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A craniometric analysis of the skull of the red sokoto (Maradi) goat (*Capra Hircus*)

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SUMMARY

The study involved the osteometric study of 32 parameters in the skull of the Red Sokoto goat in Nigeria. The mean condylobasal length was 20.3 cm while the overall length, whole skull height, and whole skull index were 17.2 cm, 10.5 cm and 0.7 x 10^2 respectively. Nearly all of the parameters studied revealed no significant differences ($p< 0.05$) between animals of one year of age and below and those above this age mark. Female goats had higher values for most of the craniometric measurements. The results are discussed as regards their importance for comparative anatomy with other breeds and a better understanding of the adaptational physiology of the Red Sokoto breed to its environment.

Key words: Metric study – Bones – Skull – Red Sokoto goat

INTRODUCTION

The Red Sokoto (Maradi) goat is a common goat of the Maradi and Tessaona regions of Niger and of northwestern Nigeria, although they now abound far beyond these areas. In Nigeria, there are over 17 million individuals and they are valued for their skin, which is used for the internationally recognized Morocco leather (Gall, 1996).

Although many scientific studies have been performed on this breed, there remains a profound dearth in the literature regarding its cranio-facial anatomy (Olopade and Onwuka, 2002, 2003). Such studies are vital for understanding the spatial relationships of organs in this region (Olopade et al., 2005), for the study of the interactions between hereditary aspects and the environment (Onar et al., 1997), and for the study of sexual dimorphism (de Paiva and Segre, 2003). An important aspect of the craniofacial anatomy of any animal is the skull typology of the species. While such studies have been reported for the West African Dwarf (Olopade, 2003; Olopade and Onwuka, 2005a, b) and the Anglo Nubian breeds (Goat Skull, 2005), there have been relatively few reports on the Red Sokoto breed (Olopade and Onwuka, 2007).

The aim of this work is to report a metric study of the bones of the skull of the Red Sokoto goat.

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Material and Methods

A total of twenty-five Red Sokoto goats were used for this study. The goats were obtained from their indigenous environment in and around Sokoto, northwestern Nigeria. The animals were weighed, their ages estimated through their dentition, and then slaughtered after restraint at the occipitoatlantal joint. The severed heads were frozen at –20°C and then macerated using the hot water technique as described by (Onar et al., 1997; University of Arizona, 1999).

A total of 32 metric indices were obtained from the skull using metric instruments. The description of the indices and the methodology used are depicted below and most are shown in figures 1-6. The data obtained were presented as means ± S.D. and were analysed using the SPSS 10 Software programme.

- **Condylobasal length (CBL):** The length of the skull measured from the front of the premaxillary bones to the rear surface of the occipital condyles.

- **Inter-orbital width (IOW):** Minimum distance between the upper edges of the orbits measured across the top of the skull.

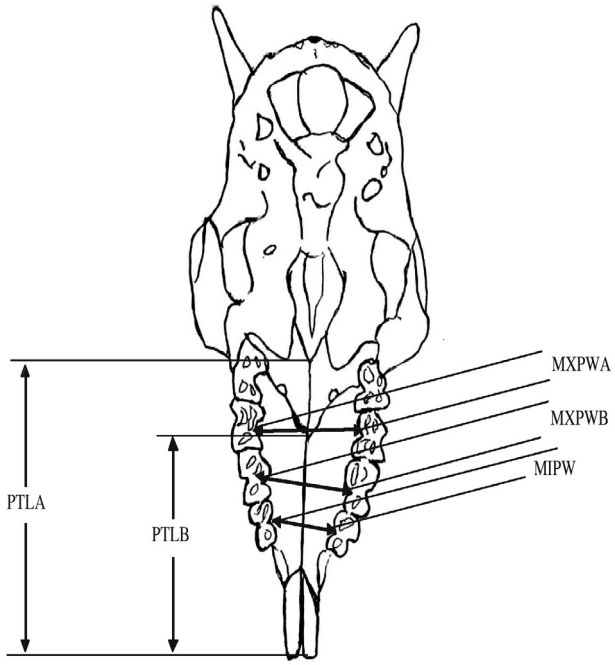

Fig. 1: Schematic diagram of the skull of the goat (Ventral view).

