FULL ARTICLE

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Ocular biometry of snakes of the species *Python bivittatus* kept in captivity

Biometria ocular em serpentes da espécie Python bivittatus *mantidas em cativeiro*

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ABSTRACT

During embryological development, the eyelids of snakes fuse and no longer open like in mammals. They become transparent, thus forming spectacles, a transparent structure that covers the eyes. The primary function of these spectacles is to provide a physical barrier to protect the eyes without eyelids. This study aimed to evaluate the ocular biometry of *Python bivittatus* snakes. Ocular ultrasound examinations were performed on four individuals using the Logic E ultrasound device (GE, United States) with a 10-22 MHz linear probe. Conduction gel was used to make transducer contact with the cornea in these snakes. Images were obtained to evaluate the following measurements: axial length of the eyeball, anterior chamber depth, lens thickness, and vitreous depth. These measurements of intraocular structures were, respectively: 0.05 ± 0.02 cm for corneal thickness in the right eye and 0.04 ± 0.007 cm in the left eye; 0.11 ± 0.04 cm for anterior chamber depth in the right and left eyes; 0.36 ± 0.07 cm for the lens thickness in the right eye and 0.39 ± 0.05 cm in the left eye; 0.35 ± 0.05 for the depth of the vitreous chamber in the right eye and 0.31 ± 0.02 cm in the left eye; and 0.85 ± 0.18 cm for the length of the globe in the axial plane in the right eye and 0.85 ± 0.14 cm in the left eye. Knowledge of snakes' anatomical and ophthalmological parameters is scarce, and the incidence of eye diseases is still little known, making further studies necessary.

Keywords: Ophthalmology. Ultrasound. Diagnostic imaging.

RESUMO

Durante o desenvolvimento embriológico as pálpebras das cobras se fundem e não reabrem mais como nos mamíferos, elas se tornam transparentes formando uma escama ocular, uma estrutura transparente que cobre os olhos. A escama ocular tem como principal função fornecer uma barreira física para proteger o olho na ausência de pálpebras. O objetivo desse trabalho foi avaliar a biometria ocular das serpentes *Python bivittatus.* O exame ultrassonográfico ocular foi realizado com um aparelho de ultrassom Logic E, GE, Estados Unidos, com sonda linear 10-22 MHz, utilizou-se gel de condução para realizar o contato do transdutor com a córnea dos 4 animais avaliados. As medidas avaliadas foram a profundidade da câmara anterior, espessura da lente, a profundidade do vítreo e o comprimento axial do globo ocular. Foram realizadas imagens obtendo as medidas do comprimento axial do globo ocular, câmara anterior, espessura da lente e a profundidade do vítreo. As estruturas intraoculares medidas foram, respectivamente: 0,05 ± 0,02 cm para espessura da córnea no olho direito e 0,04 ± 0,007 cm no olho esquerdo, 0,11 ± 0,04 cm para a profundidade da câmara anterior nos olhos direito e esquerdo, 0,36 ± 0,07 cm para a espessura da lente do olho direito e 0,39 ± 0,05 cm do olho esquerdo, 0,35 ± 0,05 para a profundidade da câmara vítrea no olho direito e 0,31 ± 0,02 cm no olho esquerdo e 0,85 ± 0,18 cm para o comprimento do globo no plano axial no olho direito e 0,85 ± 0,14 cm no olho esquerdo. O conhecimento dos parâmetros anatômicos e oftalmológicos das serpentes é escasso e a incidência de doenças oculares ainda é pouco conhecida, o que torna necessário mais estudos relacionados ao tema.

Palavras-chave: Oftalmologia. Ultrassom. Diagnóstico por imagem.

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Introduction

Over the evolutionary history of snakes, there was a stage in which they lived as burrowing animals. During this period, their eyes became smaller and atrophied. Subsequently, snakes returned to an epigeal way of life on the surface, and their eyes redeveloped (Caprette et al., 2004; Duke-Elder, 1958; Lauridsen et al., 2014; Walls, 1940). Consequently, because of this exceptional evolutionary history, snakes' eye structures differ from those of other reptiles. Most reptiles have stationary upper eyelids and mobile lower eyelids. Moreover, most reptiles with a palpebral fissure possess a nictitating membrane that sweeps the cornea from the nasal canthus to the lateral canthus. This differs from snakes, where the membrane is absent (Duke-Elder, 1958).

