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RADIOGRAPHIC STUDIES ON THE MANDIBLE OF BUFFALOES AND CAMELS WITH SPECIAL REFERENCE TO MANDIBULO-ALVEOLAR NERVE BLOCK

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ABSTRACT

The present study was carried out on a number of 40 heads of adult buffaloes and camels. The mandible was disarticulated from the skull and the skin and attached muscles were removed. A longitudinal sawing cut was performed at the mandibular symphysis to obtain two equal hemimandibles and all radiographs were arranged in sequence according to the age. All radiographic measurements were taken and documented. Radiographic features and differences between the mandible of buffaloes and camels were recorded. The position of the mandibular and mental foramina was studied radiographically and the mandibulo-alveolar and mental nerve block were described on 3 living buffaloes and camels.

Key words: Buffalo, camel, mandible, radiography

The anatomy of the mandible in bovine and camels has been discussed in the available literatures (Alur, 1964; Frandson, 1974; Getty, 1975; Bone, 1982; and Smuts and Bezuidenhout, 1987). The radiography of mandible was described in equines (Butler *et al*, 2000) but reports lack in buffaloes and camels.

Normal radiography of the mandible is essential to understand its various disorders (Singh and Nigam, 1982; Jennings, 1984; Tyagi and Singh 1996; and White and Moore, 1998). Radiographic description of the position of the mandibular and mental foramina in relation to other parts of the mandible may facilitate mandibulo-alveolar and mental nerve block at their levels (Bone, 1982 and Verstraete, 1999).

The aim of this study is to describe the normal radiographic appearance of the mandible in buffaloes and camels with special reference to the sites of the mandibulo-alveolar nerve and mental nerve blocks.

Materials and Methods

The present study was carried out on 20 heads of adult buffaloes and 20 heads of adult camels. Buffaloes were 2.5-15 years old, while camels were 3.5-15 years old of both sexes. Age was estimated according to Frandson and Spurgeon (1992) and Ommer and Harshan (1995) in buffaloes and Misk *et al* (1998) in camels.

The mandible was disarticulated from the skull and the skin and attached muscles were removed. A longitudinal sawing cut was performed at the mandibular symphysis to obtain two equal hemimandibles.

Radiography was performed for all hemimandibles in lateral projection. Exposure factors were 10-12 MAs and 45-47 KV at 90cm FFD. Standard speed film and intensifying screens were used. All radiographs were arranged in sequence according to the age of specimens. All measurements were taken from radiographs using a ruler and a divider. The following points were noted after normal radiography of the hemimandible:

1. The length of mandibular symphysis, 2. the length and width of the mandibular body, 3. the height of the mandibular ramus, 4. the shape of the rostral and caudal borders of the mandibular ramus, 5. the processes of the

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mandibular ramus: number, shape, direction, length and width, 6. the mandibular foramen: position, shape, radio-density and relations, 7. the mandibular canal: width, shape and radiodensity, 8. the accessory mandibular canal (in camels only): length, diameter, and radiodensity, 9. mental foramina: number, position, shape, radiodensity, and relations, 10. the shape of the dorsal (alveolar and inter-alveolar) and ventral borders of the mandibular body, 11. radiodensity of the body and ramus of the hemimandible.

In addition, 3 living adult buffaloes and 3 living adult camels were used for blocking mandibulo-alveolar nerve at the mandibular and mental nerve at mental foramina.

Results

Radiography of the hemimandible in camels and buffaloes

Average lengths of the mandibular symphysis, length and width of the mandibular body, and the height of the mandibular ramus are illustrated in table 1.

Table 1. Average lengths (cm) of the mandibular symphysis, length and width of mandibular body, and the height of the mandibular ramus in buffaloes (n=20) and camels (n=20).

