DOI : 10.5958/2277-8934.2021.00031.X Vol 28 No 2, p 185-190

OCULAR ULTRASONOGRAPHY IN CAMELS (*Camelus dromedarius*): A REVIEW

Mohamed Tharwat[1,2] and Omar El-Tookhy[3]

[1]Department of Veterinary Medicine, College of Agriculture and Veterinary Medicine, Qassim University, P.O. Box 6622, Buraidah, 51452, Saudi Arabia

[2]Department of Animal Medicine, Faculty of Veterinary Medicine, Zagazig University, 44519, Zagazig, Egypt

[3]Department of Surgery, Faculty of Veterinary Medicine, Cairo University, Egypt

ABSTRACT

The camel eye appears to be aspheric in shape and smaller than that of cattle and horse. The axial length of the globe is shorter than the sagittal length. Corneal thickness differs significantly between the right and left eyes, gender and age. Axial and sagittal readings are significantly different between male and female camels and between the two age groups. Lens diameter is statistically significant with age. The use of diagnostic veterinary ocular ultrasonography is currently considered as a rapid noninvasive modality that provides a detailed view of the intraocular components and soft tissues surrounding the orbit. This review article is written to describe the results of ocular ultrasonography in healthy camels as well as in camels with some ocular disorders. Ocular affections in dromedaries are blepharitis, conjunctivitis, keratitis, keratoconjunctivitis, corneal wounds, panophthalmitis, corneal opacity, eye lids laceration, xerophthalmia, ruptured eyeball, prolapse of third eyelid, descemetocele, subconjunctival hemorrhage, cataract, glaucoma, retinal detachment and blindness. From the clinical point of view, by ultrasonography the clinician can get detailed information for diagnosis of various ocular problems such as keratitis, cataract, glaucoma, penetrating corneal wounds, retinal detachment and blindness.

Key words: Camels, dromedary, eye, imaging, ultrasonography

Camels suffer from diverse ophthalmic affections, which include blepharitis, conjunctivitis, keratitis, keratoconjunctivitis, corneal wounds, panophthalmitis, corneal opacity, eyelid lascerations, xerophthalmia, ruptured eyeball, prolapse of third eyelid, descemetocele, subconjunctival haemorrhage, cataract, glaucoma, retinal detachment and blindness. A wide range of ocular affections have been reported in dromedaries in India (Bishnoi and Gahlot, 2001a,b; Kumar *et al,* 2016 and Ranjan *et al,* 2016). Most affected parts found were cornea and sclera, followed by conjunctiva and eyelids. However, a retrospective study found corneal opacity, eyelid lacerations, eye injuries, excessive lacrimation, etc. in decreasing order of incidence (Kumar *et al*, 2016). In a study from Egypt, the diagnosed dromedary ocular affections were blepharitis, keratitis, conjunctivitis, keratoconjunctivitis, corneal wounds and panophthalmitis (Fahmy *et al,* 2003). Researchers from Saudi Arabia found that dromedary ocular affections were traumatic in origin and majority of these involved anterior chamber of dromedary eye (El-Tookhy and Tharwat, 2012). Moore *et al* (1999) reported congenital ocular anomalies and ventricular septal defect in a dromedary camel.

The use of ultrasonography is currently considered as a rapid noninvasive modality that provides a detailed view of the intraocular components and soft tissues surrounding the orbit (Ramirez and Tucker, 2004; Potter *et al,* 2008). Ocular ultrasonography is also proved to be an essential tool to examine intraocular structures when opacified ocular media inhibit direct examination, and to evaluate retrobulbar structures when exophthalmos is evident (Gonzalez *et al,* 2001). Hamidzada and Osuobeni (1998) conducted clinical and experimental optometry in dromedary eye and estimated ultrasound velocity in the aqueous and vitreous humours. The greatest advantage of ocular ultrasonography is the capability to evaluate ocular components when challenged with clinically opaque refractive media (Wilkie and Colitz, 2009). The intraocular components of the eye develop in a coordinated manner such that an excess in the dimension of one component is counter balanced by a reduction adjustment in another. Consequently,

SEND REPRINT REQUEST TO MOHAMED THARWAT email: mohamedtharwat129@gmail.com

deviations from this regulated growth pattern lead to the development of refractive errors (Nelson *et al,* 1996). Recognition and familiarity with normal ocular biometry is crucial for detecting ocular abnormalities (Potter *et al,* 2008). This review article was designed to describe the results of ocular ultrasonography in healthy camels as well as in camels with some ocular disorders.

