



Comparative Investigation of Bulbus Oculi in Akkaraman and Morkaraman Sheep

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Abstract

Akkaraman and Morkaraman sheep breeds constitute more than half of the sheep breeds in Turkey. The eye is one of the most complex organs of the body in humans and animals that receives and processes light impulses from the environment, converts them into electrical signals through anatomical and physiological mechanisms, and transmits them to the visual cortex of the central nervous system. Anatomical-morphometric and histological investigations of the bulbus oculi in Akkaraman and Morkaraman sheep breeds will provide reference data for veterinary sciences and human medicine where sheep are used as models. For this purpose, a total of 80 bulbus oculi, right and left, from both breeds and sexes were used in the study. For morphometric measurements, 20 parameters were evaluated. Hematoxylin and eosin-stained preparations were examined under a light microscope after routine tissue monitoring procedures for histologic examination. In the statistical evaluation of the data, it was determined that significant differences according to sex were less in Akkaraman breed than in Morkaraman breed. In the comparison between the species, it was noteworthy that the differences in females were higher. It is thought that the results of the study will provide data both to the disciplines working in the field of veterinary medicine and to different disciplines, especially ophthalmology, as sheep are frequently used as a model in human medicine.

Key Words: Akkaraman, bulbus oculi, histologia, morkaraman, morphometrics anatomy

Akkaraman ve Morkaraman Koyunlarında Bulbus Oculi'nin Komparatif Olarak İncelenmesi

Öz

Akkaraman ve Morkaraman koyun ırkları Türkiye'deki koyun ırklarının yarısından fazlasını oluşturmaktadır. Göz insan ve hayvanlarda çevreden gelen ışık uyarılarını alıp işleyebilen, bunları anatomik ve fizyolojik mekanizmalarla elektrik sinyaline dönüştürerek merkezi sinir sistemi kortekste görme alanına ileten, vücudun en karmaşık organlarından biridir. Akkaraman ve Morkaraman koyun ırklarında bulbus oculi'nin anatomik-morfometrik ve histolojik incelemeleri, veteriner bilimleri ve koyunların model olarak kullanıldığı beşeri hekimlik bilimleri için referans veriler sağlayacaktır. Bu amaçla çalışmada her iki ırk ve cinsiyetten sağ ve sol olmak üzere toplam 80 bulbus oculi kullanıldı. Çalışmada her iki ırk ve cinsiyetten sağ ve sol olmak üzere toplam 80 adet bulbus oculi kullanılmıştır. Morfometrik ölçümler için 20 parametre değerlendirildi. Histolojik inceleme için rutin doku takibi prosedürleri sonrası Hematoksilen eozin boyalı preparatlar ışık mikroskobu altında incelendi. Verilerin istatistiksel değerlendirilmesinde Akkaraman ırkında cinsiyete göre anlamlı farklılıkların Morkaraman ırkına göre daha az olduğu belirlendi. Türler arasındaki karşılaştırmada ise dişilerdeki farklılıkların daha fazla olduğu dikkat çekti. Çalışma sonuçları hem veteriner hekimlik alanında çalışan bilim dallarına hem de beşeri hekimlikte sıklıkla model olarak koyunun kullanılması açısından oftalmoloji başta olmak üzere farklı bilim dallarına veri sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Akkaraman, bulbus oculi, histoloji, morfometrik anatomi, morkaraman

INTRODUCTION

The eye is one of the most complex organs of the body in humans and animals that receives and processes light impulses from the environment, converts them into electrical signals through anatomical and physiological mechanisms, and transmits them to the visual cortex of the central nervous system (1-3). Vision consists of bulbus oculi, organa oculi accessoria, and nervus opticus (4). Bulbus oculi is located with

in the orbit and is protected by this bone wall, and its morphometric characteristics vary between species and breeds. In mammals, it is spherical and thick, but in sheep, pigs, horses, and cattle, it is slightly flattened in the anteroposterior axis (5,6).

The structure known as the tunica bulbi is composed of three distinct layers. These layers include the tunica fibrosa bulbi, which consists of the cornea and sclera, the tunica vas-

culosa bulbi, which encompasses the choroidea, corpus ciliare, and iris, and finally, the tunica interna bulbi, which is comprised of the retina. Contained within the ocular structure are the vitreous body, lens, and aqueous humor, which are encompassed by the layers of the eye (7-9).

Akkaraman and Morkaraman sheep breeds constitute more than half of the sheep breeds in Turkey. The Akkarman breed ranks first, followed by Morkaraman in terms of population density. These breeds, which are bred especially in Central Anatolia and Eastern Anatolia, have adapted well to the regional conditions (10).

Anatomical-morphometric and histologic investigations of the bulbus oculi in these breeds will provide reference data for veterinary sciences and human medicine where sheep are used as a model.

