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RESEARCH ARTICLE

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Comparative Gross Architectural Studies on the Skull of Male Chital Deer (*Axis axis*) and Sambar Deer (*Rusa unicolor*) as an Aid in Wildlife Forensics

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ABSTRACT

Background: Madhya Pradesh is rich in biodiversity having diversified flora and fauna. But now a days, apart from various threat like loss of habitat poisoning, accident, disease facing wildlife today and poaching remain one of the important causes for fauna declination. poaching remains one of important cause for fauna declination. Poaching of wild animals particularly chital and sambar deer is more for the meat, ornamental and trophy purposes. In forensic laboratory where there is lack of molecular facilities, comparative gross morphological study plays an important role in solving wildlife crime cases. skull is a best material to compare the closely relative species. hence, the study was conducted on comparative gross morphology of 4 male chital and sambar deer skull.

Methods: The study was conducted 4 male adult skulls each of chital and sambar deer. The skulls were de-skinned and kept under maceration for a period of one month. The gross morphological differentiating features of dorsal surface, lateral surface, basal surface and nuchal surface were observed and recorded with the help of digital camera.

Result: In this study, unique differentiating features were sufficient to distinguish among the skull of male chital and sambar. The facial tuberosity was present caudal to infraorbital foramen, dorsal to the superior third premolar tooth in chital deer, whereas; it was present dorsally the superior first molar tooth in sambar deer. Rostral extremities of nasal bones in skull of male chital deer were notched; however, these were blunt and without notch in the skull of male sambar deer. Incisive (Premaxilla) bone was directed upward in chital deer; whereas, it was directed caudally in case of sambar deer. The present comparative study will provide reliable information for identification of these closely related species specially needed for wildlife forensic cases.

Key words: Chital deer, Comparative, Gross architectural, Sambar deer, Skull, Wildlife forensics.

INTRODUCTION

Chital (*Axis axis)* comes under Schedule III of the Indian Wildlife (Protection) Act, 1972 and listed on the IUCN Red List as "Least Concern" whereas sambar deer (*Rusa unicolor)* is one of the largest member of deer family and listed on the IUCN Red List as "Vulnerable" and Schedule III of the Indian Wildlife (Protection) Act, 1972.

India is now playing a pivotal role in the trade of wild animals and has become an exporter and a conduit for wildlife. Apart from various threats like loss of habitat, poisoning, accident and diseases facing wildlife today for its survival, poaching remains an important cause for wildlife extinction. Poaching of wild animals, particularly of chital deer and sambar deer for meat, ornamental and trophy purpose has been increased. Due to this, these species are facing problem for their survival and need immediate action against poachers.

The forensic science forms a vital part of the entire justice and regulatory system. Forensic scientists involved in poaching investigation and the results of their work may serve either for the defence or for the prosecution, Podhade (2007). The forensic scientist's skill is to use all the information available to determine facts.

Biological materials including bones particularly skulls of wild animals are sent routinely to State Forensic Laboratories for identification of species. Due to the lack of scientific documentation on characteristics, the custodian of wild animal's face embarrassment at many times, when some forensic cases require scientific evidence for legal proceedings against the poachers and traders.

Systematic and scientific information on comparative unique features of skull bone of male chital deer and

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sambar deer is meagre. Therefore, the identification of seized skull bones becomes difficult. Hence, the present research was conducted with the objectives to study the comparative gross morphology of skulls of male chital and sambar deer.

MATERIALS AND METHODS

The proposed work was carried out at the School of Wildlife Forensic and Health, N.D.V.S.U., Jabalpur, (M.P.). The study was conducted on 4 male adult skulls each of chital and sambar deer. The skulls were de-skinned and kept under cold water maceration for a period of one month. The gross morphological differentiating features of dorsal surface, lateral surface, basal surface and nuchal surface of adult skull bones of male chital and sambar deer were observed and recorded with the help of digital camera.