Ocular ultrasonography in camels

Ocular ultrasound is practiced in animals with ocular trauma, disparity in ocular size or with any condition that impedes visualisation of posterior ocular structures (Whitcomb, 2002). Ultrasound can be used as a tool for ophthalmological examination and to determine normal echogenicity of the main ocular structures (Kumawat and Jhirwal, 2021). The procedure is an easy, noninvasive diagnostic procedure used to evaluate ocular problems and used as a complement to traditional ocular examination. The assessment of ocular dimensions is crucial for ophthalmic surgeons that should be determined before any ophthalmic interference (Grinninger *et al,* 2010). Ultrasonography has also been used for the detection of the shape and composition of space-occupying ocular masses (Scotty *et al,* 2004), vitreous degeneration (Labruyère *et al,* 2008) and to determine ocular dimensions, corneal curvature and prediction of intraocular lens power before cataract and lens extraction (McMuller and Gilger, 2006). In addition, the technology has been used for the diagnosis of glaucoma, in evaluation of regions of the lens that are difficult to examine directly (Bentley *et al,* 2003; Wilkie and Gilger, 2004), and in the diagnosis of retinal detachment (Strobel *et al,* 2007). Most of the performed ocular studies are conducted on freshly enucleated eyes of camels by A-mode ultrasonography for measurement of optical dimensions after immersion of the eyes in distilled water kept at 20°C and the procedure is performed using a 7.5-10 MHz transducer. The measured optical dimensions include the anterior chamber depth, lens thickness, vitreous chamber depth and axial length. Generally, A-mode ultrasonography is more accurate than B-mode for estimation of intraocular measurements. Thus, A-mode ultrasonography is the procedure of choice in ocular biometry while B-mode ultrasonography is used mainly for diagnostic purposes (Abu-seida, 2016).

For ocular ultrasonography in camels, sedation is necessary by intravenous injection of Xylazine (0.2 mg/Kg). Surface corneal anaesthetic agent (Lidocaine 2%) may also be used. The camel's head should be firmly held, tilted and the eyelids are held open and a 7.5 MHz sector probe is quiet sufficient for examination. Using the direct corneal contact technique both transcorneal and transpalpebral ultrasonographic scanning techniques had been reported in camels (Abedellaah *et al,* 2019).The transducer should be placed directly on the cornea after spreading the coupling gel. Gentle pressure is then applied to maintain good contact between the transducer and the cornea. Each eye should be examined in horizontal section with the ultrasound beam running from the medial to the lateral canthi, and then the head of the transducer was rotated 90° to visualise the vertical section of the eye (Nyland and Mattoon, 1995). The aqueous and vitreous humor as well as the lens cortex and nucleus appear anechoic; however, the anterior and posterior lens capsule, sclera and iris appear hyperechoic (El-Tookhy *et al,* 2012). Similar observations were reported for the enucleated camel eyes (Kassab, 2012). The cornea generates two echoes: the first one corresponded to its epithelium and the second to its Descemet's membrane. *In vivo*, all ocular measurements are slightly increased except anterior chamber depth which is slightly decreased. Axial globe length and vitreous chamber depth are larger in she camels than male camels while the lens thickness in male camels is larger than in females (Yadegari *et al,* 2013). The cornea, anterior and posterior lens capsule and iris appear hyperechoic. The axial length vitreous chamber depth, corneal thickness, lens thickness and scleroretinal rim thickness increase with the advance of age in camels (Kassab, 2012).

