



Cranial morphologic and morphometric characteristics of Black Bengal goat of Tripura

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The Black Bengal goat, common name for a small breed of goats in Bangladesh, West Bengal and North Eastern India, are reported to have resistance against common diseases, can produce and reproduce in very low plane of nutrition, and are well adapted to the local environment. Similarly, the foramina in the skull are very important for clinical, surgical aspect and regional anesthesia around the head (Hall *et al.* 2000). Work had been done on the heads of domestic animals including the horse, ox, and West African Dwarf goat (Getty 1975, Olopade and Onwuka 2005) and on black Bengal goat (Uddin *et al.* 2009). As such no anatomical study has been traced on the morphological, craniometrical and other biometrical aspects of the skull in this important animal yet. The purpose of the present study was to analyze some of morphometrical and craniometrical variability of Black Bengal goat depending on the sex to establish a base line data on the regional anatomy of the head of black Bengal goat.

Skulls (30) from adult male and female goats were collected from an abattoir (Agartala, Tripura, India) based on apparent good health condition and without any skeletal deformity. After slaughter, the heads were severed at the atlanto-occipital joint and subsequently processed maceration techniques that have been reported by Tasbas and Tecirlioglu (1996) and Sarma (2006). Subsequently, skulls were used to study their cranial morphologic and morphometric features. Different craniometrical parameters (Miller *et al.* 1964, Sarma 2006) were recorded with the help of measuring scale, thread and digital Vernier Callipers as under.

Skull parameters: Length, width, skull/cephalic index, skull base length, weight of the skull.

Cranial parameters: Cranial length, width, index, height,

length and capacity of the cranial cavity.

Foramen magnum: Height, width, area and circumference of the foramen magnum.

Orbital parameters: Orbital length, width, index, depth, area and interorbital distance (at rostral, middle and caudal level).

Facial parameters: Facial length, width and index.

Nasal parameters: Length of nasal bone and width across the nasal bone.

The data recorded were subsequently analyzed statistically for ANOVA and regression equations (Snedecor and Cochran 2002).

The characteristic appearance of goat skull is due to the shape and size of the frontal region and presence of horn core on either side. The frontal bone was convex in all direction with median depression of interfrontal serrated suture (Fig. 1). The front nasal suture was almost “V” shaped while, it was reported “U” shaped in Mehraban sheep (Karimi *et al.* 2011) and “V” shaped in Kangai goats (Sarma 2006, Fig. 1). At the base of the horn towards the fronto rostral side two distinct prominence was observed. Cornual process was observed at the caudo-lateral extremities of frontal bone.

The parieto-occipital suture was serrated and distinct. However, the interparietal bone loses its individual identity by ossification (Bothakur 1990, in Assam local goat).

The external parietal surface was smooth and convex. It was marked by a curved line, the temporal line which joined with coronal suture rostrally and parieto-occipital suture caudally. The coronal suture formed the rostral limit of the parietal region.

The frontal bone marked the presence of two distinct prominences. A small fossa was observed between the base of the frontal prominence and zygomatic process of the frontal bone. The convex elongated prominence was curved between the supra orbital groove and roof of the zygomatic process as reported in Assam local goat (Borthakur 1990).

The temporal fossa was shallow, elongated towards the ventro-medial direction, where as deep and extensive in Kagani goat (Sarma 2006) and Mehraban sheep (Karimi *et*

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Fig.1. Skull of Black Bengal goat of Tripura showing: A. Frontal suture, B. Intra frontal suture, C. Parietal bone, D. Supra orbital foramen, E. Intra nasal suture, F. Serrated and notched orbital margin of frontal bone.

al. 2011), wider in ox (Getty 1975) and deep in yak (Archana *et al.* 1998). The fossa was observed continuous with the orbital cavity. Presence of 2–3 foramina were observed on the caudo-medial aspect of the fossa which communicate with the temporal meatus, but in Kagani goat one foramen on right side and 2 foramen on left side were observed (Sarma 2006), while these foramen were 4–5 in numbers connecting the temporal canal in mithun (Borthakur *et al.* 2000) and two on either side on the floor of the caudomedial aspect of the temporal fossa in the skull of Mehraban sheep (Karimi *et al.* 2011).