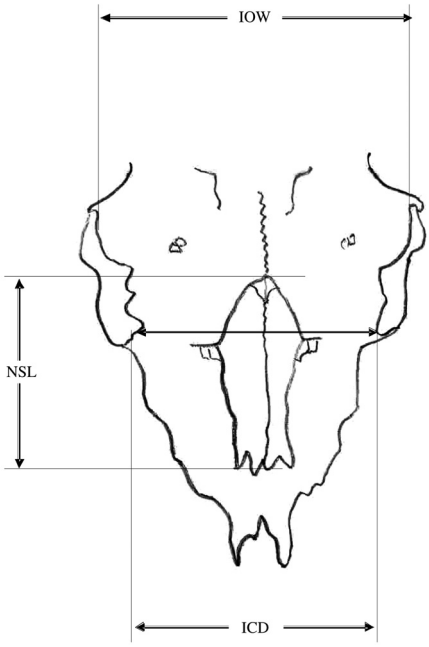

Fig. 3: Schematic diagram of the skull of the goat (Frontodorsal view).

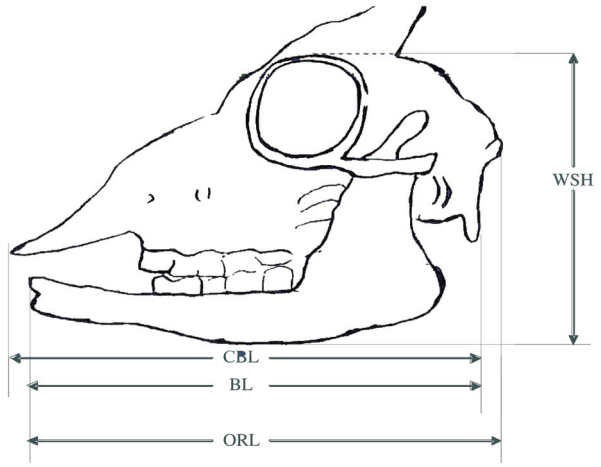

Fig. 2: Schematic diagram of the skull (with mandible) of the goat (Lateral view).

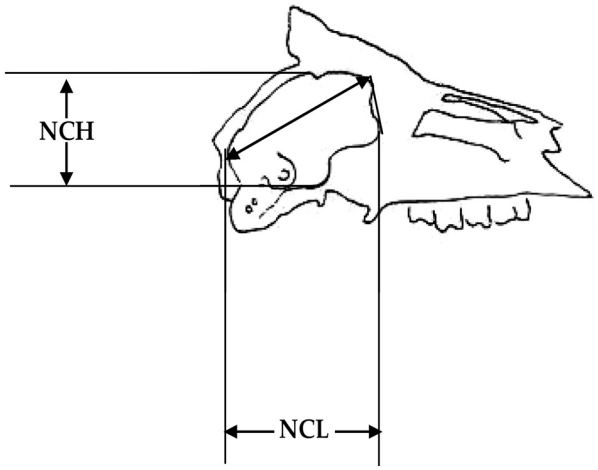

Fig. 4: Schematic diagram of the skull of the goat (Median view).

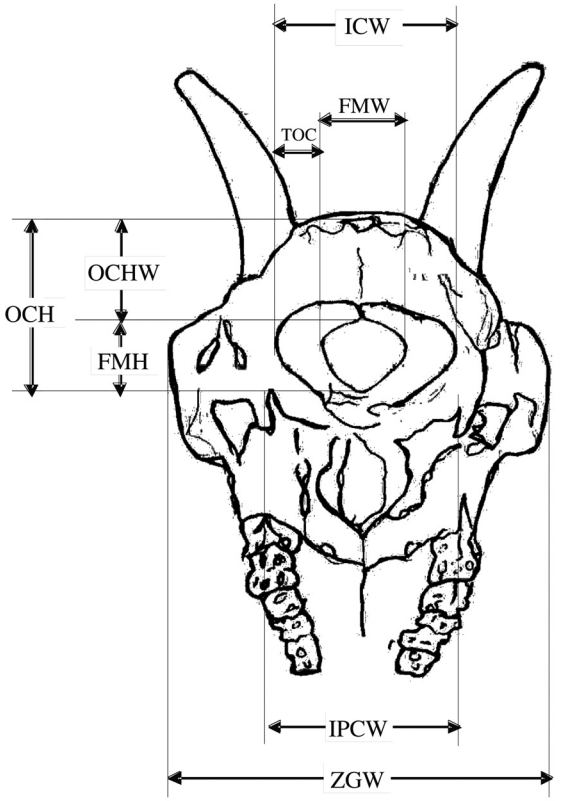

Fig. 5: Schematic diagram of the skull of the goat (Caudoventral view).