Ocular ecobiometry (dimensions) in camels and normal dimensions

The cornea appears in camels to be thin at the centre and thick towards the periphery. Table 1 shows ultrasonographic measurement of the ocular structures of the right and left eyes in adult camels. Abuagla *et al* (2016) found that the different measurements of the right and left eye of dromedary camel had no significant differences (P>0.05). With the exception of corneal measurement, there are no significant differences between the right and left ocular components (Osuobeni and Hamidzada, 1999; El-Tookhy *et al,* 2012; Kelawala *et al,* 2015). Corneal thickness has been reported to be an important parameter in corneal surgery (Wilkie and Whittaker, 1997). In camels, corneal thickness is a common parameter which significantly differs when compared to the eye-side, gender, or age. Measurements of the corneal thickness shows that the central part of the adult camel's cornea (CCT) is slightly thinner than the peripheral part (PCT) (CCT/PCT = 0.9/1.1mm) (El-Tookhy *et al,* 2012) which is similar to the cornea of the human (0.5/0.8 mm), dog (0.4/0.5mm), horse (1.5/1.6mm) and cow (1.6/1.7mm). The anterior chamber depth, lens thickness, vitreous depth and axial length in camels of are smaller than cattle (5.1, 19.2, 14.6, 33.6 mm) and the horse (5.9, 12, 21.9, 40 mm), respectively (McMuller and Gilger, 2006; Potter *et al,* 2008; Grinninger *et al,* 2010). In a study reported by Yadegari *et al* (2013), the means ± SD of the anterior-posterior length of the eye axis, thickness of the lens, depth of the anterior chamber and depth of vitreous were as 32.01±0.32, 11.64±0.06, 4.83±0.81 and 15.99±0.12 mm, respectively. In addition, the axial globe length and vitreous chamber depth in female camels was larger than male camels and lens thickness in male camels was larger than females. Ribeiro *et al* (2010) found that goat's ocular measurements between right and left eyes, as well as between males and females were not significantly different (P>0.05). The ultrasonographic appearances of goat eyes were very similar to those of other domestic and wild species.

Table 1. Ultrasonographic measurements (Mean ± SEM) of the ocular structures of the right and left eyes in adult camels (n=24)*.

Ocular Structure	**Right**	**Left**	**P**
Central corneal thickness	1.0±0.04[a]	0.8±0.06[b]	0.02
Peripheral corneal thickness	1.2±0.04[a]	1.0±0.07[b]	0.02
Anterior chamber depth	2.6±0.1[a]	2.4±0.1[a]	0.3
Lens thickness	9.7±0.1[a]	9.5±0.1[a]	0.12
Lens diameter	16.0±0.4[a]	15.7±0.3[a]	0.5
Vitreous depth	15.7±0.2[a]	15.6±0.2[a]	0.6
Axial length	30.2±0.3[a]	29.5±0.3[a]	0.1
Sagittal length	33.4±0.3[a]	32.7±0.3[a]	0.1
Anterior chamber depth/ Axial length	0.15±0.004[a]	0.15±0.004[a]	0.6
Lens thickness/Axial length	0.32±0.002[a]	0.32±0.002[a]	0.8

[a,b] Values with different superscript letters indicate significant difference (P<0.05). * (El-Tookhy *et al,* 2012).

The camel lens is long-oval in shape with average lens thickness (LT) 9.6 mm and average lens diameter (LD) 15.8 mm. The ratio between the LT and the LD was found to be 0.6; this means that camel eyes have great accommodative amplitude. The greater thickness of the lenses of camels, short vitreous depth, implied that they are more powerful and probably indicates that camel eye is adapted for far sighting (El-Tookhy *et al,* 2012). In a study designed to find the relationship between accommodative amplitude and the ratio of central lens thickness to its equatorial diameter in vertebrate eyes, it is found that vertebrates with lenses that have LT/LD ratios ≤ 0.6 have the greatest accommodative amplitudes and those vertebrates that have oval or spherical shaped lenses, like owls and most mammals have low accommodative amplitudes (Schachar *et al,* 2007).

