MORPHOLOGY AND MORPHOMETRIC STUDY OF MANDIBLE OF ASIATIC LION (*Panthera leo*), INDIAN TIGER (*Panthera tigris*) AND COMMON LEOPARD (*Panthera pardus*)

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ABSTRACT

The morphology and morphometric study on mandibles of lion, tiger and leopard was carried out at Sakkarbaug Zoo, Junagadh (Gujarat). The mandible is formed by two symmetrical halves fused rostrally by symphysis. The alveolar border presented six alveoli for lower incisors and two large deep alveoli for canine teeth. The average length of mandible was 19.08, 17.40 and 13.54 cm in lion, tiger and leopard, with the corresponding average mandible weight of 0.338, 0.271, and 0.145 kg, respectively. However, the width of mandible was significantly more in lion (3.28 cm) than that of tiger (2.51 cm) and leopard (1.71 cm). The mandibular height up to condyle and coronoid process in lion, tiger and leopard was 4.17 and 9.24, 4.19 and 9.16, 3.04 and 7.14 cm, respectively. Both the heights were significantly higher in lion and tiger than those of leopard. The average length of symphysis-mandibularis was significantly higher in lion (6.58 cm) and tiger (6.68 cm) than leopard (4.47 cm). The mental foramina were three in tiger and two in lion and leopard, and they were deeper in lion and tiger than the leopard. The angular process was placed at caudal border of horizontal ramus and found blunt and medially curved in all three species.

KEY WORDS: Mandible, Lion, Tiger, Leopard, Morphology, Morphometry.

INTRODUCTION

Gujarat state has been placed beautifully on the world map on account of its having nine species of felines which are the lion, the tiger, the leopard, the cheetah, the caracal, the jungle cat, the leopard cat and the rusti spotted cat. The lion, tiger and leopard of family pantheridae are the supreme of all the predators in food chain. Due to excessive poaching and lack of proper monitoring system, these all have become endangered species. The present study was carried out on mandibles of Asiatic lion, Indian tiger and common leopard from the Gir Sanctuary and National Park. This work will help in establishing basic data bank on gross anatomy of the mandible of wild animals. This study will also fulfill the need for authentic references in proceedings in the courts of law.

MATERIALS AND METHODS

The present study was undertaken at the Sakkarbaug Zoo, Junagadh, with the prior permission of Chief Conservator of Forest, Government of Gujarat, Gandhinagar. The mandibles of lion, tiger and leopard, were used for present study. However, the age and sex of majority of mandibles were not known. The studies were made on 15 mandibles of lion, 7 mandibles of tiger and 14 mandibles of leopard. The following parameters of mandibles of lion, tiger and leopard were recorded with the help of digital vernier calipers / non-elastic thred/scale and handmade special device.

The weight of mandible was recorded with electronic top-pan balance. The length of mandible was measured with the help of vernier calipers as the distance between the caudal borders of the vertical ramus to the rostral margin of the body. The total length of the incisive border occupied by the

incisors was measured as width of body of mandible. The distances from the highest point of the mandibular condyle and the coronoid process from the angle of jaw were taken as mandibular height up to condyle and up to coronoid process, respectively. Length of symphysis-mandibularis at ventral aspect was measured as the distance from rostral end to caudal end of the sutures between two halves of mandible. Distance between inner surfaces of mandibular ramus was taken as the maximum distance between the two horizontal parts of the mandible. Distance between the last incisor and the first premolar was measured as diastemal mandibular length. Length of mandibular condyle and length of angular process were taken as the distance between the lateral and medial ends of the mandibular condyle, and the distance from the angle of jaw to the end process of the angular process, respectively. The distance of mandibular foramen was measured from posterior border of mandible. The data were analyzed as per standard statistical procedures (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

(a) Morphological Parameters

The mandible (Fig. 1 to 9) is the largest bone of skull. It consists of two symmetrical halves fused together rostrally. It presents a body and two ramus. The two symmetrical halves remained unossified at the symphysis-mandibularis. The body (Fig. 4, 5 & 6) was thick and strong with lingual and labial surfaces and the alveolar border. The lingual surface was smooth and slightly concave. The labial surface was found more extensive than the lingual surface.