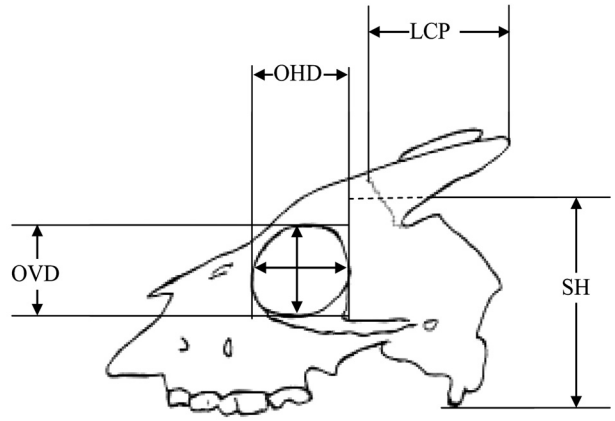

Fig. 6: Schematic diagram of the skull (with mandible) of the goat (Lateral view).

• **Inter-canthi distance (ICD)**: Minimum distance between the median margins of the orbits.

• **Orbital length (OBL):** Maximum circumference of the orbit, from rim to rim. Includes **(OHD)** maximum horizontal and **(OVD)** vertical diameters.

• **Palate width:** The width across the median limits of the alveoli of the cheek teeth at Molar 2 **(MXPW A)** and at Molar 1 **(MXPW B)**.

• **Minimum palate width (MIPW):** The minimum width across the palate measured at Premolar 1.

• **Nasal length (NSL):** Overall length of the nasal bones.

• **Overall length (ORL):** Maximum dimension of the skull when laid on a level surface from the top of the dentary of the mandible to the level of the nuchal crest.

• **Total palate length (PTL A):** From the midline of the mid-cranial end of the choana to the tip of the premaxillary.

• **Palate length (PTL B):** The length of the maxillary part from the midline of the junction of the suture of the palatine bone to the tip of the premaxillary.

• **Inter-zygomatic width (ZGW):** The maximum width across the zygomatic arches.

• **Whole skull height (WSH):** From the highest level of the frontal bone to the lowest level of the mandible.

• **Whole skull index (WSI):**

$$\frac{\text{Whole skull height x 100}}{\text{Overall length}}$$

• **Skull height (without mandible) (SH):** From the level of the highest point of the frontal bone to the base of the jugular process.

• **Basal length (BL):** From the cranial alveolar end of the mandible to the occipital condyles at the level of the jugular process.

• **Neurocranium height (NCH):** From the deepest indentation of the sella turcica directly dorsal to the inner layer of the roof of the cranium.

• **Neurocranium length (NCL):** From the deepest indentation of the fronto-ethmoidal junction to the middle of the distal surface of the cranium at the level of the cerebral surface of the external occipital protuberance.

• **Neurocranium volume (NCV):** The volume of the neurocranium in mls, measured by using plasticine or gum to block all the foramina of the intact skull and the neurocranium is then filled with rice grains from the foramen magnum. When full, the rice is emptied into a measuring cylinder, and the volume is determined.

• **Foramen magnum height (FMH):** Mid-vertical height of the foramen magnum.

• **Foramen magnum width (FMW):** Largest width of the foramen magnum.

• **Foramen magnum index (FMI):**

$$\frac{\text{Foramen magnum height x 100}}{\text{Foramen magnum width}}$$

• **Occipital triangle height (OCH):** From the nuchal crest to the lower brim of the foramen magnum.

• **Occipital triangle height (without foramen magnum) (OCHW):** From the nuchal crest to the upper rim of the foramen magnum.

• **Length of Cornual Process (LCP):** From the rostroventral line at the level of the horn corium to the tip of the bony horn.

• **Intercondylar width (ICW):** Width between the lateral ends of the occipital condyles.

• **Interparacondylar width (IPCW):** This is the greatest breadth of the ventromedial ends of the jugular processes.

• **Length of Paracondylar process (LPP):** The length from the tip of the paracondylar process to its junction with the squamous occipital bone.

• **Maximum thickness of Paracondylar process (TLPP)**: The circumference around the thickest part of the paracondylar process.

