



Intraocular pressure using rebound tonometry in the San Cristobal Galapagos tortoise (*Chelonoidis chathamensis*)

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Abstract

Intraocular pressure (IOP) is a quantitative assessment to help determine some pathology associated with the eye. Captive-reared Galápagos tortoises (*Chelonoidis chathamensis*) benefit from health assessments to make repopulation efforts as successful as possible. The goal of this study was to determine if intraocular pressure could be accurately assessed and to create a baseline measurement for intraocular pressure in Galápagos tortoises. Intraocular pressures were obtained from both eyes of 39 tortoises at the Galapaguera of Cerro Colorado on San Cristóbal Island during their health assessment examinations. The intraocular pressures were analyzed and compiled to determine a mean pressure of 13.38 mmHg±3.81 mmHg. Intraocular pressure is possible to obtain during health assessments in Galápagos tortoises, and additional measurements could lead to a reference interval.

Keywords: Intraocular pressure, rebound tonometry, *Chelonoidis chathamensis*

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Introduction

Intraocular pressure (IOP) is the quantitative measurement of fluid in the eye, determined by the production of aqueous humor from the ciliary body and outflow by draining tracts (Zouache *et al.*, 2016). Measuring IOP is a crucial part of a complete ophthalmic examination to determine abnormalities. The IOP can be accurately measured in several ways to help determine normal physiologic function of the eye. The accuracy of rebound measurement tonometry has been tested in multiple species, confirming the viability of use in animal patients. This includes assessments in multiple reptiles, including turtles, tortoises, and alligators (Ruiz *et al.*, 2014; Somma *et al.*, 2014; Rajaei *et al.*, 2015). In chelonian species, a rebound measuring principle is typically used to obtain the best reading while attempting to reduce the amount of stress on the patient (Delgado *et al.*, 2013).

Galápagos tortoises, iconic to the Galápagos archipelago, have been recognized as endangered since the 1970s. Hunting and loss of suitable habitat and vegetation has led to a population decline of 88% (Caccone *et al.*, 2017; Olson, 2017). Efforts have been made to repopulate Galápagos tortoises through captive breeding and release programs (Caccone *et al.*, 2017; Gibbs *et al.*, 2007). The current population is estimated at 6,700 individuals, a considerable increase over a 500-700 surviving individuals in

a 1974 population estimate (Caccone *et al.*, 2017).

A thorough physical examination of Galápagos tortoises ready for release is crucial. Any clinical issues need to be identified in a pre-release examination, which can be difficult as disease processes may display few clinical signs. An individual's IOP can help identify ocular disease. In order to do so effectively, an IOP range needs to be determined. While many species have an established range, Galápagos tortoises do not as very little ophthalmic work has been conducted (Lewbart *et al.*, 2018). With this in mind, IOPs were measured to begin an understanding of normal values for this species.

Materials and methods

Thirty-nine captive Galápagos tortoises from the Galapaguera of Cerro Colorado, established in 2002, were used for this study. The facility is 12 hectares in size and houses approximately 140 tortoises. The juvenile tortoises are housed outdoors year-round, with older breeding-aged animals maintained separately. The tortoises presented for annual physical examinations and bloodwork. Tortoises were manually restrained for measurements, with larger tortoises placed in dorsoventral recumbency. No ocular abnormalities were noted on physical examination; ophthalmoscopy (complete ophthalmic examination) was not performed due to conflicts with lighting conditions and inability to restrain tortoises' heads for an extended period of time.

This study and collection of data was performed during health assessments of Galápagos tortoises located at San Cristóbal Tortoise Center. The health assessments and animal handling were authorized by the Galápagos National Park Service (PNG). All handling and veterinary procedures were performed according to animal handling protocols established and approved by the University of San Francisco, Quito, and the PNG.

