Images of Normal Ocular Fundus in Saanen Goats

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SUMMARY

Imaging of the fundus during ophthalmological examination of the eye allows the evaluation and diagnosis of many diseases. Traditionally, eye examination is performed by using an ophthalmoscope. Indirect ophthalmoscopy is also used for visualization of the posterior segment in animals. By this way, posterior segment structures of the eye such as optic disc, retina, tapetal and nontapetal regions, retinal vessels and choroidea can be examined. Ultrasonography and special camera systems are also used currently to image for the ocular fundus. The structure of the fundus can vary between species, as well as between races within the same species. No study on fundus imaging of Saanen goats were found among the ophthalmological studies performed in goats. The ClearView fundus camera was used by holding it towards the goat's pupils, and both eyes were examined. Data on the tapetal region, optic disc in the nontapetal region, retina and retinal vessels were obtained. All goats tapetal regions contained predominantly blue or green (most frequently). The nontapetal region was predominantly dark brown. The optic disc was located at the tapetal-nontapetal region border mostly located in the tapetal region. The form of the optic disc was oval and round. A gray spot in the center of the disc represents the remnant of the hyaloid artery or Bergmeister's papilla. Bergmeister papillae were found in 29 animals in total, and in only one eye of 10 animals. The tapetal fundus in goats had a mild uniform stippling at the end of the capillaries called stars of Winslow. These stars are characteristic, giving these species a singular ophthalmoscopic aspect. While Winslow's stars were observed in 35 animals in total, they were found in only one eye in seven goats. Our study aimed to obtain the normal reference values of the fundus of Saanen goats and to contribute to the literature.

KEY WORDS

Caprine; optic disc; retina; tapetal; small ruminant.

INTRODUCTION

The eye is an organ of the visual system and a structure that can reflect the symptoms of diseases of the vascular and central nervous systems. Therefore, all kinds of information obtained from the eye examination is very important.[1]

Saanen goats are known to originate from the Saanen Valley of Switzerland and have the largest breed characteristics among goat breeds in Switzerland. [2] Eye problems in goats can cause serious economic losses as with all farm animals.[3] Ophthalmic studies in goats are generally encountered infrequently. However, goats are often preferred for practicing manipulative approaches to the eye in human ophthalmology.[4]

Imaging of the fundus during the ophthalmological examination of the eye allows the evaluation and diagnosis of many diseases. However, when the normal anatomical components of the ocular fundus are not fully known, it is impossible to fully evaluate the pathological changes.[5]

Traditionally, eye examinations are performed by using an ophthalmoscope. Indirect ophthalmoscopy is also used to visualize the fundus and posterior segment structures such as optic disc, retina, tapetal and nontapetal regions, retinal vessels and choroidea.[6] Anatomical and pathological information about these structures can be accessed by imaging the fundus, and the animal can be identified simultaneously.[7,8] For this purpose, various fundus imaging techniques can be used to reveal data on these structures following dilation of the pupil with mydriatics.[9] Today, ultrasonography, fluorescein angiography and special camera systems are also used for this purpose.[10] The structure of the fundus can vary between species, as well as between races within the same species. No studies were found on fundus imaging of Saanen goats among the ophthalmological studies conducted in goats. Therefore, our study aimed to obtain the normal reference values of the fundus of Saanen goats and to contribute to the literature.

MATERIAL AND METHODS

The material of the study consisted of 54 healthy adult female

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Saanen goats. No ophthalmic abnormalities were present. Preclinical examinations of all goats included in the study were performed before the procedure. Body temperatures were measured, heart and respiratory sounds were listened to in order to determine any abnormalities. Goats with normal physiological values were included in the study and then ophthalmological examinations were carried out. Reflex examinations such as pupillary light reflex, palpebral reflex, menace reflex and dazzle reflex were performed. As a result of the reflex examinations, reflexes were scored as present/weak/absent. The eyelids, conjunctiva, cornea, iris and lens were examined under direct ophthalmoscopy to determine if there were any eye problems. Tear production and intraocular pressure were assessed. Tear production values (10.2±3.4 mm/min) and intraocular pressure (16.4±5.75 mmHg) were found. And these finding were considered normal. All healthy goats were included in the fundus examination as part of the study.

Inspections of all goats was carried out in a semi-dark environment. For this purpose, the goats were brought to the examination area five minutes before the procedure, so that their eyes could become accustomed to the environment and the goats could be calmed down. Sedation and local or parenteral anesthesia were not administered to the goats. In addition, local midratics were not administered to any of the goats before or during the procedure.