• **Thickness of Occipital Condyles (TOC):** Maximum width of a single occipital condyle.

Results

Table 1. Craniometric measurements of the skull of the Red Sokoto goat (Mean ± SD)

Indices	Total	Male	Female	>1yr	= 1yr	> 15kg	= 15kg
CBL	20.3±0.9	9.3±00	20.6±1.0	20.4±1.4	20.2±1.2	20.4±0.0	20.3±1.0
IOW	9.8 ± 2.0	9.2±0.8	10.2±2.4	9.4 ± 0.8	10.6±3.3	9.8 ± 0.7	9.8 ± 2.5
ICD	8.2 ± 0.8	7.5±1.0	8.3±0.7	8.1 ± 0.7	7.8 ± 1.2	8.6 ± 0.4	7.7 ± 0.8
OBL	10.8±0.8	10.4±0.8	11.0±0.8*	10.7±0.8	10.7±1.0	11.9±1.0	10.4±0.5
OHD	3.0±0.2	3.0±0.2	3.1± 0.2	3.0 ± 0.2	3.0 ± 0.3	-	-
OVD	3.5±0.2	3.3±0.2	3.5± 0.2*	3.4 ± 0.2	3.4 ± 0.3	3.6 ± 0.3	3.4 ± 0.2
MXPWA	3.1±0.3	3.0±0.3	3.2 ± 0.4	3.2 ± 0.3	3.2 ± 0.3	3.1 ± 0.5	3.2 ± 0.3
MXPWB	3.0±0.3	2.9±0.2	3.0 ± 0.3	3.1 ± 0.3	2.9 ± 0.3	3.0 ± 0.3	3.0 ± 0.3
MIPW	2.0±0.3	2.0±0.3	2.1 ± 0.3	2.0 ± 0.3	2.1 ± 0.3	2.2 ± 0.4	2.0 ± 0.3
NSL	5.8±0.9	5.8±1.1	5.8 ± 1.0	6.0 ± 1.1	5.4 ± 0.9	6.3 ± 0.5	5.5 ± 1.1
ORL	17.2±2.5	16.9±2.1	17.3±2.6	17.0±2.5	17.3±3.3	17.5±3.1	16.8±1.2
PTLA	11.2±0.5	10.8±0.0	11.3±0.6	11.4±0.8	11.0±0.4	11.0±0.3	11.4±0.6
PTLB	8.4±0.2	-	8.3 ± 0.3	8.1 ± 0.0	8.5 ± 0.0	8.5 ± 0.0	8.3 ± 0.3
ZGW	8.1±0.8	7.6±0.7	8.2 ± 0.8	8.0 ± 0.7	7.8 ± 1.0	8.5±0.9*	7.7 ± 0.6
OCH	4.4±0.4	4.2±0.3	4.5 ± 0.5	4.3 ± 0.4	4.2 ± 0.5	4.6±0.5*	4.2 ± 0.3
OCHW	2.5±0.3	2.4±0.3	2.7 ± 0.3	2.5 ± 0.3	2.3 ± 0.4	2.7±0.3*	2.1 ± 0.3

All values in cm. *Significantly higher at 0.05

Table 2.- Craniometric measurements of the skull of the Red Sokoto goat (Mean ± SD)

