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Intraocular Pressure and Tear Production in Captive Eland and Fallow Deer

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ABSTRACT: Applanation tonometry was used to estimate intraocular pressure (IOP) and Schirmer tear test (STT) I was used to estimate tear production in both eyes of 12 juvenile elands (*Taurotragus oryx*) and one eye each of 15 Asian fallow deer (*Dama mesopotamica*). Mean (± standard deviation) IOP was 14.6 ± 4.0 mm Hg in the eland and 11.9 ± 3.3 mm Hg in the deer. Mean tear production was 18.7 ± 5.9 mm/min in the eland and 10.5 ± 6.5 mm/min in the deer. The large variation in IOP between two members of the family Bovidae, the elands reported here and the Thomson gazelle (*Gazella thomsoni*) for which we previously reported a mean pressure of 7.6 mm Hg, illustrates the need to establish reference values for each species. Tear production may be influenced by the species' natural habitat.

Key words: Asian fallow deer, *Dama mesopotamica,* eland, glaucoma, intraocular pressure, keratoconjunctivitis sicca, *Taurotragus oryx,* tear production.

Glaucoma and keratoconjunctivitis sicca (KCS) are ocular diseases that may lead to loss of vision in both domesticated and wildlife species. Glaucoma is characterized by loss of retinal ganglion cells, usually associated with elevated intraocular pressure (IOP) (Gelatt and Brooks, 1999). Keratoconjunctivitis sicca is an inflammatory disease of the conjunctiva and cornea caused by deficiencies in tear production (Moore, 1999). In chronic cases, vision may be lost due to progressive pigmentation of the cornea leading to loss of transparency, while corneal ulceration and perforation may occur in acute cases (Moore, 1999).

Many of the clinical signs associated with glaucoma and KCS are nonspecific. Ocular pain, ciliary injection and corneal edema may be indicative of glaucoma, but also are associated with uveitis and other ocular disorders. Keratoconjunctivitis sicca may be suspected when ocular discharge, corneal pigmentation and corneal vascularization are observed, but these signs may be present in most chronic corneal inflammations and infections. Therefore, in both of these diseases, a definitive diagnosis can usually be made only after the relevant ocular parameter has been measured. Thus, tonometry, or the measurement of IOP, is the hallmark for diagnosis of glaucoma (Gelatt and Brooks, 1999). Schirmer tear test (STT) I, which measures production of the aqueous portion of the tear film, is used to diagnose KCS (Moore, 1999).

However, in order for tonometry or STT to be of diagnostic value, the practitioner must be able to refer to normal reference values. Large inter-species variations in reference IOP and STT values have been documented. For example, normal IOP may range from 7.6 mm Hg in the Thomson gazelle (*Gazella thomsoni*) (Ofri et al., 2000) to 29.5 mm Hg in Burchell's zebra (*Equus burchelli*) (Ofri et al., 1998a). Thus, what would constitute a normal reading in the zebra will be diagnosed as glaucoma in the gazelle. In addition, it is not possible to extrapolate normal values from closely-related species. Normal tear production in Felidae ranges from 17.0 mm/min in the domestic cat (Veith et al., 1970) to 24.4 mm/min in the African lion (*Panthera leo*) (Ofri et al., 1997). Therefore, in order to improve the veterinary care of captive wild animals, and to further our understanding of comparative ocular physiology, it is necessary to determine normal reference values for each species. During the last few years we have evaluated IOP and tear production, and the effect of chemical restraint thereon, in a

number of captive wildlife species (Ofri et al., 1997; Ofri et al., 1998a, b, 1999a, b, 2000). The aim of this study was to determine baseline IOP and STT values in two wild ruminant species that have not been studied.

Intraocular pressure and tear production were evaluated in 12 juvenile eland (*Taurotragus oryx*) which were anesthetized for transportation. All animals were ≤ 2 yr of age; mean (± standard deviation) age of the animals (ten females, two males) was 1.5 ± 0.5 yr. The eland were studied at the Tel-Aviv Ramat-Gan Zoological Center (Tel-Aviv, Israel; 32°3′N, 34°46′E) on November 1st–2nd, 1999. Tonometry and STT also were conducted in 15 Asian fallow deer (*Dama mesopotamica*) which were anesthetized so that they could be fitted with transmitters prior to their reintroduction to the wild. Mean age of the animals (six females, nine males) was 5.3 ± 3.3 yr, with a range of 1.5 to 11 yr. The deer were studied at the Carmel Mountains Nature Reserve (Haifa, Israel; 32°48′N, 35°00′E) on November 11th, 1999. Animals were anesthetized with an intramuscular injection by dart. The anesthetic agent was a commercial mixture of etorphine hydrochloride (2.45 mg/ml) and acepromazine maleate (10 mg/ml) (Large Animal Immobilon, C-Vet Ltd., Leyland, UK). Doses were adjusted to body weight estimates, and ranged from 1.25 to 1.70 ml for the eland, and from 0.70 to 1.10 ml for the deer. Based on the results of a thorough physical examination, including complete blood count and serum biochemistry panel, animals were determined to be healthy.

Tear production and IOP, in that order, were estimated as soon as the animal could be safely approached, approximately 12 min after the animal had been darted. Bilateral measurements were conducted in the eland (24 eyes), but due to time constraints only unilateral measurements were conducted on the deer (15 eyes). The order of the eyes evaluated in the eland and the identity of the eye evaluated in the deer were determined randomly. Following evaluation of tear production and IOP, a complete ophthalmic examination, including tonometry, slit lamp biomicroscopy and indirect ophthalmoscopy, was conducted.

