



Anatomical Comparison of Mandibular Structures in Wild (*Sus scrofa cristatus*), Domestic (*Sus scrofa domesticus*) and Crossbred Pigs

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ABSTRACT

Background: The morphological structure of the pig mandible reflects a complex interplay of functional and evolutionary adaptations, positioning it as an intermediary between specialized herbivorous and carnivorous forms.

Methods: This study investigates the mandible dimensions and features across different pig types (crossbred, wild and domestic). For this purpose, 4 skulls from adult animals of each category were collected. The mandibles were de-skinned and kept under maceration for a period of one month. The mandibles were removed after maceration and whitening was done by treating the mandibles with 3% hydrogen peroxide. Mandible length, height distance from mandibular foramen and mental foramen to different parts of mandible was calculated. Student's t test was used for statistical analysis.

Result: Findings reveal that crossbred pigs exhibit greater mandible length and width, attributed to selective breeding and the relaxation of selective pressures during domestication. Notably, the study identifies significant variability in mandible dimensions, particularly in wild pigs, suggesting ecological influences on size. The incisive part of the mandible is deep and wide in crossbred and domestic pigs, while remaining narrow in wild pigs, underscoring the impact of dietary factors on jaw adaptations. The findings resonate with previous studies indicating that dietary habits lead to distinct morphological adaptations, linking muscle attachment to mandibular structure. This research elucidates the intricate relationships between ecological factors, dietary habits and evolutionary adaptations in shaping the morphological characteristics of the pig mandible, providing insights essential for husbandry and conservation efforts. Future research is encouraged to further explore these relationships to enhance understanding of pig morphology.

Key words: Adaptations, Ecological factors, Maceration, Mandible, Morphology, Wild pig.

INTRODUCTION

India is home to a rich diversity of flora and fauna, with its unique ecosystems supporting both domestic and wild pig populations. Wild pigs, such as the Indian wild boar, can be found in various habitats across the country, ranging from forests to grasslands, while domestic pigs are primarily raised in rural areas for agricultural purposes (Sahu, 2022). There are twenty-one subspecies of the wild pig (*Sus scrofa*) out of which sub-species *S. scrofa cristatus* exists in India and Pakistan (Khan, 1990). The large geographical range occupied by the wild pig population is reflected in their great morphological and size variability that characterized the species according to Albarella *et al.* (2009). This variability also lead to confusion between the domestic and wild species, so a detailed scientific documentation is required to characterize them.

The mandible of a pig, also known as the lower jaw, plays a crucial role in its dietary habits and feeding behavior. Pigs are omnivores, meaning they consume both plant and animal matter and their mandible is uniquely adapted to facilitate this diverse diet. The structure of the pig's mandible allows for a strong bite force, which is essential for grinding tough plant materials such as roots and tubers, as well as processing softer foods like fruits and small animals (Hoshi, 1971). The morphology of the mandible in wild and domestic suids

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exhibits several key differences that reflect their distinct lifestyles and dietary adaptations. Wild suids, such as boars, typically have a more robust and elongated mandible designed for foraging tough vegetation and rooting in the ground. In contrast, domestic suids often display a shorter and more gracile mandible, adapted for a diet that includes softer feed provided by humans. Understanding these morphological variations is crucial

for insights into evolutionary biology and animal husbandry practices (Owen and Thomas, 2013).

The understanding of the anatomical and functional characteristics of the pig mandible can improved health management in livestock. Additionally, such research contributes to the fields of comparative anatomy and evolutionary biology, providing insights into the adaptations of mammals. Furthermore, as pigs are a major source of protein in Indian diets, studying their jaw structure could aid in optimizing feeding strategies and improving meat quality (Stembrek *et al.*, 2012). So, looking into the importance of this topic and regional variability, the present study was planned to characterize the mandible of domestic, wild and crossbred pigs.

MATERIALS AND METHODS

The research was conducted on 4 adult skulls each of Indian wild, domestic and cross bred (domestic and large white Yorkshire) pig, which were procured from different sources. Skulls of adult wild pig were collected from Madhav tiger reserve and Satpura tiger reserve of Madhya Pradesh, whereas skulls of cross bred pig (75% large white Yorkshire and 25% indigenous pig) were collected from the Piggery Farm, N.D.VS.U, Jabalpur and skulls of domestic pig were procured from the local pig market, Jabalpur. The necessary permission for collection of wild pig was taken from the Principal Chief

Conservator of Forest (Wildlife), Government of Madhya Pradesh Bhopal.