RESULTS AND DISCUSSION

The shape of the skull of male chital and sambar deer was elongated in accordance with the findings of Sarma (2006) in kagani goat and Kumawat (2011) in chital, tapering to the anterior and dolichocephalic type as observed which was similar with the findings of Kumawat (2011) in chital; Choudhary (2015) in black buck and Keneisenuo *et al.* (2020) in barking deer and sambar deer

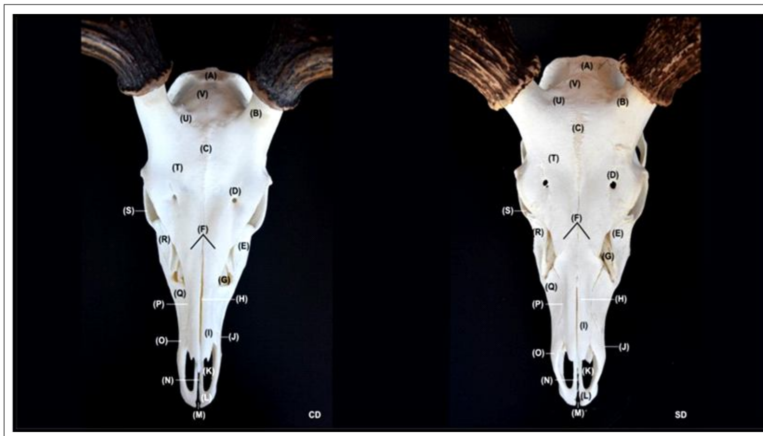
In present study, dental formula of male chital deer was I0/4, C0/0, PM3/3, M3/3, total 32 tooth (Fig 8) were present which coincides with the finding of Parmar *et al.* (2003a) in chital deer; however, it differs with the findings of Kumawat (2011) in chital deer which was I0/3, C0/1, PM3/3, M3/3.The dental formula of male sambar deer was I0/4, C1/0, PM3/3, M3/3, total 34 teeth were found (Fig 9). The alveolus for upper canine tooth was absent in male chital deer skull where as it was present in male sambar deer skull (Fig 11) tallied with the finding of Keneisenuo *et al.* (2020) in barking deer and sambar deer. The present observation for the incisors of sambar deer contradictory in accordance with the report of Keneisenuo *et al.* (2020) in sambar deer as reported six alveoli for incisors.

The dorsal surface of the skull of male chital and sambar deer was formed by parietal, frontal, nasal and incisive bones similar observation was reported by Sarma (2006) in kagani goat, Kumawat (2011) in chital deer and Choudhary (2015) in blackbuck. The frontal bone depression was deeper in skull of male chital deer; however, it was wider in the skull of sambar deer (Fig 2 and 3).

The caudal extremity of nasal bone was flatted dorso-ventrally in the skull of male sambar skull; however, in the skull of male chital, it was convex dorsally (Fig 8 and 9). Rostral extremities of nasal bone in skull of male chital deer were notched; however, these were blunt and without notch in the skull of male sambar deer (Fig 4).

The cornual processes of skull were directed caudo-laterally in male sambar deer; whereas, directed more caudally in case of male chital deer skull (Fig 13).

The frontal bone showed wide fossa/depression just medial to the frontal crest and caudo-dorsal to the orbit. The rim of orbit of the skull of sambar deer was thick, rough and pitted in its caudo-dorsal part; whereas, in the skull of male chital, it was slightly thin and sharp (Fig 10). The dorsal surface of parietal bone was more or less flattened in male sambar deer skull; however, in male chital deer, it was slightly convex in its middle (Fig 1). The caudal border of the nasal process of premaxilla was straight throughout in the of male sambar deer; whereas, in the male chital



(A); Cornual process (B); Interfrontal suture (C); Supraorbital foramen (D); Lacrimal pit (E); Nasofrontal suture (F); Nasolacrimal fissure (G); Internasal suture (H); Nasal bone (I); Maxillo incisive suture (J); Nasal process of incisive bone (N); Palatine fissure (K); Body of incisive bone (L); Interincisive fissure (M); Palatine process of incisive bone (N); Nasal process of incisive bone (O); Nasomaxillary suture (P); Maxilla bone (Q); Frontolacrimal suture (R); Orbit (S); Frontal bone (T); Frontoparietal suture (U) and Parietal bone (V).