The facial tuberosity was placed above the junction of third and fourth cheek teeth in the present study (Fig. 2), the same was observed at the junction of fourth and fifth cheek teeth in Kagani goat (Sarma 2006) at level of fifth cheek tooth in Sheep (May 1970) and dorsal to fourth cheek tooth in Assam local goat (Borthakur 1990)

The nuchal surface was mainly formed by the squamous and lateral parts of occipital bone. The nuchal surface was separated from dorsal surface by a nuchal line. On the nuchal line, the external occipital protuberance was observed. The external occipital crest was present between the external occipital protuberance and foramen magnum, each side of the crest was depressed and partially smooth, which was well developed in Kagani goat (Sarma 2006).

The occipital condyles presented a well defined ridge which divided each condyle into two articular areas. The dorsal condyloid fossa sometime had 2–3 foramina, as was reported in Assam local goat (Borthakur 1990)

The foramen ovale opened at the caudo-ventral end of the orbital fossa which was about 2 cm caudal to pterygoid crest.

Horizontal plate of palatine bone was “U” shaped with straight median palatine suture. Transverse palatine suture was “V” shaped and serrated lying over greater palatine foramen (Fig.3), same was also reported in Kagani goat (Sarma 2006).

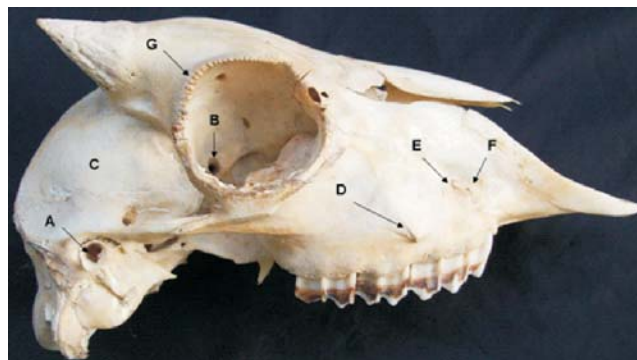


Fig.2. Skull of Black Bengal goat of Tripura showing: A. External auditory meatus, B. Optic foramen, C. Temporal fossa, D. Facial tuberosity, E. Infra orbital foramen, F. Fossa containing 3–4 numbers of foramen, G. Serrated orbital margin of orbital suture.

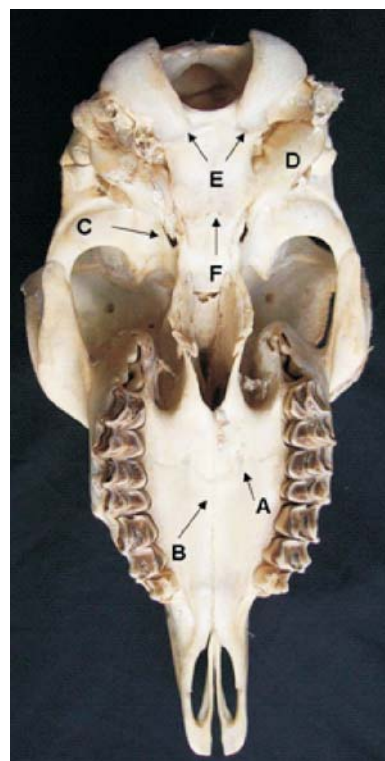


Fig. 3. Skull of Black Bengal goat of Tripura showing A, Transverse palatine suture; B, Median palatine suture, C; Foramen ovale; D, Tympanic bulla; E, Muscular tubercle; F, Sharp ridge on basi phenid bone.