MATERIAL AND METHODS

The eyes obtained from the craniums, which were approved Bingöl University Animal Experiments Local Ethics Committee (BÜ-HADYEK) (Decision No: 2023/E.106395), were used

in the study. The study materials consisted of Akkaraman and Morkaraman sheep breeds (Table 1, n numbers), which were brought to a local slaughterhouse in Bingöl province for slaughter, did not have any disease, and were determined to be adults during the dental examination. The volume of the dissected bulbus oculi was calculated according to the Archimedes principle and the morphometric data of the bulbus oculi were measured by digital caliper and stereomicroscope. The measurement parameters and their definitions are given in Table 2 (11,12).

Table 1. Bulbus oculi "n" numbers according to breeds

Sex	Breeds			
	Akkaraman Sheep		Morkaraman Sheep	
	Right	Left	Right	Left
Female	10	10	10	10
Male	10	10	10	10

Table 2. Morphometric parameters and their definitions

Parameters	Definitions	
Bulbus oculi	Dorso-Ventral (DV) diameter	The length between the endpoints of the bulbus oculi in the dorsal and ventral directions
	Medio-Lateral (ML) diameter	Length between the endpoints of the bulbus oculi in the temporal and nasal directions
	Axial diameter	Length between polus anterior and polus posterior
	Weight	Weighing with a precision balance after dissection of the muscles
	Volume	Volume calculation with Archimedes principle after dissection of muscles
Cornea	Dorso-Ventral (DV) diameter	Length between the endpoints of the cornea in the dorsal and ventral directions
	Medio-Lateral (ML) diameter	The length between the endpoints of the cornea in the temporal and nasal directions
	Thickness (periphery)	Mean thickness from dorsal, ventral, medial and lateral endpoints
	Thickness (center)	Length taken from the intersection of DV-C and ML-C measurements
Sclera	Thickness (anterior)	Length taken from the junction with the cornea
	Thickness (middle)	Length taken from the middle of the anterior and posterior distances
	Thickness (posterior)	Length taken from the polus posterior of the bulbus oculi
Pupil	Dorso-Ventral (DV) diameter	Length between the dorsal and ventral endpoints of the pupil
	Medio-Lateral (ML) diameter	The length between the endpoints of the pupil in the temporal and nasal directions
Lens	Dorso-Ventral (DV) diameter	The length between the dorsal end point of the lens and the ventral end point
	Medio-Lateral (ML) diameter	The length between the temporal and nasal endpoints of the lens.
	Thickness (periphery)	Average of thicknesses from temporal and nasal ends
	Thickness (center)	The length between the anterior and posterior endpoints of the midpoint of the lens.
	Weight	Weighing with precision scales
Volume	Volume calculation with Archimedes principle	

For histologic examination, tissues were fixed in a 10% buffered formaldehyde solution. After fixation, the tissues were washed in tap water and subjected to routine tissue processing. After dehydration, transparency, and impregnation procedures, the tissues were paraffin blocked. From each prepared block, 5µ thick sections were taken on a normal slide. The tissue sections were deparaffinized, rehydrated, and stained with hematoxylin. The sections were decolorized in tap water and stained with eosin. Finally, the tissues were passed through alcohol

and xylol series, dripped with entellan, and covered with coverslips. Hematoxylin and eosin-stained slides were examined under a light microscope.

The mean values and standard deviations of the data obtained and the pearson correlation coefficients between these features were evaluated using the SPSS 22 program. Photographs were taken with a Canon (EOS-700D, Japan) digital camera. Nomina Anatomica Veterinaria (13) was used as a reference for terminology.

RESULTS

Morphometric Results

Mean, standard error, and P values of the morphometric measurements of the bulbus oculi are given as intraspecific sex comparisons in Tables 3-4 and interspecific comparisons in Tables 5-6. Pearson correlation analyses of these data are presented in Table 7 for the right bulbus oculi and Table 8 for the left. All right and left eyes were evaluated as symmetrical, regardless of species and sex. It was determined that there were positive correlations in other parameters, but less so in corneal thickness, pupil dv and ml diameters. Negative correlation was detected only between lens volume-corneal thickness and bulbus oculi volume-corneal thickness. When the morphometric data were analyzed, it was

determined that the anterior-middle-posterior thicknesses of the sclera in Akkaraman were significant at $P<0.01$ and $P<0.001$ except the left middle thickness, while the left middle thickness was not significant ($P>0.05$). In the sex comparison of Akkaraman sheep, left pupil DV diameter was determined as $P<0.05$. The analysis of other parameters in this breed was determined as $P>0.05$. In Morkaraman sheep, intraspecies variations were determined in more parameters compared to Akkaraman sheep. It was observed that the ML diameter of Cornea was longer than the DV diameter in both breeds, thus its shape was elliptical.

In the correlation analysis of the data, it was found that there were positive and negative correlations between each other, mostly positive.

