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Normal Ocular Fundus Imaging with Smartphone Ophthalmoscope in Honamlı Goat Breed

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Abstract

It is very important to show the ocular fundus, which is useful in identifying some systemic and hereditary diseases in farm animals. However, herd-based ophthalmoscopic scanning in farm animals is quite difficult under field conditions. In this study, using a prototype D-EYE® system in the iPhone 5 model, it was aimed to record the ocular fundus images of the herd of Honamlı goat breed and to emphasize its practicality in the protection of herd health. No signs of disease were encountered in herd screening using smartphone ophthalmoscopy. In this study, the normal variations of the fundus, tapetum color, the reflectance of the tapetum, the shape of the tapetal area, the homogeneity of the tapetum, the location of the optic disc or retinal endothelium, the color, shape, border, and the relationship between the hair color and the pigmentation of the tapetal region were examined. It was revealed that herd-based ophthalmoscopic examination is difficult in field conditions to protect herd health, while herd-based scanning using smartphone ophthalmoscopy is quite practical and the video images taken are sufficient for clinical examination. With this study, normal ophthalmoscopic fundus views of Honamlı goats were presented and contributed to the literature.

Key Words: Honamlı goat breed, D-EYE®, ocular fundus, smart phone ophthalmoscopy

Akıllı Telefon Oftalmoskop ile Honamlı Keçi Irkında Normal Oküler Fundus Görüntülenmesi

Öz

Çiftlik hayvanlarında bazı sistemik ve kalıtsal hastalıkların tanımlanmasında yararlı olan oküler fundusu görüntülemek çok önemlidir. Bununla birlikte, çiftlik hayvanlarında sürü tabanlı oftalmoskopik tarama, saha koşulları altında oldukça zordur. Bu çalışmada, iPhone 5 modelinde bir prototip D-EYE® sistemi kullanılarak, Honamlı keçi sürüsünün oküler fundus görüntülerinin kaydedilmesi ve sürü sağlığının korunmasındaki pratikliğinin vurgulanması amaçlanmıştır. Akıllı telefon oftalmoskopi kullanılarak sürü taramasında herhangi bir hastalık belirtisine rastlanmamıştır. Çalışmada fundusun normal varyasyonları, tapetum rengi, tapetumun yansıması, tapetumun homojenliği, optik diskin veya retinal endotelin yeri, renk, şekil, sınır incelenmiştir ve kıl örtüsü rengi ile tapetal bölgenin pigmentasyonu arasındaki ilişki incelenmiştir. Bu çalışma ile Honamlı keçilerinin normal oftalmoskopik fundus görüşleri sunulmuş ve literatüre katkıda bulunulmuştur.

Anahtar Kelimeler: Honamlı keçi ırkı, D-EYE®, oküler fundus, akıllı telefon oftalmoskop

INTRODUCTION

Fundus imaging is very important in determining posterior segment diseases among animals (1). Traditional fundus photography, which is used to document fundus findings, is performed in a clinical setting with a fundus camera (2). However, the biggest drawback of this imaging system is its immobility and expensive equipment (3). Recently, the growing popularity of smartphones, high-resolution cameras, large data storage capacities, ease of image capture and sharing have led to the widespread use of smartphones in fundus photography, along with rapid advances in technology (4, 5). Although it is a complementary diagnostic tool by veterinary ophthalmology specialists, it is a unique, simple and affordable application that provides photo-video documentation of retinal changes in many clinical environments where retinal imaging was not possible before, allowing for consultation sharing (6, 7).

The ophthalmoscopic features of sheep and goats are superficially compared to bovine ophthalmoscopy (8). While the ocular fundus of cattle and sheep is quite similar to ophthalmoscopically, the ocular fundus of goats is slightly different (9). These species have many individual variations in their ocular fundus. Before really diagnosing ocular fundus pathology, the fundus of a large number of animals should be examined to truly understand what normal is (1, 8). Most of the posterior segment changes reported in farm animals are acquired and foodborne. Also, congenital fundus abnormalities are common. It has been reported Bacterial, parasitic (mycoplasmosis, listeriosis, elaeophorosis, trypanosomiasis, and toxoplasmosis), viral (bovine viral diarrhea, blue tongue, scrapie), nutritional disorders (vitamin A deficiency), systemic poisonings (stypandra glauca, pteris aquilinum and geven poisoning) that posterior segment changes are observed due to teratogenic (veratrum californicum) and hereditary (storage diseases) causes. In addition, changes in the tapetum, retina and retinal vessels can be monitored ophthalmoscopically in hematological disorders such as anemia, icterus, and polycythemia (10). Systemic diseases can be identified by visualizing the ocular fundus and programming can be used to eliminate hereditary eye diseases (11).