Indices	Total	Male	Female	>1yr	= 1yr	> 15kg	= 15kg
WSI**	10.5±1.5	9.4 ± 1.1	11.3±1.3*	10.0±1.3	9.9 ± 1.6	11.8±1.4*	10.1±1.2
SH	0.7 ± 0.2	0.6 ± 1.0	0.7 ± 0.2	0.7±0.2	0.7 ± 0.9	0.7 ± 0.2	0.7 ± 0.1
BL	8.9 ± 0.9	7.5 ± 0.8	8.5± 0.7*	8.2±0.7*	7.3 ± 1.2	8.7± 0.5*	7.7 ± 0.9
NCH	15.4±2.3	13.8±1.9	16.3±2.1*	15.5±1.8	14.7±3.0	17.1±2.1	14.2±1.5
NCL	4.5 ± 0.2	4.5 ± 0.2	4.6 ± 0.3	4.5±0.3	4.5 ± 0.2	4.7±0.3*	4.4 ± 0.2
NCV **	7.8 ± 0.4	7.6 ± 0.4	7.9 ± 0.3	7.8±0.2	7.8 ± 0.2	8.0±0.3*	7.6 ± 0.3
FMH	99.5±10.8	92.5±11.4	104.0±8.5	101.1±7.8	101.1±7.8	106.4±7.8	95.3±10.3
FMW	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1
FMI	1.8 ± 0.2	1.8 ± 0.1	1.9 ± 0.2	1.8 ± 0.2	1.8 ± 0.2	1.8 ± 0.2	1.8 ± 0.1
LCP	98.9±7.7	100.0±3.9	98.2±10.0	99.2±9.5	98.4±3.9	96.3±9.9	100.5±5.7
ICW	4.0 ± 1.7	3.7 ± 1.5	4.3 ± 2.0	3.9 ± 1.6	4.5 ± 2.4	4.9±2.0*	3.5 ± 1.3
IPCW	4.4 ± 0.3	4.3 ± 0.2	4.4 ± 0.3	4.4 ± 0.3	4.4 ± 0.5	4.6±0.2*	4.3 ± 0.2
LPP	4.2 ± 0.4	4.1 ± 0.4	4.3 ± 0.3	4.2 ± 0.4	4.0 ± 0.3	4.4±0.3*	4.2 ± 0.3
TLPP	1.9 ± 0.3	1.7 ± 0.2	2.1± 0.3*	1.7 ± 0.2	1.8 ± 0.5	2.2±0.2*	1.7 ± 0.2
TOC	0.8 ± 0.2	0.8 ± 0.1	0.9 ± 0.3	0.8 ± 0.1	0.8 ± 0.1	0.9 ± 0.3	0.8 ± 0.1
	1.5 ± 0.2	1.4 ± 0.3	1.6 ± 0.2	1.4 ± 0.3	1.4 ± 0.3	1.6 ± 0.2	1.5 ± 0.2

**All data are in cm except NCV and WSI, which is in ml and an index $x10^2$ (see Materials and Methods), respectively.
*Significantly higher at 0.05

The whole skull height was 10.5 cm while the overall length was 17.2 cm. The whole skull index was $0.7x10^2$. The neurocranium volume was 99.5ml while the orbital circumference was 10.8 cm.

The female Red Sokoto Goats had significantly higher values ($p<0.05$) for orbital and basal skull lengths, whole skull height, vertical diameter of the orbit, among others, than the male goat. Goats older than one year had significantly higher values ($p<0.05$) for skull height without mandibles than animals below this age, while heavier goats (>15kg) had significantly higher measurements ($p<0.05$) for whole skull height, skull height without the mandible, and cornual process length, among others, than animals below this body weight.

Discussion

The condylobasal length of the Red Sokoto goat at 20.2 cm observed in this study was longer than the 17.0 cm, but lower than the 21.5 cm obtained in the West Africa Dwarf (WAD) and Anglo Nubian breeds respectively (Olopade and Onwuka, 2005b; Goat Skull, 2005). The values for skull height (without mandibles) whole skull height and basal length of the skull were all clearly larger than those obtained in WAD goats (Olopade and Onwuka, 2005b). The fact that the whole skull index of 0.7×10^2 was higher than the 55.11 obtained for the WAD breed demonstrates that the Red Sokoto skull is relatively bigger in height than in length when compared to the WAD goat. While the neurocranium length of 7.8cm shows more disparity than the 7.3 cm obtained in the WAD animals, the neurocranium heights at 4.5 cm and 4.6 cm respectively were similar; this result may conform to the relationships of the brain length and depth of both breeds, respectively.

The neurocranium volume in this study was 99.5 ml. The mean brain weight of the Red Sokoto goat has already been reported (Olopade and Onwuka, 2002); this, coupled with the facts that brain substance forms about 85-90% of the weight of the cranial content (Sheperd, 2004) and that cranial volume has a direct correlation with brain volume (Golalipour et al., 2006), the density of the brain of the Red Sokoto can easily be assessed from these information and thus make the breed a model for studies of cranial pressure. The larger cranial volume obtained in females than males in this study correlates with the heavier brains reported for female Red Sokoto goats (Olopade and Onwuka, 2002).

Foramen magnum height is consistent in the Red Sokoto goat irrespective of sex, age or body weight. This may conform to an early and uniform morphological dorsoventral development of the medulla oblongata and spinal cord in this breed. The slight deviation and relative lack of uniformity in foramen magnum width between sex, age and weight groups accounted for the lack of uniformity in the foramen magnum index between these same groups.

