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Fundus Imaging via Infrared Camera without Mydriatics in Holstein Calves

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Abstract: This study aimed to record the ocular fundus images of healthy Holstein calves under field conditions. The fundus of 34 eyes of healthy 17 Holstein calves was examined with a fundus camera, which does not require mydriatics, as it has been designed especially for animals and provides imaging with infrared light. The findings showed that the green-yellow tapetal zone was dominant in all calves, the optic disc was oval, and the number of primary arteries and veins originating from the center varied between 4 and 5. The vascular pattern was holangiotic. A remnant of the hyaloid artery (Bergmeister's papilla) was detected as a gray dot in the middle of the disc. It was noted that the non-tapetal area was homogeneous, brown-black, and rich in choroidal vascular structure. Imaging the ocular fundus is essential in diagnosing some systemic and hereditary diseases in farm animals. However, herd-based ophthalmoscopic screening in farm animals is difficult under field conditions. By using this portable fundus camera, fundus examination can be performed easily under field conditions without taking the animals to the hospital. The standard ophthalmoscopic fundus images of healthy Holstein calves presented in this study will contribute to the literature.
Keywords: *Calf, Fundus photography, Ocular fundus, Retina*.

Holstein Buzağılarda Midriyatik Ajan Kullanmadan İnfrared Kamerayla Fundus Görüntülenmesi

Özet: Çalışmanın amacı sağlıklı Holstein buzağıların oküler fundusunun saha şartlarında görüntülenmesidir. Sağlıklı 17 Holstein buzağının 34 fundusu midriatiklerin kullanımını gerektirmeyen, hayvanlar için özel olarak üretilmiş bir fundus kamerası ile incelendi. Tüm buzağılarda yeşil sarı tapetal bölge baskın, optik disk ovaldi. Merkezden çıkan primer arter ve toplardamar sayısı 4-5 arasında değişmekteydi. Vasküler desen holanjiyotik olarak kaydedildi. Tüm buzağılarda diskin ortasında gri nokta şeklinde hyaloid arter kalıntısı (Bergmeister's papilla) tespit edildi. Tapetal olmayan bölgenin homojen, kahverengi-siyah renkte ve koroid damar yapısından zengin olduğu kaydedildi. Çiftlik hayvanlarında bazı sistemik ve kalıtsal hastalıkların tanısında oküler fundusun görüntülenmesi çok önemlidir. Ancak çiftlik hayvanlarında sürü bazlı oftalmoskopik tarama saha koşullarında oldukça zordur. Portatif fundus kamerası ile hastaların saha şartlarında hastaneye getirilmeden kolaylıkla fundus muayenesi yapılabilmiştir. Bu çalışmada sağlıklı Holstein buzağıların normal oftalmoskopik fundus görüntüleri sunulmuştur.
Anahtar Kelimeler: *Buzağı, Fundus görüntüleme, Oküler fundus, Retina*.

Introduction

The retina is the eye layer containing light-sensitive cells enabling vision. Defects and disorders formed in the retina, which is associated with the brain, affect the sense of sight. In order to detect visual impairments, we need to know the normal function of the retina and the diseases affecting the retina. Early identification of conditions affecting the retina without causing irreversible damage is vital in terms of early treatment and prognosis. Diagnosis of retinal disorders can be made with direct ophthalmoscopy, indirect ophthalmoscopy, smartphone-based ophthalmoscopy, scanning laser ophthalmoscope, optical coherence tomography, fluorescein angiography, ultrasonography, and electroretinography methods (Pearce and Moore, 2013; Şirin, 2020).

Diseases such as bovine virus diarrhea (BVD), rabies, malignant catarrhal fever (MCF), infectious meningoencephalitis, listeriosis, septicemia, particularly in calves with scours and umbilical infections, tuberculosis, and toxoplasmosis can cause retinal damage. Findings of tapetal color changes and loss of texture, attenuation of retinal vessels, focal depigmentation, varying degrees of retinitis, and choroiditis in the non-tapetal region can be observed (Martin et al., 2019). Thorough knowledge of the normal ocular fundus image is essential to diagnose diseases.

Considering how common eye diseases are in bovine (Gökçe and Gençelep, 2021; Han et al., 2019; İşler et al., 2014; Sarierler and Kilic, 2003), it is necessary to have a good knowledge of the healthy fundus image to perform a detailed eye examination. The normal fundus of animals consists of the neurosensory retina, retinal pigment epithelium, choroid, sclera, optic nerve head, and tapetum. Each species has a typical retinal fundus (Rajathi and Muthukrishnan, 2020). There are some detailed studies on the presence of retinal tapetum, visibility of choroidal vessels, retinal vascular pattern, optic disc position and shape, nerve fiber location, and gross anatomic findings in cattle (Çatalkaya and Özaydin, 2019).

Due to the large number of animals in dairy cattle farms, veterinarians have limited time. Fundoscopy with fundus cameras requires the use of mydriatic agents. Fundus camera needs a wired computer connection. There are many determining factors such as examination area, the need for more staff for restrain, waiting time for mydriasis, and drug cost. In dairy cattle farms, a fundoscopic examination should be fast, easy to apply, and inexpensive. This study aimed to obtain detailed standard fundus imaging of Holstein's calves under farm conditions with a portable non-mydriatic fundus camera.