Animals	Buffaloes	Camels
Length of mandibular body (Fig 1-A)	43.13 (42-44)	37.4 (34-41.5)
Width of mandibular body a - At the interalveolar space (Fig 1-B)	3.2 (3.1-3.4)	3.2 (2.8 - 3.8)
b- Caudal to the last molar tooth (Fig 1-B)	8.3 (8.2-8.6)	8.6 (7.3-9.5)
Height of mandibular ramus (Fig 1-C)	24.25 (22-26)	18.96 (17-21)

The shape of the rostral and caudal borders of the ramus

The rostral border of the ramus was convex from above and concave from below in young buffaloes; however, it was completely convex in older buffaloes. In camels, the rostral border was slightly convex in all ages. The caudal border was concave from above and convex from below in young buffaloes but it was completely concave in older buffaloes. In camels, the caudal border was slightly convex in all studied ages. The connection between the caudal border of the ramus and ventral border of the body was smoothly convex in camels but it had a large convex protruberance at the mandibular angle (*angulus mandibulae*) in buffaloes.

The processes of the mandibular ramus

In buffaloes, the ramus of the hemimandible had two processes, coronoid process (*processus coronoideus*) and condylar process (*processus condylaris*). Camels had the same two processes in addition to a third one known as angular process (*processus angularis*).

Coronoid process in buffaloes was a long rectangle with a convex rostral border and a concave caudal border. It was directed upward and slightly caudal. Its length varied between 6.5 and 7.0 cm (average 6.6 cm), and its width varied between 4.0 and 5.0 cm (average, 4.4 cm). In camels, coronoid process had nearly the same shape as in buffaloes. It was directed mainly upward with slight caudal direction in young ages and slight rostral direction in old ages. The length varies between 5.0 and 6.2 cm (average, 5.2 cm), and the width varies between 2.1 and 4.0 cm (average, 3.5 cm).

Condylar process in buffaloes was a short rectangular process that directed mainly dorso-caudally. It had indistinct neck and head (caput mandibulae), which was a part of the mandibular joint. The length of the process varied between 2.7 and 3.0 cm (average, 2.9 cm), and its width was 2.0 to 2.3 cm (average, 2.1 cm). In camels, condylar process was always triangular in shape and was directed dorso-caudally. Its length varied between 1.5 and 2.2 cm (average, 1.9 cm), and its width varied between 2.0 and 3.0 cm (average, 2.6 cm).

Angular process was present only in camels. It was triangular in shape and was situated ventral to the condylar process and projects caudo-dorsally. Its length varied between 0.8 and 2.0 cm (average, 1.4 cm), and its width varies between 1.3 cm and 3.2 cm (average, 2.0 cm).

Mandibular foramen

In buffaloes, mandibular foramen was present at the medial aspect of the mandibular ramus and appeared radiographically as a radiolucent vertical oval structure that was located closer to the caudal border (2.0 - 3.0 cm, average, 2.8 cm) (Fig 1-D) than the rostral border (4.0 - 5.5 cm, average, 4.6 cm) (Fig 1-E) of the ramus. However, it was far away from the ventral border of the mandibular body (9.0 - 10.0 cm, average, 9.8 cm) (Fig 1-F). In camels, the foramen was clear radiographically within the surrounding high-density cancellous bone of the ramus. It was a radiolucent vertical oval structure situated 4-5 - 6.2 cm (average, 5.2 cm) from the caudal border of the ramus (Fig 1-D), 3.5-4.5 cm (average, 4.0 cm) from the rostral border of the ramus (Fig 1-E), and 5.0 - 8.0 cm (average, 7.1 cm) from the ventral border of the mandibular body (Fig 1-F).

The mandibular canal

The mandibular canal (*Canalis mandibularis*) started at the mandibular foramen and appeared as a tortuous radiolucent duct traversing ventrally then curved rostrally through the body of the hemimandible and ended at the mental foramen. The diameter and shape varied along its whole length. It is 1.5-2.5 cm (average, 2.0 cm) in buffaloes and 0.7-1.5 cm (average, 1.1 cm) in camels. The duct was clearer radiographically in camels than in buffaloes.