Goats are quite common compared to other species that exist in the world. This is due to their ability to adapt to environmental conditions, to be resistant to many diseases and parasites compared to other species, and to their adaptation to different feeding and care conditions under the conditions in which they are raised in human hands (12). In our country, the Honamlı goat race was included in the scope of indigenous breeds protected by the General Directorate of Agricultural Research and Policies in 2005, according to the communiqué numbered 2005/8503 within the scope of Conservation of Animal Genetic Resources and necessary studies were started. The number of studies on the Honamlı goat race, which has superior characteristics than other domestic goat breeds in terms of morphological, fertility and growth characteristics, is low (13). The most characteristic feature of Honamlı goats is their curved noses. The most common color was determined as black, and also in gray and pied colors (14).

The aim of this article is to reveal that herd-based ocular fundus examination can be performed easily by using smartphone ophthalmoscopy in field conditions in farm animals and to contribute to the literature by presenting normal ophthalmoscopic views of honamlı goats.

MATERIAL AND METHODS

110 (4 brood and 46 yearling) Honamlı goat breed who were raised in the small cattle Breeding Unit of the Mehmet Akif Ersoy University Veterinary Faculty Research and Application Farm Directorate, were included in this study.

Considering the convenience and accessibility it provides during the examination of the fundus, D-EYE®, which consists of a meta cell shell and original optical systems provided by Galileo Diagnostics Corporation (Galileo Genclis, Nancy, France), was selected for the imaging and evaluation of the fundus. In this study, a prototype D-EYE® was used on the iPhone 5 model. (Figure 1).

D-EYE® was introduced to the market with a metal frame compatible with Apple (iPhone 5, iPhone 5s and iPhone 6; Apple Inc., Cupertino, CA, USA) and Samsung (Galaxy S4 and Galaxy S5; Samsung, Taegu, South Korea) brand phones. This metal frame is a bumper designed to fit the outer mold of the phone, allowing the smartphone to be precisely aligned with the optics of the D-EYE®. The metal frame allows the D-EYE® to be easily mounted thanks to its two neodymium magnets. D-EYE® consists of special lenses, polarizing filters, a beam splitter, a diaphragm and mirrors in a configuration that reduces light reflections, aligns the LED light beam and can compensate for corneal glare. The optical path of the D-EYE® allows fundus imaging with the camera lens of the smartphone. It has two polarization filter combinations that significantly reduce corneal reflection with cross-polarization. A diaphragm is added to the device to reduce the intensity of the light emitted by the flash.

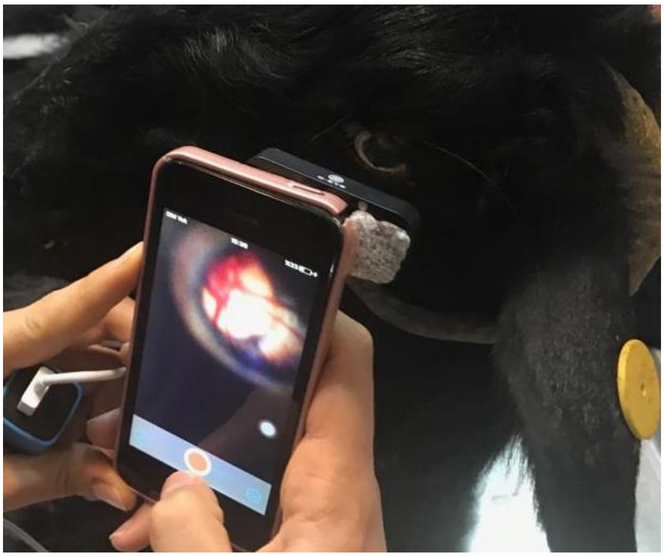

Figure 1. Fundus imaging with D-EYE® in a Honamlı goat. Iphone 5 equipped with the D-EYE® adapter. It is magnetically attached to the Iphone 5.

In order to create photos and videos, an application called “D-EYE®” is required, which can be used on both iOS and Android platforms. "Retina scan" is selected after login to the application. The patient's descriptive information is entered, and then the operator chooses Oculus Dexter (OD) (right eye) or Oculus Sinister (OS) (left eye). Image recording and video recording called “multishot” can be taken with the application.