The similarity in orbital dimensions observed in this study (OBL, OHD and OVD) among Red Sokoto goats irrespective of age has a striking correlation with the development of the ocular dimensions of the breed. Olopade et al. (2005) reported that, unlike other goat breeds in Nigeria, the eyeballs of the Red Sokoto goat nearly attain maximum weights and linear dimensions before the age of one and that there were minimal differences in these measurements between animals above one year and those below this age mark. This trend, however, also seems evident in other craniometirc dimensions of the skull obtained in this study, since only one (skull height without mandible) of the 32 parameters measured was significantly higher in animals above one year of age than those of one year and below. Although they are regarded as delicate animals as compared to other goat breeds in Nigeria (Gall, 1996), it seems clear that the Red Sokoto breed may be an early maturing animal but lacking the corresponding strength to cope with environmental harzards. It may as well be that the relatively early development of osteologic support structures for vision and the entire bony apparatus of the skull of the Red Sokoto goat are adaptational strategies aimed at coping with the relatively harsh environment that animal has found for itself.

The reports of a relatively higher body weight for female goats than males are abundants (Olopade and Onwuka, 2002, 2003, 2005a). One way used to explain this is that the females are either lactating or pregnant (Onwuka et al., 2002). This study, however, shows that in most cases the female goat actually has higher osteometric measurements and this may correlate to higher bone weights. This suggests that the heavier bodies found in

female goats, particularly the Red Sokoto, could be more of a genetic feature than that due to the physiology of lactation and pregnancy.

The information provided in this study should be useful in comparative skull typology with other breeds of goats and should further help in the understanding of the adaptational physiology of the Red Sokoto goat breed.

References

De Paiva LA and Segre M (2003). Sexing the human skull through the mastoid process. *Rev Hosp Clin,* 58: 15-20.

Gall CF (1996). Goat breeds of the world. 1st edition. Margraf Verlag, Weikershem, Germany.

Goat Skull (2005). "http://www.skull.co.uk/Goat/ goat.htm"

Golalipour MJ, Jahanshaei M and Haidari K (2005). Estimation of cranial capacity in 17-20 year olds in South East of Caspian Sea Border (North of Iran). *Int J Morphol*, 23: 301-304.

Olopade JO (2003). *The morphometry of the craniofacial and maxillofacial regions of the West African Dwarf Goats (Capra hircus).* M.Sc thesis, Department of Veterinary Anatomy, University of Ibadan. Ibadan, Nigeria.

Olopade JO and Onwuka SK (2002). Preliminary morphometric investigation of the brain of Red Sokoto (Maradi) goat. *Trop Vet,* 21: 80-84.

Olopade JO and Onwuka SK (2005a). Some aspects of the clinical anatomy of the mandibular and maxillofacial regions of the West African Dwarf Goat in Nigeria. *Int J Morphol,* 23: s 33-36.

Olopade JO and Onwuka SK (2005b). Morphometric study of the skull of West African Dwarf Goat in South West Nigeria. *NVJ*, 26: 18-21.

Olopade JO and Onwuka SK (2007). Osteometric studies of the skull of Red Sokoto (Maradi) goats (*Capra hircus*): Implications for regional anaesthesia of the head. *Int J Morphol,* 25: 407-410.

Olopade JO, Kwari HD, Agbase IO and Onwuka SK (2005). Morphometric studies of the eyeballs of three breeds of goat in Nigeria. *Int J Morphol,* 23: 377-380.

Onar V, Mutus R and Kahvecioglu KO (1997). Morphometric analysis of the foramen magnum in German shepherd dogs (Alsatian). *Ann Anat,* 179: 563-568.

Onwuka SK, Yahaya A and Furo PS (2002). A survey of the slaughter pattern of small ruminants at Yola abattoir (1987-1996). *Afr J Biomed Res*, 4: 73-77.

Sheperd S (2004). Head Trauma. In: e-medicine, instant access to the minds of medicine. www.emedicine.com/med/topic2820.htm. Dated August 20, 2004.

University of Arizona (1999). The University of Arizona cooperative extension consultancy paper on cleaning and preserving animal skulls (Sullivan ML and Park Romney C, authors), ag Arizona. Edu/Pubs/inatresources/az1144.pdf.