The mandibles were de-skinned and kept under maceration for a period of one month. After maceration, whitening was done by treating the skulls with 3% hydrogen peroxide. The following parameters were recorded.

- 1) Mandibular length (Fig 1, 2, 3).
- 2) Mandibular height (Fig 1, 2, 3).
- 3) Distance between mandibular foramen to base of mandible (Fig 4, 5, 6).
- 4) Distance between Caudal border of mandible to below mandibular foramen (Fig 4, 5, 6).
- 5) Distance between Mandibular foramen to angle (Fig 4, 5, 6).
- 6) Distance between Caudal border of mandible to level of mandibular foramen (Fig 4, 5, 6).
- 7) Distance between Condylod fossa to base of mandible (Fig 4, 5, 6).
- 8) Distance between Condylod fossa to height of mandible (Fig 4, 5, 6).
- 9) Distance between Mental foramen to caudal border (Fig 1, 2, 3).
- 10) Distance between Mental foramen to lateral border of alveolar root of lower incisor (Fig 1, 2, 3).
- 11) Distance between the hemimandibles at the caudal end of the alveolar margin of the last molar tooth (TAHM).

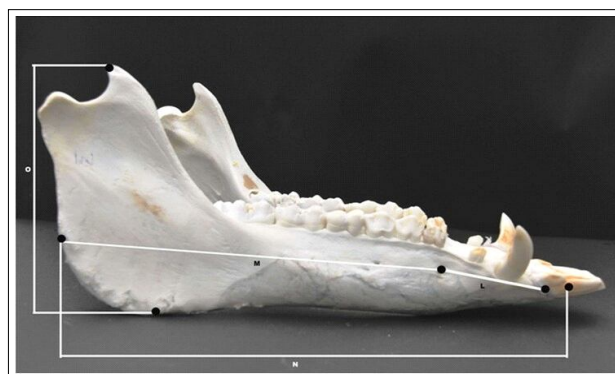


Fig 1: Measurements of the lateral surface of mandible of the wild pig (WP) showing distance from lateral alveolar root to mental foramen (L), mental foramen to caudal mandibular border (M), mandibular length (N) and mandibular height (O).

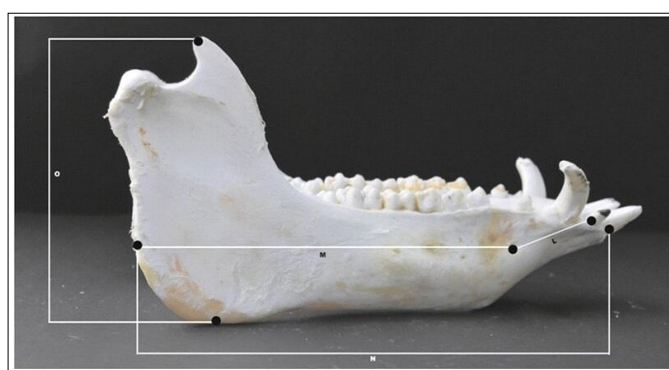


Fig 2: Measurements of the lateral surface of mandible of the domestic pig (DP) showing distance from lateral alveolar root to mental foramen (L), mental foramen to caudal mandibular border (M), mandibular length (N) and mandibular height (O).

- 12) Distance between the hemimandibles at the level of the rostral edge of the alveolar margin of the second molar tooth (TAHPM).
- 13) Distance between the hemimandibles at the caudal edge of the alveolar margin of the lower canine tooth (TAHC).
- 14) Longitudinal length of the dorsal margin of the mandibular symphysis (MS).

RESULTS AND DISCUSSION

Mandibles of all animals were characterized by the presence of body and two vertical rami. The body of the mandible was comprised of two parts-rostral part which contains the incisor teeth and the caudal part which contains the molar teeth (cheek teeth) in wild, domestic and cross bred pig mandibles (Fig 7). The length of mandible was maximum in cross bred pig (23.75 ± 0.11 cm) followed by wild (22.30 ± 0.21 cm) and domestic pig (19.52 ± 0.19 cm) (Table 1). The length of mandible of wild pig was significantly lower from the cross bred pigs.