Artificially dark was created in the diagnostic area for correct fundus examination. In the direction of experience from previous studies, mydriatic was not used when obtaining fundus images. Both eyes were examined at the same time. While the goats were physically in a standing position, the eye was approached from a distance of 10 cm. The light intensity was adjusted by moving from left (minimum level) to right (maximum level) with the slider available in the application. Minimum light intensity was preferred to display tapetum lucidum. During the imaging of the nontapetal region, medium and high light intensities were selected. In animals where the autofocus algorithm failed to achieve a sharp image, the focus was locked to infinity before aiming at a distant object (a few meters). When the subject appears clearly on the screen, AF is locked by pressing the AF button. Records were created by following the same method for each animal. Images were checked at every stage and repeated if not satisfactory.

RESULTS

Throughout the study, the smartphone was held in the left hand while performing the right eye examination and in the right hand while performing the left eye examination. In cases where autofocus was not able to lock the fundus, it was locked to infinity for the first time as described before and the examination was repeated. The smartphone was positioned at a distance of 1-2cm from the patient's eye. The fundus of the examined eye was examined in real-time on the phone screen before recording. When the fundus image was captured, the record button was pressed. While the fundus examination was performed, the animals were quite compatible and fundus images could be recorded in a short time, such as 1 minute.

When the fundus images of the examined eye were examined, it was observed that the images obtained using the multishot feature were not suitable for the evaluation of the fundus due to the low quality. It was determined that the video records taken during the examinations with D-EYE® were more effective in the evaluation of the fundus. In this study, the images of the fundus examination of Honamlı goats were created by examining the screen images taken from video recordings. During the examinations with D-EYE®, all the structures belonging to the fundus were displayed through the video recording feature. The image field capacity and the need for mydriatic use of the device were not found to be important since the video recordings allowed the entire fundus to be examined.

Normal variations of the fundus were tapetum color, the reflectance of the tapetum, the shape of the tapetal area, the homogeneity of the tapetum, the junction of the tapetal and non-tapetal boundary, the location, color, shape, border, and degree of myelin of the optic disc or retinal endothelium were evaluated. Focal light artifacts were common when displaying fundus. These light artifacts were generally located on the dorsal part of the image (Figure 2).

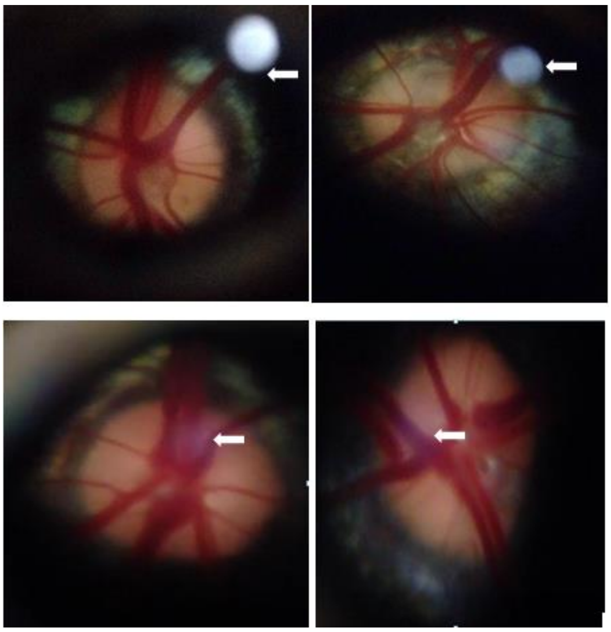

Figure 2. Focal light artifacts were common in the photographs. (Shown with white arrow).

The ophthalmoscopic evaluation of the ocular fundus of Honamlı goats used in the study was normal and no signs of disease were encountered. In examinations performed using smartphone ophthalmoscopy, the ocular fundus of goats was different from cattle and sheep (Figure 3). The optic disc had round (61.81%) and oval (38.18%) shape (Table 1). The optical disc was located at the junction of the tapetal and non-tapetal region, with a large part of it located in the tapetal fundus. The optical disk encircled a partially or fully oval-shaped pigmented ring (Table 1). Depending on the myelinization of the disc, a diffuse transition line was observed. The pigmented ring of orange or grayish color was more prominent in the temporal and medial regions of the optic disc. Bergmeister's papillae were seen in varying colors depending on the degree of vascularization (Figure 4). As a result of the fundus examination of the goats included in this study, the display rate of Bergmeister's papilla was determined to be 80% (Table 1). The number of retinal blood vessels was high. Although the number of vessels displayed in the optic disc area is variable, generally 3 to 6 primary arteries (88.18%) and 5 to 8 primary venules (84.54%) were seen (Table 1). The capillary choroid was mostly pierced by the capillaries (stars of Winslow) and was surrounded mostly by a light yellowish area (Figure 5). It was observed that the tapetal fundus had yellow, green, and blue colors (Table 1). The fundus of the dark-feather animals had more intense pigmentation. The non-tapetal fundus had a dark and light brown color (Table 2). It had a heterogeneous appearance due to the varying density of the pigment.

