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OCULAR FINDINGS IN SLOTH BEARS (*MELURSUS URSINUS*) RESCUED FROM THE DANCING BEAR TRADE IN INDIA

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Abstract: The aim of this study was to descriptively characterize the ophthalmic findings identified in 43 adult sloth bears *(Melursus ursinus)* rescued from the dancing bear trade in India and examined at two sloth bear rehabilitation centers in Agra and Bannerghatta nr. Bangalore. Animals were selected where ocular disease was suspected except for two bears which were examined while anesthetized for other reasons (fight wound, health check). Full ophthalmic examinations were undertaken under general anesthesia. Ocular ultrasonography, electroretinography, and photography were also performed. Forty-three bears (86 eyes) were examined. Mean Schirmer tear test (STT) = 12+/−6.2 (median 12, 95% CI −0.4–24.4) mm/min. Mean intraocular pressure (IOP) = 11.4+/−3.7 (median 12, 95% CI 4–18.8) mmHg excluding phthisical or grossly hydrophthalmic eyes. Ocular disease perceived to result in uni- or bilateral blindness was common (35 bears) with one or more of the following: phthisis bulbi (19 eyes; 13 bears), cataract (28 eyes; 17 bears), retinal detachment (29 eyes; 21 bears), and retinal degeneration (19 eyes; 16 bears) recorded frequently. Ocular ultrasound recorded mean axial globe diameter in non-phthisical/non-hydrophthalmic eyes as 16.5 +/−1.4 (median 16.4, 95% CI 13.7–19.3) mm and mean axial lens diameter of 4.9 +/−0.1 (median 4.7, 95% CI 4.7–5.1) mm. Blinding ocular disease was common, in particular, phthisis bulbi, retinal degeneration, and retinal detachment. Retinal detachment and phthisis bulbi may relate to blunt force ocular trauma prior to rescue, but ocular tuberculosis (TB) cannot be excluded, and retinal degeneration could result from a poor diet prior to rescue.

INTRODUCTION

Taxonomically, bears belong to the order *Carnivora*, suborder *Caniformia* ('dog-like'), and the family *Ursidae*. The sloth bear (*Melursus ursinus*) is an insectivorous species (myrmecophagous) that also consumes fruit (season-dependent). It has a long shaggy black coat, a mane around the face and neck, and a cream-colored crescent on the chest. The sloth bear has a longer-limbed frame than the Asiatic or American black bears with a bodyweight of 55–192 kgs.[7] The sloth bear has evolved a long lower lip and palate advantageous for sucking up insects (ants and termites) as well as well-developed nasal alar cartilages capable of closing the nostrils during feeding. A sloth bear has been recorded to live 33 years in captivity (unverified reports of up to 40 years), while estimates of wild bear lifespans range from 16–25 years. The sloth bear is classified as vulnerable on the International Union for Conservation of Nature (IUCN) Red List and is covered under Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) legislation.[3]

Sloth bears have been recorded in India, Nepal, Sri Lanka, and very rarely in Bhutan, with an estimated 90% of the population in India.[7,26] Populations are believed to be in decline due to habitat destruction, poaching (conflict animals and for body parts), and capture for exploitation[6]. Sloth bears have smaller home ranges than other ursid species, and will climb to feed and rest, although apparently not to avoid predators when they prefer to stand their ground. They have been described as the most aggressive of the bear species, although this may simply reflect the proximity of large human populations close to

From Animal Health Trust, Newmarket, CB8 7UU U.K. (Hartley, Busse, Riera); Jeanne Marchig Centre for Animal Welfare, University of Edinburgh, Edinburgh, EH25 9RG U.K (Bacon); Wildlife SOS, D-210, Defence Colony, New Delhi – 110024, India (Arun, Khadpekar, Selvaraj, Satyanarayan, Seshamani), International Animal Rescue, Lime House, Regency Close, Uckfield, East Sussex, TN22 1DS, U.K. (Knight). Present addresses: Hartley: Royal (Dick) School of Veterinary Science, Edinburgh, U.K.; Busse: University of Veterinary Medicine Hannover, Foundation, Bünteweg 9, 30559 Hanover, Germany; Riera: Memvet - Centre de Referència, C/Reina Esclaramunda 6 baixos, 07003 Palma - Spain; Bacon: University of Central Lancashire, Preston, Lancashire, PR1 2HE, U.K. Correspondence should be directed to Claudia Hartley (claudia.hartley@ed.ac.uk).

their home ranges, resulting in greater opportunities for human–animal conflicts.