Fig 1: Dorsal view of skull of male chital deer (CD) and sambar deer (SD) showing lambdoid suture.

deer, this border turned rostrally in its distal part to from an angle.

The lateral surface of the skull of male chital and sambar deer was elongated and triangular in shape, wide posteriorly and narrow anteriorly. The zygomatic process of temporal bone did not join with the zygomatic process of the frontal bone in the skull of male chital and sambar deer similar to findings of Kumawat (2011) in chital deer and Choudhary (2015) in blackbuck.

The portion of the body of maxilla, which was bounded dorsally by the facial crest was convex in the skull of male chital deer; however, in the male sambar deer skull, it was flattened. The facial crest was straight in the skull of male sambar deer; however, it was curved with dorsal convexity dorsally in male chital skull. The paramastoid process/ jugular process was triangular proximally like with blunt tubercle at its distal end in the skull of both of species. In the skull of male chital, rostral border of the paramastoid process was convex; however, it was straight in male

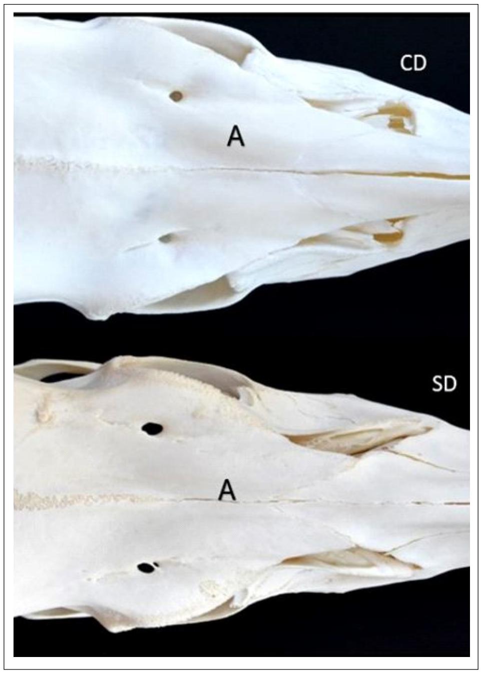


Fig 2: Dorsal view of the skull of the male chital (CD) and Sambar deer (SD) showing frontal bone (A).

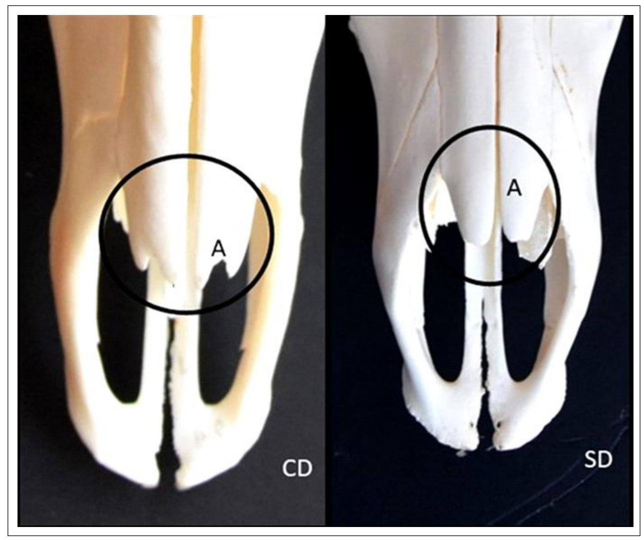


Fig 4: Dorsal view of the skull showing of male chital (CD) and Sambar deer (SD) the rostal extremities of nasal bone (A).