Material and Methods

Animals: The study was conducted on the Arif Gürdal Dairy Farm. The Evaluation was made of 17 healthy male and female Holstein calves aged 3.5-4.5 months.

Ethical approval was granted by The Animal Research Ethics Committee ADÜ HADYEK (64583101/2021/169).

Fundus Examinations: All the calves included in the study underwent ophthalmological examination. All the animals were healthy, with no ophthalmological anomalies. The fundus examination of 34 eyes was performed with no drug administration to the animals using Ocellus-Vet (Vivente, Türkiye) fundus camera (Figure 1).

Animals were examined without anaesthesia, with proper restraining by one farm staff. While the eyelids were opened with the left hand, the camera was held with the right hand. Starting at a distance

Figure 1. Fundoscopy with a non-mydriatic portable fundus camera.

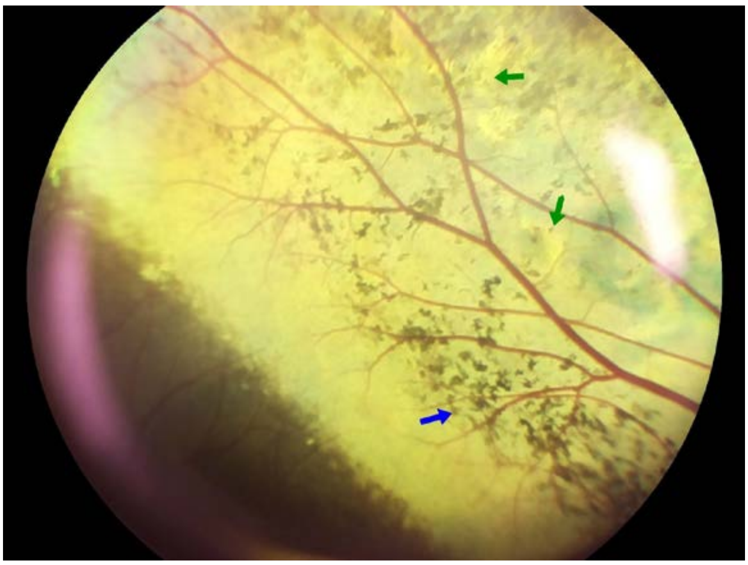

Figure 2. The Tapetal zone appears green-yellow. A rich vascular pattern in tapetal and non-tapetal areas is also seen. There are multifocal areas of pigmentation of the retinal pigment epithelium (blue arrow). Dark spots/Winslow stars are observed in the tapetal area (green arrows).

of 10 cm, we approached the eye until we had a clear fundus image. The device consists of an infrared LED (white), an optical lens, and a camera with infrared and daylight features to illuminate the eye. The device features include a sensor resolution of 8 megapixels, a field of view of 40°, and the required minimum pupil size of 3,5 mm. The obtained images were recorded on the device and transferred to the computer in jpeg format with a USB data cable.

In fundus images, tapetal colour, shape of the tapetal area, homogenicity of the tapetum, junction of tapetal and non-tapetal border, vascularization (artery, vein, small vessels), structure and color of the optic disc, and position of the optic disc were evaluated.

Results

Fundoscopy was performed on 34 eyes of 17 Holstein calves, eight males and nine females aged between 113-137 days.

The tapetal region, non-tapetal region, optic disc, and retinal vessels were examined. The green-yellow tapetal zone was dominant in all calves (Figure 2). The optic disc was dark and oval (Figure 3) and located in the non-tapetal area juxtaposed to the tapetal area (Figure 4) in all calves. The disc was seen to be cupped, with veins emerging near the center. The number of primary arteries and veins originating from the center varied between 4 and 5 (Figures 2-11). In some calves, artery-vein pairs traversing in the tapetal area were intertwined (Figure 6). The periphery of the main artery and vein pairs in the non-tapetal region appeared paler than their central parts (Figure 7). The small vessels originating from the disc largely disappeared about 1-2 disc diameters away (Figure 8). The vascular pattern was holangiotic. Hyaloid artery remnant (Bergmeister's papilla) was detected as a gray dot in the middle of the disc (Figure 9) in all 17 calves. The non-tapetal area was homogeneous with brown-black in color and rich in choroidal vascular structure (Figure 10).

