Short Communication

Ultrasonographic biometry of the eyes of healthy adult donkeys

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SIXTY-TWO healthy adult donkeys were included in this study, giving a total of 124 eyes for examination. The weight of the donkeys was estimated and an ultrasonography of the eyes was performed using a curvilinear transducer. Ocular measurements were taken in a horizontal plane and included the following values: globe axial length (GAL), anterior chamber depth (ACD), vitreous body depth (VD), lens diameter (LDi) and lens depth (LDe). The mean and sds for each measurement are reported in mm: GAL 34.22±2.05; ACD 3.01±0.58; VD 20.20±1.63; LDi 17.96±1.66 LDe 11.06±0.71. Gender was not a variability factor for ocular biometry in donkeys, while the weight was directly related to the ultrasonographic ocular values. Lens dimensions represented an exception and further investigation should be carried out to verify a possible correlation with age rather than weight. This is the first paper reporting reference data for ocular biometry in donkeys.

Introduction

The ultrasonographic evaluation of the equine eye is a manageable procedure that is easy to perform and can provide information not always obtainable with direct ocular examination. It allows the imaging of intraocular and retrobulbar structures and the diagnosis of some important disorders involving these areas (Scotty and others 2004, Michau 2005, Dietrich 2007). Ocular ultrasound is also indicated where it is impossible to directly visualise (eg, with an ophthalmoscope) posterior structures of the globe in cases of corneal oedema or ulceration, cataract or ocular masses (Withcomb 2002). Ultrasound can be used to investigate enophthalmos, buphthalmos or exophthalmos in cases of ocular protrusion and suspicion of disparity in globe size (Withcomb 2002).

The most common diseases that can be detected or confirmed with ultrasound are corneal diseases, cataract, lens luxation, intraocular cysts or masses, glaucoma and retinal detachment (Reef 1998, Withcomb 2002). Although horses and donkeys can be affected by similar ocular diseases, until now there have been only a few reports regarding the examination of donkeys' eyes and the differences with respect to those of horses (Donisa and others 2009).

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Ultrasonography can be performed in the standing horse, and only in some cases sedation or local nerve block are required. The first reports concerning ultrasonographic evaluation and biometry of equine eyes were those of Rogers and others (1986) who used normal extirpated equine eyes. Measurements obtained on extirpated eyes show some differences from those obtained from live horses but, nevertheless, there is little difference between reports where measurements were taken using live animals (Rogers and others 1986, Mettenleiter 1995, McMullen and Gilger 2006, Barsotti and others 2010, Grinninger and others 2010). Although horses and donkeys vary considerably in size depending on different breeds, the use of the mean eye dimension of horses to evaluate those of donkeys may not be appropriate. Donkeys have some anatomical features that often make them very different from horses, with inevitable consequences in clinical behaviour of diseases (Laus and others 2010).

In scientific literature, the most common measurements used are reported below: globe axial length (GAL), anterior chamber depth (ACD), vitreous body depth (VD), lens diameter (LDi) and lens depth (LDe). In the present paper, the same biometric evaluation used in horses and now obtained in normal donkeys is reported; the aim was to obtain mean values to be used as a reference in the ultrasonographic ocular evaluation of this species, considering the weight variability, which is higher in donkeys than in horses.

Materials and methods

Sixty-two healthy adult donkeys (16 male and 46 female) of different breeds and sizes (from 71 to 306 kg) were used in this study, giving a total of 124 eyes for examination. The donkeys came from three different stables and all of them had a body condition score of 5 or 6 on a range of 1–9 (Pearson and Ouassat 2000).

To estimate the live weight of each donkey, the measurements of the heart girth (just behind the front legs) and the length from the tuber ischii to the elbow were recorded in centimetres. The weight in kg was then calculated using the following formula: estimated donkey weight (kg)=(heart girth$^{2.12}$)×(length$^{0.688}$)/3801 (Pearson and Ouassat 1996, 2000).