Fig 3: Lateral view of the skull of the male chital (CD) and Sambar deer (SD) showing frontal bone (A).

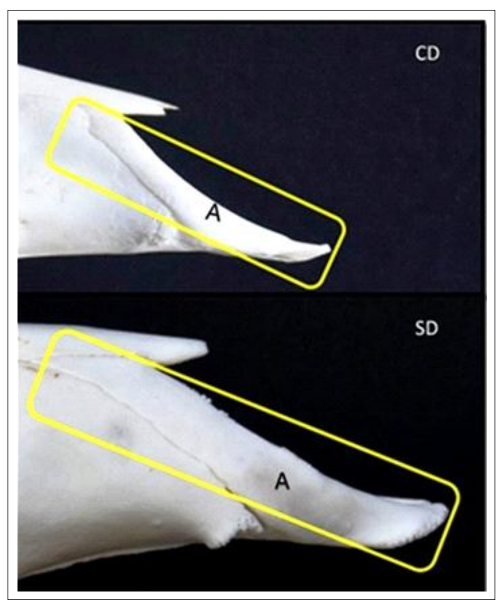
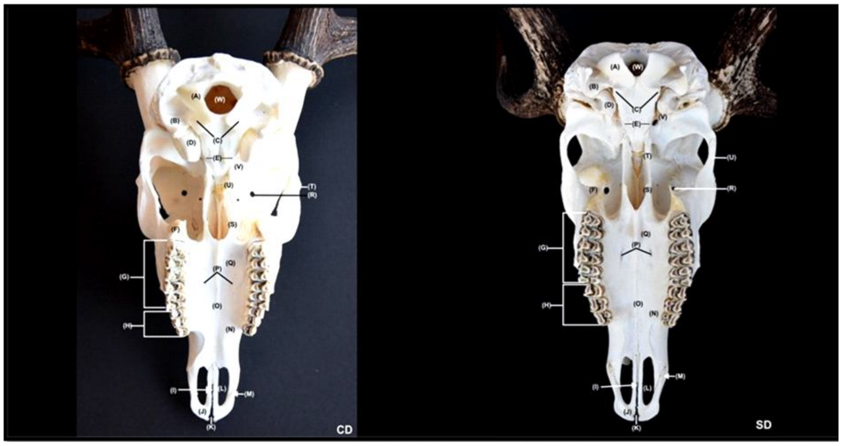
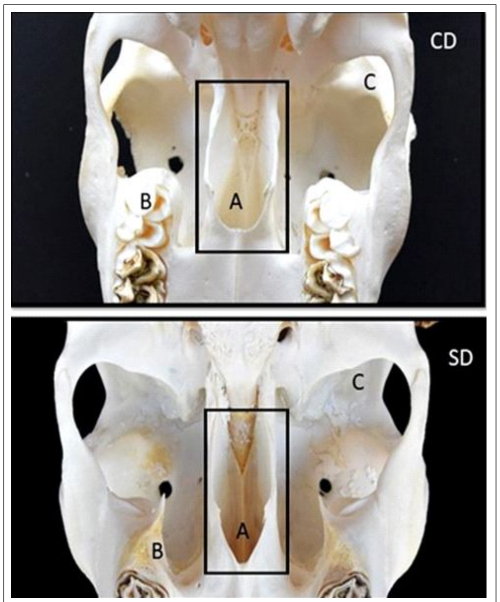


Fig 5: Lateral view of the skull of male chital (CD) and Sambar deer (SD) Premaxilla bone (A).



Occipital condyle (A); Paracondylar or paramastoid process (B); Jugular foramen (C); Tympanic bulla (D); Muscular tubercle (E); Lacrimal bulla (F); Superior first, superior second and superior third malar tooth (G); Superior first, superior second and superior third premolar tooth (H); Palatine process of incisive bone (I); Body of the incisive bone (J); Interincisive fissure (K); Palatine fissure (L); Nasal process of incisive bone (M); Maxillary process of palatine bone (Q); Supraorbital foramen (R); Pterygoid hamulus (S); Pterygoid bone (T); Zygomatic arch (U); Foramen ovale (V) and Foramen magnum (W).