The height of mandible was maximum in cross bred pig followed by wild and domestic pig (Table 1). Significant difference was observed between the height of mandible in wild, cross bred and domestic pig. Mandibular angle

was wide in cross bred pig skull in comparison with wild and domestic pig skulls. The inter alveolar border runs downward in wild pig mandibles in comparison with domestic and cross bred pig mandibles. The incisive part projects dorsally in domestic pig mandibles and slightly dorsally in cross bred mandibles and anteriorly in wild pig mandibles. The incisive part was deeper and wider in cross and domestic pig mandibles in comparison with wild pig mandibles. The incisive part was deeper and wider in mandible of cross and domestic pigs in comparison to that of wild pigs. The molar part was laterally convex in domestic and wild pig mandibles in comparison with cross bred pig mandibles (Fig 8).

Mental foramen was present at the level of first premolar in indigenous and wild boar; however, in cross bred, it was located 1.6 cm rostral to the first premolar. Distance from the mental foramen to caudal border of the mandible of cross bred pig was maximum, followed by wild and domestic pig (Table 2). The Mental foramen to lateral border of alveolar root of lower incisor of wild pig was maximum, followed by cross bred pig and domestic (Table 2). Location of mental foramen is important because desensitization of mental nerve has to be performed in this foramen during the lower lip surgeries.



Fig 3: Measurements of the lateral surface of mandible of the cross bred pig (CBP) showing distance from lateral alveolar root to mental foramen (L), mental foramen to caudal mandibular border (M), mandibular length (N) and mandibular height (O).

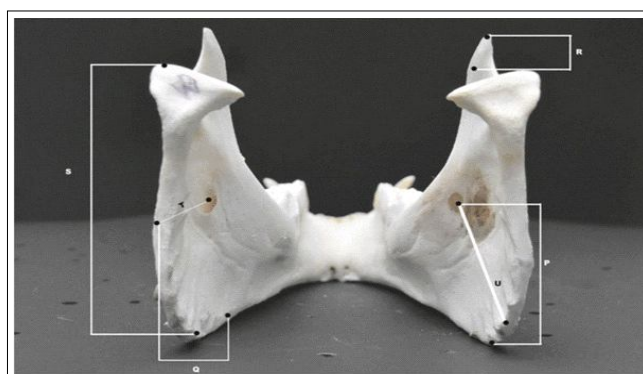


Fig 4: Measurements of the posterior view of the mandible of wild pig (WP) showing maximum mandibular height (S), distance from mandibular foramen to base of mandible (P), caudal border of mandible to below mandibular foramen (Q), condyloid fossa to height of mandible (R), condyloid fossa to the base of the mandible (S), caudal border of mandible to the level of mandibular foramen (T) and mandibular foramen to mandibular angle (U).

The ramus was wide and extensive in mandible of cross bred pig in comparison with wild and domestic pigs. Masseteric fossa was deeply concavated in cross bred pig

and domestic pig in comparison to the wild pig mandibles (Fig. 8). The upper part of the condyle was highly convex in cross bred, less convex in indigenous and flattened in wild

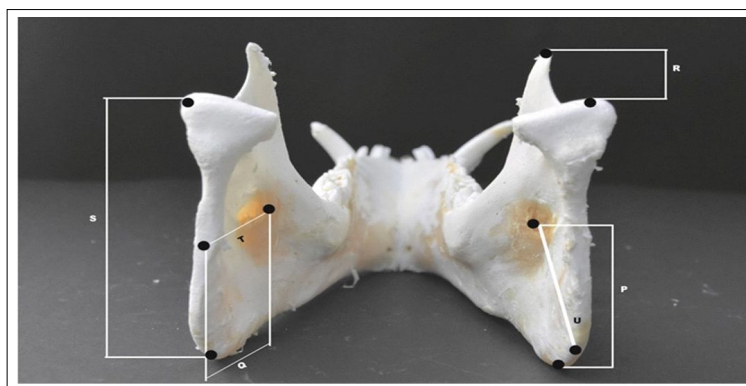


Fig 5: Measurements of the posterior view of the mandible of domestic pig (DP) showing maximum mandibular height (S), distance from mandibular foramen to base of mandible (P), caudal border of mandible to below mandibular foramen (Q), condyloid fossa to height of mandible (R), condyloid fossa to the base of the mandible (S), caudal border of mandible to the level of mandibular foramen (T) and mandibular foramen to mandibular angle (U).