Fig. 1, 2, 3: **a**-coronoid process, **b**-condyloid process, **c**-massateric fossa **d**-diastemal space, **e**-mental foramina

The alveolar border showed bony ridge protruding outward (Fig. 4, 5 & 6) and was placed oblique mediolaterally on either side of symphysis. The alveolar border presented six alveoli for lower incisors. There were 3 pairs of incisors, the central, the middle and the corner. The size of alveoli

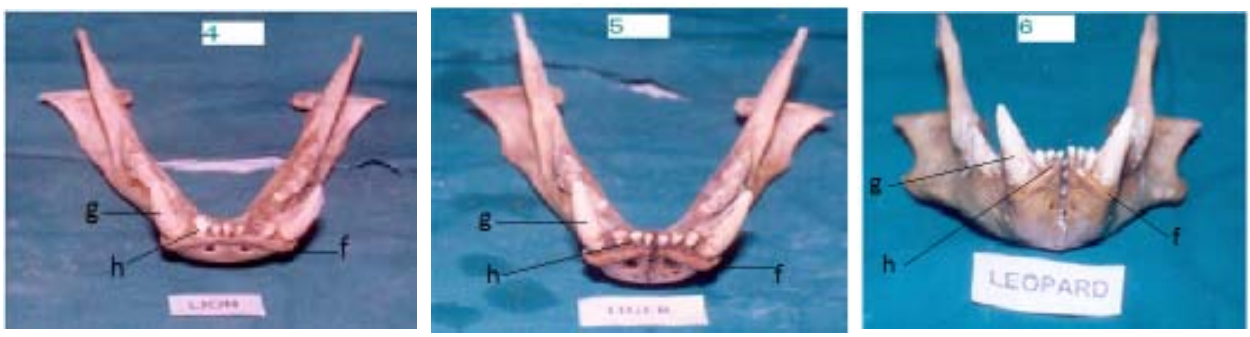

Fig. 4,5, 6: **f**-alveolar border, **g**-canine teeth, **h**-incissors teeth

increased from center pair to corner pair of incisors. There were two large deep alveoli at corner for lower canine teeth which were placed obliquely outward in direction. There were two rami, the right and left, placed in a manner forming intermandibular space (Fig. 7, 8 & 9). The space was 'V' shaped and formed angle of divergence. The degree of angle was different in all three species. The mandible in all species contained only horizontal ramus which ended into coronoid, condyloid and angular processes giving no visual appearance of vertical ramus and hence of the angle of jaw. Malik *et al.* (1988) also reported no distinct vertical ramus of mandible in tiger.

The horizontal ramus (Fig. 1, 2 & 3) showed two borders, lateral and ventral and two surfaces lateral and medial. The dorsal border presents alveoli for cheek teeth so called as alveolar border. The alveolar border of ramus was found concave in shape. Large inter-dental space/diastemal space were found between the canine and the first premolar teeth. Ray *et al.* (1997) observed short interalveolar space in leopard. There were three alveoli, two for premolars and one for molar.

The ventral border (Fig. 1, 2 & 3) was thick, round and remained in touch with ground throughout its length in all three felines. Malik *et al.* (1988) also observed straight ventral border of mandible in tiger when laid on a flat surface. Ray *et al.* (1997) observed thick and rounded ventral border of horizontal ramus of mandible in leopard.

The lateral surface of ramus (Fig. 1, 2 & 3) was narrow anteriorly and broad posteriorly. The mental foramina were found three in tiger (Fig. 2), two in lion and leopard (Fig. 1 & 3). The rostral foramena were found larger in all three felines. Malik *et al.* (1988) reported three mental foramina in tiger and Ray *et al.* (1997) observed two in leopard. While McClure *et al.* (1973) reported two mental foramina in cats between canine and first premolar teeth. The rostral foramena was placed below the interdental space, whereas the caudal foramena was just below the 1st premolar tooth in all three felines. The medial surface of ramus was convex and smooth. The single large mandibular foramen was found caudal to the alveolar border of ramus. Just below the mandibular foramen a rough ridge was present which extended up to the angular process.