A ClearView Fundus (Kruuse / Langeskov - Denmark) camera was used by holding to the goats' pupil, and both eyes were examined. Fundus examination in goats was performed while the animals were standing with their heads held in a natural position to maintain the natural position of the eyeball. The images were then transferred and recorded in a computer environment. Following the adaptation of the goats to the semi-dark environment, the examination was started without general or local anesthesia and any mydriatic drops. The camera was held at a 90-degree angle to the horizontal plane of the goat's eyes while they were standing. The camera lens was approximately 1 cm away from the cornea. This position was attempted to be maintained in all fundus examinations performed in goats. Fundus images were taken while the optic disc located in the center (Figure 1). In addition, this position contributed to the accurate visualization and interpretation of the retinal vascular system. The color of the tapetal area during fundoscopy was evaluated on the images in which the optic disc was fully visible in order to prevent different reflections of light. Data on the tapetal region, optic disc in the nontapetal region, retina and retinal vessels were obtained.

Figure 1 - Fundoscopy via ClearView fundus camera. Optic disc can be seen on screen at the center of the fundus image.

The pupils of the goats were observed to be rectangular shape and extended horizontally. Fundus findings in goats were analyzed, such as tapetal region, nontapetal region and optic disc. Additionally, differences in the retinal vessels were revealed. The color, shape, and homogeneity of the tapetal region, the border of the tapetal-nontapetal region, the color of the nontapetal region, the border, location and characteristics of the optic disc, and retinal vessels were determined.

GraphPad Prism7 (Carlsbad, CA, USA) was used to compare the significance levels between fundus differences amongst goats. The chi-square method conducted for evaluation of data with an accepted significance level as $p<0.05$.

RESULTS

All goats' tapetal regions contained predominantly blue or green regions, however, green (81.48%) was observed most frequently. Apart from this, there was 3 goats (5.55%) with green-orange, green-blue and purple-blue tapetal region color. The pigment ratio in the tapetal regions was more intense in the temporonasal region.

The nontapetal region was predominantly dark brown and heterogeneous due to the pigment density in 51 goats (94.44%), green-brown in 2 goats (3.70%), and blue in 1 goat (1.85%). The optic disc was located at the border of the tapetal and nontapetal regions, mostly in the tapetal region. The form of the optic disc was oval and round. The optic disc structure was different in the right and left eyes of 5 goats (9.25%). The optic disc was mostly light orange (82.40%), while in some goats it appeared in a faint orange contrast (15.74%) due to differences in the homogeneity of the papillae. Brown areas were observed in the optic disc of one eye of 2 goats (3.70%) (Table 1). The optic disc was partially or completely surrounded by oval-shaped, pigmented rings. Oval pigmented Bergmeister papillae have been found in goats due to myelination of the optic nerve head. Due to the myelination of the disc, orange or grayish pigment rings were evident in the temporal and medial regions of the optic disc. It was accepted that the remnant of the hyaloid vessel appears frequently in congenital vascular anomalies in goat and sheep.

A gray spot in the center of the disc represents the remnant of the hyaloid artery or Bergmeister's papillae. It was observed that these papillae created bumps that resembled fingers on the optic nerve head and their color changed depending on the degree of vascularization. In the study, Bergmeister papillae were found in 29 goats (53.70%). In 10 of these goats, it was found in a single eye (18.51%) (Figure 2). In 15 animals (27.77%), Bergmeister papillae could not be observed in either eyes (Table 2).

The tapetal fundus in goats had a mild uniform stippling at the end of the capillaries called stars of Winslow. Winslow's stars surrounding the optic disc were usually a pale, yellowish color (Figure 3). While Winslow's stars were observed in 35 animals (64.81%) in total, they were found in only one eye in 7 goats (12.96%). In 12 goats (22.22%), Winslow's stars could not be detected in either eyes (Table 2).

Dominant retinal vessels were visible in all goats. The vascular structure in the retina was homogeneous. Vascular patent was similar to other ruminates. Three types of vessels emerging from the optic disc were observed; the first of these was the veins which

Table 1 - Fundus differences among goats.