The accessory mandibular canal

In camels only, a radiolucent canal started at the mandibular foramen and directed rostrally to the alveolar border of the body caudal to the last molar tooth was seen radiographically and anatomically in all specimens. Its length varied between 3.7 and 5.0 cm (average, 4.6 cm) while its width varied between 0.1 - 0.2 cm (average, 0.15 cm).

Mental foramina

The lateral aspect of the mandibular body had one mental foramen in buffaloes and two mental foramina in camels. In buffaloes, the mental foramen was located at the rostral part of the lateral aspect of the mandibular body. It was situated at the level of the root of the fourth incisor tooth midway between the dorsal and ventral borders of the mandibular body. It was

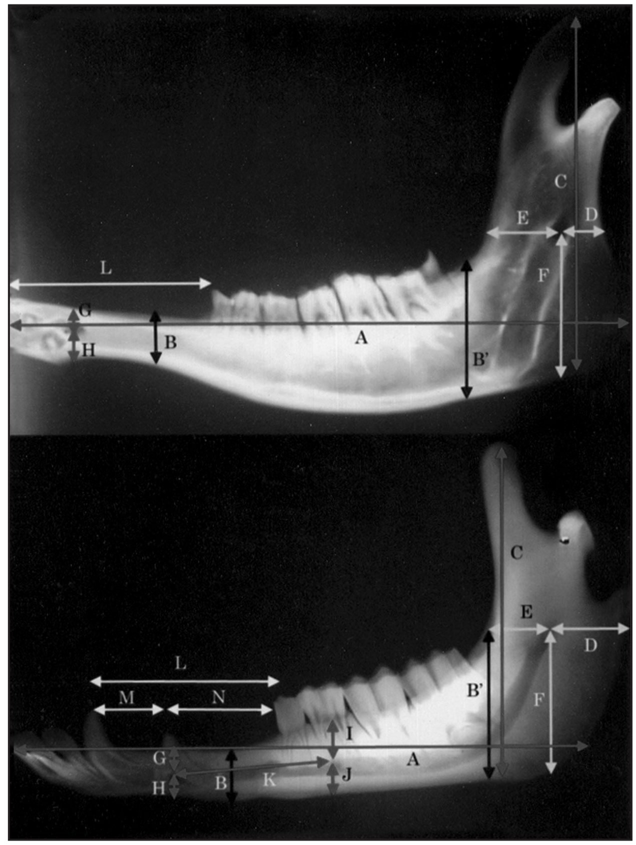

Fig 1. A radiograph of a hemimandible in buffalo (above) and camel (below) showing: **A** = Length of the mandibular body. **B** = Width of the mandibular body at the interalveolar space. B' = Width of the mandibular body caudal to the last molar tooth. **C** = Height of the mandibular ramus. **D** = Distance between mandibular foramen and caudal border of mandibular ramus. **E** = Distance between mandibular foramen and rostral border of mandibular ramus. **F** = Distance between mandibular foramen and ventral border of mandibular body. **G** = Distance between mental foramen and dorsal border of mandibular body. **H** = Distance between mental foramen and ventral border of mandibular body. **I** = Distance between caudal mental foramen and dorsal border of mandibular body. **J** = Distance between caudal mental foramen and ventral border of mandibular body. **K** = Distance between rostral and caudal mental foramina in camel. **L** = Length of the inter-alveolar (inter-dental) space. **M** = Distance between the 4th incisor to the canine tooth (in camel only). **N** = distance between the canine tooth and the 3rd premolar tooth (in camel only).

also present at the level of the caudal end of the mandibular symphysis.

