SEXUAL DIMORPHISM IN LORI SHEEP VOMERONASAL ORGAN DIMENSIONS AND THEIR RELATIONSHIPS WITH EXTERNAL BODY MEASUREMENTS

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ABSTARCT

This experiment was carried out to study the effect of gender on anatomy of vomeronasal organ (VNO) and their correlations with some external body measurements in Lori sheep. Six external body characteristics were measured on 21 Lori sheep (10 ewes and 11 rams). Heads of the animals were collected and several transverse sections were made through the rostral region of incisive tubercle and repeated at every 1.5 cm up to the point that macroscopic signs of the VNO disappeared. The mean length of VNO was not differ between males and females (p<0.05). The average width of VNO in the middle and rostral third parts, the mean height of the organ in the middle third part and the mean distance between left and right VNO cartilaginous capsule in the middle third part were significantly greater in males compared with females. The width of the tubercle on incisive was significantly greater in males than females (9.99 vs. 8.42 mm). Average width of VNO in rostral third was significantly correlated with trunk length (p>0.05). The mean height of VNO lumen in middle and rostral third was negatively correlated with chest height (r = -0.476) and testis circumference (r = -0.731), respectively (p>0.05). The average width of the distance between left and right VNO lumen in middle third segment was significantly correlated with external nose circumference (p>0.05). Width and length of the tubercle on incisive were both significantly related with trunk length, and the former showed also a significant positive association with heart girdle (p>0.05). In conclusion, minor macroscopically differences exist especially in the middle third segment of VNO in Lori ram and ewe. The VNO anatomical parameters show significant correlations with common external body measures which their physiological interpretation needs further investigation.

Keywords: Vomeronasal organ, Hard palate, External body measures, Lori sheep

INTRODUCTION

The vomeronasal organ (VNO) is a tabular blind-ending structure located in the mucosa of the ventral portion of the nasal septum (Dursun, 1994; Troiter *et al.,* 1996). This organ has an important role in sexual behaviors in ram (Salazar *et al.,* 1998) as well as in male animals in many other mammalian species through detecting pheromones and identifying perspective mates (Bargman, 1997; Doring and Troiter, 1998).

Johnston (1998) and Booth and Katz (2000) reported that the VNO has significant role in ewes as it is used for neonatal offspring recognition.

The anatomy and histology of VNO has been studied in horses (Lindsay *et al.,* 1978), sheep (Kratzing, 1971; Salazar *et al.,* 1998; Booth and Katz, 2000; Booth, 2006), buffalos (Saksena and Chandra, 1980; Kumar *et al.,* 1981; Ardalani *et al.,* 2000), camel (Nagpal *et al.,* 1998), goats (Kumar *et al.,* 1992), dogs (Adams and Wiekamp, 1984) and humans, mouse, lemurs and voles (Roslinski *et al.,* 2000). The vomeronasal lumen has been described as a crescent-shaped in transverse section with a lateral convex wall and a medial concave mucosal wall (Dellmann and Brown, 1987). From a comparative view point, a considerable structural diversity exists in different segments across the length of VNO among the animal species studied (Smith, 1998; Roslinski *et al.,* 2000). In a number of the sheep and buffalo the VNO is reported to be connected to oral cavity by incisive ducts, with their openings are located in both sides of incisive tubercle (Ardalani *et al.,* 2000; Booth and Katz, 2000). In contrast, incisive duct in equine is blind-ending ventrally located with no openings into oral cavity (Dellmann and Brown, 1987). In these species the VNO ducts are connected to nasal cavity (Teindelli *et al.,* 1998).

In most of the reports, VNO has mainly been studied in male animals. Therefore, comparative information on sexual dimorphism in anatomy of the VNO needs further investigation. This experiment was carried out to study the influence of gender on the anatomical measurements of VNO in Lori sheep. The association between dimensions of VNO and some external body measurements were also evaluated.

MATERIALS AND METHODS

Twenty one Lori sheep (10 ewes and 11 rams) were randomly selected (based on anatomical features of the ecotype) from the animals considered for slaughtering in central abattoir of Khorramabad, Lorestan, Iran. Lori is the most common native breed of sheep in mountainous area of Lorestan province. Before slaughtering, six external body characters; external nose circumference (ENC), chest height (CH), trunk length (TL), heart girdle (HG) fat-tail circumference (FTC) and testis circumference (TC) were measured on each animal to 0.01 mm accuracy.