Sloth bears *(Melursus ursinus)* kept for 'dancing' as a popular entertainment was traditional in India dating back to the 13th century. The practice was banned in 1972, but bears remained on the streets, often within the Kalandar community. The Kalandar are an endogamous ethnic group of nomadic entertainers widely dispersed across India and are a typically impoverished.[4] The income from one dancing bear was able to support an extended family, and Kalandar households typically rely on a single income from a male member with an average household of 12 people.[4]

Sloth bear cubs would be trained from an early age (poached from the wild and often involved killing the protective mother) and later fitted with a nose ring (running through a stoma created via the skin and nasal bone) attached to a short leash. Some had teeth removed or broken to reduce the risk of injury to handlers, and most handlers also used sticks to coerce their bears into submission. The last dancing bear on Indian streets was rescued in 2009 by a coalition of Indian and International welfare groups, although undercover work has found that some bears remain within the Kalandar community in remote rural areas (28 bears in 13 districts in seven states across India) and particularly states bordering Nepal.[4] Kalandars have been supported in finding alternative sources of income through a 'sustainable livelihoods approach' (SLA) initiative, and some have been employed by sanctuaries caring for the rescued bears.

There are no previous published studies on ocular disease in sloth bears. Ocular disease in this population of bears rescued from the 'bear dancing' trade was noted to be high by the resident veterinary surgeons. The aim of this study was to descriptively characterize the ophthalmic abnormalities identified in this population of rescued bears. We considered the implications of human captivity in relation to these findings.

MATERIALS AND METHODS

Animals studied

The examined bears were from two populations cared for by Wildlife SOS (India), International Animal Rescue and Free the Bears non-governmental organizations (NGOs) at rescue centers near Bangalore and Agra, India. Examinations took place in May 2011. Inclusion criteria were bears identified with ocular abnormalities on routine health checks by experienced resident veterinarians or reported visual disturbances/ocular abnormalities on den checks by bear keepers. One bear was examined without ocular disease due to acute injury (periocular fight wound), and another bear was examined that had been reared at the sanctuary since a cub as part of a scheduled general health screen.

Chemical restraint

Initial ophthalmic exams were performed with the bears conscious dens by coaxing them to bars with food treats. For full ophthalmic exam the bears were anesthetized using xylazine (2 mg/kg; Xylaxil-100 2% injection, Brilliant BioPharma, elangana 502307 India) with ketamine (5 mg/kg; Vetalar, Boehringer-Ingelheim, MO 64506 USA) administered using a blow pipe. Once unconscious the bear was transported to the hospital building, intubated (size 18 endotracheal tube) and maintained with isoflurane anesthesia and oxygen to effect.

Ophthalmic examinations

Ophthalmic examinations included Schirmer tear tests (STT, Schirmer tear test strips MSD Animal Health™, Milton Keynes, MK7 7AJ, UK), slit-lamp biomicroscopy (Kowa™ SL-14, Kowa Europe GmbH, Immermannstrasse 43B, 40210, Duesseldorf, Germany), direct and indirect ophthalmoscopy (Keeler professional™ direct ophthalmoscope and Keeler Vantage LED ™ indirect ophthalmoscope, Windsor, SL4 4AA UK), tonometry (Tonopen, Reichert-Carleton Optical, Chesham, HP5 2BD, UK; proxymetacaine 0.5% Minims, Bausch & Lomb, Kingston upon Thames, KT2 6TN, UK), ocular ultrasonography (Sonosite Titan 5-8MHz, Fujifilm Sonosite Inc., Bedford, MK42 0ZE, UK), electroretinography (Handheld Multispecies ERG; HMsERG, OcuScience™, Henderson, Nevada, NV89014, USA; short protocol for gross retinal function[16]), and adnexal, anterior segment and retinal photography (Canon EOS DSLR with 40D Volk™ condensing lens, Kowa Genesis™ digital retinal camera) were undertaken. Pupils were dilated using 1% tropicamide (Mydriacyl™, Alcon Eye Care UK Ltd, Camberley, GU15 3YL Surrey, UK).

All cases had co-incidental general physical examinations, including joint mobility assessments, bodyweight and condition scoring, and dental examination. Some bears also underwent digital radiography and routine hematology, blood biochemistry, and urinalysis, if indicated.

Statistical analysis

The parameters were evaluated by descriptive statistical analysis. The results were expressed as the mean +/−SD, confidence interval (95%), and median values. Comparison of the data between the left and right eyes was performed using a paired t-test. Comparison of the data between the males and females was performed using an unpaired t-test. Differences were considered significant at P values ≤ 0.05.