An ultrasonography of the eyes was performed with a curvilinear transducer used at the highest frequency available (13 MHz; MyLabOne, Esaote). Ocular globe structures were displayed at a depth of 4–6 cm, depending on the animal size. The transducer was placed on the closed upper eyelid, positioning the lateral canthus to the left of the screen and the medial canthus to the right. A long-axis scan in a horizontal plane was performed using the probe approximately parallel to the eyelid margin (Fig 1). Minimal pressure was applied to the eyelid in order to avoid deforming the globe. Minimal restraint was used and sedation was never required. Globe measurements were taken in a horizontal plane corresponding to the maximum diameter of the eye, at the point where the anterior chamber, the anterior and posterior lens capsule, and the layers of the fundus were all included in the image. All measurements were repeated three times and the mean values were recorded. For evaluation of repeatability, the first and second measurements have been compared since we would not expect systematic differences between the first and subsequent measurements. Repeatability has been determined according to Bland and Altman (1986) and considered to have been satisfied if 95 per cent or more of the differences between duplicate measurements was less than two sds. The measurements taken are reported below: GAL, from the cornea to the retinochoroid layer; ACD, from the cornea to the anterior reflection of the lens; VD, from the posterior reflection of the lens to the retina; lens diameter (LDi), distance from the opposite points nearest the ciliary bodies; lens depth (LDe), from the anterior to the posterior reflection of the lens (Fig 1). Ranges were estimated using a 95% CI.

The differences between the biometric evaluation found in scientific literature for horses' eyes and those of donkeys were statistically evaluated using a Student's *t* test. The correlation coefficient between the

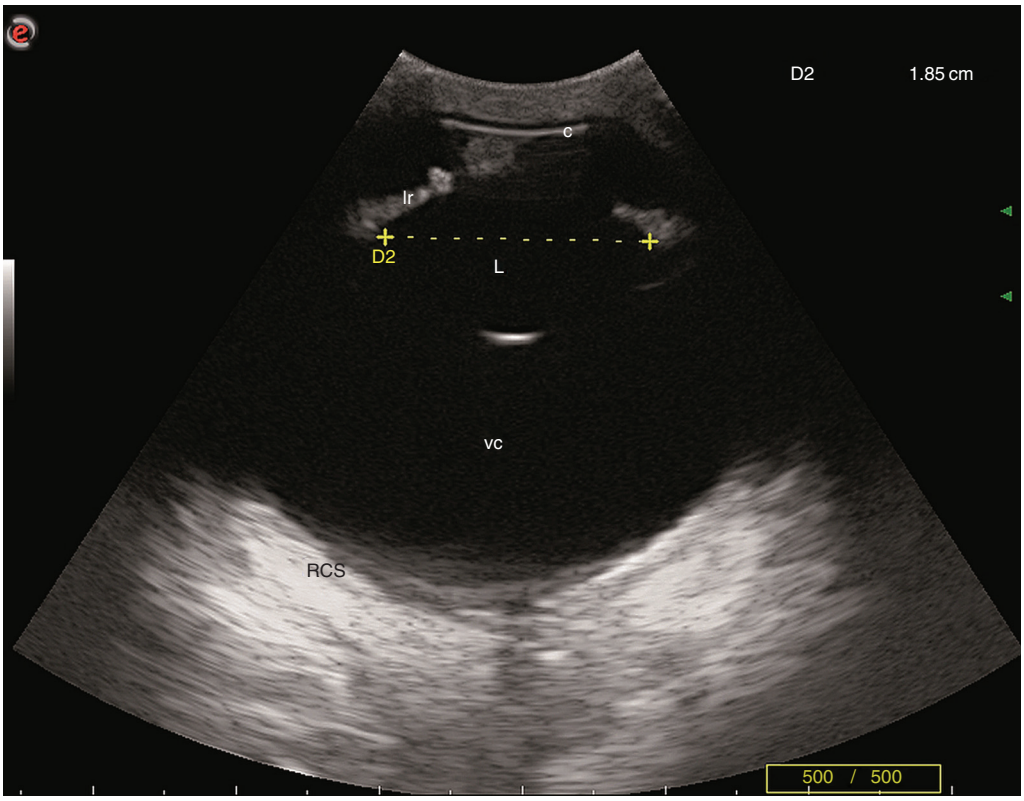

FIG 1: Measurement of the lens diameter (LDi). To the left: lateral canthus . To the right: medial canthus. From top to bottom: cornea (C), iris (Ir), lens (L), vitreous body chamber (VC) and combination of retina, choroids and sclera (RCS)

estimated weight and the various measurements was also determined. Differences between groups of animals, divided according to gender, and between three weight categories (1=W≤100, n=15; 2=100<W≤200, n=30; 3=W>200, n=17) were estimated using an ANOVA (analysis of variance) test. P values were fixed at <0.05 for all tests.

Results

Results of the ocular measurements are reported in Table 1.