Table 3. Morphometric data of right and left bulbus oculi in Akkaraman according to sex (mm)

Parameters	Breed	Right			Left		
		Mean	S.E.	P value	Mean	S.E.	P value
DV diameter	Ak-M	26.48	0.30	N.S.	26.18	0.40	N.S.
	Ak-F	26.51	0.28		26.78	0.15	
ML diameter	Ak-M	27.87	0.32	N.S.	27.85	0.32	N.S.
	Ak-F	27.54	0.22		27.79	0.22	
Axial diameter	Ak-M	25.73	0.32	N.S.	25.57	0.28	N.S.
	Ak-F	24.89	0.34		25.11	0.22	
Bulbus oculi Weight	Ak-M	10.61	0.19	N.S.	10.40	0.27	N.S.
	Ak-F	10.32	0.27		10.16	0.31	
Volume	Ak-M	10.22	0.40	N.S.	10.26	0.35	N.S.
	Ak-F	9.88	0.17		9.89	0.19	
DV diameter	Ak-M	14.22	0.27	N.S.	14.10	0.30	N.S.
	Ak-F	13.37	0.32		13.61	0.37	
ML diameter	Ak-M	19.73	0.31	N.S.	19.60	0.26	N.S.
	Ak-F	18.88	0.24		19.16	0.28	
Thickness (periphery)	Ak-M	0.91	0.12	N.S.	0.91	1.01	N.S.
	Ak-F	0.90	0.14		1.01	0.32	
Thickness (center)	Ak-M	1.28	0.02	N.S.	1.26	0.01	N.S.
	Ak-F	1.25	0.03		1.18	0.04	
Thickness (anterior)	Ak-M	0.85	0.09	**	0.85	0.08	**
	Ak-F	0.99	0.13		0.98	0.09	
Thickness (middle)	Ak-M	0.96	0.03	***	11.69	0.16	N.S.
	Ak-F	0.72	0.03		11.68	0.16	
Thickness (posterior)	Ak-M	1.26	0.14	***	1.30	0.12	***
	Ak-F	1.48	0.24		1.64	0.28	
DV diameter	Ak-M	4.11	0.14	N.S.	4.04	0.09	*
	Ak-F	4.17	0.22		4.45	0.15	
ML diameter	Ak-M	10.07	0.20	N.S.	9.92	0.19	N.S.
	Ak-F	9.77	0.19		9.81	0.19	
DV diameter	Ak-M	11.74	0.17	N.S.	11.69	0.16	N.S.
	Ak-F	11.75	0.20		11.68	0.16	
ML diameter	Ak-M	12.09	0.15	N.S.	12.08	0.16	N.S.
	Ak-F	11.98	0.18		12.02	0.31	
Thickness (periphery)	Ak-M	4.36	0.55	N.S.	4.24	0.49	N.S.
	Ak-F	4.31	0.60		4.19	0.37	
Thickness (center)	Ak-M	8.51	0.18	N.S.	8.39	0.17	N.S.
	Ak-F	8.45	0.21		8.27	0.22	
Weight	Ak-M	0.70	0.02	N.S.	0.70	0.02	N.S.
	Ak-F	0.70	0.03		0.71	0.03	
Volume	Ak-M	0.60	0.02	N.S.	0.60	0.02	N.S.
	Ak-F	0.54	0.03		0.54	0.02	

(Ak: Akkaraman, M: Male, F: Female * : $P<0.05$, ** : $P<0.01$, *** : $P<0.001$, N.S. : Not significant)

Table 4. Morphometric data of right and left bulbus oculi according to sex in Morkaraman (mm)