Ocular ultrasound examinations are well used in veterinary medicine for small animals because they form a widely available low-cost screening method that provides information on the ocular components and retrobulbar region (Penninck et al., 2001). Ultrasonography is a valuable tool for eye assessments, especially in cases that present opaque alterations of transparent media, such as the cornea, aqueous humor, crystalline lens, and vitreous humor. Along with providing ocular information, ultrasonography can also be used to assess and diagnose some other abnormalities, such as phthisis bulbi, microphthalmia, pseudoexophthalmia, scleral ectasia, detachment of the retina and congenital glaucoma (Gonzalez et al., 2001; Rainwater et al., 2011).

The ocular biometry of some snakes, alligators, lizards, and marine turtles has already been described. The literature remains sparse (Hollingsworth et al., 2007; Martin de Bustamante et al., 2020; Muramoto et al., 2020; Ruiz et al., 2015). The present study aimed to obtain ocular ultrasound and biometry parameters for the species *Python bivittatus* through ocular ultrasound evaluations in B mode.

The eyes of snakes differ from those of other reptiles and mammals. The characteristic that makes them different is the absence of mobile eyelids (Figure 1A and B). During the embryological development of snakes, their eyelids fuse and no longer open like in mammals. Instead, they become transparent and form spectacles, a transparent structure that covers the eyes (Schwartz-Karsten, 1933).

Between the spectacle and the cornea is a narrow space called the subspectacle, which separates the spectacle from the cornea and allows free eye movement (Duke-Elder, 1958). The spectacle provides a physical barrier to protect the eye without eyelids (Lawton, 2006).

Spectacles form a shared characteristic of all snakes (the reptile suborder Serpentes). However, this feature is also present in other reptiles, particularly geckos. The spectacle is irrigated from a large postocular Harderian gland and drained through a tear duct system to the roof of the mouth. This drainage system forms an entrance for ocular pathogens coming from the mouth and respiratory tract (Schwartz Karsten, 1933; Walls, 1934).

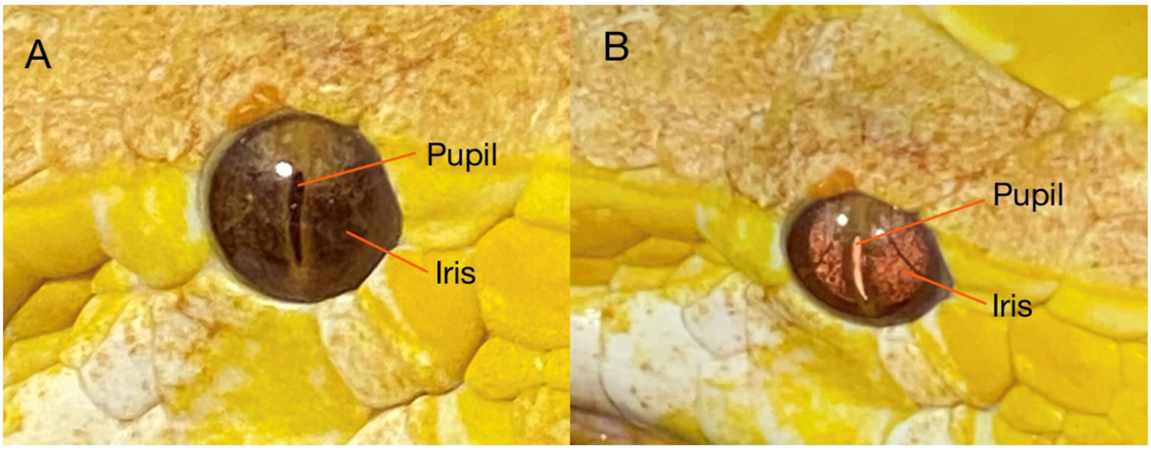

Figure 1 – Eyes of snakes of the species *Python bivittatus* in the axial plane. (A) The absence of eyelids and a slit-shaped pupil in the iris can be seen. (B) With brighter illumination, details of the iris and pupil are revealed.

