

DETERMINATION OF REFERENCE VALUES FOR INTRAOCULAR PRESSURE AND SCHIRMER TEAR TEST IN CLINICALLY NORMAL OSTRICHES (*STRUTHIO CAMELUS*)

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Abstract: The purpose of this study was to establish normal physiologic reference values for intraocular pressure (IOP) and Schirmer tear test (STT) results in clinically normal ostriches (*Struthio camelus*). Twenty ostriches of both sexes, 10 juveniles (1.5–2 yr of age) and 10 adults, were included in this study. Complete ophthalmic examination was performed prior to this investigation. STT was performed by inserting a standard sterile STT strip over the ventral lid margin into the ventral conjunctival sac for 60 sec. Following the STT, IOP was measured using applanation tonometry with the Tono-Pen Vet™ tonometer after topical instillation of one drop of 0.5% proparacaine ophthalmic solution. The mean \pm SD and range of Tono-Pen readings of IOP for all birds was 18.8 ± 3.5 , with a range of 12–24. Mean IOP in juvenile ostriches was 19.7 ± 3.6 . Mean IOP in adult ostriches was 16.9 ± 2.9 . There was no statistically significant difference between young and adult birds ($P=0.07$). The mean STT values in the present study were 16.3 ± 2.5 mm/1 min when measurements from both eyes were averaged. Mean STT in juvenile and adult ostriches was 15.4 ± 1.8 and 17.2 ± 2.9 mm/1 min, respectively. There was no statistically significant difference between young and adult birds ($P=0.11$). No statistically significant differences between genders were found for any of the results ($P \geq 0.41$). In conclusion, this study provides normal reference range values for STT and IOP in clinically healthy ostriches.

Key words: Intraocular pressure, Schirmer tear test, ostriches (*Struthio camelus*).

INTRODUCTION

The ostrich (*Struthio camelus*) belongs to the group of large, flightless birds known as ratites. Ratites have in common a distinctive palate and the lack of a bony keel to the sternum (breastbone), to which the powerful musculature required for flight would be attached. The ostrich formerly occupied Africa north and south of the Sahara, east Africa, Africa south of the rainforest belt, and much of Asia Minor.⁷

The ostrich eye has selected anatomic and morphologic features. It is the largest among contemporary terrestrial vertebrates, measuring about 50 mm in diameter, and is of the flat type. The lower eyelid is thinner and more extensive than the upper eyelid and is mainly responsible for closing of the eye. The free margins of both

lids carry rows of long, overlapping bristle feathers that resemble eyelashes.²

There are few publications specifically pertaining to the ostrich eye, with most being case reports highlighting medical or surgical therapy for specific ocular lesions such as granulomatous conjunctivitis, eye complications due to avian influenza and poxviruses, and a spontaneously occurring cataract.^{1,11,12}

Keratoconjunctivitis sicca and glaucoma have not been previously reported in ostriches. Obviously, this does not mean that these diseases do not exist in these species. The measurements of the Schirmer tear test (STT) and intraocular pressure (IOP) have been common ophthalmic diagnostic tests in routine eye examination for diagnosis of keratoconjunctivitis sicca and glaucoma. Interpretation of results of selected ophthalmic diagnostic tests such as STT and IOP in a particular species can only be achieved if reference values for that species, preferably established by the same methods, are available. A review of the veterinary literature has indicated that such data is lacking in ostriches. The purpose of this study was to establish STT and IOP results in clinically normal eyes of ostriches.

MATERIALS AND METHODS

Twenty ostriches of both sexes, 10 juveniles (1.5–2 yr of age) and 10 adults (ranging from 3 to 5

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yr of age) were included in this study. The study was approved by the Iran Society for Prevention of Cruelty to Animals in accordance with Iranian ethical codes for studies on laboratory animals (permit number 906-V26102).

The ostriches were obtained from a local farm in the Tehran province of Iran. They were kept in a fenced pen and separated according to age. The diet of birds was a mixture of commercial ostrich pellets, alfalfa hay, and vitamin and mineral supplements. Water was provided ad libitum.

The birds were restrained manually without sedation and all ophthalmic examinations performed by the same examiner (MSG). Following the STT, a complete ophthalmic examination including biomicroscopy, tonometry, and indirect ophthalmoscopy was performed prior to this investigation. No obvious abnormalities were noted during the ophthalmic examinations.

STT was performed by inserting a standard sterile STT strip over the ventral lid margin into the ventral conjunctival sac for 60 sec (Fig. 1). A 35-mm \times 5-mm commercial tear test strip (Schirmer Tear Strip, Ophtech Inc., Carson City, Nevada 89706, USA) was used to record tear production in millimeters wetting in 1 min. Following the STT, IOP was measured using applanation tonometry (Reichert Tono-Pen Vet™ Applanation Tonometer, Dan Scott & Associates, Inc., Westerville, Ohio 43081, USA) after topical instillation of one drop of 0.5% proparacaine ophthalmic solution (Paracain, Sunways Ltd., Mumbai 400 063, India) (Fig. 2).

Statistical analysis was performed by using the software package SPSS version 15.0 for Microsoft Windows® (SPSS Inc., Chicago, Illinois 60606, USA). Data were expressed as mean \pm SD. Differences in mean values (between IOP and



Figure 2. Measurement of intraocular pressure using applanation tonometry in an ostrich (*S. camelus*).