In camels, the rostral mental foramen was clearly evident radiographically and was situated

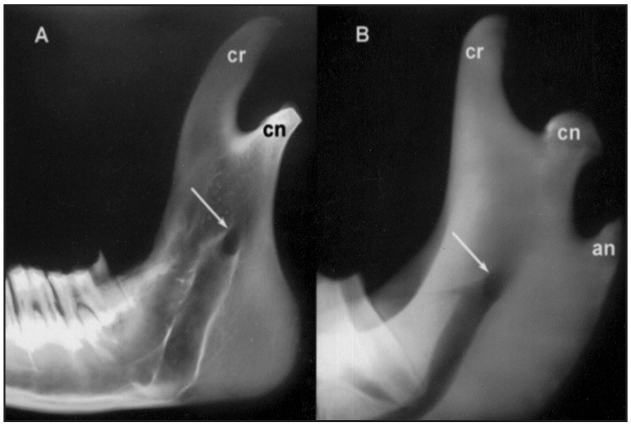

Fig 2. The ramus of a hemimandible in buffalo (A) and camel (B) showing: **a** = The shape of the rostral and caudal border of the ramus. **b** = The processes of the mandibular ramus: cr - coronoid process, cn - condylar process, an-angular process, c-mandibular foramen (arrows).

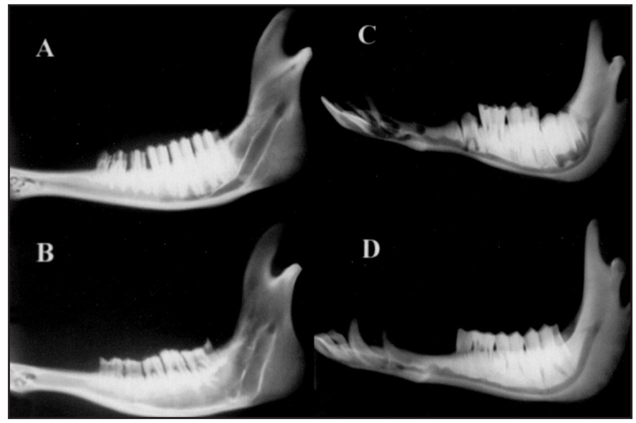

Fig 4. Accessory mandibular canal in camels: **a** = Anatomical specimen showing a piece of wire inside the accessory mandibular canal. **b** = The canal in a 3.5 year old camel. **c** = The canal in a 7 year old camel. **d** = The canal in a 10 year old camel.

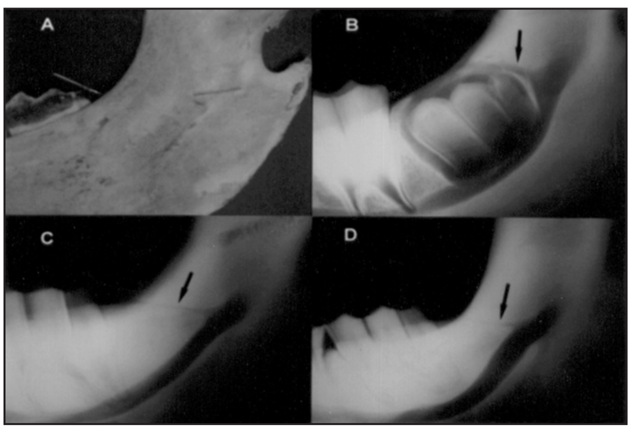

Fig 3. Hemimandibles in buffaloes and camels: **a** = Hemimandible of a 3.5 year old buffalo, **b** = Hemi-mandibles of a 15 year old buffalo, **c** = Hemimandible of a 5 year old camel, **d** = Hemimandible of a 10 year old camel. Illustrating the shape and directions of the mandibular canal and the shape of the dorsal and ventral borders of the mandibular body.