Histologically, the spectacle is similar to the cornea, but it is thinner and contains nerves and traces of blood. It has three layers: an external epithelium with flat basal cells overlain by keratin; a central stroma formed by collagen fibrils with nerve fibers and blood vessels; and an internal epithelium with squamous cells containing vesicles and microvilli (Silva et al., 2014).

The ocular pathological conditions most observed in snakes are retention of the spectacle, subspectacle abscesses, and pseudobuphthalmos. All of these alterations contribute to the thickening of the anterior structures of the eyeball, which can be evaluated and measured through ocular ultrasound examinations. Knowledge of the normal anatomy of snakes' eyes thus becomes necessary in order to establish reference parameters (Hollingsworth et al., 2007).

Materials and Methods

Four snakes were used, and thus, eight eyes were assessed. The animals used in the present study are kept at the Wild Animal Rehabilitation Center (Projeto Selva Viva, i.e., "Living Jungle Project") in Taubaté, São Paulo, Brazil. These captive snakes of the species *Python bivittatus* (Pythonidae family) were all assessed previously and found to be in good health, without any history of disease. All snakes examined were adults of similar lengths and weights and comprised two males and two females of unknown age. No anesthesia was needed for the ocular evaluations; the animals were manually restrained.

The ocular ultrasound examinations were performed using a Logic E ultrasound device (GE, United States) with a 10-22 MHz linear probe. A 20 MHz frequency was used in all the animals evaluated. Conduction gel was used to ensure contact between the evaluated animals' transducer and cornea. Measurements of the anterior chamber's depth, lens thickness, vitreous chamber depth, and eyeball's axial length were made (Figure 2).

Images in B mode were obtained bilaterally in the horizontal and vertical planes to evaluate the intraocular structures, retrobulbar space, and ocular biometry. The measurements were defined as follows: axial length of the eyeball, measured from the anterior surface of the cornea to the retina; depth of the anterior chamber, measured as the distance between the echoes of the posterior surface of the cornea and the anterior surface of the lens; lens thickness, measured as the distance between the echoes of the anterior and posterior surfaces of the lens; and depth of the vitreous chamber, measured as the distance between the echoes of the posterior surface of the lens and the retina.

Results

All the ocular structures were assessed using ultrasonography in B mode. The cornea was seen as two parallel curvilinear lines separated by an anechoic stroma. The anterior capsule of the crystalline lens was identified as a convex curvilinear echogenic structure, and its posterior capsule was a concave curvilinear echogenic structure. The vitreous and the lens were anechoic (Figure 3).

The measurements of the intraocular structures were as follows, respectively: 0.05 ± 0.02 cm for the thickness of the cornea in the right eye and 0.04 ± 0.007 cm in the left eye; 0.11 ± 0.04 cm for the depth of the anterior chamber in both the right and the left eye; 0.36 ± 0.07 cm for the lens thickness in the right eye and 0.39 ± 0.05 cm in the left eye; 0.35 ± 0.05 cm for the depth of the vitreous chamber in the right eye and 0.31 ± 0.02 cm in the left eye; and 0.85 ± 0.18 cm for the length of the eyeball in the axial plane in the right eye and 0.85 ± 0.14 cm in the left eye. (Table 1).

Discussion

Knowledge of snakes' anatomical and ophthalmological parameters is sparse, and the incidence of ocular diseases remains little known. The present study was conducted with a small number of animals, but it was the first study of ocular biometry using only ultrasound on snakes of the species *Python bivittatus*. Thus, it aimed to contribute to future investigations.

A previous study assessing the ultrasound appearance of alligators' eyes showed that their eyes were similar to those of other wild, exotic, and domestic species (Ruiz et al., 2015).