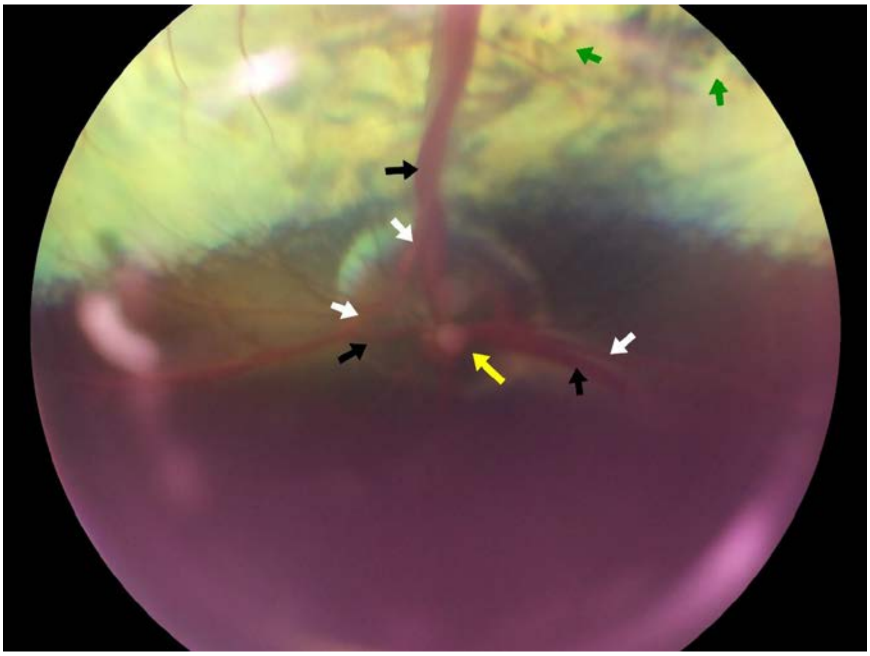

Figure 3. Oval and dark optic disc. The Tapetal zone appears green-yellow. Winslow stars are visualized in different sizes and morphology (green arrows). Bergmeister's papilla is also seen (yellow arrow). Large primary retinal vessels emerge from the optic disc's center. The periphery of the artery (white arrows) and vein (black arrows) pairs originating from the optic disc is pale in the non-tapetal region.

Discussion

Fundus examination is one of the most challenging but essential methods of the ophthalmic examination. It is necessary to know the normal fundus appearance to recognize any abnormality. Factors such as species, breed, age, sex, and coat color affect the normal fundus appearance (Martin et al., 2019). The animals were housed according to specific age groups in the establishment where the study was carried out. We preferred weaned calves regardless of gender. The age range was kept narrow to reduce the effect of the age factor.

In this study, the fundus examination was performed using an Ocellus-Vet fundus camera which can operate with infrared light. Infrared

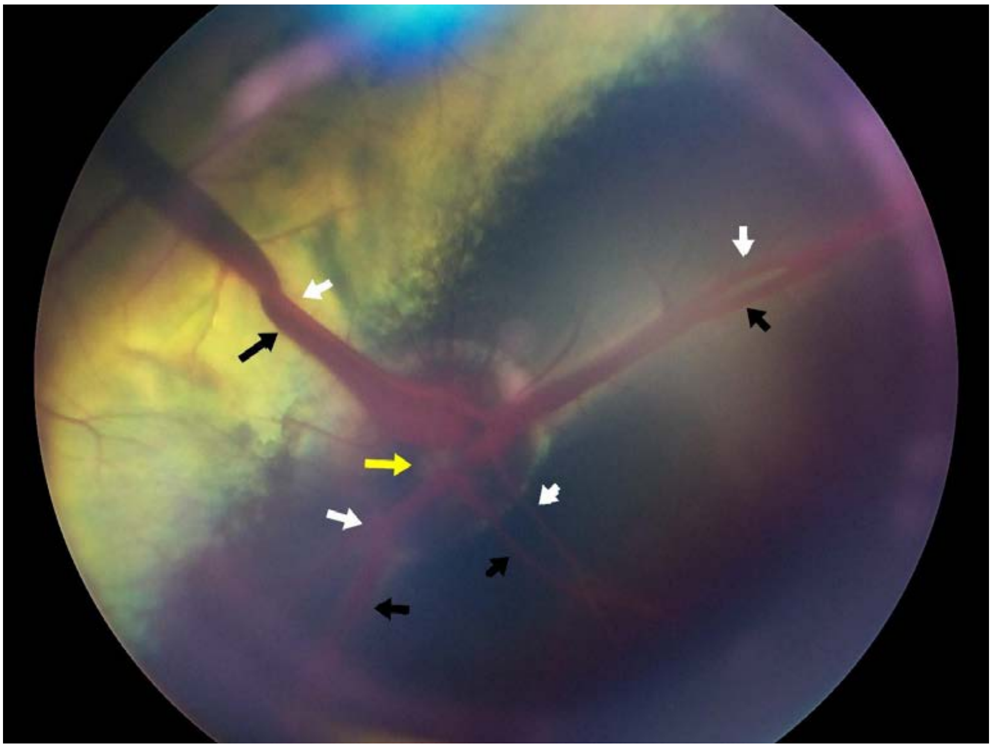

Figure 4. The optic disc is located in the non-tapetal zone, slightly below the junction of the tapetal and non-tapetal fundi. There are four primary arteries (white arrows) and four primary veins (black arrows). In the center of the optic disc is a remnant of the posterior hyaloid vessels/Bergmeister's papilla (yellow arrow).