Heads of the animals were transferred to the Anatomy Laboratory, Lorestan University, and subjected to several transverse sections from the rostral region of incisive tubercle and repeated at every 1.5 cm up to the point that macroscopic signs of the VNO disappeared. The length of the VNO was measured from the point of connection to incisive duct up to the caudal extremity to 0.01 mm precision. The height and diameter of the VNO ducts in various regions was measured form outside of the cartilaginous capsule to 0.01mm accuracy. The conformity of the VNO extremity with cheek teeth and palatine ridges was examined. The distance between left and right lumen of the VNO measured to 0.01 mm accuracy in rostral, middle and caudal third portions. The morphological characteristics of hard palate including number of ridges, length and width of incisive tubercle, and average distance of tubercle from the rostral limit of the upper lip were also evaluated.

Data Analysis

The data collected from VNO measurements and hard palate characters in male and female animals were subjected to t-test using SAS (2003) to reveal the influence of gender. The Pearson phenotypic correlation coefficients among VNO anatomical measurements and external body characters were computed using SAS (2003). For the different statistical tests, $p \leq 0.05$ was accepted as significant.

RESULTS

In both sexes, the VNO capsule was complete in the proximal segment of the length with disentanglement of the cartilaginous capsule located at lateral wall of the organ (Figure 1). The lateral wall of the cartilaginous capsule was thicker than the medial wall with no dissimilarity

or inconsistency in male and females. The mean lengths of VNO were not statistically different ($p<0.05$) between rams and ewes (Table 1). The average width of VNO in the rostral and middle third parts and the mean height of the organ in the middle third part of organ were significantly greater in males than in females.

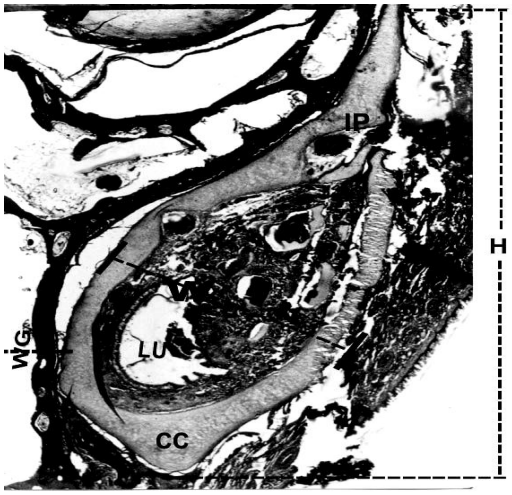

Figure 1: A cross-section of the left duct of vomeronasal organ in sheep; H = height of the duct, W = width of the duct including cartilaginous capsule, WG= width of the gap between left and right ducts, CC = cartilaginous capsule, IP = incomplete portion of the capsule in lateral wall, and LU = lumen of the organ.

The mean distance between left and right VNO capsule was differed between the sexes in the middle third part of the organ with greater significant value in rams (Table 1). No significant ($p<0.05$) sex dimorphism was noticed in morphological measurements of hard palate in both sexes (Table 2); except for width of tubercle on incisive which it was significantly greater in males compared with females (9.99 *vs.* 8.42 mm; $p>0.05$). The mean external nose circumference (ENC; $p>0.05$), trunk length (TL; $p>0.05$), heart girdle (HG; $p>0.05$) and fat-tail circumference (FTC; $p>0.05$) were significantly influenced by sex of animal and all parameters were greater in rams than in ewes (Table 3).

The phenotypic correlations among the external body dimensions and VNO as well as hard palate measurements are presented in Table 3. Average width of VNO in rostral third was significantly correlated with TL ($p>0.05$). The mean height of VNO lumen in middle and rostral third found to have significant negative association with CH ($r = -0.476$) and testis circumference (TC; $r = -0.731$), respectively ($p>0.05$). The average distance between left and right VNO lumen in middle third segment was significantly correlated with ENC ($p>0.05$). Width and length of tubercle on incisive were both significantly related with TL, and the former showed also a positive significant association with HG ($p>0.05$). The average distance of tubercle from the rostral limit of lip (ADTOL) was found to be negatively correlated with TC ($p>0.05$).