Tear production was estimated using a commercial tear flow test strip (Schering Plough Animal Health Corp., Kenilworth, New Jersey, USA) of a single lot number. The test strips contain a small amount of dye that is carried by the tears which the paper absorbs. A sterile strip was inserted for 1 min in the lower conjunctival fornix of the eye. The distance (in mm) which the dye covered in 1 min was determined from the scale imprinted on the test strips. Tonometry was conducted using an applanation tonometer (Tono-Pen™ XL, Mentor Ophthalmics, Inc., Norwell, Massachusetts, USA) following application of topical anesthesia (benoxinate HCl 0.4%) (Localin®, Fischer Pharmaceuticals Ltd., Tel-Aviv, Israel) to the cornea. This digital tonometer takes several readings of IOP through the cornea, and then displays the average IOP and variance. Three such averaged readings, with a variance ≤10% (as determined by the instrument) were taken from each eye. The instrument had recently been calibrated by the manufacturer, and its calibration was rechecked at the beginning of each recording day; the latex cover was changed following measurement in each animal.

Repeated measures analysis of variance was used to evaluate the potential effects of age, gender, side (left versus right) and species on IOP and STT measurements. When equal number of measurements were not available across species, repeated measures were averaged and species were compared using a two-group Student's *t*-test. All analyses were performed using a computer statistics program (PC 90, BMDP Statistical Software, Los Angeles, California, USA). Values of $P < 0.05$ were considered statistically significant.

Mean (± standard deviation) IOP was 14.6 ± 4.0 mm Hg in the eland and 11.9

± 3.3 mm Hg in the deer. Mean tear production was 18.7 ± 5.9 mm/min in the eland and 10.5 ± 6.5 mm/min in the deer. Both IOP ($P = 0.04$) and tear production ($P < 0.001$) were significantly higher in the eland than in the deer. No ocular abnormalities were detected during the ophthalmic examination.

Tear production in the deer is significantly lower than in the eland. This finding continues an interesting trend noted in our previous studies. To date, we have evaluated tear production in six herbivorous wildlife species. Three of these species, the Arabian oryx (*Oryx leucoryx*) and Nubian ibex (*Capra ibex nubiana*) (Ofri et al., 1999a) as well as the Asian fallow deer (present report) are desert-dwelling species, with mean STT values of 12.7, 13.2 and 10.5 mm/min, respectively. The Burchell's zebra (Ofri et al., 1999a), Thomson gazelle (R. Ofri, unpubl. data) and eland (present report), have mean STT values of 23.4, 21.0 and 18.7 mm/min, respectively. Tear production values in the three desert dwelling species were significantly lower than in the three species living in more moderate climates ($P < 0.0001$). They are also lower than the values reported for domestic species including the cat (17.0 mm/min) (Veith et al., 1970), the dog (>15 mm/min) (Moore, 1999), and horse (23.9 mm/min) (Brightman et al., 1983). The small volume of tears produced daily (1.7 ml/eye in humans) (Lemp and Wolfey, 1992) makes it unlikely that decreased tear production has evolved as a fluid conservation mechanism. However, it is interesting to note that herbivorous wildlife species living in arid areas of the world seem to have significantly lower tear production than herbivorous and non-herbivorous species living elsewhere.

Despite the relatively low STT values in the fallow deer, tear production in this species appears to be adequate. No signs of conjunctivitis or keratitis were noted in any of the animals studied, nor are we aware of any reports of such inflammations in this species. However, cases of infectious keratitis and conjunctivitis have been reported in other *Cervidae* species, including free-ranging mule deer (*Odocoileus hemionus*) (Dubay et al., 2000) reindeer (*Rangifer tarandus*) (Rehbinder and Glatthard, 1977) and moose (*Alces alces*) (Dubay et al., 2000). Since tears contain lysozymes and immunoglobulins that play an important role in protecting the outer coats of the eye (Moore, 1999), low tear production could be a factor that contributes to increased susceptibility of the conjunctiva and cornea of these species to infectious agents.

Mean IOP measured in the eland was significantly higher than in the deer ($P = 0.04$). The significance of this finding remains unknown. Other members of the Bovidae family, to which the eland belongs, have significantly lower IOP than the deer. In gazelles, we measured a mean IOP of 7.6 mm Hg (Ofri et al., 2000), significantly lower than that of the deer ($P < 0.001$). The range of IOP that we recorded in the Bovidae family, from 7.6 mm Hg in gazelles to 14.6 mm Hg in juvenile eland, reinforces the point raised earlier. Namely, that even in the case of closely related species, reference IOP values can not be extrapolated from one species to another; rather, reference values must be determined separately for each species.

Glaucoma and KCS occur most frequently in the dog. Spontaneous glaucoma afflicts 0.5% of the canine population (Gelatt and Brooks, 1999), and secondary glaucoma is observed in the domestic cat (Wilcock et al., 1990) and the horse (Wilcock et al., 1991). Keratoconjunctivitis sicca accounts for 1% of the canine caseload in North American veterinary colleges (Moore, 1999), and is considered the most important lacrimal disease in the cat (Glaze and Gelatt, 1999). However, these diseases are rarely diagnosed in wild species. There are rare case reports of glaucoma in species ranging from lions (Gerding et al., 1987) to lemurs (*Lemur fulvus rufus*) (Shields and Ritch, 1991), but these are usually anecdotal reports limited to

one or a few individuals. To the best of our knowledge there are no documented cases of KCS in wildlife species. Undoubtedly, the need for chemical restraint during examination contributes to the paucity of documented cases of glaucoma and/or KCS in wildlife species. In addition, veterinarians examine domestic animals more often than free-ranging wildlife species. However, we propose that the lack of normal reference values in most species hampers the diagnosis of these two ocular diseases in wild animals. It is our hope that this report, and similar works, will contribute to improved diagnostic capabilities of wildlife veterinarians.

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