Parameters	Right			Left					
	Breed	Mean	S.E.	P Value	Mean	S.E.	P Value		
Bulbus oculi	DV diameter	Mor-M	26.20	0.33	***	26.28	0.35	**	
		Mor-F	28.19	0.27		27.92	0.28		
	ML diameter	Mor-M	27.49	0.35	***	27.71	0.37	*	
		Mor-F	29.17	0.18		28.92	0.20		
	Axial diameter	Mor-M	24.97	0.31	**	25.29	0.31	*	
		Mor-F	26.50	0.32		26.30	0.35		
	Weight	Mor-M	10.38	0.25	**	10.08	0.33	**	
		Mor-F	11.90	0.29		11.77	0.29		
	Volume	Mor-M	9.95	0.18	**	10.04	0.30	**	
		Mor-F	11.35	0.25		11.23	0.27		
	Cornea	DV diameter	Mor-M	14.85	0.23	N.S.	13.63	0.30	N.S.
			Mor-F	14.62	0.17		14.25	0.07	
ML diameter		Mor-M	21.35	0.24	**	18.79	0.22	*	
		Mor-F	20.45	0.12		19.55	0.22		
Thickness (periphery)		Mor-M	0.93	0.15	*	0.93	0.08	*	
		Mor-F	0.86	0.06		0.86	0.06		
Thickness (center)		Mor-M	1.28	0.04	*	1.38	0.06	*	
		Mor-F	1.10	0.05		1.19	0.04		
Thickness (anterior)		Mor-M	0.89	0.07	N.S.	0.95	0.12	*	
		Mor-F	0.89	0.06		0.87	0.06		
Thickness (middle)		Mor-M	1.00	0.09	N.S.	11.48	0.22	**	
		Mor-F	1.07	0.03		12.37	0.16		
Thickness (posterior)	Mor-M	1.06	0.20	**	1.07	0.23	**		
	Mor-F	1.29	0.17		1.43	0.22			
Pupilla	DV diameter	Mor-M	4.20	0.17	N.S.	4.20	0.17	N.S.	
		Mor-F	3.97	0.13		3.95	0.13		
	ML diameter	Mor-M	10.36	0.22	N.S.	10.27	0.19	N.S.	
		Mor-F	9.95	0.20		9.93	0.18		
Lens	DV diameter	Mor-M	11.62	0.26	*	11.48	0.22	**	
		Mor-F	12.46	0.16		12.37	0.16		
	ML diameter	Mor-M	11.76	0.22	*	11.76	0.21	**	
		Mor-F	12.54	0.17		12.06	0.15		
	Thickness (periphery)	Mor-M	4.60	0.33	**	4.44	0.32	**	
		Mor-F	4.31	0.18		4.19	0.08		
	Thickness (center)	Mor-M	8.49	0.21	*	8.53	0.21	N.S.	
		Mor-F	9.03	0.08		9.02	0.16		
	Weight	Mor-M	0.67	0.04	**	0.66	0.04	*	
		Mor-F	0.83	0.03		0.80	0.03		
	Volume	Mor-M	0.58	0.04	**	0.57	0.04	**	
		Mor-F	0.77	0.03		0.79	0.04		

(Mor: Morkaraman, M: Male, F: Female * : P<0.05, ** : P<0.01, *** : P<0.001, N.S. : Not significant)

Table 5. Morphometric data of right and left bulbus oculi of female animals according to breeds (mm)

Parameters	Female Right				Female Left				
	Breed	Mean	S.E.	P Value	Mean	S.E.	P Value		
Bulbus oculi	DV diameter	Ak	26.51	0.28	***	26.78	0.15	**	
		Mor	28.19	0.27		27.92	0.28		
	ML diameter	Ak	27.54	0.22	***	27.79	0.22	**	
		Mor	29.17	0.18		28.92	0.20		
	Axial diameter	Ak	24.89	0.34	**	25.11	0.22	*	
		Mor	26.50	0.32		26.30	0.35		
Weight	Ak	10.32	0.27	***	10.16	0.31	**		
	Mor	11.90	0.29		11.77	0.29			
Volume	Ak	9.88	0.17	***	9.89	0.19	***		
	Mor	11.35	0.25		11.23	0.27			
Cornea	DV diameter	Ak	13.37	0.32	**	13.61	0.37	N.S.	
		Mor	14.62	0.17		14.25	0.07		
	ML diameter	Ak	18.88	0.24	***	19.16	0.28	N.S.	
		Mor	20.45	0.12		19.55	0.22		
	Thickness (periphery)	Ak	0.90	0.14	N.S.	1.01	0.32	*	
		Mor	0.86	0.06		0.86	0.06		
	Thickness (center)	Ak	1.25	0.03	*	1.18	0.04	N.S.	
		Mor	1.10	0.05		1.19	0.04		
	Sclera	Thickness (anterior)	Ak	0.99	0.13	*	0.98	0.09	*
			Mor	0.89	0.06		0.87	0.06	
		Thickness (middle)	Ak	0.72	0.03	***	11.68	0.16	*
			Mor	1.07	0.03		12.37	0.16	
Thickness (posterior)		Ak	1.48	0.24	***	1.64	0.28	***	
		Mor	1.29	0.17		1.43	0.22		
Pupil	DV diameter	Ak	4.17	0.22	N.S.	4.45	0.15	*	
		Mor	3.97	0.13		3.95	0.13		
	ML diameter	Ak	9.77	0.19	N.S.	9.81	0.19	N.S.	
		Mor	9.95	0.20		9.93	0.18		
Lens	DV diameter	Ak	11.75	0.20	*	11.68	0.16	*	
		Mor	12.46	0.16		12.37	0.16		
	ML diameter	Ak	11.98	0.18	*	12.02	0.31	N.S.	
		Mor	12.54	0.17		12.60	0.15		
	Thickness (periphery)	Ak	4.31	0.60	N.S.	4.19	0.37	N.S.	
		Mor	4.31	0.18		4.19	0.08		
	Thickness (center)	Ak	8.45	0.21	*	8.27	0.22	*	
		Mor	9.03	0.08		9.02	0.16		
	Weight	Ak	0.70	0.03	***	0.71	0.03	N.S.	
		Mor	0.83	0.03		0.80	0.03		
	Volume	Ak	0.54	0.03	***	0.54	0.02	***	
		Mor	0.77	0.03		0.79	0.04		