Based on the gender, significant differences are noticed in the corneal, globe axial and sagittal measurements (El-Tookhy *et al,* 2012) (Table 2). Axial and sagittal ocular measurements differ significantly between males and females, being longer in males than females contradicting previous reports (Nyland and Mattoon, 1995). This difference is reflected on the animal's bony structure including the skull and more specifically the orbital bones. Lens thickness does not differ significantly, however; lens diameter is highly significantly with camel age. Similar findings have been reported in camels (Nyland and Mattoon, 1995; Osuobeni and Hamidzada, 1999; and Ramsey *et al,* 1999). With increasing age of the camel, there are significant increases in the corneal thickness, lens diameter, globe axial and sagittal measurements. The axial length of the camel eye is shorter than the sagittal length (El-Tookhy *et al,* 2012) (Table 3).

Table 2. Ultrasonographic measurements (Mean ± SEM) of the ocular structures adult camels in relation to gender (n=24)*.

Ocular Structure	**Gender**		**P**
	male (n= 13)	**female (n=11)**	
Central corneal thickness	1.0±0.05[a]	0.9±0.04[b]	0.03
Peripheral corneal thickness	1.2±0.04[a]	1.1±0.04[b]	0.03
Anterior chamber depth	2.3±0.08[a]	2.3±0.08[a]	0.8
Lens thickness	9.7±0.1[a]	9.5±0.1[a]	0.2
Lens diameter	16±0.1[a]	15.6±0.3[a]	0.1
Vitreous depth	13.9±0.3[a]	13.4±0.1[a]	0.8
Axial length	30.5±0.4[a]	29.1±0.3[b]	0.04
Sagittal length	33.7±0.4[a]	32.3±0.3[b]	0.04
Anterior chamber depth/ Axial length	0.15±0.007[a]	0.15±0.001[a]	0.6
Lens thickness/Axial length	0.32±0.003[a]	0.33±0.003[a]	0.2

[a,b] Values with different superscript letters indicate significant difference (P<0.05). * (El-Tookhy *et al,* 2012).

Table 3. Ultrasonographic measurements (mean ± SEM) of the ocular structures adult camels in relation to age (n=24)*.

Ocular Structure	Age		*P*
	5- 7year (n= 16)	> 7year (n=8)	
Central corneal thickness	0.9±0.03[a]	1.1±0.05[b]	0.0001
Peripheral corneal thickness	1.1±0.03[a]	1.3±0.04[b]	0.0001
Anterior chamber depth	2.4±0.1[a]	2.3±0.06[a]	0.5
Lens thickness	9.5±0.1[a]	9.7±0.1[a]	0.1
Lens diameter	15.6±0.3[b]	16.0±0.1[a]	0.004
Vitreous depth	10.3±0.9[a]	10.7±1.0[a]	0.7
Axial length	28.2±0.3[b]	29.5±0.5[a]	0.001
Sagittal length	31.4±0.3[b]	32.8±0.5[a]	0.001
Anterior chamber depth/Axial length	0.08±0.002[a]	0.08±0.03[a]	0.5
Lens thickness/Axial length	0.3±0.003[a]	0.33±0.002[a]	0.3

[a,b] Values with different superscript letters indicate significant difference (P<0.05). * (El-Tookhy *et al,* 2012).

Ultrasonography in ocular disorders

Keratitis

Keratitis is the most prevalent ocular condition affecting the anterior ocular segment. It may be acute, moderate or pigmentary. Keratitis may be diagnosed with or without involvement of the iris and ciliary body. Acute conditions are characterised by corneal oedema, zone of neovascularisation and hypopyon. Ultrasonographically, corneal oedema is seen as a thickened and diffusely hypoechoic area. The anterior chamber appear anechoic except when aqueous flare is present which appear as hyperechoic dots floating in the anterior chamber.