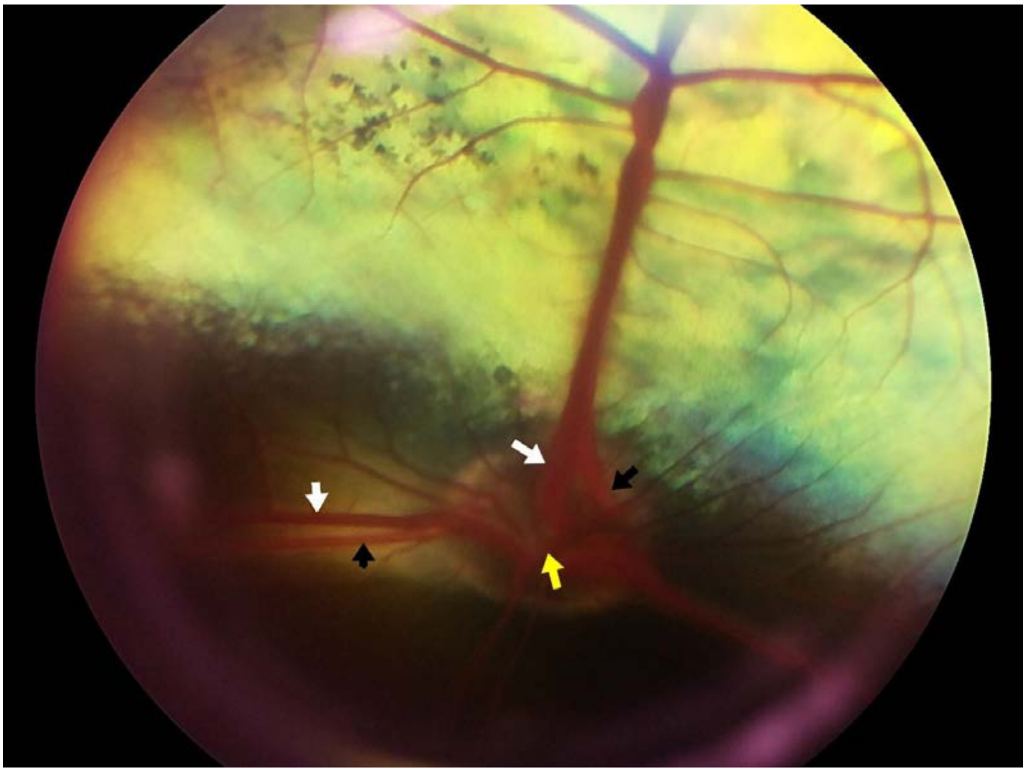

Figure 5. White arrows show arteries, and black arrows show veins. There are seven primary vessels, one artery, one vein in the tapetal zone, and three arteries and four veins in the non-tapetal zone. The yellow arrow shows Bergmeister's papilla.

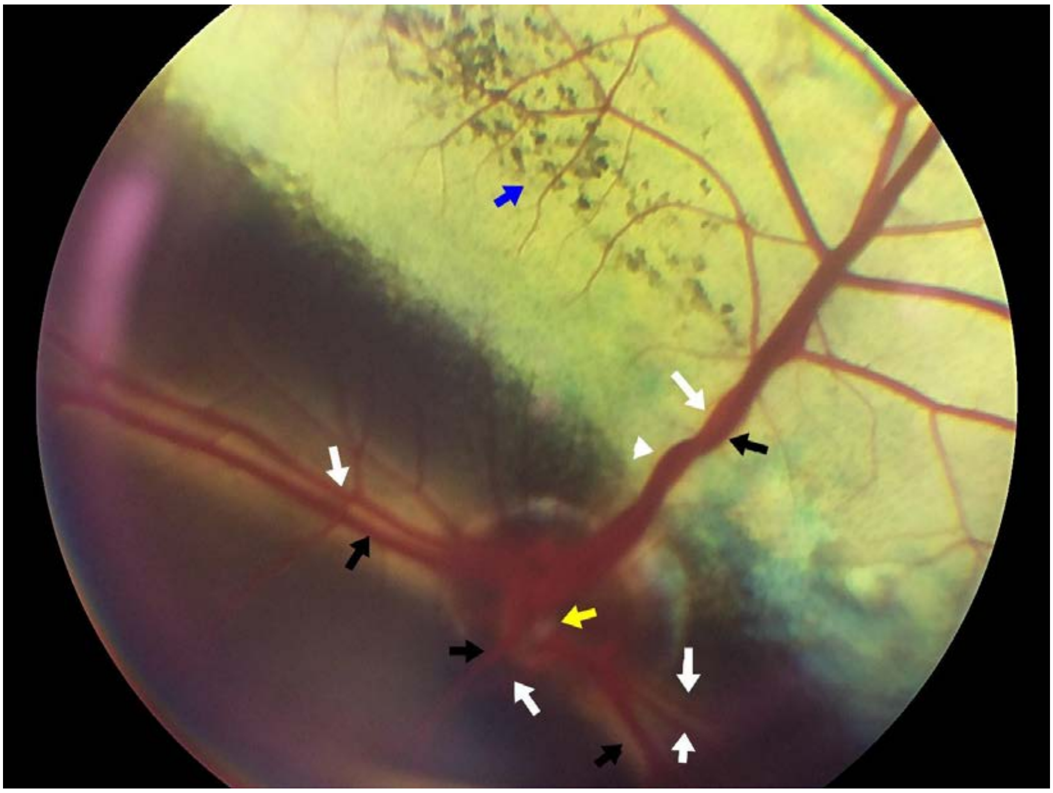

Figure 6. White arrowhead shows intertwined artery and vein. Multifocal pigmented areas are found (blue arrow) in the tapetal zone. There are five primary arteries (white arrows) and four veins (black arrows) originating from the optic disc. The yellow arrow shows Bergmeister's papilla.