(Ak: Akkaraman, Mor: Morkaraman, * : P<0.05, ** : P<0.01, *** : P<0.001, N.S.: Not significant)

Table 6. Morphometric data of right and left bulbus oculi of male animals according to breeds (mm)

Parameters	Male Right				Male Left			
	Breed	Mean	S.E.	P Value	Mean	S.E.	P Value	
Bulbus oculi	DV diamater	Ak	26.48	0.30	N.S.	26.18	0.40	N.S.
		Mor	26.20	0.33		26.28	0.35	
	ML diamater	Ak	27.87	0.32	N.S.	27.85	0.32	N.S.
		Mor	27.49	0.35		27.71	0.37	
	Axial diamater	Ak	25.73	0.32	N.S.	25.57	0.28	N.S.
		Mor	24.97	0.31		25.29	0.31	
Weight	Ak	10.61	0.19	N.S.	10.40	0.27	N.S.	
	Mor	10.38	0.25		10.08	0.33		
Volume	Ak	10.22	0.40	N.S.	10.26	0.35	N.S.	
	Mor	9.95	0.18		10.04	0.30		
Cornea	DV diamater	Ak	14.22	0.27	N.S.	14.10	0.30	N.S.
		Mor	14.85	0.23		13.63	0.30	
	ML diamater	Ak	19.73	0.31	***	19.60	0.26	N.S.
		Mor	21.35	0.24		18.79	0.22	
	Thickness (periphery)	Ak	0.91	0.12	N.S.	0.91	0.01	N.S.
		Mor	0.93	0.15		0.93	0.08	
Thickness (center)	Ak	1.28	0.02	***	1.26	0.01	*	
	Mor	1.28	0.04		1.38	0.06		
Thickness (anterior)	Ak	0.85	0.09	N.S.	0.85	0.08	*	
	Mor	0.89	0.07		0.95	0.12		
Thickness (middle)	Ak	0.96	0.03	N.S.	11.69	0.16	N.S.	
	Mor	1.00	0.09		11.48	0.22		
Thickness (posterior)	Ak	1.26	0.14	**	1.30	0.12	***	
	Mor	1.06	0.20		1.07	0.23		
Pupilla	DV diamater	Ak	4.11	0.14	N.S.	4.04	0.09	N.S.
		Mor	4.20	0.17		4.20	0.17	
ML diamater	Ak	10.07	0.20	N.S.	9.9	0.19	N.S.	
	Mor	10.36	0.22		10.27	0.19		
DV diamater	Ak	11.74	0.17	N.S.	11.69	0.16	N.S.	
	Mor	11.62	0.26		11.48	0.22		
ML diamater	Ak	12.09	0.15	N.S.	12.08	0.16	N.S.	
	Mor	11.76	0.22		11.76	0.21		
Thickness (periphery)	Ak	4.36	0.55	**	4.24	0.49	N.S.	
	Mor	4.60	0.33		4.44	0.32		
Thickness (center)	Ak	8.51	0.18	N.S.	8.39	0.17	N.S.	
	Mor	8.49	0.21		8.53	0.21		
Weight	Ak	0.70	0.02	N.S.	0.70	0.02	N.S.	
	Mor	0.67	0.04		0.66	0.04		
Volume	Ak	0.60	0.02	N.S.	0.60	0.02	N.S.	
	Mor	0.58	0.04		0.57	0.04		

(Ak: Akkaraman, Mor: Morkarman, * : P<0.05, ** : P<0.01, *** : P<0.001, N.S.: Not significant)

Table 7. Correlation analysis of morphometric data of the right bulbus oculi (* P<0.05, ** P<0.01)

	L-ML	L- Thick- ness (cen- ter)	L- Weight	L- Vo- lume	S- Thick- ness (middle)	Bo- DV	Bo-ML	Bo-Axial diama- ter	Bo- We- ight	Bo- Vo- lume	C-DV	C-ML	C- Thick- ness (cen- ter)	P-DV	P-ML
L-DV	0.937**	0.549**	0.748**	0.519**	0.308	0.630**	0.576**	0.508**	0.326*	0.451**	0.290	0.163	-0.091	0.076	0.108
L-ML		0.549**	0.774**	0.528**	0.157	0.613**	0.593**	0.510**	0.299	0.436**	0.272	0.117	-0.078	0.093	0.073
L- Thick- ness (cen- ter)			0.637**	0.303	0.242	0.533**	0.605**	0.457**	0.483**	0.577**	0.113	-0.014	-0.103	-0.122	0.086
L- Weight				0.604**	0.169	0.671**	0.668**	0.651**	0.286	0.565**	0.304	0.157	-0.244	0.245	0.122
L- Volume					0.134	0.538**	0.516**	0.393*	0.468**	0.480**	0.508**	0.312	-0.401*	0.155	0.053
S- Thick- ness (middle)						0.307	0.315*	0.326*	0.239	0.230	0.262	0.375*	0.023	0.022	0.284
Bo- DV							0.859**	0.746**	0.465**	0.648**	0.235	0.189	-0.160	-0.036	-0.049
Bo-ML								0.834**	0.560**	0.773**	0.245	0.150	-0.170	0.027	0.035
Bo-Axial diamater									0.401*	0.758**	0.182	0.152	-0.187	0.105	-0.002
Bo- Weight										0.511**	0.095	0.023	-0.331*	-0.271	0.031
Bo-Volume											0.158	0.058	-0.252	-0.022	-0.140
C-DV												0.682**	-0.143	0.350*	0.393*
C-ML													-0.068	0.107	0.218
C- Thick- ness (cen- ter)														-0.083	-0.069
P- DV															0.311