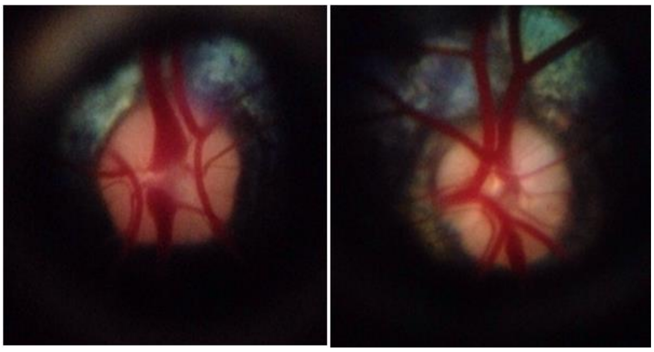

Figure 3. Normal ocular fundus appearance of Honamlı goats. The optical disc has a round shape. Retinal blood vessels are abundant and have different variations.

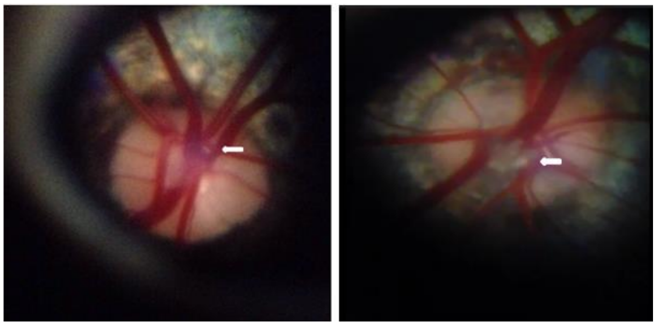

Figure 4. Bergmeister's papilla projects from the central portion of the optic disc into the vitreous body (arrow).

Table 1. Details of fundoscopic findings between individuals

Fundoscopic findings	**n**	**%**
Blue tapetal zone	15	%13.63
Green tapetal zone	22	%20,00
Yellow. blue and green tapetal zone	73	%66.36
Yellowish area surrounding Winslow's Stars	91	%82.78
Round optic disc	68	%61.81
Oval optic disc	42	%38.18
Bergmeister's papilla	88	%80,00
Pigmented and delimited edge	85	%77.27
Primary artery	97	%88.18
Primary venules	93	%84.54

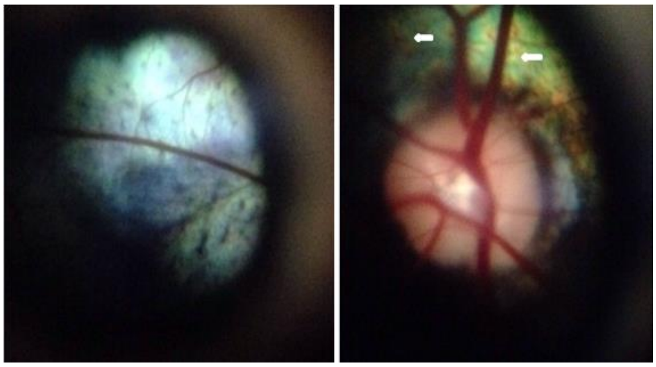

Figure 5. Winslow's stars, surrounding by a yellowish area (arrows), show different colour, size and morphology

Table 2. The relationship between individuals' dark feather color and pigmentation

	n		**n**	**%**
Honamlı goats with dark feather color	86	Honamlı goats with intense pigmentation	67	%77.90
Total Honamlı goat	110	Honamlı goats with intense pigmentation	67	%60.90

DISCUSSION AND CONCLUSION

Khanamiri et al. (2) compared the quality of the fundus images taken with a smartphone and the quality of the images taken using traditional fundus cameras, and there was no significant difference between the images. Fundus photography can be done in a clinical setting using fundus cameras, but the expensive and immovable equipment is the biggest disadvantage of this method (2). Miniaturization and improvement of internal photographic equipment (lenses, sensors, lighting systems, and autofocus systems, etc.) have made smartphone-based fundus imaging very powerful tools. An example of a small optical device that can be connected to a smartphone is the D-EYE® module (D-EYE® Srl, Padova, Italy). Smartphone-based fundus imaging systems have been described in both humans and animals. Although the ophthalmoscopic technique used by D-EYE® for visualization of the fundus is not clearly replaced, it is very similar to direct ophthalmoscopy (15). In this study, it was tested the availability of D-EYE® in the veterinary field, especially in farm animals. It was obtained the images within 1 minute during the fundus examination it was performed in Honamlı goat herd. It is thought that D-EYE® may be the reason for preference in ophthalmological examinations while performing herd screening in the veterinary field and farm animals. During the fundus examination in Honamlı goat herd, it was approximately obtained the images within 1 minute. It was thought that D-EYE is very practical in obtaining ophthalmological data in the veterinary field in general screenings for the protection of herd health of farm animals and maybe the reason for preference.