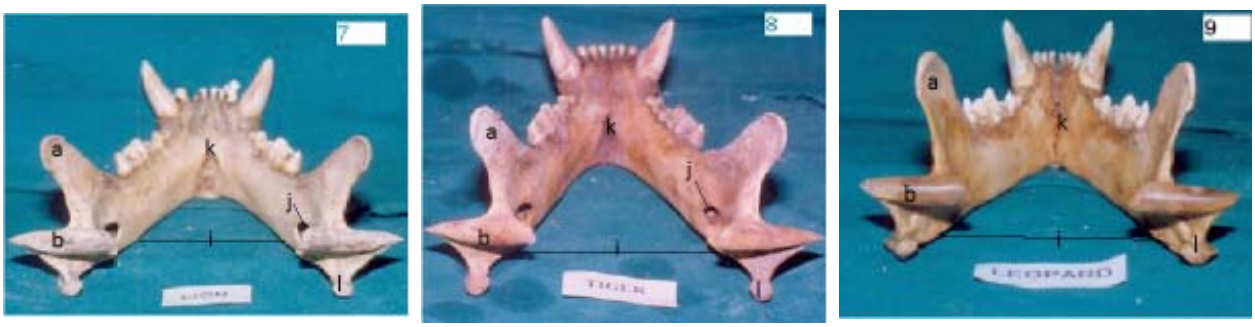

Fig. 7, 8, 9: **k**-symphysis mandibularis, **j**-mandibular foaramena,

i-ntermandibular space, **l**-angular process

The rough triangular fossa was found on lateral surface of ramus which is known as massateric fossa (Fig. 1, 2 & 3). It was found deep in tiger and lion compared to leopard. Malik *et al.* (1988), Pandit (1994) and Tiwari *et al.* (2011) also observed deep and extensive massateric fossa in tiger. Gowane *et al.* (2000) has reported absence of massateric fossa in wild ungulates like nilgai and deer.

The alveolar border of horizontal ramus continued caudally upward and formed dorsal prominent ridge of massateric fossa. The ridge was obliquely straight in direction in all three felines. The oblique direction of ridge gave an angle of divergence at ramus. The angle was found more in lion and

moderate in tiger and leopard.

The three prominent processes, coronoid, cotyloid and angular were found at caudal aspect of ramus (Fig. 1, 2 & 3). The coronoid process was found dorsally, cotyloid process in middle and angular process ventral to the massateric fossa. The coronoid process projected caudo-dorsally and was located rostral to the zygomatic process of temporal bone and medial to the zygomatic arch. The mandibular notch was a concave surface between the coronoid and cotyloid processes.

The condylar process (Fig. 1, 2, 3) was smooth, elongated, round articular process which formed tempero-mandibular joint. This process was found at the level of alveolar border of the ramus. The process was thick medially and thin and pointed laterally.

The angular process (Fig. 7, 8 & 9) was placed caudally at the ventral border of horizontal ramus. The process was found blunt and curved medially in all three species. Malik *et al.* (1988) reported prominent and latero-medially compressed angular process in tiger. Ray *et al.* (1997) revealed rough angular process in leopard which projected backward. A large mandibular foramen was present at caudal aspect of medial surface of ramus in all three species.

(b) Morphometric parameters

The findings on various morphometric mandibular parameters studied in lion, tiger and leopard of Gir Sanctuary are presented in Tables 1 to 4.

(1) Mandibular Weight, Length and Width of Body:

The average value of mandibular weight was the highest in lion and the least in leopard. The weight in lion was at par with that of tiger, but significantly higher than leopard (Table 1). Pandit (1994) observed 0.466 kg weight of mandible in tiger which is more than twice the weight of mandible in tiger but Tiwari *et al.* (2011) reported 0.350 kg, which is similar to observed value in present study.

Table 1: Average mandibular weight (kg) and length (cm), and width (cm) of body of mandible in different wild animal species

Species	Mandibular weight (kg)		Mandible length (cm)		Width (cm) of body of mandible	
	Mean ± SE	CV %	Mean ± SE	CV %	Mean ± SE	CV %
Lion	0.338 0.025[a]	28.19	19.08 0.39[a]	8.00	3.28 0.08[a]	10.37
Tiger	0.271 0.039[ab]	37.76	17.40 0.71[a]	10.82	2.51 0.18[b]	19.53
Leopard	0.145 0.010[c]	24.61	13.54 0.28[b]	7.79	1.71 0.06[c]	14.96

Means with different superscripts within a column differ significantly ($P < 0.01$).

The mean mandibular length was significantly higher in lion and tiger than leopard. Malik *et al.* (1988) reported 18.0 cm, and Tiwari *et al.* (2011) reported 20.1 cm mandibular length in tiger, while Kalita *et al.* (2000) reported it as 12.0 to 13.5 cm in leopard, which support the present findings. The width of body of mandible was significantly higher in lion than other two species (Table 1). Pandit (1994) and Tiwari *et al.* (2011) observed comparable 2.5 and 3.5 cm thickness of mandible in tiger, respectively.

(2) The Length of Symphysis-Mandibularis, Diastemal Length and Distance between Inner Surface of Mandibular Ramus:

The lengths of symphysis-mandibularis at ventral aspect were at par in lion and tiger, and both were significantly (P< 0.01) higher than that in leopard (Table 2). Pandit (1994) reported 5 to 6 cm length of symphysis in tiger which is near to the length observed in tiger in present study.