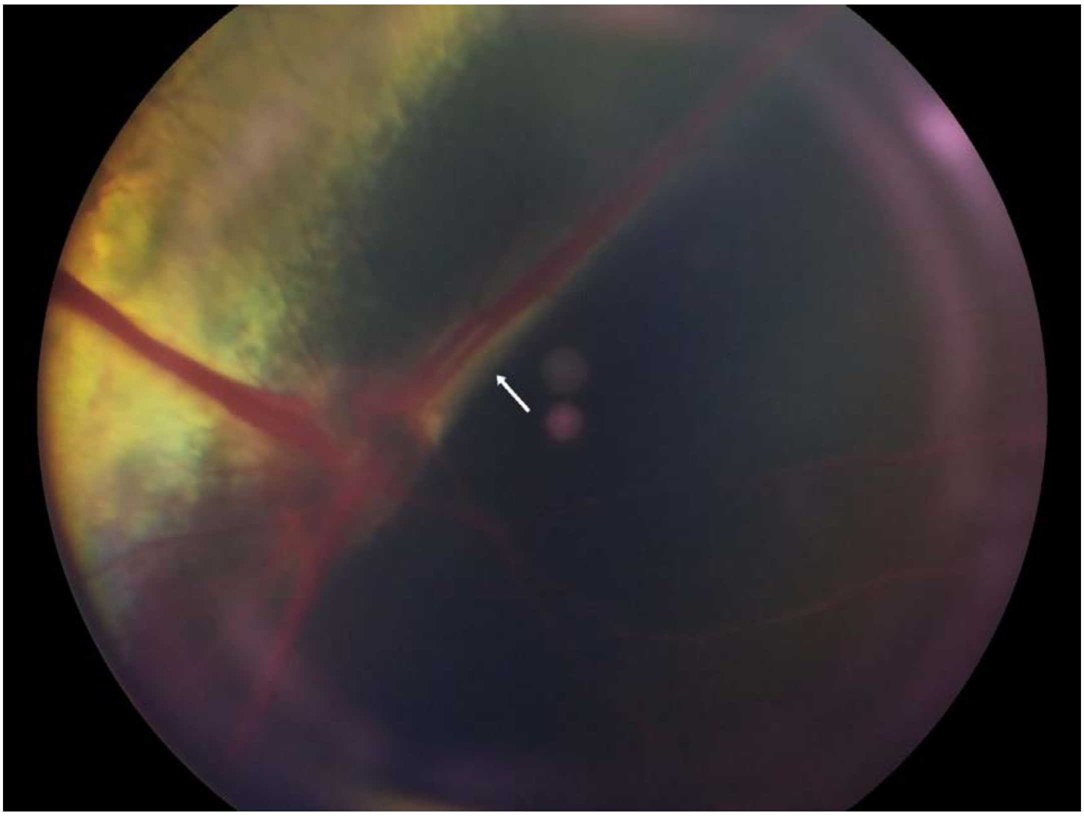

Figure 7. The arrow shows the periphery of an artery-vein pair. There are four primary arteries and five veins originating from the optic disc.