Iridocyclitis

In iridocyclitis, the iris is highly reflective than normal and in most cases is partially adhered to the cornea with a thin hypoechoic strands extending from the iris to the posterior surface of cornea. Deep keratitis with severe corneal opacity and corneal abscessation is reported where the Iris is displaced forward towards the posterior corneal surface and the ciliary body appears hyperechoic indicating iridocyclitis. Pigmentary keratitis with long branched neovascularisation surrounding a central area of corneal ulceration has been also reported (El-Tookhy and Tharwat, 2012). The iris adhered to the posterior corneal surface with hyperechoic ciliary body; corneal tissue is thickened with hyperechoic aqueous flare. Regression of symptoms of keratitis, yet partial corneal opacity, neovascularisation exists with two patches of melanin pigment deposition within the corneal stroma; clearer corneal tissue can be seen ventrally with long thin blood has been reported. Ultrasonographically, backward retraction of the iris with slight signs of iridocyclitis is reported (El-Tookhy and Tharwat, 2012).

Cataract

The incidence of cataract was seen in dromedaries (16%) and llamas (20%) (Gionfriddo *et al,* 1997); it may be unilateral or bilateral in dromedaries. The lens appears as hyperechoic mass, either in situ or displaced, with clearly defined thickened echogenic lens capsule with or without irregular margins. The interior of the cataractous lenses exhibits echogenic material. Hypermature cataract as with short, brush-like neovascularisation indicating severe deep keratitis has been reported. By ultrasound, there was an increased echogenicity of the lens with irregular lenticular borders. The cataract appear to involve the anterior capsule, nucleus and slightly affecting the posterior lens capsule (El-Tookhy and Tharwat, 2012).

Glaucoma

Glaucoma is a rare condition in dromedaries as reported in other camelids such as llamas (Gionfriddo *et al,* 1997). Clinical signs of glaucoma included buphthalmia, dilated irresponsive pupil, elevated intra ocular pressure, and chemosis. By ultrasound, the anterior chamber depth, axial and sagittal globe measurements exceeds the normal values compared to the opposite eye (El-Tookhy *et al,* 2012). Ultrasound showed that the anterior chamber contained hyperechoic material (fibrin), the lens was dislocated and vitreal hemorrhage represented by point-like echoes. Buphthalmia with severely dilated unresponsive pupil in case of glaucoma has also been reported where a dilated pupil with increased ocular dimensions was detected ultraonographically (El-Tookhy and Tharwat, 2012). An evident distention of the anterior chamber was noted similar to the findings in horses (Whitcomb, 2002). The iris and ciliary body were seen as echogenic linear structures which extend from the peripheral globe towards the cornea and the anterior chamber depth, the axial and sagittal globe measurements exceeded the normal values (El-Tookhy *et al,* 2012).

Penetrating corneal wounds

Penetrating corneal wounds occur accidentally in dromedaries due to sharp objects. The severity of damage varied from simple corneal cut with partial iris prolapse to complete visual loss due complications involving other ocular tissues such a lens dislocation, vitreal prolapse, vitreal hemorrhage and retinal detachment. The majority of ocular problems seen in dromedary camels are traumatic with the involvement of one of more ocular tissue. Gionfriddo (2010) reported that trauma-related diseases were the most common eye problems in camelids. In cases of ocular trauma, ultrasound can be used to evaluate the integrity of the globe. Ultrasound can also be used to confirm ophthalmoscopic findings, such as retinal detachment or early cataractous changes. Old infected penetrating corneal wound shows corneal opacity, deep keratitis, prolapsed iris with purulent ocular discharge. A dislocated lens with capsular cataract, vitreal membrane represented by point-like echoes with a uniform high reflective mass seen on the fundus has also been reported (Whitcomb, 2002). Vitreal affections are best diagnosed using the ultrasound; the normal vitreal chamber is filled with anechoic fluid. In most traumatic cases, echogenic pinpoint swirling echoes are seen; these echoes represent vitreal haemorrhages or vitreal debris secondary to inflammation (Whitcomb, 2002). Partial retinal detachment and retinal folds has also been seen within the vitreous body. Relatedly, in other camelids such as llamas, it was reported that retinal diseases were infrequent (Gionfriddo *et al,* 1997). A high reflective wide-spread opacities covering the lens and occupying the vitreal space corresponding to vitreal haemorrhage has been reported (El-Tookhy and Tharwat, 2012).

