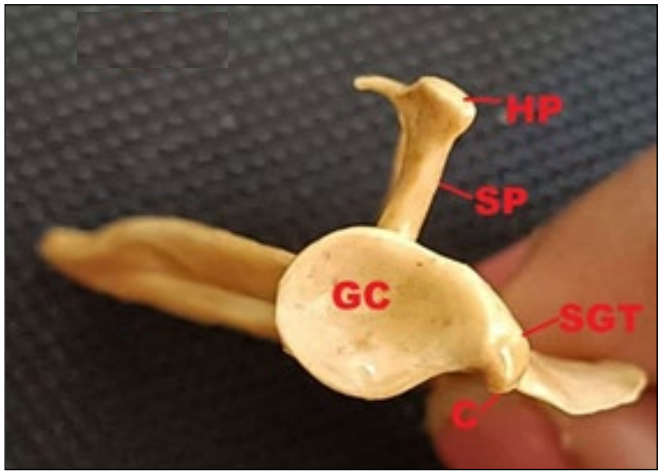

Figure 3: The glenoid angle (GA)of the scapula shows the supraglenoid tubercle (SGT) on its anterior side, coracoid process(C), scapular spine (SP), and hamate process (HP)

and the infraspinous fossa. The infraspinous fossa was flat (Figure 1). This result was in agreement with previous results of the scapula of tigers (Tomar et al., 2018) and in partial agreement with that of the lion where the infraspinous fossa was also undulating (Sohel et al., 2021). The scapular spine begins at the dorsal border as a thick, low ridge that gradually increases in height distally (Figure 4). The spine presents a cranial and a caudal surface throughout most of its length. The spine was upright and not inclined in the upper 2/3 portion and slightly inclined to the infraspinous fossa in the lower third, but the spine of the tiger was inclined towards the infraspinous fossa in the upper ¾ of the scapula (Tomar et al., 2018). The tuber spinae scapula was thick in the upper part, which was rough for muscular attachment. The scapular spine terminated in the acromion process as also reported by Konig and Liebich (2009); The acromion process was composed of the hamate and supra-hamate process (Processus hamatus et suprahamatus) similar to the findings of Konig and Liebich (2009). The hamate process was quadrilateral with the blunt end and over-hanged the glenoid notch. The supra-hamate process was triangular and directed caudally similar to the muscular dogs (Evans and de Lahunta, 2017) and the Royal Bengal tiger (Uddin et al., 2022).

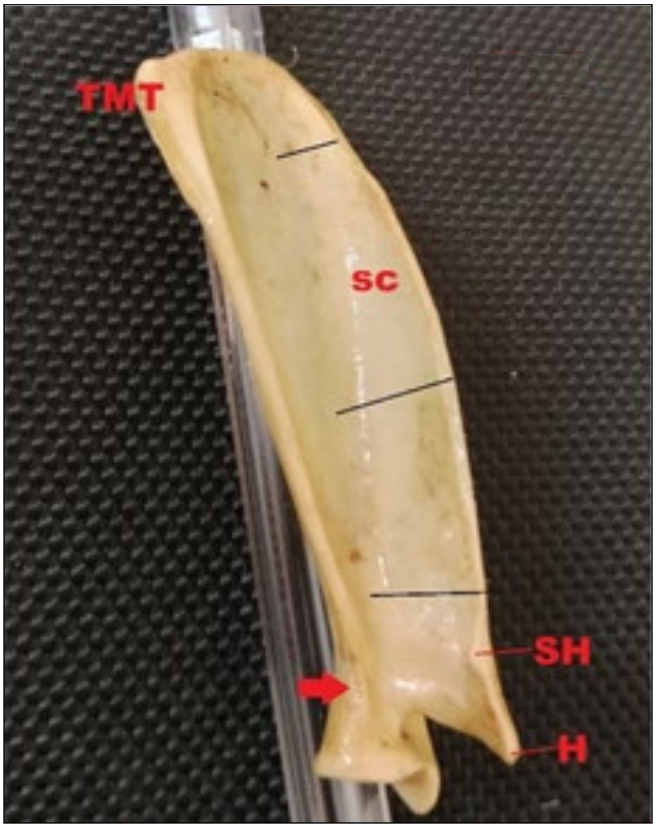

Figure 4: photograph showing the height of the scapular spine (SP) at different levels. TMT: Teres major tubercle, SH: Suprahamate process, H: Hamate process, red arrow represents infra glenoid tubercle in the form of low ridge

Table 1: Morphometrical data for different parameters of the scapula in Indian fox

Sl. No.	Parameter	Right (Average in cm)	Left (Average in cm)
1.	Maximum length (Dorsal border to glenoid cavity)	6.0	5.93
2.	Maximum width (Cranial border to caudal angle)	3.24	3.25
3.	Length of cranial border	6.6	6.5
4.	Length of caudal border	5.8	5.8
5.	Length of the Dorsal border	3.8	3.8
6.	Length of scapular spine	5.8	5.8
7.	Height of scapula spine from supraspinous fossa	1	1
8.	Height of scapula spine from infraspinous fossa	1.1	1.1
9.	Maximum width of supraspinous fossa	1.7	1.8
10.	Maximum width of infraspinous fossa	1.9	1.8
11.	Length of glenoid cavity	1.28	1.29
12.	Width of glenoid cavity	0.81	0.79
13.	Distance between the glenoid cavity and acromion process	1.4	1.4

The medial surface of the scapula has shallow subscapular fossa along the attached border of the scapular spine. The remaining flat medial surface has three muscular lines, two were anterior to the subscapular fossa and converge ventrally and one is a small muscular line posterior to the subscapular fossa. All three straight muscular lines converge towards the distal end of the bone (Figure 2) similar to those of dog (Evans and de Lahunta, 2017).

4. CONCLUSION

The morphology of the Indian fox's scapula was almost similar to that of the domestic dog. Unlike most species, the scapula was a flat, imperfect triangular bone. It had two surfaces, three angles, and three borders. The scapular spine terminated as an acromion process. The roughly triangular caudally directed metacromion process was a striking feature. The costal surface of the scapula has three rough lines.

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