The differences in diastemal mandibular lengths among the species studied were significant (P<0.01), with values of lion, tiger and leopard in descending order. The average distances between inner surface of mandibular ramus in lion and tiger were at par in lion and tiger with significant difference from that of leopard. (Table 2). Tiwari *et al.* (2011) measured 2.90 cm inter alveolar space in tiger which was more in present finding. Kalita *et al.* (2000) reported 0.9 to 1.3 cm diastemal length in mandible of leopard which is less than half in the present study.

Table 2: Average length of symphysis-mandibularis, diastemal mandibular length and distance between inner surface of mandibular ramus in different wild animal species

Species	Length (cm) of symphysis-mandibularis		Diastemal mandibular length (cm)		Distance (cm) between inner surface of mandibular ramus	
	Mean ± SE	CV %	Mean ± SE	CV %	Mean ± SE	CV %
Lion	6.58 0.19[a]	11.45	5.11 0.14[a]	10.69	10.41 0.21[a]	7.65
Tiger	6.68 0.36[a]	14.48	4.24 0.26[b]	16.52	10.24 0.58[a]	15.22
Leopard	4.47 0.13[b]	10.65	3.05 0.07[c]	10.72	7.04 0.17[b]	9.01

Means with different superscripts within a column differ significantly (P < 0.01).

(3) Length and Height of Condylar Process and Height of Coronoid Process:

The average length of mandibular condyle was in descending order for lion, tiger and leopard, with significantly higher values in lion and tiger than leopard. The lion had even significantly higher value than tiger. Lion and tiger had significantly higher values of average heights of mandible up to condyle and up to coronoid process than those of leopard (Table 3). Malik *et al.* (1988) Tiwari *et al.* (2011) reported 9.0 and 10.5 cm height of mandible in tiger which is same as that recorded in present study. Kalita *et al.* (2000) reported 2.2 to 3.0 cm height of mandible up to condyle in leopard which is similar to present study, however, the mandibular height at coronoid process reported as 5.6 to 6.3 cm which is somewhat lower than that found in present study.

Table 3: Average length of mandibular condyle, height of mandible up to condyle and up to coronoid process, at ventral aspect in different wild animal species

Species	Length (cm) of mandibular condyle		Height (cm) of mandible up to condyle		Height (cm) of mandible up to coronoid process	
	Mean ± SE	CV %	Mean ± SE	CV %	Mean ± SE	CV %
Lion	5.55 0.13[a]	9.39	4.17 0.14[a]	13.13	9.24 0.26[a]	10.99
Tiger	4.69 0.28[b]	15.75	4.19 0.20[a]	12.85	9.16 0.41[a]	12.11
Leopard	3.50 0.08[c]	8.56	3.04 0.07[b]	9.49	7.14 0.18[b]	9.89

Means with different superscripts within a column differ significantly (P < 0.01).

(4) Length of Angular Process and Distance of Mandibular Foramen from Posterior Border:

The average length of angular process was the highest in lion followed by tiger and leopard. The leopard had the least (P < 0.01) length among three species studied. The average of distance of mandibular foramen from posterior border measured differed significantly (P< 0.01) among three

species, being highest in lion and lowest in leopard (Table 4). Pandit (1994) also observed mandibular foramen situated 4.0 to 5.0 cm away from posterior end in tiger. Ray *et al.* (1997) and Kalita *et al.* (2000) observed mandibular foramen 2.3 to 2.7 cm away from ventral border in leopard, which was lesser than that found in the present study.

Table 4: Average length (cm) of angular process and distance (cm) of mandibular foramen from posterior border in different wild animal species

Species	Length (cm) of angular process		Distance (cm) of mandibular foramen	
	Mean ± SE	CV %	Mean ± SE	CV %
Lion	1.56 0.05[a]	13.41	5.20 0.12[a]	9.15
Tiger	1.28 0.06[b]	14.21	4.65 0.21[b]	11.77
Leopard	0.92±0.04[c]	14.07	3.45 0.10[c]	11.12

Means with different superscripts within a column differ significantly ($P < 0.01$).

In summary, the average length and width of mandible and mandibular heights up to condyle and coronoid process were more in lion followed by tiger and leopard. The weight of mandible was the highest in lion followed by tiger and leopard. The average length of symphysis-mandibularis was more in tiger followed by lion and leopard with non-significant differences between lion and tiger as well as leopard. The mental foramina were three in tiger and two in lion and leopard. The massateric fossa was deeper in lion and tiger than the leopard. The angular process was found placed at caudal border of horizontal ramus and found blunt and medially curved in all three species.

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