In conclusion, ocular ultrasonography in dromedary camels is an important methodology for imaging the normal eye as well as for diagnosis of ocular disorders such as keratitis, cataract, glaucoma, penetrating corneal wounds, retinal detachment and blindness. Ocular imaging in the dromedaries by ultrasonography helps determining the precise diagnosis which helps in deciding the appropriate line of treatment and a possible prognosis can be drawn.

References

Abedellaah B, Sharshar A, Shoghy K and Rashed R (2017). Normal ocular structure of dromedary camel (*Camelus dromedarius*): gross, ultrasonographic and computed tomographic study. Assiut Veterinary Medicine Journal 63(153):231-236.

Abuagla IA, Ali HA and Ibrahim ZH (2016). An anatomical study on the eye of the one-humped camel (*Camelus dromedarius*). International Journal of Veterinary Science 5(3)137-141.

Abu-seida A (2016). A systemic review on ultrasonographic applications in camels. Journal of Camel Practice and Research 23:139-146.

Bentley E, Diehl KA and Miller PE (2003). Use of high-resolution ultrasound as a diagnostic tool in veterinary ophthalmology. Journal of the American Veterinary Medical Association 223:1617-1622.

Bishnoi P and Gahlot TK (2001a). A note on incidence and occurrence of diverse ophthalmic affections in camels (*Camelus dromedarius*). Journal of Camel Practice and Research 8:73-75.

Bishnoi P and Gahlot TK (2001b). Descemetocele and subconjunctival haemorrhage in camels (*Camelus dromedarius*). Journal of Camel Practice and Research 8:87.

El-Tookhy O and Tharwat M (2012). Clinical and ultrasonographic findings of some ocular affections in dromedary camels. Journal of Camel Practice and Research 19:183-191.

El-Tookhy O, Al-Sobayil FA and Ahmed FA (2012). Normal ocular ecobiometry of the dromedary camels. Journal of Camel Practice and Research 19:13-17.

Fahmy LS, Hegazy AA, Abdelhamis MA, Hatem ME and Shamaa AA (2003). Studies on eye affections among camels in Egypt. Scientific Journal of King Faisal University 4:159-176.

Gionfriddo JR (2010). Ophthalmology of South American camelids. Veterinary Clinics of North America, Food Animal Practice 26:531-555.s

Gionfriddo JR, Gionfriddo JP and Krohne SG (1997). Ocular diseases of llamas: 194 cases (1980-1993). Journal of American Veterinary Medical Association 210:1784-1787.

Gonzalez EM, Rodriguez A and Garcia I (2001). Review of ocular ultrasonography. Veterinary Radiology and Ultrasound 42:485-495.

Grinninger P, Skalicky M and Nell B (2010). Evaluation of healthy equine eyes by use of retinoscopy, keratometry, and ultrasonographic biometry. American Journal of Veterinary Research 71:677-681.

Hamidzada Wali A and Osuobeni Ebi P (1998). Ultrasound velocity in the aqueous and vitreous humours of the one-humped camel (*Camelus dromedarius*). Clinical and Experimental Optometry 81.5:222-227.

Kassab A (2012). Ultrasonographic and macroscopic anatomy of the enucleated eyes of the buffalo (Bos bubalis) and the one-humped camel (*Camelus dromedarius*) of different ages. Anatomia, Histologia, Embryologia 41:7-11.

Kelawala DN, Patil DB, Parikh PV, Sini KR, Parulekar EA, Amin NR, Ratnu DA and Rajput PK (2015). Normal ocular ultrasonographic biometry and fundus imaging of Indian camel (*Camelus dromedarius*). Journal of Camel Practice and Research 22:181-185.