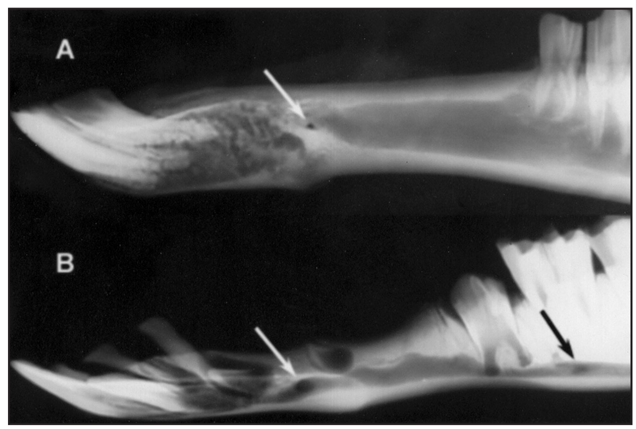

Fig 5. Lateral radiographs of the rostral part of the hemimandible in buffalo (A) and camel (B) showing the seats of the mental foramina (arrows).

just ventral to the root of the canine tooth. It was 1.7 - 2.0 cm (average, 1.9 cm) from the dorsal interdental margin (fig 1-G) and 0.9 - 1.2 cm (average, 1.1 cm) from the ventral border of the mandibular body (Fig 1-H).

The caudal mental foramen was smaller in size than the rostral one and was detected radiographically at the level of the first molar tooth. It is 2.2-3.0 cm (average, 2.8 cm) from the dorsal border (Fig 1-I) and 1.0 - 2.0 cm (average, 1.6) from the ventral border of the mandibular body (Fig 1-J). The distance between the rostral and caudal mental foramina ranged from 9.7 - 13.0 cm (average, 11.3 cm) (Fig 1-K).

The dorsal and ventral borders of the mandibular body

The dorsal border of the mandibular body of the hemimandible consisted of alveolar and inter-alveolar parts. The alveolar part had an

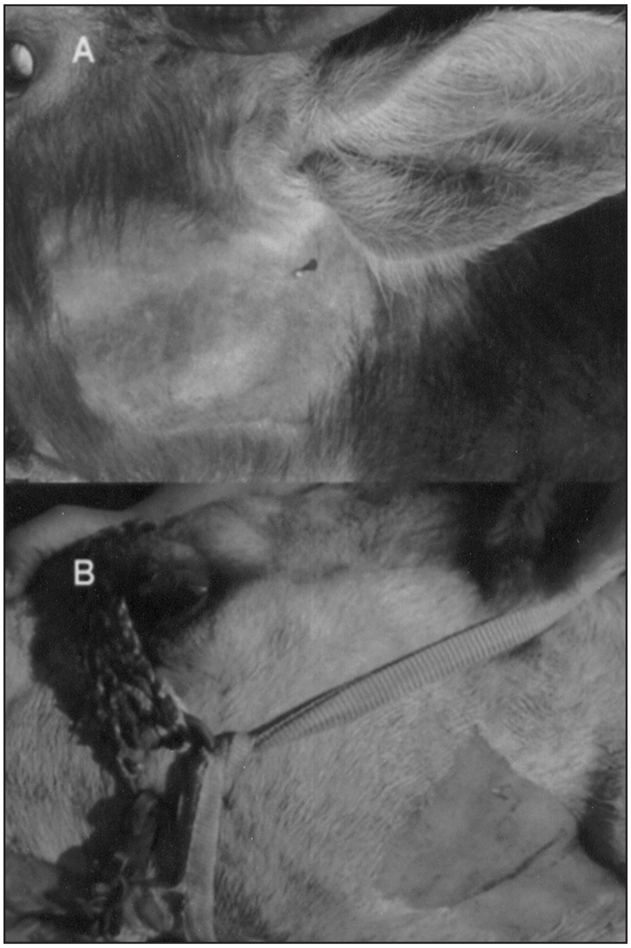

Fig 6. Showing the seats of injection for mandibulo-alveolar nerve block in buffalo (A) and camel (B).