Fig 6: Vantral view of skull of male Chital deer (CD) and Sambar deer (SD).



Central end of the pterygoid bone (A); Lacrimal bulla (B) and articular area of mandibular condyle (C).

Fig 7: Ventral view of the skull of the male chital deer (CD) and sambar deer (SD).

sambar deer skull. The zygomatic process of the malar bone was flattened dorsoventrally in male in both the species (Fig 8 and 9).

The ventral surface of skull of flatted in both the species and cerebral choanal and palatine area was distinguished. The ventral surface of the skull of male chital and sambar deer was long and broad extending to the posteriorly. The cranial part was extended from foramen magnum to the hard plate.

The articular area of the mandibular condyle was wider in male sambar than chital deer (Fig 7). The muscular processes were ill developed in male chital skull; however, in male sambar deer skull, they were triangular in shape and pointed distal end (Fig 6).

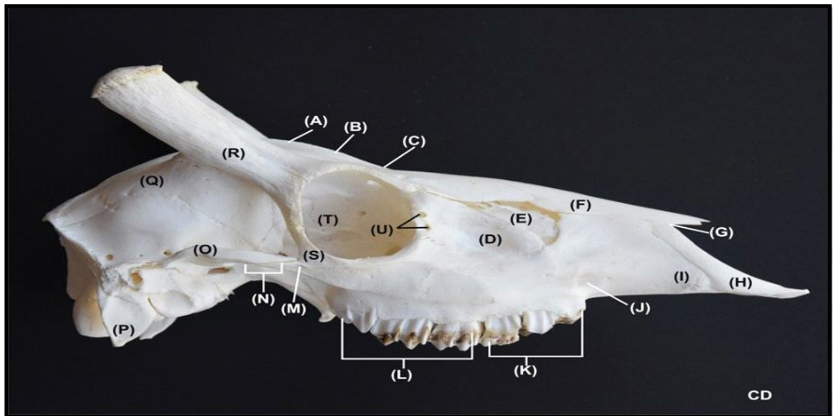
Caudal central end of the pterygoid bone was "U" shape in male chital; however, it was "V" shaped in male sambar deer (Fig 7). The sphenopalatine fossa was deeper in the of male chital in comparison to the sambar deer. The zygomatic process of temporal bone was the widest part of the skull in both the species.

The nuchal crest was more prominent and wider in the skull of male sambar deer than chital deer (Fig 12), which was tallied with the findings of Joshi (2004) in tiger; however, it was less prominent in blackbuck as reported by Choudhary (2015).

The occipital bone consisted of two occipital condyles similar with the findings of Sarma *et al*. (2001) in leopard cat. The muscular processes were ill developed in male chital deer concurrent with the finding of Parmar *et al.* (2004) in chital deer; however, they were triangular in shape and sharp pointed at the distal end in male sambar deer skull.

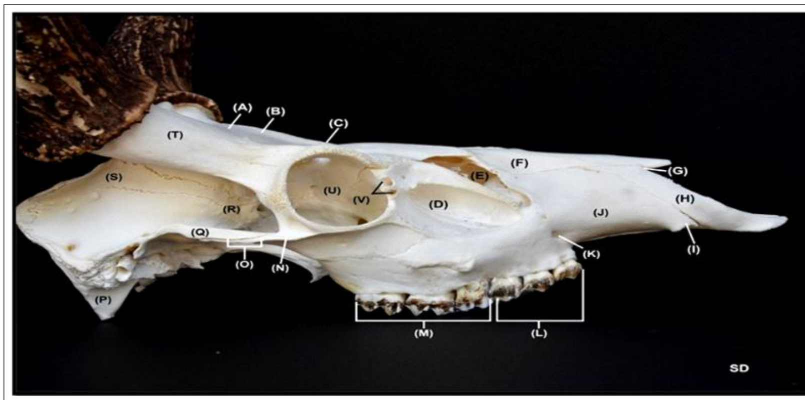
The foramen magnum was large and roughly oval in shape in the skull of male chital and sambar deer, accordance with the finding of Kumawat (2011) in chital and Choudhary (2015) in blackbuck; however, this was unlike with the findings of Sharma *et al.* (2001) in leopard cat, where it was round in shape.