	Number of eyes (n=108)	Number of animals (n=54)	*p-value*
Tapetal region color			
Green	88 (81.48%)	44 (81.48%)	
Blue	14 (12.96%)	7 (12.96%)	**0.010**
Green-Orange	2 (1.85%)	1 (1.85%)	
Purple-Blue	2 (1.85%)	1 (1.85%)	
Green-Blue	2 (1.85%)	1 (1.85%)	
Nontapetal region color			
Brown	102 (94.44%)	51 (94.44%)	**0.012**
Green-Brown	4 (3.70%)	2 (3.70%)	
Blue-Brown	2 (1.85%)	1 (1.85%)	
Optic disc morphology			
Oval	69 (63.88%)	32 (59.25%)	**0.064**
Round	39 (36.11%)	17 (31.48%)	
Oval-Round	0 (0%)	5 (9.25%)	
Optical disc color			
Orange	89 (82.40%)	41 (75.92%)	
Pale Orange	17 (15.74%)	6 (11.11%)	**0.078**
Brown-Orange	2 (1.85%)	2 (3.70%)	
Orange-Light Orange	0 (0%)	5 (9.25%)	
	0 (0%)	0 (0%)	
Bergmeister papillae	68 (62.96%)	29 (53.70%)	**0.036**
Unilateral Bergmeister papillae	0 (0%)	10 (18.51%)	
Winslow's stars	77 (71.29%)	35 (64.81%)	**0.028**
Unilateral Winslow's stars	0 (0%)	7 (12.96%)	

were the largest in diameter and the darkest in color. The second one was determined to be arteries, with a lighter color and smaller diameter compared to the veins, and originates more peripherally on the disc. The third vessel was determined as capillaries, which have a much smaller diameter than arteries and veins. The capillaries originate from the disc and disappear 1 or 2 disc diameters distance away from the disc (Figure 4). The measurements in these vessels were evaluated visually.

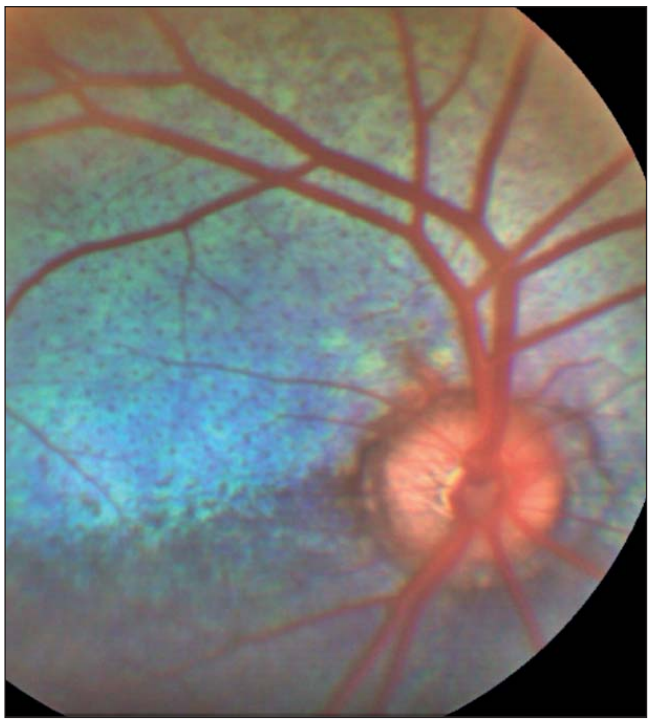

Figure 2 - Bergmeister papillae projects from the central portion of the optic disc into the vitreous body.

Generally, the numbers of veins, arteries and capillaries displayed in the optic disc area varies in animals. Indeed, a total of 3-6 retinal arteries and 2-5 retinal veins were found in goats. We observed that most of the goats had 4 retinal arteries (38.8%). This was followed by 3, 5 and 6 arteries, respectively. Additionally, considering the number of retinal veins, goats with 2 retinal veins were predominant (63.8%). This was followed by 3, 5 and 4 veins. In a total of 51 eyes (47.22%), the number of arteries extending dorsally was higher than those extending ventrally. In 14 eyes (12.96%), the number of ventral arteries was higher. In 43 eyes (40.95%), the numbers of dorsal and ventral arteries were equal.