The orbit has a complete rim formed by frontal, zygomatic and lacrimal bone. The caudo-dorsal part of the bony rim was concave and serrated and the ventro-lateral border formed by zygomatic bone was also concave, smooth and sharply ridged. The orbital margin of the frontal bone was notch and serrated (Fig.1). The orbital surface of the lacrimal bone was smooth and lacrimal fossa was observed as in Kagani goat (Sarma 2006), Asom local goat (Borthakur 1990).

Table 1. Measurements (cm) of skull, cranial and foramen magnum parameters of the skull of Black Bengal goat

Parameters	Mean $\pm$ SE		CV%		Range		Overall (60)		
	Male (30)	Female (30)	Male (30)	Female (30)	Male (30)	Female (30)	Mean $\pm$ S.E	CV%	Range
Skull parameters									
Skull length	17.37 $\pm$ 0.17	16.91 $\pm$ 0.20	5.30	6.33	15.6–19.8	15.5–20.3	17.14 $\pm$ 0.13	5.95	15.5–20.3
Skull width	9.20 $\pm$ 0.07	8.41 $\pm$ 0.10	4.13	6.30	8–9.7	7.8–10	8.80 $\pm$ 0.08	6.93	7.8–10
Skull/ cephalic index	50.36 $\pm$ 0.11	49.83 $\pm$ 0.12	1.23	1.28	48.99–51.1	49.2–51.38	50.10 $\pm$ 0.09	1.36	48.99–51.38
Skull base length	18.45 $\pm$ 0.12	17.01 $\pm$ 0.19	3.47	6.17	16–19.9	15.3–20.3	17.73 $\pm$ 0.15	6.37	15.3–20.3
Weight of the skull	135.03 $\pm$ 3.10	135.15 $\pm$ 3.43	12.57	13.92	99.2–159.1	99.2–161.12	135.09 $\pm$ 2.29	13.15	99.2–161.12
Cranial parameters									
Cranial length	12.14 $\pm$ 0.07	11.74 $\pm$ 0.07	3.13	3.07	11.6–12.9	11.3–12.8	11.94 $\pm$ 0.05	3.52	11.3–12.9
Cranial width	3.75 $\pm$ 0.05	3.73 $\pm$ 0.07	6.67	10.19	3.2–4.1	3.1–4.5	3.74 $\pm$ 0.04	8.56	3.1–4.5
Cranial Index	32.11 $\pm$ 0.28	31.45 $\pm$ 0.35	4.73	6.17	27.59–33.33	26.96–33.59	31.78 $\pm$ 0.23	5.54	26.96–33.59
Cranial height	7.15 $\pm$ 0.04	7.26 $\pm$ 0.03	3.36	2.48	6.8–7.5	6.8–7.6	7.21 $\pm$ 0.03	3.05	6.8–7.6
Length of cranial cavity	7.85 $\pm$ 0.07	7.67 $\pm$ 0.06	4.71	4.56	7.3–8.4	7.2–8.6	7.76 $\pm$ 0.05	4.77	7.2–8.6
Capacity of cranial cavity	77.90 $\pm$ 1.00	75.20 $\pm$ 0.61	7.06	4.45	65–85	65–85	76.55 $\pm$ 0.61	6.17	65–85
Foramen magnum									
Height of foramen magnum	1.77 $\pm$ 0.01	1.71 $\pm$ 0.02	2.82	7.02	1.7–1.8	1.5–1.9	1.74 $\pm$ 0.01	5.52	1.5–1.9
Width of foramen magnum	1.93 $\pm$ 0.03	1.85 $\pm$ 0.01	8.29	3.78	1.7–2.3	1.8–2.1	1.89 $\pm$ 0.02	6.88	1.7–2.3
Area of foramen magnum	0.82 $\pm$ 0.01	0.81 $\pm$ 0.01	4.88	4.94	0.74–0.90	0.76–0.95	0.81 $\pm$ 0.01	4.94	0.743–0.945
Circumference of foramen magnum	6.68 $\pm$ 0.05	6.54 $\pm$ 0.06	3.74	4.89	6.2–7.1	6.1–7.2	6.61 $\pm$ 0.04	4.54	6.1–7.2