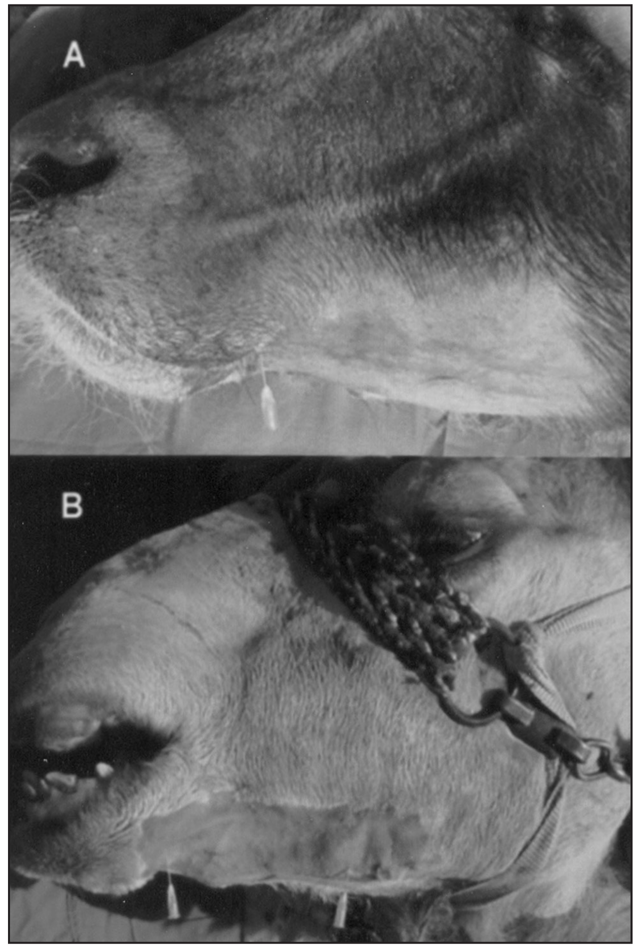

Fig 7. Showing the seats of injection for mental nerve block in buffaloes (A) and camel (B).

incisive part that bears 4 alveoli for incisor teeth in buffaloes and camels, and molar part that carries the alveoli for cheek teeth (buffaloes = 6 and camels = 4). The interalveolar part (interdental space or diastema) was shorter in camels (7.6-11.4 cm, average, 9.8 cm) than in buffaloes (12.4 - 14.0 cm, average, 13.5 cm) (Fig 1-L). In buffaloes, the canine tooth and its alveolus were absent while in camels, a well-developed canine tooth was present in the interalveolar space in males and ill developed in females. The position of the canine tooth, which started to appear as a tooth bud in 4-year-old camel, was closer to the fourth incisor than to the third premolar. The length of the interdental space was divided into incisor-canine (IC) (Fig 1-M) and canine-premolar (CP) (Fig 1-N) with a ratio of 2:3 in a 4-year-old camel to approximately 1:2 in a 15-year-old camel.

Radiodensity of the hemimandible

The ramus of the mandible was more radiolucent than the body due to presence of an excavation (*fossa massetrica*) at the lateral aspect for the masseter muscle and an excavation (*fossa pterygoidea*) at the medial aspect for the pterygoideus muscle. However, there was a great difference between the radiodensity of the ramus in camels and that in buffaloes. In camels, the ramus was more radiopaque than that of buffaloes. Also, the body of the mandible was more radio-opaque in camels than in buffaloes and the cancellous bone that replacing the migrating teeth was more radio-opaque and denser in camels than in buffaloes.

Nerve Block

Mandibulo-alveolar nerve block in buffaloes and camel

In buffaloes, the head of the animal was tilted away from the side of injection and the mandibulo-temporal joint was palpated at the proximal end of the caudal border of the mandibular ramus. Eight cm long, 18 - gauge needle was inserted 5-7 cm distal to the joint and along the caudal border of the ramus. It was directed rostrally for 4-5 cm medial to the caudal border of the ramus. 10 ml of lidocaine 2% was sufficient for nerve block.