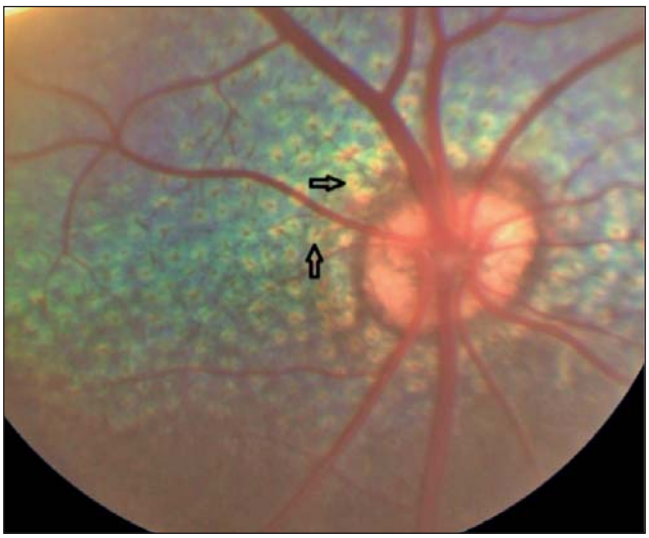

Figure 3 - Winslow's stars that surrounded by a yellowish area (arrows), show different color, size and morphology. Winslow's stars are visible throughout the tapetal fundus and represent end-on choroidal capillaries extending vitread through the retinal pigment epithelium.

Table 2 - Number of vessels determined in goats.

	Number of eyes (n=108)	Dorsal/Ventral ratio
Number of Arteries		
3	37 (34.25%)	2/1=26 1/2 = 11
4	42 (38.88%)	2/2=41 3/1 =1
5	26 (24.07%)	3/2=23 2/3 =3
6	3 (2.85%)	4/2=1 3/3=2
Number of Veins		
2	69 (63.88%)	1/1 =69
3	36 (33.33%)	2/1= 31 1/2 =5
4	1 (0.92%)	3/1=1
5	2 (1.85%)	3/2=2

Figure 4 - White arrows: Veins. Black-white arrows: Arteries. Black arrows: Small vessels. The veins are larger than arteries and darkest. The vessels have the smallest diameter and originate from the optic disc.

While the number of veins extending towards the dorsally was high in 34 eyes (31.48%), the number of veins towards the ventrally was high in 5 eyes (4.62%). In 69 animals (57.40%), the number of veins extending both dorsally and ventrally were equal. The number of arteries in both eyes was equal in 23 (42.59%) of the goats and the number of veins was equal in 28 (51.85%) (Table 2). It was observed that the vessels extended to the middle part of the optic disc. No signs of diseases such as active chorioretinal disease, retinal detachment, or scarring were found in any of the goats. It was determined that the ophthalmoscopic fundus images of goats were different from those of cattle and sheep.

There's no significance between optic disc morphologies ($p>0.05$). The most frequency amongst tapetal region color is green (44) and brown (51) is most frequent color amongst nontapetal region. There is also small significance (p 0,036) between Bergmeister papillae- unilateral Bergmeister papillae and Winslow's stars- unilateral Winslow's stars.

DISCUSSION

There are several methods of evaluating the posterior segment, such as ocular ultrasonography, retinal optical coherence tomography, fluorescein angiography, fundus photography and direct and indirect ophthalmoscopy. Whereas direct and indirect ophthalmoscopy and fundus photography are often used for fundus imaging.[9,11]

Fundus structures may differ between animals and between species. Currently, no study has been conducted to reveal ophthalmological data using fundus imaging in Saanen goats. Our study aimed to obtain the normal reference values of the fundus of Saanen goats and to contribute to the literature. In the presented study, a ClearView fundus camera was used to take fundus images of the posterior segment of a total of 54 Saanen goats.

In the presented study, no mydriatic drug was applied locally to the eye. Some structures of the fundus were evaluated, likely due to the rectangular shape of the pupils of goats which allows for examination. Winslow's stars could not be detected in both eyes of all goats. It is thought that the differences in the imaging angle and the lack of mydriatic medication during the fundus images caused the Winslow's stars not to be seen sometimes. [10] The different angles of the images taken during fundoscopy were considered as an individual error. It is necessary to look at different angles to view the entire fundus, and it was thought that the shape of the pupil may have influenced these angles. The lack of visualization of structures such as Winslow's stars in some animals is thought to be due to the insufficient mydriasis. [10]

The most dominant color of the tapetal regions of goats was determined as green. While green tapetal color was dominant in 44 goats (81.48%), blue tapetal color was observed in 7 goats (12.96%). Galán et al. [10] reported that the dominant tapetal color in goats is blue, and Sengoz Sirin [12] found a higher rate of mixed tapetal colors, including yellow, blue and green.