Measurements compared for each eye and structure resulted to be repeatable since they were in concordance with the satisfaction criteria exposed in material and methods.

All the measurements recorded showed no statistically significant differences between males and females. However, a direct positive correlation was recognised between the weight of the donkey and GAL (correlation coefficient=0.64), ACD (correlation coefficient=0.46) and VD (correlation coefficient=0.54); there was no direct positive relationship between the weight of the donkey and LDi (correlation coefficient=0.04) and LDe (correlation coefficient=0.11).

When compared among the three estimated weight categories of donkeys (W≤100, 100<W≤200, W>201), there was a significant difference in the GAL (P=0.00007), ACD (P=0.0005) and the VD (P=0.0009) but the LDi (P=0.01) and LDe (0.04) were close to the limit. Table 2 shows the mean and sd of the various measurements after the animals had been divided into the three weight categories.

When the authors compared the values recorded in donkeys with those found in current scientific literature for live horses, all the means gave statistically lower results in donkeys with the exception of the values for the VD in category 3, and LDi and LDe in category 2 which did not show any significant difference from those of the horses population. Surprisingly, the mean values of LDi and LDe in category 2 resulted higher than those in category 3.

TABLE 1: Mean (mm), sd and ranges (mm; 95% CI) for each measurement

	GAL	ACD	VD	LDi	LDe
Mean	34.22	3.01	20.20	17.96	11.06
Sd	2.05	0.58	1.63	1.66	0.71
Ranges (95% CI)	33.71 to 34.72	2.87 to 3.15	19.80 to 20.60	17.56 to 18.37	10.89 to 11.24

ACD, anterior chamber depth; GAL, Globe axial length; LDe: lens depth; LDi: lens diameter; VD, vitreous body depth

TABLE 2: Mean (mm) and sds in the three weight categories. n: numbers of animals

	Weight category (kg)	Mean and sd (mm)	GAL	ACD	VD	LDi	LDe
1 (n: 15)	W≤100	Mean	31.09	2.01	18.72	16.33	10.35
		sd	0.45	0.35	0.70	1.03	0.56
2 (n: 30)	100<W≤200	Mean	34.17	3.07	20.10	18.26	11.16
		sd	1.87	0.53	1.52	1.46	0.72
3 (n: 17)	W>200	Mean	36.35	3.30	22.00	17.01	10.91
		sd	1.20	0.23	1.40	2.39	0.25

ACD, anterior chamber depth; GAL, Globe axial length; LDe, lens depth; LDi, lens diameter; VD, vitreous body depth

Discussion and conclusions

The data obtained and reported in the present study suggest that gender does not represent a variability factor for ocular biometry in donkeys. The weight of the animals was directly related to the ultrasonographic ocular size, but lens dimensions represented an exception.

In fact, the lens size showed a difference when related to the weight, resulting in larger category 2 (101<W<200) compared with category 3 (W>200), with regard to the LDi and the LDe. This result agrees with the lack of correlation between weight and lens measurements as shown by the correlation coefficient. The lens grows during embryonic development and continues to do so throughout life (Colitz and McMullen 2011). For this reason, it can be assumed that old donkeys have larger lenses than those of adults and young ones. Since the information regarding their ages was available only for a few of the animals in this paper, the authors believe that further ultrasonographic studies will confirm this supposition. Furthermore, the crystalline lens is biconvex with an appreciably steeper curvature on the posterior surface, and this can lead more easily to errors of alignment in evaluating the thickness of the lens. It is also interesting to note that, unlike the other measures, only the lens has given, for category 2, values not statistically different from those of horses. Very little scientific literature is available on this subject, and the lack of differences in lens dimensions could contribute with more information to the debate on lens growing models, which is also very topical in human medicine (Augusteyn 2008).

As reported in the results, only the VD for category 3 is comparable with that reported in horses. In absolute terms, the mean was even higher than that reported for horses by other authors (Rogers and others 1986, Mettenleiter 1995, Barsotti and others 2010, Grinninger and others 2010). Although we consider this assessment reliable, we believe it would be appropriate to perform further examinations in larger donkeys to confirm and explain this result and, possibly, to compare measurements with extirpated donkeys' eyes. From the comparison with the data available in scientific literature on horses (Rogers and others 1986, Mettenleiter 1995, Barsotti and others 2010, Grinninger and others 2010) it appears fairly clear that the average eye size of horses is significantly larger than that of donkeys, and no overlapping seems to exist. These considerations are of clinical relevance and should be taken into account in evaluating donkeys' eyes to avoid misinterpretation of results. It should also be highlighted that the weight of the donkeys in this research was only an estimation. However, it was carried out with a scientifically recognised method (Pearson and Ouassat 1996).