STT values for the right and left eyes) were analyzed using paired-samples *t*-test. Mean and SD were calculated for all eyes combined and for right and left eyes separately. An independent-samples *t*-test was used to compare the mean IOP and STT values for sex and age. A *P*-value of less than 0.05 was considered statistically significant.

RESULTS

The data for means and ranges of STT and IOP values are summarized in Table 1. IOP values from right (17.7 ± 3.9) and left (18.9 ± 3.8) eyes were not statistically different (paired-samples *t*-test, *P* = 0.11). Therefore, the data for the left and right eyes of each bird were averaged and used for further calculations. The mean and range of Tono-Pen readings of IOP for all birds was 18.8 ± 3.5 , with a range of 12–24. Mean IOP in juvenile ostriches was 19.7 ± 3.6 . Mean IOP in adult ostriches was 16.9 ± 2.9 . There was no statistically significant difference between young and adult birds (*P* = 0.07).

Mean \pm SD STT values for right and left eye were 16.6 ± 2.9 and 15.9 ± 3.3 mm/1 min, respectively. Comparison between STT values of right and left eyes revealed no statistically significant differences (*P* = 0.41). The mean STT values in the present study were 16.3 ± 2.5 when measurements from both eyes were averaged.

Table 1. Mean and ranges for Schirmer tear test and Tono-Pen readings of intraocular pressure in the ostrich.

Ophthalmic test	Mean \pm SD	Range
Schirmer tear test (mm/1 min)	16.3 ± 2.5	13–22.5
Intraocular pressure	18.3 ± 3.5	12–24



Figure 1. Placement of a Schirmer tear strip over the ventral lid margin into the ventral conjunctival sac in an ostrich (*S. camelus*).

Mean STT in juvenile ostriches was 15.4 ± 1.8 . Mean STT in adult ostriches was 17.2 ± 2.9 . There was no statistically significant difference between young and adult birds ($P = 0.11$). No statistically significant differences between genders were found for any of the results ($P \geq 0.41$).

DISCUSSION

Results of the present study provided information on ranges of values for STT and IOP in healthy ostriches. In the current study, the mean Tono-Pen readings of IOP (18.3 ± 3.5 ; ranging from 12 to 24), as determined using the Tono-Pen Vet tonometer, are similar to IOPs reported for other birds, including red-tailed hawks (*Buteo jamaicensis*) (20.6 ± 3.4), Swainson's hawks (*Buteo swainsoni*) (20.8 ± 2.3), golden eagles (*Aquila chrysaetos*) (21.5 ± 3.0), and bald eagles (*Haliaeetus leucocephalus*) (20.6 ± 2.0).¹³

Mean IOP in ostriches is higher than values reported for great horned owls (*Bubo virginianus virginianus*) (10.8 ± 3.6) and Eurasian eagle owls (*Bubo bubo*) (9.3 ± 1.8).^{8,13} These results are consistent with the reported differences in IOP values between diurnal and nocturnal raptors, considering ostriches' natural diurnal behavior. The exact cause of this difference between diurnal and nocturnal species is unknown.^{8,13}

The limitation of the study is that the validity of Tono-Pen readings has not been confirmed in this species. In order to confirm the (lack of) validity of Tono-Pen readings in this species, the method should have been validated in vitro by comparison of Tono-Pen measurements and manometry in ostrich eyes. No manometric studies of IOP in ostriches have been published to the date, so readings by applanation tonometer in this study have been described as Tono-Pen readings.

The STT has long been the clinical standard for evaluating tear production in veterinary ophthalmology,⁵ but the conventional test strip has been found to be too large to use in most bird eyes. Some investigators have used the phenol red thread (PRT) tear test for measuring tear production in birds.^{6,14} The PRT tear test is an alternative method of tear measurement by which tear production is measured using a 75-mm-long cotton thread that has been impregnated with 1 μ l of phenolsulfonphthalein, a pH-sensitive indicator. When the more alkaline tears are absorbed, the pH indicator turns the thread from yellow to red. The test is used to measure tear production when placed for 15 sec between the cornea and the midinferior eyelid of the patient. The shorter time required to perform the PRT tear test and the

small size of the thread may make this test particularly suitable for use in birds and other small animals.^{3,6}

In the present investigation, the commonly available Schirmer tear strips were used, because these birds have considerably large eyes and placement of conventional Schirmer tear strips in these birds is practically possible without difficulty.

Little has been published about birds' baseline tear test values, with the exception of several studies of some owls (*Strix aluco*), Amazon parrots, and penguins.^{4,14,15}

The wide range of normal STT values in avian species justifies the importance of determining baseline values for individual species and demonstrates the risk of extrapolating normal values from one species to another.¹⁰ The mean STT values in the present study were 16.3 ± 2.5 mm/1 min when measurements from both eyes were averaged. The range of values for STTs obtained in this study was 13–22 mm/1 min. Values for the STT in the present study were higher than those previously reported for penguins (6.4 ± 2.9 mm/1 min), Amazon parrots (7.9 ± 2.6 mm/1 min), Falconiformes (2.1 ± 1.7 mm/1 min), and Accipitriformes (10.7 ± 4.0 mm/1 min).^{4,9,14,15}

In conclusion, this study provides normal reference range values for STT and IOP in clinically healthy ostriches. This data will assist with accurate diagnosis and management of ophthalmic diseases in ostriches, including keratoconjunctivitis sicca and glaucoma.

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