Foramen ovale was situated at the middle of the wings of post sphenoid in both male chital and sambar deer



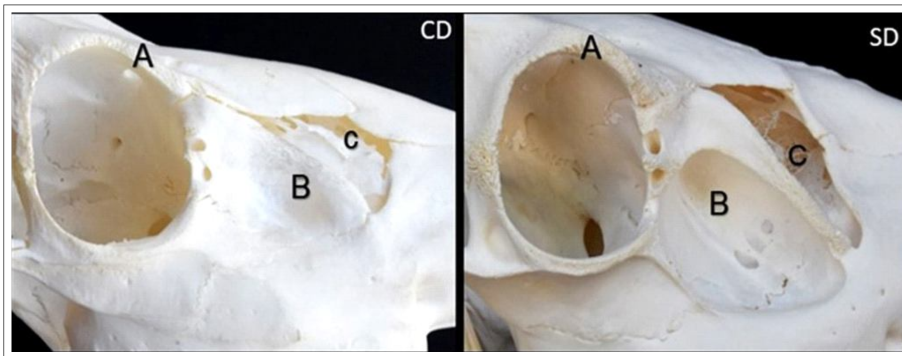
Frontal bone (A); Frontal crest (B); Shallow concavity on rostral part of frontal bone (C); Lacrimal bones (D); Nasolacrimal fissure (E); Nasal bone (F); Nasoincisive fissure (G); Incisive bone (H); Maxilla bone (I); Infraorbital foramen (J); First, second and third superior premolar tooth (K); First , second superior and third superior molar tooth (L); Temporal process of zygomatic bone (M); zygomatic arch (N); Zygomatic process of temporal bone (O); Paracondylar/paramastoid process (P) Parietal bone (Q); Orbit (S) and Lacrimal foramen (T).

Fig 8: Latest surface of the skull of male chital deer (CD).



Frontal bone (A); Frontal crest (B); Shallow concavity on rostral part of frontal bone (C); Lacrimal bone (D) Nasolacrimal fissure (E); Nasal bone (F); Naso incisive bone (H); Socket for alveolar tooth (I) Maxilla bone (J); Infraorbital foraman (K); First , second and third superior premolar tooth (L); First, second superior and third superior molar tooth (M); Temporal process of zygomatic bone (N); Zygomatic arch (O); Paracondylar/paramastoid process (T); Orbit (U) and Lacrimal foramen (V).

Fig 9: Lateral surface of the Skull of male sambar deer (SD).



Rim of orbit (A); lacrimal pit (B) and Nasolacrimal fissure (C).

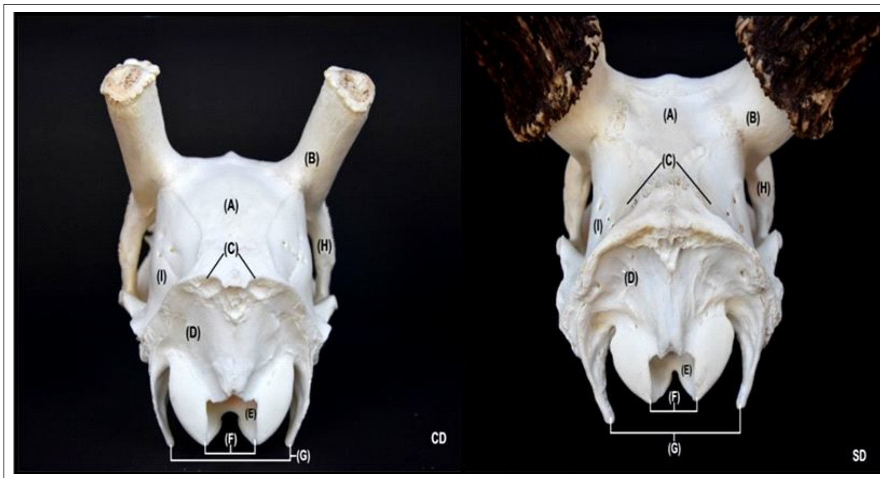
Fig 10: Lateral view of skull of male chital (CD) and sambar deer (SD).