The nontapetal region was predominantly dark brown in 51 goats (94,44%) and was heterogeneous due to the pigment density. However, Galán et al. [10] and Sengoz Sirin [12] reported that nonpigmented nontapetal regions are more dominant.

The location of the optic disc was mostly observed in the tapetal region, and less at the border of the tapetal-nontapetal region. While Rambabu and Ramani [11] detected the optic disc in the tapetal region in goats, Galán et al. [10] and Sengoz Sirin [12] observed the optic disc at the tapetal-nontapetal region border in goats. Aksoy et al. [13] found the optic disc mostly in the tapetal region in dogs, while Shinozaki et al [14] found the optic disc is in the ventral of the tapetal region in horses. In our study, optic disc localization was observed at the border of the tapetal-nontapetal region similar to the studies of Galán et al. [10] and Sengoz Sirin [12].

The shape of the optic disc was found as horizontal in deer [1], oval in dogs and horses [13,15]. In other studies conducted in goats, Broadwater et al. [4] found the optic disc to be oval, Rambabu and Ramani [11] found it to be round, Sengoz Sirin [12] and Ledbetter and Gilger [16] found it to be oval and round. In our study, the optic disc was observed in both oval and round forms in goats, and the dominant form was oval (63.88%). Additionally, in 5 goats (9.25%), it was observed that the form and shape differed between in the right and left eyes. The color of the optic disc was found to be orange light (82.40%) as stated by Galán et al. [10] and Sengoz Sirin [12].

Oval pigmented Bergmeister papillae have been found in goats due to myelination of the optic nerve head. It has been observed that these papillae create finger-like bumps on the optic nerve head and appear in varying colors depending on the degree of vascularization. While Bergmeister papillae were observed in 29 animals (53.70%) in total, it was not found in one eye of 10 animals (18.51%) and in both eyes of 15 animals (27.77%). Galán et al. [10] and Sengoz Sirin [12] also detected Bergmeister papillae in their study in goats and these results consistent with our study.

Nasisse [17] suggested that Winslow's stars are red only when the tapetal region is yellow in their study of foals. Ledbetter and Gilger [16], stated that the color of Winslow's stars is independent of the color of the tapetal region. In the present study, Winslow's stars surrounding the optic disc were seen bilaterally (64.81%) in 35 goats and unilaterally in 7 goats (12.96%), appearing as light yellowish in color. In 12 goats (22.22%), Winslow's stars could not be detected in both eyes because of the mydriatic was not applied. Galán et al. [10] and Sengoz Sirin [12] stated that the color of Winslow's stars is independent of the color of the tapetal region and that the yellowish area around the optic disc may originate from capillaries that cross the tapetum. In this study, it has been determined that the Winslow's stars can appear in different colors and shapes.

In goats, three recognizable retinal vessels originating from the optic disc were observed. These are arteries, veins and capillaries. In our study, it was observed that the number of arteries ranged from 3 to 6 and the number of veins ranged from 2 to 5. It was observed that the arteries were mostly extended dorsally (47.22%), while the veins were mostly located equally in both the dorsal and ventral directions (57.40%). Sengoz Sirin [12] detected 3-6 arteries and 5-8 veins. Galán et al. [10] found 3-6 arteries and 2-3 veins in goats. They determined the ratio of the number of arteries extending to the dorsal area to be 1/3. Also they found the ratio of the number of veins to the dorsal and ventral areas to be half.

CONCLUSION

In conclusion, this study of 54 Saanen goats provides valuable information on ophthalmic examination findings in these animals. No signs of diseases such as active chorioretinal disease, retinal detachment, and scarring were found in any of the goats. It was determined that the ophthalmoscopic fundus images of goats were distinct from those of cattle and sheep.

The limitations of this study were that lack of mydriatic usage and the angles of imaging affected the images. However, the pupillary structure of goats allowed examination without the use of mydriatics. Examination was possible without the mydriatic, but this limited the visibility of the Winslow's stars. The angle of the fundus camera may cause color differences in the tapetal area; however, these differences were minimized as the color of the tapetal area was evaluated in the images where the optic disc was in the center.

Ocular fundus images results provide normal means and ranges to help identify clinical cases of ophthalmic disease in Saanen goats

Conflict of Interest Statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

Ethical Approval

The ethical approval of the study was provided by the University's Institutional Animal Care and Use Committee (approval number:64583101/2021/121). In this study, a signed information confirmation form was obtained from the patient owners.

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