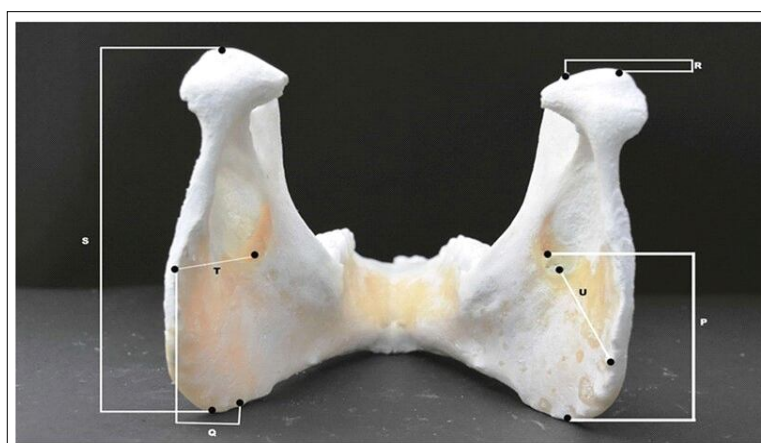


Fig 6: Measurements of the posterior view of the mandible of cross bred pig (CBP) showing maximum mandibular height (S), distance from mandibular foramen to base of mandible (P), caudal border of mandible to below mandibular foramen (Q), condyloid fossa to height of mandible (R), condyloid fossa to the base of the mandible (S), caudal border of mandible to the level of mandibular foramen (T) and mandibular foramen to mandibular angle (U).



Fig 7: Caudal view of mandible of wild pig (WP), domestic pig (DP) and cross bred pig (CBP) showing body of mandible (A), mandibular foramen (B) and caudal border of mandible (C).

pig. The caudal part of the condyle was inclined gradually in cross bred and indigenous; while steep in wild pig.

The coronoid process was pointed and curved caudally in cross bred, while in wild pig, it was thin triangular plate with pointed plate like apex. In indigenous pig, the apex of coronoid process was a thick plate and directed caudally. Cranial border of ramus of mandible was more or less vertical in cross bred, while slanting in wild and indigenous breeds (Fig 8). Line drawn from the mandibular foramen to the caudal margin of the coronoid process was straight in cross bred pig while directed oblique caudally in indigenous breed pig. The coronoid process was equal in height of condylar process in cross bred; however, in wild pig, it was 1.2 cm higher and in indigenous pig, it was 1.8 cm higher than the condylar process (Fig 8). The mandibular notch was completely semicircular, sharp and thin in cross bred while in wild pig, it faces caudo-dorsally and in indigenous pig, it faces caudally because of the orientation of the coronoid process.

The condyloid fossa to the base of the mandible of cross bred pig was measured at 13.80 ± 0.10 cm, which was highest, followed by wild (10.52 ± 0.11 cm) and domestic

pig (10.15 ± 0.13 cm) skulls (Table 2). The condyloid fossa to the height of the mandible of domestic pig was measured as 01.47 ± 0.12 cm which was highest, followed by wild (01.05 ± 0.08 cm) and cross bred pig (0.52 ± 0.14 cm) (Table 2).

Mandibular foramen present on the medial surface was more extensive and wider in cross bred pig, slightly wide in domestic pig mandibles; whereas in wild pig, mandibles as narrow (Fig 7). The mandibular foramen to the base of the mandible of cross bred pig was measured as 06.37 ± 0.17 cm which was highest, followed by mandibles of wild (05.42 ± 0.18 cm) and domestic pig (04.47 ± 0.18 cm) (Table 2). From the caudal border of the mandible to beneath the mandibular foramen of cross bred pig was measured as 06.37 ± 0.20 cm which was highest, followed by the mandibles of wild (04.47 ± 0.17 cm), and domestic pig (04.15 ± 0.10 cm) (Table 2). The mandibular foramen to the angle of the mandible of cross bred pig was measured as 05.87 ± 0.13 cm which was highest, followed by mandibles of wild (05.35 ± 0.18 cm), and domestic pig (04.37 ± 0.19 cm) (Table 2). Mandibular foramen to the angle of the mandible to below mandibular foramen was recorded as 7.13 ± 0.03 cm. The divergence or angle between the two halves was more in cross bred pig mandibles in comparison with wild and domestic pig mandibles. The caudal border of the mandible to the level of mandibular foramen of cross bred pig was measured as 06.40 ± 0.21 cm, which was highest, followed by mandibles of wild (04.62 ± 0.13 cm) and domestic pig (04.12 ± 0.11 cm) (Table 2). The angular part of the mandible was very thick up to the mandibular foramen; however, in wild boar, it was uniformly thin up to the mandibular foramen.