Intraocular pressure (IOP) measurements were acquired utilizing rebound tonometry without topical anesthesia to obtain the most accurate reading. Measurements were taken of the left and right eye using a rebound tonometer (TonoVet®, iCare, Tiolat, Helsinki, Finland). Intraocular pressures were measured on the Tonovet's®

rebound tonometer on undefined patient setting (p). Disposable probes were used and changed between every patient. The tonometer was held in position perpendicular to the patient and approximately 5-10 mm from the corneal surface (Figure 1). Tortoise heads were minimally restrained to avoid false elevation in IOP readings; limbs were gently retracted if necessary to gain access to the eye. IOP readings were obtained for the right and left eye and values were determined from an average of six readings per eye. Readings were discarded and re-evaluated if an erroneous value occurred due to excessive movement of the tortoise or non-centralized placement of the probe on the cornea.



Figure 1: A juvenile San Cristóbal Galápagos tortoise (*Chelonoidis chathamensis*) being minimally restrained in ventral recumbency for ocular rebound tonometry using a TonoVet® device.

Results

The range of individual IOP measurements was 6-24 mmHg for the left eye and 7-21 mmHg for the right eye. The mean of individual IOPs for the left and right eyes were 13.31 ± 4.19 mmHg and 13.46 ± 3.46 mmHg, respectively. Mean for the total dataset was 13.38 ± 3.81 mmHg (Table 1).

Table 1: Mean intraocular pressures (IOP) of juvenile Galápagos tortoises (*Chelonoidis chathamensis*).

Dataset	Mean IOP in mmHg
Left Eye	13.31 ± 4.19
Right Eye	13.46 ± 3.46
Total	13.38 ± 3.81

Discussion

Intraocular pressure has been previously determined in multiple tortoise species, including red-foot tortoises (*Geochelone carbonaria*), yellow foot tortoises (*Geochelone denticulata*), and Hermann's tortoises (*Testudo hermanni*). Results determined in this study are consistent with other reported values. Red-foot tortoises had a total mean IOP of 15.3 ± 8.81 mmHg (Selmi *et al.*, 2002). For Hermann's tortoises the mean was 15.74 ± 0.20 mmHg and for yellow foot tortoises, the mean was 14.2 ± 1.2 mmHg (Selmi *et al.*, 2003; Selleri *et al.*, 2012). While too few samples have been collected to definitively determine a reference range, the current results suggest that IOP in Galápagos tortoises is similar to other tortoise species.

Tortoise compliance was a limiting factor in acquiring accurate pressure readings for this study, especially for

animals that were too large for restraint without artificially increasing IOP. IOP measurements for larger tortoises were most frequently discarded and reassessed. Utilizing sedation may be required to gain a more reliable assessment of intraocular pressure with fewer errors in measurement. Field conditions limited the ability to acquire a thorough ophthalmic examination and should be utilized in captive settings to acquire a more complete assessment of ocular health.

In order to accurately measure IOP as normal, more measurements need to be obtained. Sample size is commonly a problem in zoological medicine due to a limited number of specimens. This is accentuated with Galápagos tortoises with the limited habitat and current population number (Caccone *et al.*, 2017). As current repopulation efforts are used, IOPs can be obtained on juvenile tortoises ready for release around 5 to 7 years of age. The eventual creation of a reference interval will allow guidance and early diagnosis of ophthalmic disease, with treatment where appropriate, and increasing success of reintroduction programs.

Conclusion

Rebound tonometry is a good option for this species as readings can be taken with limited restraint, especially for large tortoises where restraint can be challenging. Rebound tonometry does not require topical anesthetic, minimizing the amount of pharmacologic residue. Including IOP measurement as a part of routine health

assessment may be an option to non-invasively monitor ocular disease in this species. This is of clinical significance for an endangered species where ocular disease may have a significant effect on survivability and reproductive success. Galápagos tortoises are commonly kept in zoological collections as well, and rebound tonometry is a viable option for ophthalmologic assessment in these animals.

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