DISCUSSION

There are numerous reports demonstrating sexual dimorphism in VNO morphology in small animals; rats (Weiler, 2005), ferret (Kelliher *et al.,* 2001) and salamander (Dawley, 1992). However, experimental results are scarce on gender-associated dimorphism of VNO in farm animals. The VNO in both male and females Lori sheep observed as two parallel cartilaginous ducts positioned in either sides of the nasal septum. In harmony with the previous reports, the duct is pear-shaped when cross sectioned in both sexes (Kratzing, 1971; Dyce *et al.,* 2010).

Kumar *et al.* (1992) reported that the VNO capsule in male goats was oval and complete in the most parts of its length with diminutive incomplete patches in its dorsal region. The VNO capsule also observed in pigs, cows and horses had incomplete patches in its dorsal region (Dyce *et al.,* 2010). The findings of this study were in contrast with the above reports as in the examined samples VNO capsules were complete in the proximal portion of the length. The incomplete portion of the cartilaginous capsule of VNO in Lori sheep was located at the median lateral wall of the organ but its exact location is lopsided. There are no evidences confirming such morphological diversity had effect on the organ functionality.

In consistent with the previous reports on goats (Kumar *et al.,* 1992) the lateral wall of cartilaginous capsule in Lori sheep was found to be thicker than the medial wall.

Table 1: Mean and coefficient of variation (CV) for morphological measurements of sheep's vomeronasal organ (VNO) for the effect on sex

Trait	Males		Females		t-value
	Mean	CV	Mean	CV	
Total Length (mm)	93.50 ± 9.290	5.96	88.01 ± 8.789	5.81	0.34^{ns}
	Av. width of the VNO (mm)				
In rostral third	3.35 ± 0.207	19.05	2.63 ± 0.132	19.05	2.35^{*}
In middle third	3.61 ± 0.155	12.43	3.43 ± 0.085	12.43	2.07^{*}
In caudal third	3.40 ± 0.137	12.74	3.03 ± 0.155	16.16	0.60^{ns}
	Av. height of the VNO (mm)				
In rostral third	5.57 ± 0.306	18.20	4.73 ± 0.225	18.20	1.26^{ns}
In middle third	9.03 ± 0.471	15.33	8.25 ± 0.360	15.33	2.17^{*}
In caudal third	7.82 ± 0.532	22.03	8.35 ± 0.354	22.03	0.64^{ns}
	Distance between left and right VNO tubes (mm)				
In rostral third	3.76 ± 0.503	41.05	2.93 ± 0.664	41.05	0.09^{ns}
In middle third	2.93 ± 0.364	37.79	2.11 ± 0.242	37.79	1.75^{*}
In caudal third	2.87 ± 0.298	29.35	2.81 ± 0.338	29.35	0.35^{ns}

* *p<0.05,* ^{ns} *Non significant*

Table 2: Some morphological measurements on Lori sheep's hard palate for the effect on sex

Traits	Males		Females		t-value
	Mean	CV	Mean	CV	
Av. number of ridges of hard palate	15.62±0.500	9.57	15.70±0.473	9.52	0.05^{ns}
Width of tubercle on incisive (mm)	9.99±0.360	8.38	8.42±0.281	9.34	4.47^{*}
Length of tubercle on incisive(mm)	10.05±0.381	10.59	9.47±0.981	18.9	1.39^{ns}
Av. distance of tubercle from the outer limit of lip (mm)	8.79±0.528	15.30	8.65±0.269	14.7	1.20^{ns}

* *P<0.05;* ^{ns} *Non significant*

Table 3: Effect of sex on external nose circumference (ENC), chest height (CH), trunk length (TL), heart girdle (HG) fat-tail circumference (FTC) and testis circumference (TC) in Lori sheep and their phenotypic correlations with vomeronasal organ (VNO) and hard palate measurements

Characters	ENC	CH	TL	HG	FTC	TC
Males	32.9±1.018	37.7±1.139	64.8±1.851	114.8±1.843	73.8±3.736	32.3±0.828
Females	28.7±0.409	35.2 ±0.920	60.1± 0.888	105.5± 2.290	64.6± 2.329	-
t-test result	*	ns	*	*	*	-
	Correlations					
VNO length	0.052^{ns}	-0.406^{ns}	-0.004ns	-0.064^{ns}	0.057^{ns}	-0.233^{ns}
	Av. width of the VNO (mm)					
In rostral third	0.248^{ns}	0.152^{ns}	0.584^{*}	0.242^{ns}	-0.063^{ns}	-0.365^{ns}
In middle third	0.059^{ns}	0.176^{ns}	0.376^{ns}	0.268^{ns}	0.121^{ns}	-0.079^{ns}