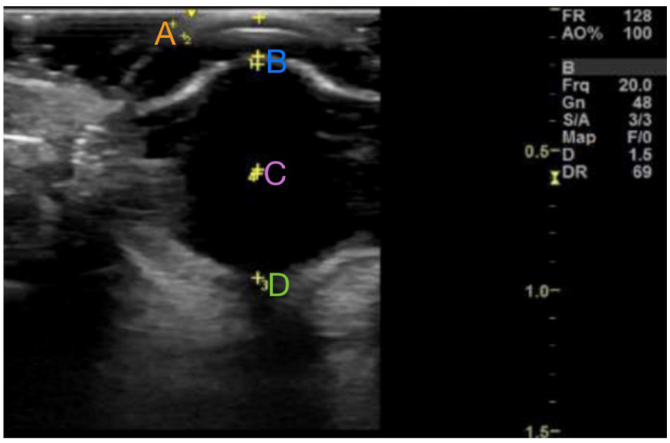

Figure 2 – Ultrasound image of the eyeball of the species *Python bivittatus* in the axial plane: (A) measurement of the anterior chamber; (B) measurement of the cornea; (C) measurement of the lens; and (D) measurement of the posterior chamber.

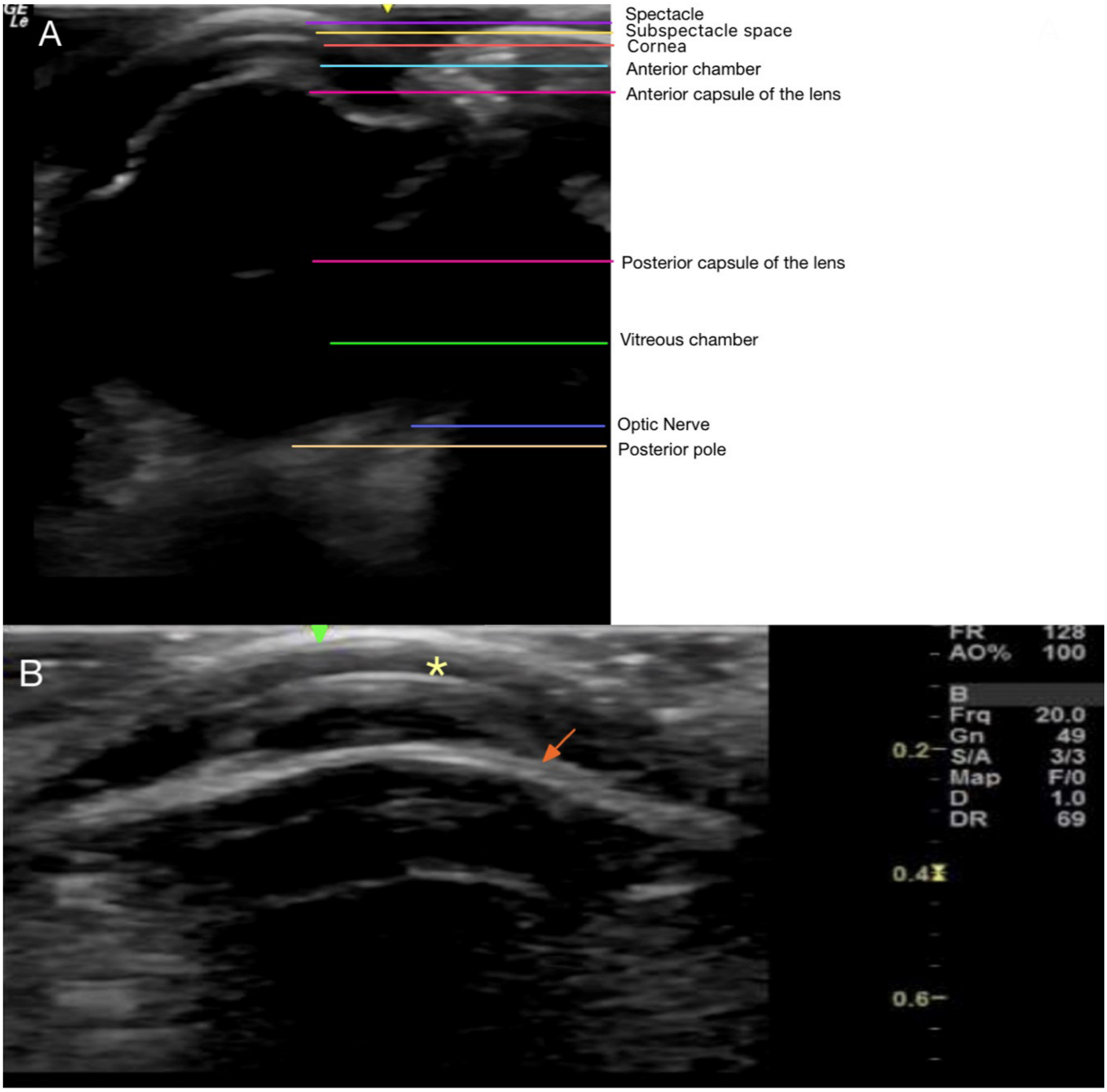

Figure 3 – (A) and (B) Anatomical diagram of a snake's eye and images obtained through ocular ultrasonography. In (A), the spectacle, subspectacle space, cornea, anterior chamber, anterior capsule of the lens, posterior capsule of the lens, vitreous chamber, and posterior pole can be identified. In (B), the cornea can be seen as two parallel curved structures separated by an echogenic line (*). The anterior capsule of the lens is viewed as a convex echogenic structure (tip of the orange arrow).

Table 1 – Measurements of the ocular structures obtained through biometry in snakes of the species *Python bivittatus*

	Right eye				
	Cornea	**Anterior chamber**	**Lens**	**Posterior chamber**	**Axial length**
Animal 1	0.05	0.11	0.41	0.32	0.89
Animal 2	0.05	0.14	0.37	0.37	0.97
Animal 3	0.08	0.08	0.31	0.29	0.71
Animal 4	0.04	0.12	0.37	0.32	0.84
Mean/SD*	**0.05 ± 0.02**	**0.11 ± 0.04**	**0.36 ± 0.07**	**0.32 ± 0.05**	**0.85 ± 0.18**
	Left eye				
	Cornea	**Anterior chamber**	**Lens**	**Posterior chamber**	**Axial length**
Animal 1	0.04	0.11	0.42	0.32	0.88
Animal 2	0.04	0.14	0.41	0.33	0.93
Animal 3	0.04	0.08	0.34	0.29	0.72
Animal 4	0.05	0.12	0.4	0.31	0.87
Mean/SD *	**0.04 ± 0.007**	**0.11 ± 0.04**	**0.39 ± 0.05**	**0.31 ± 0.02**	**0.85 ± 0.14**

*SD: standard deviation.

However, a study on birds found that their scleral ossicles generated a lateral acoustic shadow in ultrasound examinations (Gumpenberger & Kolm, 2006; Squarzoni et al., 2010). This characteristic was not observed in alligators' eyes, probably because only young individuals were studied (Ruiz et al., 2015). Through ultrasonography, it was observed that the intraocular chambers and structures resembled those seen in other species.