skull (Fig 6) which coincides with the findings of Kumawat (2011) in chital and Choudhary (2015) in blackbuck.

The ethmoidal foramen was located in an orbital of the frontal bone in both male chital and sambar deer skull tallied with the findings of Kumawat (2011) in chital; Choudhary (2015) in blackbuck and Keneisenuo *et al.* (2020) in sambar deer and barking deer.

The interparietal was a small, quadrilateral bone wedged in between the parietal anterolaterally and the supraoccipital posteriorly in both male chital and sambar

Fig 11: Lateral view of the skull of the male chital (CD) and sambar deer (SD) showing premaxilla bone (A) and socket for canine tooth (B).



(A); Cornual Process (B); Nuchal crest (C); Occipital bone (D); Foramen magnum (E); Occipital condyle (F); Paracondylar / Paramastoid process (G); Temprol bone (I) and Zygomstic bone (H).

Fig 12: Caudal view of skull of male chital deer (CD) and sambar deer (SD) showing Parietal bone.

Fig 13: Caudal view of the skull of male chital deer (CD) and Sambar deer (SD) Showing cornual process.

deer skull resembled with the findings of Kumawat (2011) in chital and Keneisenuo *et al.* (2020) in sambar deer and barking deer; however, it was not traceable in chital as reported by Parmar and Shrivastava (2003). The interparietal process of occipital represented the paired interparietal bone. It formed roof of cranial cavity with parietals in tallied with the findings of Din *et al.* (2020) in chinkara.

The frontal surface below the orbit presented a triangular opening area known as lacrimal fissure (Fig 10) which was bounded by frontal bone and nasal bone above, maxilla bone in front and lacrimal bone below in both male sambar and male chital deer skull tallied with the findings of Kumawat (2011) in chital and Keneisenuo *et al.* (2020) in barking deer and sambar deer. The supraorbital foramen was present in frontal bone both skull of male chital and sambar deer and two to three in number with a very deep supraorbital groove in male sambar deer skull concurrent to the finding Archana *et al*. (2003) in sambar deer whereas supraorbital foramen absent as reported by Zuoliang (2004) in arctic foxes and Joshi (2004) in tiger.

In male chital deer, the body of temporal partially formed the temporal fossa which was deeper; whereas, it was shallow in male sambar deer (Fig 8 and 9) similar to finding of Sarma (2006) in kagani goat. The tympanic bulla was large in male sambar deer than the chital deer skull. The petrous and tympanic parts of temporal bone were united by the occipito-tympanic suture as reported in chital and tailed with findings of Kumawat (2011) in chital deer.

The infraorbital foramina were present above the first cheek tooth in male chital and sambar deer skull (Fig 8 and 9) concurrent to finding of Parmar and Shrivastav (2003a) and Kumawat (2011) in chital and Keneisenuo *et al.* (2020) in sambar deer and barking deer**.**

The facial tuberosity was present at the level of the third cheek tooth in both male chital deer and sambar deer skull (Fig 8 and 9) similar to finding of Archana *et al*. (2003) in sambar deer and Parmar and Shrivastava (2003) in chital deer (Fig 11).

Incisive (Premaxilla) bone was directed upward in chital deer; whereas it was directed caudally in case of sambar deer (Fig 5).