Table 8. Correlation analysis of morphometric data of the left bulbus oculi (* P<0.05 ** P<0.01)

	L-ML	L- Thick- ness (cen- ter)	L- We- ight	L- Vo- lume	S- Thick- ness (middle)	Bo- DV	Bo-ML	Bo-Axial diamater	Bo- Weight	Bo- Vo- lume	C-DV	C-ML	C- Thick- ness (cen- ter)	P-DV	P-ML
L-DV	0.894**	0.674**	0.582**	0.652**	1.000**	0.504**	0.614**	0.579**	0.401*	0.561**	0.576**	0.490**	-0.134	0.142	0.257
L-ML		0.591**	0.394*	0.526**	0.894**	0.458**	0.567**	0.503**	0.419**	0.547**	0.474**	0.506**	-0.194	0.204	0.316*
L- Thick- ness (center)			0.404**	0.387*	0.674**	0.530**	0.506**	0.583**	0.387*	0.598**	0.282	0.138	0.168	-0.031	0.243
L- Weight				0.623**	0.582**	0.281	0.354*	0.476**	0.296	0.354*	0.379*	0.178	-0.020	-0.053	0.026
L- Vo- lume					0.652**	0.332*	0.437**	0.472**	0.374*	0.416**	0.467**	0.301	-0.122	-0.220	-0.001
S- Thick- ness (middle)						0.504**	0.614**	0.579**	0.401*	0.561**	0.576**	0.490**	-0.134	0.142	0.257
Bo- DV							0.717**	0.618**	0.510**	0.621**	0.127	0.343*	-0.178	0.065	-0.137
Bo-ML								0.756**	0.608**	0.799**	0.221	0.428**	-0.014	0.087	0.003
Bo-Axial diamater									0.546**	0.743**	0.322*	0.292	0.117	0.059	0.006
Bo- We- ight										0.571**	0.159	0.204	0.131	-0.044	0.137
Bo-Vo- lume											0.179	0.240	-0.071	-0.009	-0.008
C-DV												0.623**	0.064	0.113	0.376*
C-ML													-0.033	0.143	0.161
C- Thick- ness (center)														0.036	0.348*
P- DV															0.179

Histological Results

In the microscopic examination, no pathological lesion was found in the eye tissues of Akkaraman and Morkaraman sheep breeds and a normal histological appearance was observed in each sample. The eyes basically consisted of tunica fibrosa, tunica vasculosa and tunica nervosa from outside to inside.

Tunica fibrosa bulbi corneal layer consisted of corneal epithelium layer, bowman's membrane, corneal stroma and descemetet membrane and corneal endothelium (Figure 1). The tunica vasculosa bulbi was found to contain numerous iris pigments, contractor and dilator muscles, capillary arteries and neural plexuses (Figure 2).

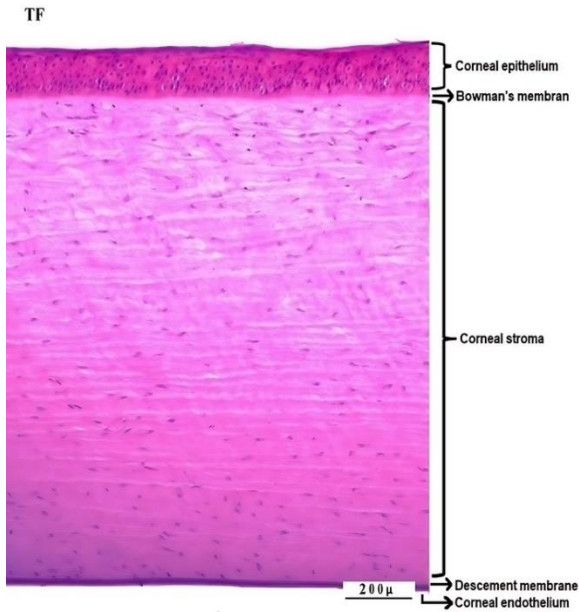


Figure 1. Structure of the tunica fibrosa (TF: Tunica fibrosa) (Male-Akkaraman/ Hematoksilen&Eozin)