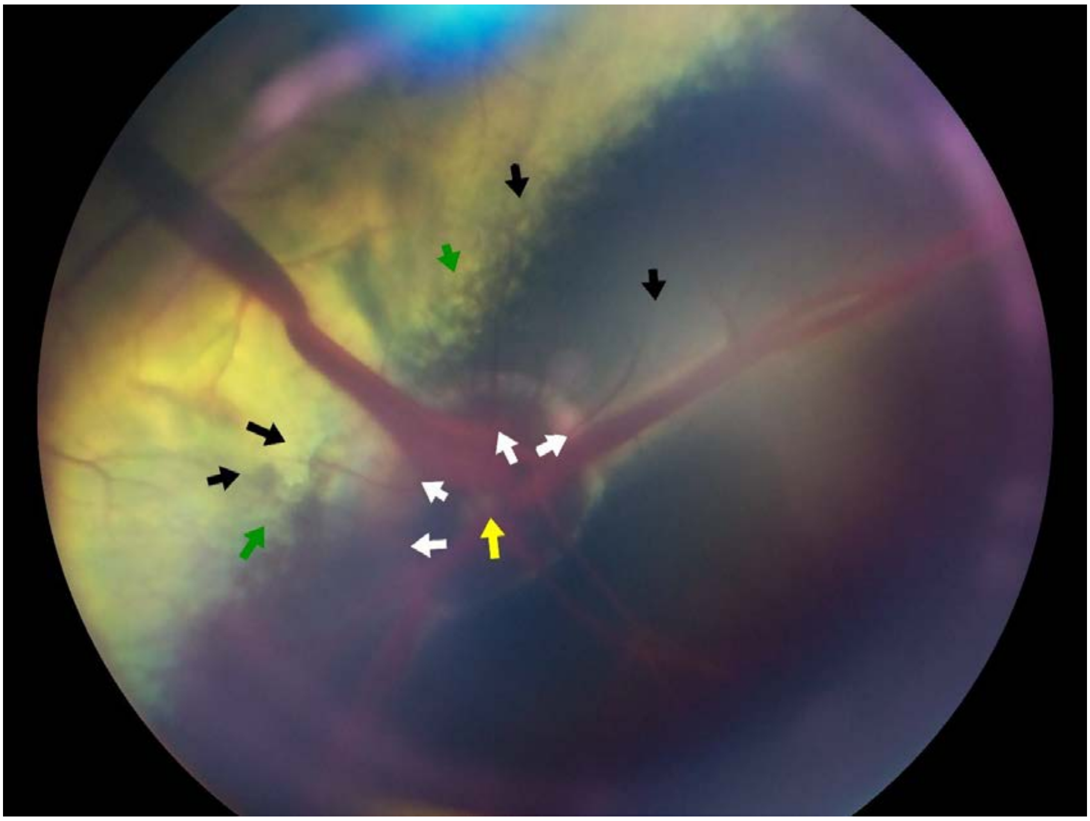

Figure 8. White arrows show the origin of small veins, and black arrows indicate where they disappear. The yellow arrow shows Bergmeister's papilla. Winslow stars appear in different sizes (green arrows).

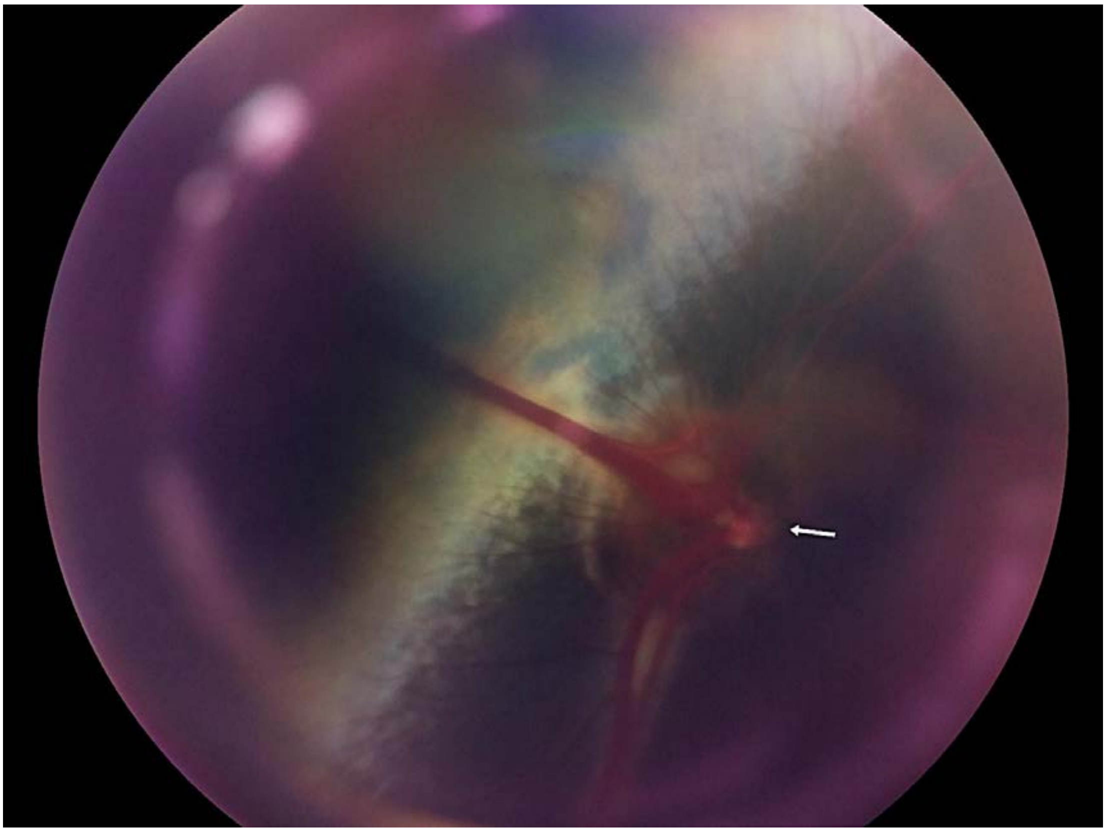

Figure 9. Bergmeister's papilla.