The pterygoid bone was a flat, thin and inserted between the sphenoid and perpendicular part of the palatine bone in both male chital and male sambar deer skull tallied with the findings of Joshi (2004) in tiger and Choudhary (2015) in blackbuck.

A median septum nasi separated the right and left parts of it in the skull of both male chital and sambar deer skull coincides with the findings of Kumawat (2011) in chital and Choudhary (2015) in blackbuck. The nasal bone of the skull was articulated anteriorly with incisive bone in both male chital and sambar deer skull as reported Kumawat (2011) in chital and Joshi (2004) in tiger. The nasal bone formed the greater part of a roof of nasal cavity in both male chital and sambar deer skull as reported in tiger, Joshi (2004).

The lacrimal bone was large and didn't make contact with nasals in both the species (Fig 8 and 9). It was roughly triangular in shape in chital deer; whereas, it was roughly pyramidal in sambar deer. However, the present finding was contradictory with the findings of Kumawat (2011) in chital. Nasolacrimal fissure was present in both chital and sambar deer skull tallied with findings of Keneisenuo *et al.* (2020) in sambar deer.

The lacrimal bone was marked by prominent depression for the lodgement of the infraorbital gland in both male chital and sambar deer skull. The lacrimal pit or depression was shallower and shorter in male chital deer skull whereas lacrimal pit or depression was dipper and longer in male sambar deer skull (Fig 8 and 9) tallied with the findings of Archana (2003) and Keneisenuo *et al*. (2020) in sambar deer and which was one of the unique differentiating features between male sambar deer and male chital deer skull. Lacrimal bulla was present in both male chital and sambar deer skull coincides with the findings of Kumawat (2011) in chital and Choudhary (2015) in blackbuck; however, it was absent in tiger (Joshi, 2004).

The zygomatic process of the temporal bone was curved in sambar deer; whereas, it was roughly straight in male chital deer skull; however, it was horizontally placed in wild pig and vertically in cross-bred pig and domestic pig in between as reported by Guntoju (2022). It was placed between the lacrimal above and the maxilla below and in front in both male chital and sambar deer skull as reported Kumawat (2011) in chital and Keneisenuo *et al.* (2020) in sambar deer. It had a curved crest arose at the the infra-orbital margin, which continued on to the maxilla in both male chital and sambar deer skull which was similar to the findings of Kumawat (2011) in chital and Keneisenuo *et al.* (2020) in sambar deer; however, it was absent in tiger (Joshi, 2004).

Orbit was oval, complete and placed rostro laterally which was formed by the frontal, lacrimal and malar bones in male sambar deer skull (Fig8 and 9) tallied with the findings of Keneisenuo *et al.* (2020) in sambar deer and Sarma *et al.* (2001) in adult leopard cat;whereas, orbit was round and complete in male chital deer skull coincides with the findings of Keneisenuo *et al.* (2020) in barking deer and Sarma (2006) in Kagani goat; however, orbit was incomplete as reported by Kale *et al.* (1999) in hyena and Joshi (2004) in tiger.

CONCLUSION

The present research was planned on 4 adult skulls each of male chital and sambar deer to develop database on the basis of comparative morphology and identify the species. The frontal bone depression was deeper and narrow in male chital; however, shallow and wider in male sambar. The alveolus for upper canine tooth was absent in male chital deer skull whereas it was present in male sambar deer skull. The caudal central end of the pterygoid bone was "U" shape in male chital skull; however, it was

"V" shaped in male sambar deer skull. The lacrimal pit or depression was shallower and shorter in male chital deer skull whereas was deeper and longer in male sambar deer skull. The facial crest was straight in the skull of male sambar deer; however, it was curved with dorsal convexity dorsally in male chital skull. Therefore, this comparative study will to helpful to differenced the skull of these two closely related species as well as form the basis for forensic study.

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Conflict of interest

There is no conflict of interests among the authors.

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