Morphometrical significance

Regarding the significance of differences for mean values of wild pig and domestic pig from all the 10 indicators of mandible were considered in this study. There were a total of 8 values that were statistically significant. Statistically significant values were recorded for mandibular length, mandibular height, mental foramen to caudal border, mental foramen to lateral border of alveolar root of lower incisor, mandibular foramen to base of mandible, mandibular foramen to angle, condyloid fossa to height of mandible, caudal border of mandible to level of mandibular foramen.

The morphological structure of the pig mandible is a testament to its functional and evolutionary adaptations, the pig mandible occupies an intermediate position

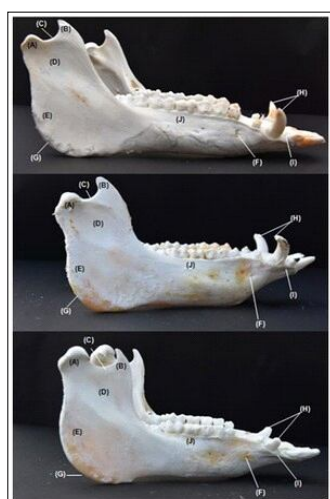


Fig 8: Lateral surface of mandible of the wild pig (WP), domestic pig (DP) and cross bred pig (CBP) showing condylar process (A), coronoid process (B), condyloid fossa (C), masseteric fossa (D), ramus of the mandible (E), mental foramen (F), mandibular angle (G), canine teeth (H), incisive part (I) and molar part (J).

Table 1: Mean length and height parameters of mandible of wild, domestic and cross bred pig.

Parameter (cm)	Length parameter (Mean $\pm$ S.E)			t' test
	Wild pig ¹	Domestic pig ²	Cross bred pig ³	
Mandibular length	22.30 ± 0.21	19.52 ± 0.19	23.75 ± 0.11	9.67^{*1-2} 5.96^{*1-3}
Mandibular height	12.35 ± 0.18	11.37 ± 0.17	13.65 ± 0.11	3.83^{*1-2} 5.91^{*1-3}

*Significant ($p < 0.05$), NS- Non significant, 1-2 (wild pig-domestic pig), 1-3 (wild pig-cross bred pig).

between the specialized forms of herbivores and carnivores, highlighting the complex interplay of dietary, functional and evolutionary factors in shaping its structure. Presence of general morphological features like body, rami and angle were also been described by Konig and Liebich (2006) in domestic pig mandibles. In present study, the length and width of mandible was greater in crossbred followed by wild and domestic pig resembling with the findings of Neaux *et al.* (2020), attributing these variations to the selective breeding and relaxation of selective pressure associated with the process of domestication. Length of wild pig mandible was lesser in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (33.25 ± 0.122 cm), Doychev *et al.* (2012) in wild boar (32.57 ± 1.51 cm) and Constantinescu *et al.* (2014) in wild and domestic pig (32.78 ± 1.49 cm and 27.73 ± 0.48 cm respectively). However, these values were in accordance with the findings of Endo *et al.* (1998) in wild pig (21.16 ± 2.7 cm). Height of mandible of wild pig was lesser in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (16.88 ± 0.124 cm), Doychev *et al.* (2012) in wild boar (13.24 ± 0.85 cm) and Constantinescu *et al.* (2014) in wild and domestic pig (13.28 ± 2.37 cm and 15.23 ± 0.48 cm, respectively). The present finding was tallied with the findings of Choudhary *et al.* (2018) in local Mizo pig (10.54 ± 0.07 cm). Variability in length and width of mandible in crossbred, wild and domestic pigs might be attributed to ecological conditions. In the present study, the incisive part of the mandible was deep and wide in crossbred and domestic pigs, while narrow in the wild pig. Neaux *et al.* (2021) experimentally fed the wild pig and found that pigs fed with hazelnuts had a reduced gonial angle and a longer ramus, while those fed with barley and corn had a wider mandible. These changes suggest that

the type of food consumed influences the mechanical demands placed on the jaw, leading to different adaptations.