B-mode ultrasonography is the primary method used clinically within veterinary medicine. It enables simultaneous estimation of intraocular structures and visualization of the spatial layout of these eyeball structures (Hernandez-Guerra et al., 2007; Lehmkuhl et al., 2010). Previously, it was observed that there were no significant differences in ocular structure measurements among bearded dragons (*Pogona* sp.) (Martin de Bustamante et al., 2020). Likewise, in ocular ultrasound evaluations of marine turtles, no significant differences in measurements obtained through biometry were observed (Muramoto et al., 2020). In the present study, no significant differences in the measurements of these snakes' eyeballs were seen.

A study on 19 snakes of five different species evaluated the anterior section of the eye with transducers of 21 and 50 MHz (Lauridsen et al., 2014). However, in the present study, evaluations were only conducted with the 20 MHz transducer, which proved to be very effective; with adequate gain adjustment, it was possible to evaluate the ocular structures clearly, minimizing reverberation artifacts.

Final Remarks

The ultrasound appearance of the eyes of this snake species was similar to that of other domestic and wild species. There were no differences in measurements between the animals about the mean thickness of the eyeball, depth of the subspectacle space, thickness of the cornea, or thickness of the lens.

Ocular ultrasonography is a valuable tool for identifying ocular alterations. Its use is growing and developing within veterinary medicine.

Conflict of Interest

The authors state that there are no conflicts of interest regarding financial or personal support for the work conducted in this article.

Ethics Statement

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to.

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