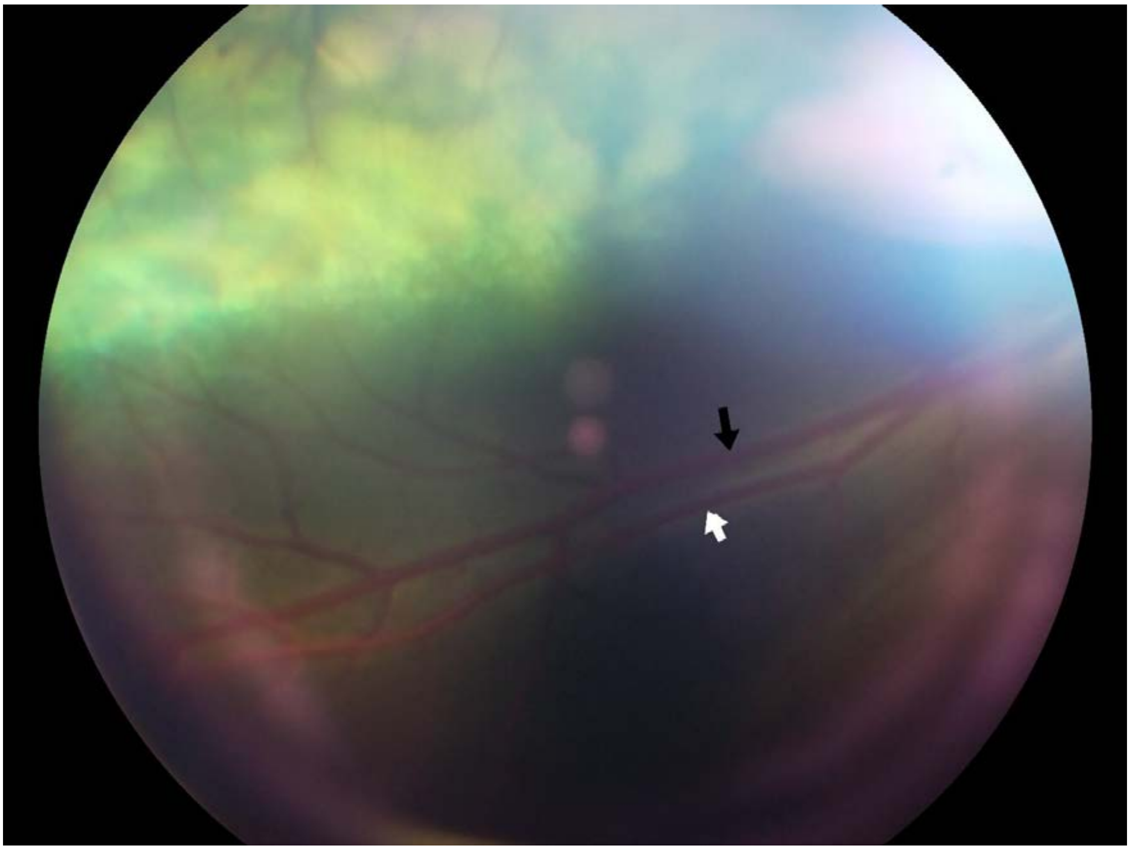

Figure 10. Non-tapetal zone. The white arrow shows the artery, and the black one shows the vein.