Distance of mental foramen from the caudal border of the mandible was lesser in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (29.33 ± 0.15 cm.) while the distance of mental foramen from the lateral border of the alveolar root was greater in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (3.00 ± 0.02 cm). Variability in different structure like condylar process, coronoid process was further supported by the findings of Odman *et al.* (2008) in rats as they reported that rat exposed to soft diet develop hypofunctional masticatory system reflecting a less steep condylar process and shorter corpus and angular processes. The inclination of condylar process was found to be more acute, along with less acute mandibular line angle.

Omnivorous and carnivorous mammals possess large mandibular coronoid processes, while herbivorous mammals have proportionally smaller or absent coronoids. This is correlated with the relative size of the temporalis muscle that forms an attachment to the coronoid process.

Deeply concavated massetric fossa was also reported by Mohamed (2019) in wild boar. The distance from the condyloid fossa to the base of the mandible was lesser compared to the findings of Choudhary *et al.* (2017) in Indian wild pig (15.96 ± 0.05 cm).

Mandibular foramen to the base of the mandible was lesser in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (7.44 ± 0.006 cm). The caudal border of the mandible to mandibular foramen was lesser in comparison with the findings of Choudhary *et al.* (2017) in Indian wild pig (7.04 ± 0.02 cm). The caudal border of the mandible to the level of mandibular foramen compared

Table 2: Mean distance parameters of mandible of wild, domestic and cross bred pig.

Parameter (cm)	Distance parameters (Mean $\pm$ S.E)			
	Wild pig ¹	Domestic pig ²	Cross bred pig ³	't' test
Mental foramen to caudal border	17.62 $\pm$ 0.22	16.90 $\pm$ 0.14	19.70 $\pm$ 0.15	2.69* ¹⁻² 7.54* ¹⁻³
Mental foramen to lateral border of alveolar root of lower incisor	4.70 $\pm$ 0.09	4.0 $\pm$ 0.08	4.40 $\pm$ 0.12	5.71* ¹⁻² 1.89NS ¹⁻³
Mandibular foramen to base of mandible	5.42 $\pm$ 0.18	4.47 $\pm$ 0.18	6.37 $\pm$ 0.17	3.64* ¹⁻² 3.78* ¹⁻³
Mandibular foramen to angle	5.35 $\pm$ 0.18	4.37 $\pm$ 0.19	5.87 $\pm$ 0.13	3.64* ¹⁻² 2.31NS ¹⁻³
Condyloid fossa to height of mandible	1.05 $\pm$ 0.08	1.47 $\pm$ 0.12	0.52 $\pm$ 0.14	2.79* ¹⁻² 3.04* ¹⁻³
Caudal border of mandible to below mandibular foramen	4.47 $\pm$ 0.17	4.15 $\pm$ 0.10	6.37 $\pm$ 0.20	1.62NS ¹⁻² 7.11* ¹⁻³
Caudal border of mandible to level of mandibular foramen	4.62 $\pm$ 0.13	4.12 $\pm$ 0.11	6.40 $\pm$ 0.21	2.82* ¹⁻² 7.01* ¹⁻³
Condyloid fossa to base of mandible	10.52 $\pm$ 0.11	10.15 $\pm$ 0.13	13.80 $\pm$ 0.10	2.17NS ¹⁻² 21.15* ¹⁻³

*Significant ($p < 0.05$), NS- Non significant, 1-2 (wild pig-domestic pig), 1-3 (wild pig-cross bred pig).

with the findings of Choudhary *et al.* (2017) in Indian wild pig which was greater in comparison with the present findings. Further, measurements related to the mandibular foramen and other anatomical features highlight discrepancies with existing literature, emphasizing the role of ecological conditions in shaping mandibular morphology.

CONCLUSION

This study elucidates the intricate relationships between ecological factors, dietary habits and evolutionary adaptations in shaping the morphological characteristics of the pig mandible. The observed variability in mandible dimensions and structures among different pig types serves as a testament to the evolutionary pressures and selective breeding practices that have influenced these animals over time. Close relationship in the dimensions of skull parameters of domestic and wild pig indicate towards their close ecological relationship however higher dimensions of mandible of crossbred pigs reflect the selective influence of genetic morphology of exotic breeds. Future research should continue to investigate these relationships to enhance our understanding of pig morphology and its implications for husbandry and conservation efforts.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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