Kumar P, Purohit NR and Gahlot TK (2016). Retrospective analysis of ocular affections in dromedary camels. Journal of Camel Practice and Research 23:247-250.

Kumawat NK and Jhirwal SK (2021). B-mode ultrasonographic appearance of the globe and intraocular structures of eye in dogs. The Pharma Innovation Journal SP-10(2): 68-71.

Labruyère JJ, Hartley C, Rogers K, Wetherill G, McConnell JF and Dennis R (2008). Ultrasonographic evaluation of vitreous degeneration in normal dogs. Veterinary Radiology and Ultrasound 49:165-171.

McMuller RJ and Gilger BC (2006). Keratometry, biometry and prediction of intraocular lens power in the equine eye. Veterinary Ophthalmology 9:357-360.

Moore CP, Shaner JB, Halenda RM, Rosenfeld CS and Suedmeyer WK (1999). Congenital ocular anomalies and ventricular septal defect in a dromedary camel (*Camelus dromedarius*). Journal of Zoo and Wildlife Medicine 30(3):423-430. PMID: 10572869.

Nelson MJ, Mutti DO, Zadnik K and Murphy CJ (1996). A naturally occurring model of axial myopia in the Labrador retriever. Investigative Ophthalmology and Visual Science 37:S323.

Nyland TG and Mattoon JS (1995). Veterinary Diagnostic Ultrasound. WB Saunders Company, Philadelphia, 1st ed. pp 178-197.

Osuobeni EP and Hamidzada WA (1999). Ultrasonographic determination of the dimensions of ocular components in enucleated eyes of the one-humped camel (*Camelus dromedarius*). Research in Veterinary Science 67:123-127.

Potter TJ, Hallowell GD and Bowen IM (2008). Ultrasonographic anatomy of the bovine eye. Veterinary Radiology and Ultrasound 49:172-175.

Ramirez S and Tucker RL (2004). Ophthalmic imaging. Veterinary Clinics of North America: Equine Practice 20:441-457.

Ramsey DT, Hauptman JG and Petersen-Jones SM (1999). Corneal thickness, intraocular pressure, and optical corneal diameter in Rocky Mountain horses with cornea globosa or clinically normal corneas. American Journal of Veterinary Research 60:1317-1321.

Ranjan R, Nath K, Naranware S and Patil NV (2016). Ocular affections in dromedary camel - a prevalence study. Intas Polivet 17:348-349.

Ribeiro, Alexandre Pinto *et al* (2010). Ultrasonographic and ecobiometric findings in the eyes of adult goats. Ciência Rural [online] 40(3)568-573. https://doi.org/10.1590/S0103-84782010005000019

Schachar RA, Pierscionek BK, Abolmaali A and Le T (2007). The relationship between accommodative amplitude and the ratio of central lens thickness to its equatorial diameter in vertebrate eyes. British Journal of Ophthalmology 91:812-817.

Scotty NC, Cutler TJ, Brooks DE and Ferrell E (2004). Diagnostic ultrasonography of equine lens and posterior segment abnormalities. Veterinary Ophthalmology 7:127-139.

Strobel BW, Wilkie DA and Gilger BC (2007). Retinal detachment in horses: 40 cases (1998-2005). Veterinary Ophthalmology 10:380-385.

Whitcomb MB (2002). How to diagnose ocular abnormalities with ultrasound. AAEP Proceedings 48:272-275.

Wilkie DA and Colitz CM (2009). Update on veterinary cataract surgery. Current Opinion in Ophthalmology 20:61-68.

Wilkie DA and Gilger BC (2004). Equine glaucoma. Veterinary Clinics of North America: Equine Practice 20:381-391.

Wilkie DA and Whittaker C (1997). Surgery of the cornea. Veterinary Clinics of North America: Small Animal Practice 27:1067-107.

Yadegari M, Salehi A, Ashtari A and Ashtari MS (2013). B-mode ultrasound biometry of intraocular structures in dromedary camels (*Camelus dromedarius*). Global Veterinaria 10:71-74.