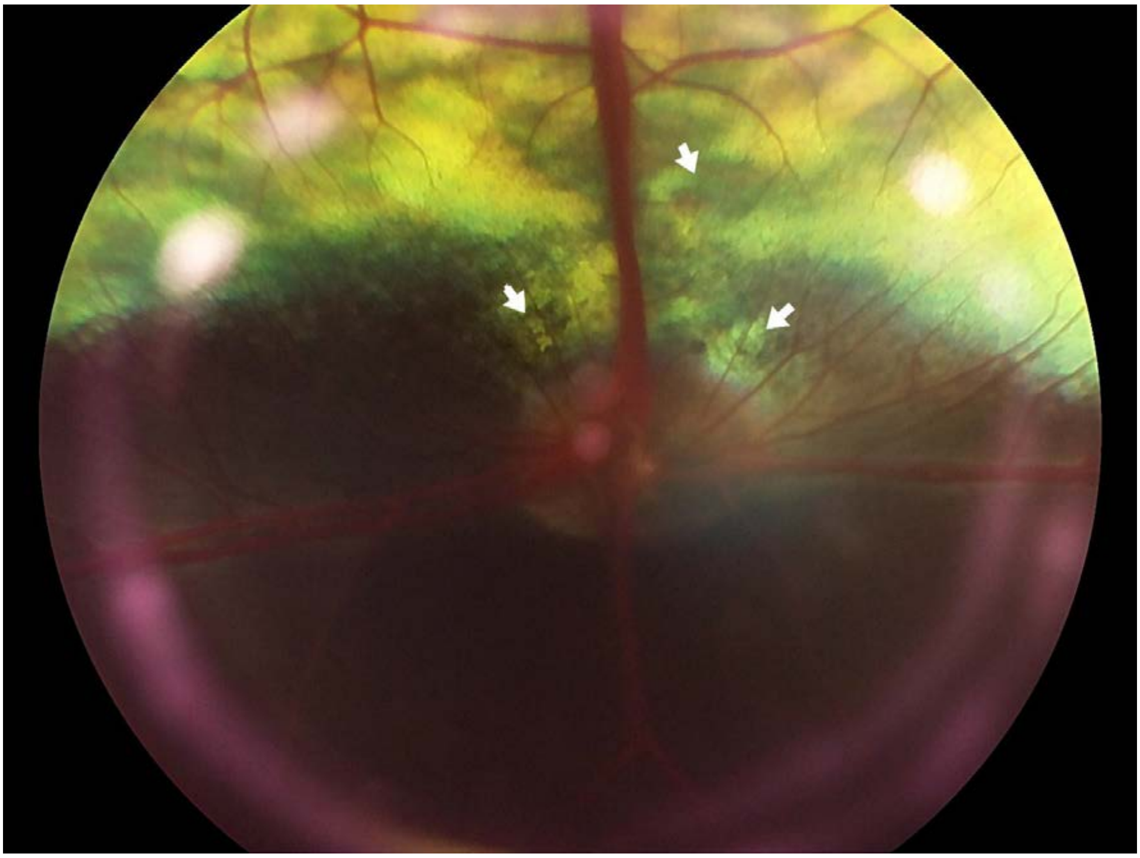

Figure 11. White arrows show Winslow stars surrounded by a yellowish area.

illumination does not cause pupil constriction, eliminating the need for using mydriatics. It also provides a tremendous advantage for animals because of its handheld portability, especially in field conditions. Although there are various examination methods in the hospital environment, a fundus camera that offers ease of use in field conditions will significantly facilitate the work of veterinarians and farm owners.

The bovine optic disc is oval with a long horizontal axis. Çatalkaya and Özaydın (Çatalkaya and Özaydin, 2019) reported that the optic disc could be observed in the tapetal region, in the non-tapetal region, or in between. In the present study, the optic disc was seen to be located in the non-tapetal region, with its dorsal aspect touching the tapetum. The optic disc appears dark because it is unmyelinated (Martin et al., 2019). In this study, the optic disc of the calves was oval and dark.

The retinal vascular pattern is holangiotic in dogs, cats, sheep, and primates, where the entire retinal surface receives a direct blood supply (Maggs et al., 2008; Şirin, 2020). In line with the literature, the vascular pattern was holangiotic. The dorsal arteriole and vein pair are intertwined in small ruminants (Çatalkaya and Özaydin, 2019; Galán et al., 2006; He et al., 2012; Kang et al., 2017; Şirin, 2020), the structure of the vessels of the calves was similar in this study. Arterioles originate more peripherally on the disc. There can be 15 to 20 smaller vessels originating from the disc and then disappearing 1-2 disc diameters away from the disc and these results are similar to the literature (Maggs et al., 2008).

Mild glial proliferation on the disc surface, known as Bergmeister's papilla, represents the remnant of a persistent hyaloid artery. The Bergmeister's papilla is routinely seen as a gray, translucent linear structure protruding from the center of the optic disc into the vitreous cavity in ruminants such as cows and sheep (Galán et al., 2006; Maggs et al., 2008; Martin et al., 2019; Shunmugam et al., 2020). In the current study, the hyaloid artery was detected in all calves.

The larger vessels disperse epiretinally rather than running through the nerve fiber layer. In calves, blood is usually present in the hyaloid vein for several months (Martin et al., 2019). However, we detected no blood in any calf in this study. In small ruminants, it has been reported that the area around the artery and vein pair in the non-tapetal region appears pale (Galán et al., 2006). In this study, the part of the pairs of major arteries and veins advancing to the non-tapetal region was paler than the rest because the optic nerve fibers appear to radiate outward from the temporal portion of the myelin disc.

Tapetal colors were seen to vary but were usually dark green with scattered dark spots or Winslow stars (Figure 11). Similar to the results of Martin et al. (Martin et al., 2019), there were often prominent pigment islets in the nasal tapetal region bilaterally. The non-tapetal region was also detected as dark brown. This result is similar to that reported in goats (Şirin, 2020). Green-yellow colors were dominant in the tapetal region of all the calves. In another study (Çatalkaya and Özaydin, 2019), a similar tapetal color was mentioned in some calves. It has been previously reported that age is associated with the tapetal area (Aksoy et al., 2011). Calves of similar ages were preferred in the present study. The observation of similar colors in the tapetal region of all calves examined in the current study is thought to be related to the evaluation of only one breed (Holstein) of similar age.

Conclusion

Ophthalmological disease on dairy farms causes significant economic losses along with individual pain and suffering in animal welfare (Irby and Angelos, 2018). Retinal fundus examination provides information about the presence and severity of many systemic and hereditary diseases, which will form the basis for disease diagnosis. Knowledge of healthy fundus images is of great value for identifying abnormal conditions. The fundus images of healthy Holstein calves presented in this study may guide for future studies and contribute to diagnosing ophthalmological diseases.

A limitation of the study is that only calves were examined, so future studies should include adult cattle.

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Conflict of Interests

The authors stated that they did not have any real, potential or perceived conflict of interest.

Ethical Approval

The current research was carried out at the Arif Gürdal Dairy Farm. ADÜ–HADYEK (64583101/2021/169).

Similarity Rate

We declare that the similarity rate of the article is 11% as stated in the report uploaded to the system.

Author Contributions

Idea/Concept: BKK
Design: BKK
Supervision-/Consultancy: BKK, AB, MS
Data Collection and/or Processing: BKK
Analysis and/or Interpretation: BKK
References Scanning: BKK, AB, MS
Writing of the Article: BKK
Critical Review: BKK, AB, MS

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