Table 2. Measurements (cm) of orbital, facial and nasal parameters of the skull of Black Bengal goat

Parameters	Mean $\pm$ S.E.		CV%		Range		Overall (60)		
	Male (30)	Female (30)	Male (30)	Female (30)	Male (30)	Female (30)	Mean $\pm$ SE	CV%	Range
Orbital parameters									
Orbital length	3.10 $\pm$ 0.04	2.93 $\pm$ 0.02	7.74	4.10	2.7–3.6	2.7–3.3	3.02 $\pm$ 0.03	6.62	2.7–3.6
Orbital width	3.18 $\pm$ 0.04	3.28 $\pm$ 0.04	6.60	6.10	2.8–3.6	3–3.7	3.23 $\pm$ 0.03	6.50	2.8–3.7
Orbital index	107.66 $\pm$ 0.29	107.4 $\pm$ 0.46	1.49	2.35	105–110.71	105.2–116.67	107.56 $\pm$ 0.27	1.95	105–116.67
Orbital depth	4.46 $\pm$ 0.07	4.42 $\pm$ 0.07	8.52	9.05	3.8–5	3.7–5	4.44 $\pm$ 0.05	8.78	3.7–5
Orbital area	32.36 $\pm$ 0.26	31.57 $\pm$ 0.70	4.36	12.23	27.28–35.2	27.28–38.37	31.96 $\pm$ 0.38	9.11	27.28–38.37
Infraorbital distance at rostral level	6.79 $\pm$ 0.07	6.82 $\pm$ 0.08	5.45	6.89	6.1–7.5	6.1–7.6	6.80 $\pm$ 0.05	6.18	6.1–7.6
Infraorbital distance at middle level	8.12 $\pm$ 0.05	7.84 $\pm$ 0.12	3.69	8.67	7.3–9.1	7–9.1	7.98 $\pm$ 0.07	6.77	7–9.1
Infraorbital distance at caudal level	9.18 $\pm$ 0.09	8.72 $\pm$ 0.09	5.23	5.73	8.5–10.2	8.2–10.3	8.95 $\pm$ 0.07	6.03	8.2–10.3
Length of frontal bone forming orbital rim	3.33 $\pm$ 0.04	3.23 $\pm$ 0.03	6.31	5.57	2.9–3.6	3–3.6	3.28 $\pm$ 0.03	6.10	2.9–3.6
Length of lacrimal bone forming orbital rim	1.41 $\pm$ 0.02	1.44 $\pm$ 0.03	9.93	11.81	1.2–1.6	1.2–1.8	1.43 $\pm$ 0.02	10.49	1.2–1.8
Length of Malar bone forming orbital rim	3.21 $\pm$ 0.04	3.19 $\pm$ 0.03	7.17	5.33	2.8–3.7	3–3.5	3.20 $\pm$ 0.03	6.25	2.8–3.7
Facial parameters									
Facial length	8.92 $\pm$ 0.16	8.66 $\pm$ 0.14	9.87	9.12	7.6–11.1	7.6–11.4	8.79 $\pm$ 0.11	9.56	7.6–11.4
Facial width	6.42 $\pm$ 0.06	6.18 $\pm$ 0.14	5.14	12.62	5.6–6.9	5.3–7.8	6.30 $\pm$ 0.08	9.68	5.3–7.8
Facial index	70.14 $\pm$ 0.76	67.64 $\pm$ 0.57	5.93	4.63	61.26–75.32	62.8–73.68	68.89 $\pm$ 0.50	5.60	61.26–75.32
Nasal parameters									
Length of nasal bone	5.52 $\pm$ 0.06	5.26 $\pm$ 0.07	5.43	6.86	5–6.1	4.9–6.2	5.53 $\pm$ 0.04	6.15	4.9–6.2
Width across nasal bone	1.82 $\pm$ 0.03	1.75 $\pm$ 0.03	9.34	9.71	1.5–2.1	1.4–2.1	1.79 $\pm$ 0.02	9.50	1.4–2.1