The present work provides, for the first time, an indication of the possible values to be expected when estimating the biometry of donkeys' eyes, particularly with regard to global axial length, ACD and VD. As also demonstrated by statistical analysis, ocular ultrasonographic evaluation in donkeys is easy to perform and is repeatable.

However, the authors believe that further ultrasound data are required to establish a range of lens dimensions related to the known age of the individual donkeys and to specific donkey breeds.

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References

AUGUSTEYN, R. C. (2008) Growth of the lens: in vitro observations. *Clinical and Experimental Optometry* **91**, 226–239

BARSOTTI, G., CITI, S., BROVELLI, M., MUSSI, E., LUCHETTI, E., CARLUCCI, F. & SGORBINI, M. (2010) Esame ecografico oftalmico nel cavallo:valutazione di alcune misurazioni biometriche. *Ippologia* **21**, 39–43

BLAND, J. M. & ALTMAN, D. G. (1986) Statistical methods for assessing agreement between two methods of clinical assessment. *The Lancet* **1**, 307–310

COLITZ, C. M. H. & MCMULLEN, R. J. (2011) Diseases and surgery of the lens. In Equine Ophthalmology. 2nd ed. Ed B.C Gilger. Maryland Heights, Missouri, USA: Saunders. pp 282–316

DIETRICH, U. M. (2007) Ophthalmic examination and diagnostic, part 3: diagnostic ultrasonography. In Veterinary Ophthalmology. 4th ed. Ed K.N. Gelatt. Oxford, UK: Blackwell Publishing. pp 507–519

DONISA, A., MUSTE, A., BETEG, F. & KRUPACI, A. (2009) Morphological characteristics of horse and donkey eye fundus. *Veterinary Medicine* **55**, 149–154

GRINNINGER, P., SKALICKY, M. & NELL, B. (2010) Evaluation of healthy equine eyes by use of retinoscopy, keratometry, and ultrasonographic biometry. *American Journal of Veterinary Research* **71**, 677–681

LAUS, F., PAGGI, E., CERQUETELLA, M., SPAZIANTE, D., SPATERNA, A. & TESEI, B. (2010) Guttural pouch mycosis in a donkey (Equus asinus): a case report. *Veterinarni Medicina* **11**, 561–565

MCMULLEN, R. J. & GILGER, B. C. Jr (2006) Keratometry, biometry and prediction of intraocular lens power in the equine eye. *Veterinary Ophthalmology* **9**, 357–360

METTENLEITER, E. M. (1995) Sonographic diagnosis (B-Mode technique) for the eyes of horses. Methods and normal findings. *Tierarztliche Praxis* **23**, 481–488

MICHAU, T. M. (2005) Equine Ocular examination: basic and advanced diagnostic techniques. In Equine Ophthalmology. Ed B.C. Gilger. St. Louis, Missouri, USA: Saunders. pp 1–62

PEARSON, R. A. & OUASSAT, M. (1996) Estimation of the live weight and body condition of working donkeys in Morocco. *The Veterinary Record* **138**, 229–233

PEARSON, R. A. & OUASSAT, M. (2000) A Guide to Body Condition Scoring and Live Weight Estimation of Donkeys. Edited by Centre for Tropical Veterinary Medicine, University of Edinburgh. Easter, Bush, Roslin, Midlothian, Scotland: Thomson Colour Printers

REEF, V. B. (1998) Equine Diagnostic Ultrasound. Philadelphia, USA: Saunders. pp 480–547

ROGERS, M., CARTEE, R. E., MILLER, W. & IBRAHIM, A. K. (1986) Evaluation of the extirpated equine eye using B-Mode ultrasonography. *Veterinary Radiology* **27**, 24–29

SCOTTY, N. C., CUTLER, T. J., BROOKS, D. E. & FERRELL, E. (2004) Diagnostic ultrasonography of equine lens and posterior segment abnormalities. *Veterinary Ophthalmology* **7**, 127–139

WITHCOMB, M. B. (2002) How to diagnose ocular abormalities with ultrasound. Proceeding of American Association of Equine Practitioner. Orlando, Florida, USA, December 4 to 8, 2002. pp 272–275

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