Tunica nervosa, which is characterized as the retina, was seen to consist of different histologic compartments. At the outermost part of the tunica nervosa, rod and conical cells were observed side by side. Below these, a layer of outer nuclear cells was observed. Under the outer nuclear cells, the outer plexiform, also known as the outer limiting membrane, was observed. A layer of inner nuclear cells was observed under the outer plexiform. Below the outer nuclear layer, the inner plexiform, also known as the inner limiting membrane, was observed. The inner plexiform layer had an array of ganglion cells and beneath it were nerve fibers connected to the ganglion cells (Figure 3). It was determined that this multilayered structure in the tunica nervosa was the same in both breeds and there was no histological difference between the two breeds in this layer of the eye. In general, it was observed that the eye tissues of Akkaraman and Morkaraman sheep had the same histologic structure.

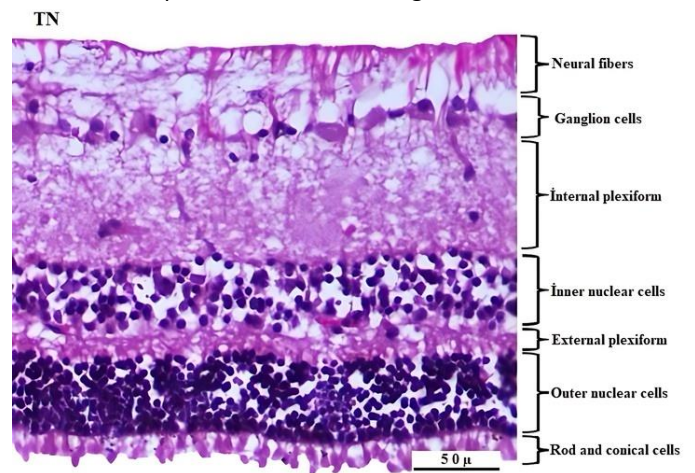


Figure 2. Structure of the tunica vasculosa (TV: Tunica vasculosa) (Male-Morkaraman/ Hematoksilen&Eozin)

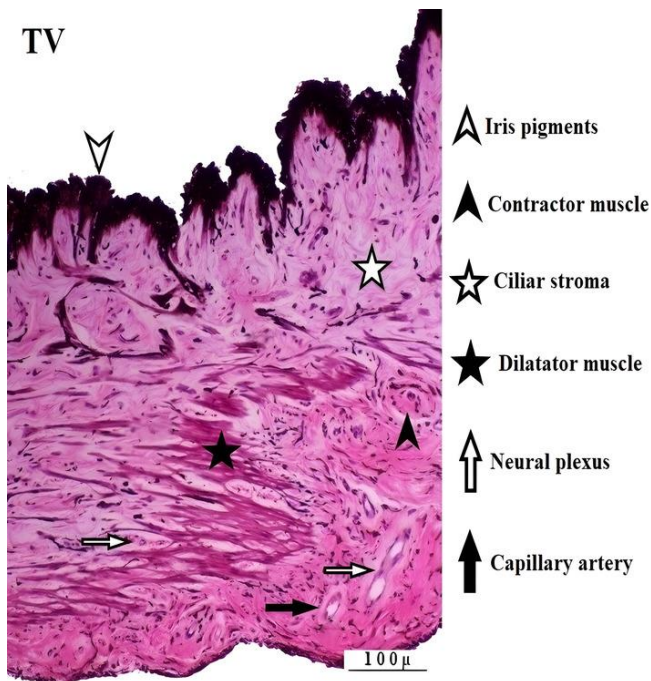


Figure 2. Structure of the tunica vasculosa (TV: Tunica vasculosa) (Male-Morkaraman/ Hematoksilen&Eozin)

DISCUSSION AND CONCLUSION

The weight of bulbus oculi was determined as in females right 10.32±0.27 g and left 10.16±0.31 g in Akkaraman sheep and 11.90±0.29 g and 11.77±0.29 g in Morkaraman sheep, respectively. These data were 10.61±0.19 g and 10.40±0.27 g for Akkaraman and 10.38±0.25 g and 10.08±0.33 g for Morkaraman males. In similar studies, it was reported that in Awassi sheep females, right 15.69±0.47 g, left 15.57±0.48 g and males 11.92±0.37 g and 12.39±0.37 g (11). In Sahel, West African dwarf and Red Sokoto goats, these data were reported as 7.43±0.87 g, 5.93±1.57 g and 6.35±0.65 g for the left bulbus oculi in males and 7.42±1.37 g, 8.00±1.19 g and 8.96±0.85 g in females, respectively. The right bulbus oculi of these goat breeds were reported as 7.27±0.73 g, 5.88±1.22 g and 6.43±0.48 g in males, 7.28±1.18 g, 7.94±0.82 g and 8.74±0.65 g in females (14). In buffaloes (15), it was expressed as 20.35±0.17 g. Demircioğlu and Yılmaz (11), the volume of bulbus oculi in Awassi sheep was reported to be 12.15-16.31 cm³ on average and there was a significant difference between the sexes for both eyes. In this study, the volume of the bulbus oculi was 10.22-9.88 cm³ in females and males, which was not statistically significant, while it was

between 11.35-9.95 cm³ in Morkaraman and a significant difference was found between sexes for both eyes.