Mental nerve block in buffaloes and camels

In buffaloes, the needle was introduced either percutaneous 2 cm distal to the extra-alveolar part of the fourth incisor tooth or the lower lip was everted and 4 cm long, 20 gauge needle was introduced at the same distance distal to the extra-alveolar part of the fourth incisor tooth. The caudal end of the mandibular symphysis was also located and the needle was introduced 1-2 cm dorsal to it. 5 ml of lidocaine 2% was sufficient for nerve block.

In camels, the rostral branch of the mental nerve was blocked at the level of rostral mental foramen. Four cm long, 20-gauge needle was introduced 1-2 cm distal to the extra-alveolar part of the canine tooth. The needle was also introduced percutaneous or the lip was everted and injection is performed 1-2 cm ventral to extra alveolar part of the canine tooth. The caudal branch of the mental nerve was blocked caudal to the rostral one by 9-13 cm (average, 11 cm) at the level of the roots of the first molar tooth. 5 ml of lidocaine 2% were infiltrated subcutaneously to block the caudal mental nerve.

Discussion

Many affections of the mandible have been studied elsewhere (Jennings, 1984; Harari, 1996; Tyagi and Singh, 1996; Thrall, 1998 and Verstraete, 1999). Jennings (1984) stated that fracture of the mandible is uncommon condition in food animal species, however, Purohit *et al* (1984) mentioned that fracture of the body of the mandible is common in camels. Singh and Nigam (1982) used radiography for the diagnosis of the uni- and bilateral fracture of the mandible in camel. They also added that the level of the fracture is at the interdental space just rostral to the canine teeth. The results of the present study revealed that the narrowest part of the hemimandible is at the interdental space, which is predisposed to fractures than other parts, which are wide and supported by muscles.

The present study revealed that bone density of the mandible in camels is higher than that of buffaloes. This fact may be of interest in suggesting that fracture of the mandible may occur more frequently in buffaloes than in camels. Radiographs revealed that the cheek teeth are implanted in a high-density bone in camels and a low density cancellous bone in buffaloes, which may render extraction and repulsion easier in buffaloes than camels.

Smith (1996) stated that radiography plays a role in diagnosis of actinomycosis when the disease affects the mandibular bone. Radiography of the mandible reveals whether there is dental involvement or pathologic fracture. Also, the author described the radiographic picture of the mandible affected with actinomycosis as certain radiolucent areas of osteomyelitis surrounded by a periosteal new bone and fibrous tissue formation. A good knowledge about the radiodensity of the mandible in both buffaloes and camels might be helpful in differentiating early cases of actinomycosis of the mandible. Moreover, traumatic osteomyelitis of the mandibular body can be diagnosed radio-graphically without difficulty. Bone tumors that can be diagnosed radiographically as areas of radiolucency and radiopacity can also be diagnosed when different normal bone densities of the mandible are established.

The presence of accessory mandibular canal in camel, which appears radiographically as a radiolucent line might be misdiagnosed as a fissured fracture of the mandibular ramus. According to the available literatures, the accessory mandibular canal is first recorded by the authors of the present study and may need further anatomical studies to establish the nature and function of its contents.

Several anatomical differences were detected radiographically between the mandible of buffaloes and that of camels. These differences are summarised in table (2).

Table 2. The most common radiographic differences between hemimandible of buffaloes and camels.