Table 3 continues

Characters	ENC	CH	TL	HG	FTC	TC
In caudal third	0.105^{ns}	0.192^{ns}	0.062^{ns}	0.312^{ns}	-0.086^{ns}	0.355^{ns}
Av. height of the VNO (mm)						
In rostral third	-0.015^{ns}	-0.296^{ns}	0.357^{ns}	0.116^{ns}	-0.178^{ns}	-0.347^{ns}
In middle third	0.207^{ns}	-0.034^{ns}	0.341^{ns}	0.195^{ns}	0.278^{ns}	-0.731*
In caudal third	-0.240^{ns}	-0.476*	0.074^{ns}	-0.144^{ns}	-0.052^{ns}	-0.060^{ns}
Distance between left and right VNO ducts (mm)						
In rostral third	0.222^{ns}	0.202^{ns}	-0.274^{ns}	0.214^{ns}	0.363^{ns}	0.174^{ns}
In middle third	0.564*	-0.226^{ns}	-0.217^{ns}	0.321^{ns}	0.095^{ns}	-0.106^{ns}
In caudal third	-0.075^{ns}	-0.226^{ns}	0.061^{ns}	0.154^{ns}	-0.167^{ns}	-0.360^{ns}
Hard palate measures[1]						
ANR	-0.333^{ns}	0.109^{ns}	-0.195^{ns}	-0.041^{ns}	-0.103^{ns}	0.006^{ns}
WT	0.301^{ns}	-0.061^{ns}	0.494*	0.586*	-0.264^{ns}	-0.331^{ns}
LT	0.190^{ns}	-0.208^{ns}	0.604*	0.124^{ns}	0.227^{ns}	0.141^{ns}
ADTOL	-0.041^{ns}	-0.221^{ns}	0.093^{ns}	0.226^{ns}	-0.263^{ns}	-0.681*

$^{*}p<0.05$, ^{ns} non significant; [1]ANR = Av. number of ridges of hard palate, WT = Width of tubercle on incisive, LT = Length of tubercle on incisive, ADTOL = Av. distance of tubercle from the outer limit of lip.

In many mammalian species the VNO lumens connects to the oral cavity through incisive duct and the lumen join to incisive duct at a site close to its oral opening resulting to a direct connection between the mouth and nose cavities (Doring and Troiter, 1998; Roslinski *et al.,* 2000). This study indicated that in Lori sheep the VNO connects to the oral cavity via the incisive openings located on both sides of incisive tubercle behind the dental pad.

The VNO length varies in different animals so that the length of the organ from the incisive openings up to its posterior extremity was reported as 6.5 cm in male Angora goats (Besoluk *et al.,* 2001), 15 to 20 cm in cows, 12 to 15 cm in horses and 18.9 cm in buffaloes (Lindsay et al., 1978; Ardalani *et al.,* 2000). The current study revealed that the length of VNO was greater in males by 5.4 mm than in females, but the difference was not statistically significant. The minor differences in length of VNO tubes could be attributed to different body sizes of the male and female animals examined.

Such inference could be verified by the significant association between VNO dimensions and some external characters of sheep in the current study.

Significant correlation coefficients were observed between some VNO dimensions and external body measurements such as CH, TC, ENC, TL and HG in the current study. These body characteristics are among the variables used for appraising body score and judging practices of sheep in breeding season.

The negative correlations among height of VNO lumen in middle and rostral third with CH (r = -0.476) and TC (r = -0.731), were interesting as such relationship are uncommon in literatures. A significant Pearson correlation coefficient between a pair of variables do not necessarily demonstrate cause and effect relationship, however, they reveal environmental or genetic association (Udovicic *et al.,* 2007) which may help in the interpretation of physiological relationship among body functions (Dawson *et al.,* 2004). In biological research, correlation should be primarily employed to build hypotheses rather than to test them, the latter being a frequent and entirely wrong application (Zou *et al.,* 2003). If correlation is established between variables, causal relationship should be demonstrated by scientific experiment (Petro-vecki *et al.,* 2006).

Conclusion: This study revealed minor macroscopically differences especially in the middle third segment of VNO in Lori ram and ewe. Significant correlations between some VNO measurements and external body characters were found which may shed light on future studies on VNO in sheep.

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