RESULTS

Animals studied

Ocular disease in this population was noted to be high by the resident veterinary surgeons, with 41 bears identified as having ophthalmic disease in their combined population of 389 sloth bears (11%). In total, 43 sloth bears were examined, including two bears that were ophthalmologically normal but anesthetized for other reasons (routine health screening and treatment of fight wound respectively). Of these, 16 were resident in the Bannerghatta sanctuary and 27 in Agra. There were 25 males and 18 females examined. The mean age of bears examined was 13.3 (median 13, range 8–26) years, this was based on the estimated age and history established at confiscation.

Ophthalmic examination findings

Mean Schirmer tear test (STT) = 12+/−6.2 (median 12, 95% CI 0.4–24.4) mm/min. There was no statistical significance in STT readings between right and left eyes ($p = 0.25$) or between male or female animals ($p = 0.13$). Mean intraocular pressure (IOP) = 11.4+/−3.7 (median 12, 95% CI 4–18.8) mmHg excluding phthisical or grossly hydrophthalmic eyes. Females had significantly lower IOP than males (female: mean 9.4, median 10mmHg; male: mean 12.1, median 11.5 mmHg, $p = 0.05$). There was no statistical significance in IOP readings between right and left eyes ($p = 0.46$). B mode ocular ultrasound performed in eyes with no evidence of hydrophthalmos or phthisis revealed a mean axial globe diameter of 16.5 +/−1.4 (median 16.4, 95% CI 13.7–19.3) mm and mean axial lens diameter of 4.9 +/−0.1 (median 4.7, 95% CI 4.7–5.1) mm in this population of bears.

Bilateral blindness with no potential for vision was documented in 18 bears (36 eyes), and unilateral blindness in 17 bears. Four bears (six eyes) were considered to have poor vision due to retinal degeneration and demonstrated reduced electroretinography (ERG) results. Two bears were identified as having potential for vision due to cataract (no retinal detachment on ultrasound and positive ERG results), of which one underwent bilateral phacoemulsification surgery. The second bear had signs of concurrent tuberculosis with rupture of an abscessated axillary lymph node, and phacoemulsification was not pursued (see Figure 1). Two bears were noted to cough under anesthesia and one of these had multifocal pulmonary nodules suspicious for tuberculosis.

Figure 1. Sloth bear under general anaesthesia with right axillary wound and suspected tuberculosis (from a ruptured axillary lymph node).

Ophthalmoscopically normal sloth bears (n = 2) had well-fitting pigmented eyelids with meibomian gland openings visible along their margins. Two rows of well-developed cilia (eyelashes) were present along the upper eyelid but were absent on the lower eyelid. Nasolacrimal punctae were present in the medial upper and lower eyelid a few millimeters from the medial canthus. The conjunctiva was pale pink in color, with variable dark brown pigmentation (sometimes extensive). The third eyelid was usually pigmented along the leading edge and variably so over the palpebral conjunctiva (similar to the domesticated dog) (see Figure 2A). Sparse episcleral vessels could be appreciated through the conjunctiva in ophthalmoscopically normal animals. The cornea was clear with some aged animals displaying a perilimbal rim of white opacity (resembling fibrosis, sometimes accompanied by pigment) reminiscent of senile arcus seen in elderly humans. The iris was brown in color, the pupil round, and maximal dilation with tropicamide was achieved in 20–40 mins. Nuclear sclerosis was also common even in apparently normal eyes within this population of bears (41/43 bears were >8 years). Funduscopy of ophthalmoscopically normal bear eyes revealed a large central tapetum with a peripheral tapering ring of non-

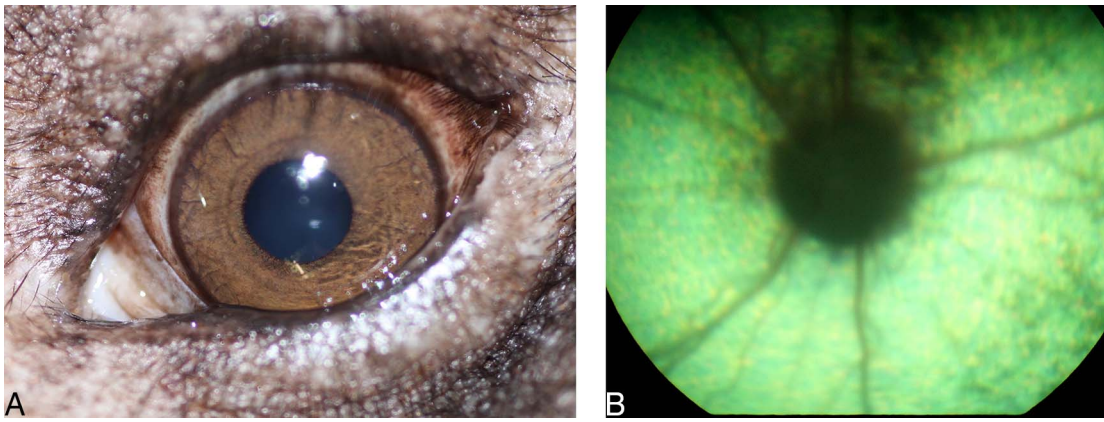

Figure 2. The normal appearance of the sloth bear eye. **A.** Normal external ocular appearance of the sloth bear. **B.** Normal fundus appearance of the sloth bear.