	Item	Buffaloes	Camels
1.	Mental foramen	One	Two (rostral and caudal)
2.	Canine tooth	Absent	Present
3.	Cheek teeth	Six	Four
4.	No. of processes in the ramus	Two (coronoid and condylar)	Three (coronoid, condylar and angular)
5.	Accessory mandibular canal	Absent	Present
6.	Mandibular angle	Has a protuberance	Smoothly convex
7.	Bone density	Low	High

Mental and mandibulo-alveolar nerve blocks are used extensively to desensitise the mentum, lower lip, incisors, canines and mandibular cheek teeth (Lawrence, 1971; Verstraete, 1999 and Cornick-Seahorn, 2001). Nerve block at the mandibular foramen is used to block the mandibulo-alveolar nerve. In bovine, the needle is inserted from the angle of the jaw along the medial surface of the ramus of the mandible at a point when an imaginary line along the masticatory surface of the lower molar teeth is crossed by another imaginary vertical line from the lateral canthus of the eye (Lawrence, 1971). A 15 cm long needle is used. Presence of a large protuberance at the mandibular angle in buffaloes makes the process of nerve block from this point difficult. The results of the present study suggest an easier technique. The needle penetrates the skin behind the caudal border is concave and the foramen is situated only 3-4 cm rostral to the caudal border of the ramus 5-7 cm distal to the mandibular joint where the caudal border is concave and the foramen is situated only 3-4 cm rostral to the caudal border of the ramus. Also in camels, the palpated angular process can be taken as a landmark. The needle is inserted, 3-4 cm distal to the process, rostrally and medial to the ramus for 5-7 cm to reach the mandibular foramen. Tilting the head to the opposite side of injection will facilitate introduction of the needle medial to the ramus between it and the pterygoid muscle.

In bovine, Tyagi and Singh (1996) stated that mental nerve block could be used for surgery of the lower lip and lower jaw. They added that the mental foramen could be reached on the lateral aspect of the ramus just behind the fourth incisor teeth. The results of the present study are in agreement with that of aforementioned authors. In camels, the same authors reported the methods of nerve block of the rostral and caudal mental nerves. They mentioned that the rostral mental foramen is located 3-4 cm below the canine tooth. In our present study, the rostral mental foramen is located radiographically 1.7 - 2.0 cm (average, 1.9 cm) below the dorsal margin of the interalveolar space and 0.9-1.2 cm (average, 1.1 cm) from the ventral border of the mandibular body. They added that the caudal mental foramen is located 4-5 cm below the second molar tooth. However, the present study revealed that the caudal mental foramen is located 2.2-3.0 cm (average, 2.8 cm) from the dorsal border and 1.0 - 2.0 cm (average, 1.6 cm) from the ventral border of the mandibular body below the first molar tooth and about 11 cm caudal to the rostral foramen.

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Density dependence in the camelid *Vicugna vicugna*: the recovery of a protected population in Chile

The vicuña *Vicugna vicugna* is a wild South American camelid. Following over-exploitation, which brought the species to the brink of extinction in Chile in the 1960s, the population was protected. Since 1975 the population has been censused annually, generating one of the most extensive long-term census databases for any South American mammal. In this paper we use these data, and measures of environmental parameters, to describe the population growth trend of the species and to estimate carrying capacity. Our results indicate that the vicuña has been protected successfully in northern Chile. The census data reveal that, following protection, the population displayed logistic growth between 1975 and 1992. Population growth rate declined linearly with population size, which indicates a degree of density dependence. Density independent factors, such as rainfall, may also have been important. The principal density dependent effect observed was that birth rate declined in those family groups with the most breeding females. The carrying capacity of the study area was estimated from the census data and from models based on precipitation and local primary productivity. Using the census data, an estimation of carrying capacity as the asymptote of the fitted logistic curve suggested that the vicuña population should reach approximately 26,000 vicuñas, whereas estimation when the population growth rate was equated to zero gave a carrying capacity of *c.* 22,000. Coe's method based on local precipitation predicted 31,000 vicuña, whereas Lavenroth's method based on local primary productivity predicted 26,000 vicuña. In reality, the census data showed that the population peaked at 22,463 vicuñas in 1990. The results are discussed in relation to the need for better census techniques and the implications density dependent effects for the management of the vicuña in Chile.

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