Verma et al. (15) in buffaloes, Olopade et al. (14) in three goat breeds in Nigeria, Demircioglu and Yılmaz (11) in Awassi sheep reported that the DV diameter of the bulbus oculi was smaller than the ML diameter. In this study, ML diameters of right and left bulbus oculi of Akkaraman and Morkaraman sheep were found to be longer in both sexes in accordance with the literature. It has been reported that the cornea of Marwari sheep is elliptical in shape and its horizontal diameter is larger than its vertical diameter (16). It has been reported that the mean ML diameter of the cornea for both eyes of male and female Awassi sheep is between 24.09-21.99 mm and the mean DV diameter is between 16.87-18.66 mm (11). The mean value of ML diameter of cornea in Akkaraman sheep was 20.27 mm and DV diameter was 14.08 mm (12). In this study, the ML diameter of the cornea was found to be longer than the DV diameter in both sexes and both eyes of Akkaraman and Morkaraman sheep and it was observed that the cornea had an elliptical shape in these species in accordance with the literature.

In Marwari sheep, the mean value of corneal thickness was reported to be 0.85±0.03 mm on both sides, 0.91±0.04 in the center and 0.79±0.02 mm in the periphery (16). In Akkaraman sheep, corneal thickness in females was reported to be 0.73±0.09 mm in the periphery and 0.61±0.08 mm in the center, while in males these values were 0.87±0.03 mm and 0.83±0.05 mm, respectively (12). In this study, it was determined that the cornea was thicker in the center in both eyes and both sexes in Akkaraman and Morkaraman sheep in accordance with the data of Barhaiya et al. (16). Dalga et al. (17) reported pupil DV and ML diameters of Morkaraman sheep as 6.07±0.66 mm and 11.39±0.37 mm in females and 5.50±1.32 mm and 11.50±0.62 mm in males, respectively. In the same study, in Norduz sheep, pupil DV and ML diameters were reported as 3.17±0.30 mm and 4.45±1.00 mm in females and 10.34±0.45 mm and 10.97±0.88 mm in males, respectively. Abuagla et al. (18) reported that pupil diameter in camels was 2.08±0.23 cm left and 2.04±2.1 cm right. In this study, it was determined that the ML diameter of the pupil was larger than the DV diameter in both sexes and both eyes of Akkaraman and Morkaraman sheep.

The average lens thickness reported in Barbary sheep is 9.04±0.33 mm (19), in buffaloes it is 8.67±0.15 mm (15), in Awassi sheep it is 8.87±21 mm on the right and 9.26±0.16 mm on the left in males (11), and Dalga et al. (17) reported 7.09±0.24 mm in females and 8.42±0.63 mm in males in Morkaraman sheep, and 5.08±0.87 mm and 5.57±0.81 mm in Norduz sheep, respectively. In this study, the thickness at the center of the lens was 8.51±0.18 mm on the right and 8.39±0.17 mm on the left in males and 8.45±0.21 mm and 8.27±0.22 mm in females in Akkaraman sheep, in morkaraman sheep, right 8.49±0.21 mm and left 8.53±0.21 mm in males and 9.03±0.08 mm and 9.02±0.16 mm in females, respectively.

While the thickest part of the sclera is the region where the plexus venosus is located in cats and dogs, it was reported to be polus posterior in equus and ruminates. In this study, the thickest part of the sclera in both sexes was found

to be polus posterior in the thickness measurements made from the anterior - middle and posterior parts of the sclera in Akkaraman and Morkaraman sheep.

It is thought that knowing the anatomical characteristics of Akkaraman and Morkaraman sheep, which constitute an important part of sheep breeds in Turkey, will contribute to different branches of science. In the study, it was observed that significant differences according to sex were less in Akkaraman sheep but more in Morkaraman sheep. In this study in which two breeds were compared, it is noteworthy that the differences in females were higher according to sex.

The use of animal models in scientific research is an important step for both animal and human health. When some studies are examined, it is seen that there are many similarities between humans and sheep in terms of bone ratio, size and microstructure. Therefore, sheep bones are the most suitable animal models preferred in various biomedical research fields (20-23). A recent comprehensive literature review described various animal models for implant biomaterial research (24). Additionally, Sakarya et al. (25) stated in their research where they applied an eye autotransplantation model in sheep that a complete postoperative vascularization was formed. It is thought that determining the sexual dimorphism and symmetrical variations of bulbus oculi will contribute to both veterinary ophthalmology and human ophthalmology where sheep are preferred as model animals.

CONFLICTS OF INTEREST

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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