Table 3. Simple regression equations for the prediction of different unknown parameters (Y) of the skull of Black Bengal goat

Predicted parameters (Y)	Correlation coefficient	Known parameters X = skull length regression equation	Correlation coefficient	Known parameters X = skull width regression equation
Cephalic index	-0.245	$Y = 53.241 - (0.166 * X)$	-0.312	$Y = 55.066 - (0.511 * X)$
Skull base length	0.470	$Y = 12.819 + (0.324 * X)$	0.713	$Y = 7.445 + (1.196 * X)$
Cranial index	0.134	$Y = 28.272 + (0.221 * X)$	0.307	$Y = 20.798 + (1.229 * X)$
Orbital depth	0.213	$Y = 2.944 + (0.0875 * X)$	0.0934	$Y = 3.605 + (0.0933 * X)$
Orbital index	0.237	$Y = 100.530 + (0.410 * X)$	-0.0609	$Y = 110.017 - (0.257 * X)$
Infraorbital distance at Caudal	0.333	$Y = 6.151 + (0.175 * X)$	0.134	$Y = 7.621 + (0.170 * X)$
Infraorbital distance at middle	0.651	$Y = 4.430 + (0.212 * X)$	0.344	$Y = 5.608 + (0.273 * X)$
Infraorbital distance at rostral	0.359	$Y = 4.261 + (0.146 * X)$	0.345	$Y = 3.665 + (0.340 * X)$
Cranial capacity	0.340	$Y = 42.678 + (2.028 * X)$	0.333	$Y = 33.441 + (4.833 * X)$
Cranial length	0.228	$Y = 10.523 + (0.0931 * X)$	0.157	$Y = 10.709 + (0.156 * X)$

The supra orbital foramen was situated about 2 cm medial to the orbital margin, also supported by similar views on goat (Singh and Patel 1964). They were observed to be two in number (Borthakur 1990) or multiple. However, the supra orbital foramen was single on each sides in sheep (May 1970), Mehraban sheep (Karimi *et al.* 2011) and in Kagani goat (Sarma 2006). The infra orbital foramen is single and placed over the second cheek tooth in a depression. Cranial to the infra orbital foramen there were 3–4 numbers of small foramina were present (Fig. 2).

The data recorded in the present study related to mean, standard error and coefficient of variation simple regression equations for the prediction of different unknown parameters (Y) of the skull of Black Bengal goat were depicted in Tables 1–3.

The cranial length recorded in the present study for male and female goats were 12.14 ± 0.07 and 11.74 ± 0.07 cm respectively, which was higher then the facial length in both the sexes. But the report on Kagani goat showed the higher value of facial length then the cranial length (Sarma 2006). This might be due to species variation. The measured parameters showed that the skull of Black Bengal goat of Tripura was elongated in shape as in Asom local goat (Borthakur *et al.* 1998).

The orbital length was recorded to be more in male goat 3.10 ± 0.04 cm then female goat 2.93 ± 0.02 cm. But the orbital width was more in female goat being 3.28 ± 0.04 cm then in male goat 3.18 ± 0.04 cm (Table 2).

SUMMARY

Present investigation was carried out on thirty skulls of adult male and female goats. Parieto-occipital suture was serrated and fronto-nasal suture was “V” shaped. Supra orbital foramina were 2 in each side. Infra orbital foramen was single and over second cheek tooth. Cranial to the infra orbital foramen 3–4 small foramina were also present. Temporal fossa was shallow and continuous with orbital cavity having 2–3 numbers of foramina. Palatine bone was

“U” shaped and the transverse palatine suture was “V” shaped. Cranial length was recorded maximum in male goat being 12.14 ± 0.07 cm. The Orbital width was recorded more in female goat being 3.28 ± 0.04 cm which in the male recorded 3.18 ± 0.04 cm respectively.

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