In this study, it was observed that mild focal artifacts were common in the focal region. Balland et al. (15) reported that the tapetum area is overexposed and the works appear as smooth areas that do not cover the entire tapetal area, their size varies, and there are no visible details. Exposure problems have manifested themselves as light artifacts in images. This problem can be solved by turning off autofocus and manually focusing forever through the app. In contrast, the relatively small size of the iPhone sensor may be responsible for overexposure in the tape region (15). Kanemaki et al. (2) stated that the light intensity should be increased when photographing the tapetal region and the light intensity should be increased during photographing the non-tapetal region to prevent overexposure when recording images. In contrast, although high image resolution is set during video recording, it has been suggested that image resolution may be low due to low light (7). With this study, it was determined that mild artifacts resulting from this overexposure could be confused with retinal pathologies. It was created photo and video recordings through fundus examination with D-EYE®. It was found the opportunity to examine the light works in the videos, which provide a more dynamic examination opportunity. For this reason, it has been argued that the video recording feature offers a dynamic examination opportunity during the examinations with D-EYE® and is extremely important in distinguishing pathologies.

Galan et al. (8) reported that the tapetal fundus consists of almost a triangular area and more pigment is seen in the dorsonasal quadrant than the dorsotemporal quadrant. The authors stated that they could not detect a change in the non-tapetal region caused by the change in hair color (8). Crispin (16) stated that the tapetal fundus of herbivores consists of green, yellow and blue collagen (tapetum fibrosum) and this creates an effective barrier. For this reason, they suggested that by examining the non-tapetal fundus of herbivores, fundus pathologies would be more easily identified. As a result of this study, this confirms the literature information.

Brooks (17) suggested that the stars of Winslow in the foals are colored red only when the tapetal region is yellow. Galan et al. (8) stated that the color of Winslow's stars is independent of the color of the tapetal region, and the yellowish area around the veins may be caused by capillaries crossing the tapetum. In this study, it was found that the appearance of Winslow's stars was very variable in goats. It was observed that it can be brown or reddish, linear or round, and small or large in size.

Pearce and Moore (9) stated that in the goats, the optical disc is round and often completely inside the tapetal fundus. Kalaka and Ramani (1) stated that the optical disc is more prominent due to the presence of round and large amounts of myelin. In this study, the optical disc was displayed as round or oval-shaped. While the pigmented edges of the optic disc create a distinct Galan et al. (8) stated that the homogeneous color of Bergmeister's papilla varies from pinkish, orange to grayish and depends on the degree of the visible vascular system. They reported that there was no relationship between the animal's age and the presence of papillae (8). In this study, the Bergmeister's papilla was displayed in the vast majority of goats. This study also supports the knowledge that there is no relationship between the presence of papillae and age.

Goats have a holoangiotic vascular retina pattern (18). Galan et al. (8) suggested that there are three types of veins according to their size. These are: (i) large vessels, veins; (ii) middle vessels, often arteries; and (iii) small vessels, veins and arteries radiating from the optical disc. They stated that there were three to six retinal arteries in goats and that these arteries were in the dorsal and ventral. They stated that the dorsal fundus showed a split pattern due to the more intense branching of the vessels, therefore it was more vascularized than the ventral region. They also stated that the veins and arteries spread from the optic disc towards the temporal and medial region of the fundus (8). When it was examined the fundus of Honamlı goats with D-EYE®, it was saw that the primary artery originating from the dorsotemporal part of the optic disc branched and the retinal arteries emerged from several different points of the optic disc. It was saw that the veins reach the central of the optic disc and often articulate before leaving the fundus. In addition, in the video recordings, it was obtained while fundus images, arterial pulse can be observed on the optical disc.

It has been recommended the ophthalmological scans of the ocular fundus on the basis of the herd with smartphone ophthalmoscopy systems, as the system is light, compact, and inexpensive because it is done quickly. The photographs and video recordings have taken through the D-EYE® device was stored clinically via wireless connection and cloud memory and shared for consultation purposes. It was revealed with the examinations that the video images taken during the herd screening with the D-EYE® device allowed the ocular fundus to be examined. As a result of, it has been believed that more literature studies are required so that clinicians can easily make distinction between normal variations and signs of pathology since the fundus images of goats have several variations.

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