tapetal fundus. The fundus was holangiotic with approximately 15–20 radiating mildly branching retinal arterioles and venules (see Figure 2B). The tapetum varied in color from yellow to green. The optic nerve head appeared similar to the domestic cat — round and unmyelinated with vessels reflecting over the rim. In some cases, retinal vessels could be appreciated coursing over the surface of the disc. The intraocular pressure in these two bears was 16 mmHg Oculus Uterque (OU).

Phthisis bulbi was evident in 19 eyes (13 bears) with a typical shrunken, often mis-shapen appearance to the globe with total corneal fibrosis giving a blue-white opacified appearance. In some cases, folding of the cornea with pigment encroachment was present (see Figure 3). Phthisical globes were commonly accompanied by ocular discharge. Where the anterior chamber was still visible it was universally shallow, and this was also demonstrated on ultrasonography. Mean axial globe diameter was 12.4 mm (range 6.8–14 mm) in phthisical globes. The mean age of bears with one or more phthisical globes was 13.5 (median 13, range 9–26) years, which was not statistically significantly different from the whole population of examined bears ($p = 0.93$), or those without phthisis bulbi ($p = 0.60$).

In one bear (14 y, M) with bilateral phthisis, ocular ultrasound revealed an axial globe diameter of 14 mm and an absence of a lens in both eyes. Another bear with advanced unilateral phthisis (axial globe diameter 6.8 mm) had a history of chronic ocular discharge with entropion. This globe was enucleated.

One bear (9 y, M) that had been rescued as a juvenile with a history of blindness since a cub had microphthalmos with third eyelid protrusion and a noticeably smaller corneal diameter (more marked oculus dexter (OD) vs oculus sinister (OS)) than conspecifics. Axial globe measurement by B mode ultrasound was 14 mm, and axial lens diameter was 4.5 mm bilaterally. Posterior lens luxation and retinal detachment was present in both eyes. There was an absence of corneal opacification and a slightly deeper anterior chamber and flattened iris contour due to posterior lens luxation.

Unilateral hydrophthalmos was identified in two bears (mean axial globe diameter 20.9 mm). The IOP of the hydrophthalmic globes was 30 mmHg and 31 mmHg and both were enucleated.

Bilateral blepharitis was diagnosed in one bear (see Figure 4A), and periocular skin lacerations (suspected fight wounds, see Figure 4B) around the right eye was observed in another bear. A

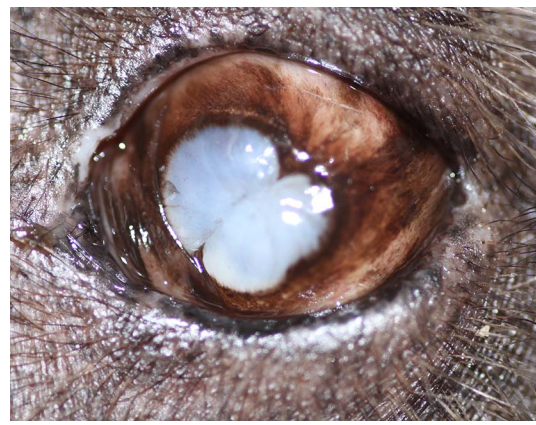

Figure 3. Phthisis bulbi of the left globe in a sloth bear: note the shrunken, wrinkled and opaque cornea with increased third eyelid prominence due to globe size reduction.

Figure 4. Eyelid abnormalities identified in this population of sloth bears. **A.** Blepharitis in a sloth bear: note the moderate periocular alopecia and wet lower eyelid (epiphora) along with mucopurulent discharge. **B.** Periocular skin wounds around the right eye in a sloth bear: this was suspected to be due to claw wounds inflicted by a conspecific.

mucoid or mucopurulent discharge was present in eight bears (12 eyes).

Corneal opacities were identified in 24 eyes (18 bears). Opacities ranged from gray–white relatively minor stromal lesions, presumed to be fibrosis resulting from previous corneal injury (e.g., ulceration), to severe opacification, including superficial pigmentation occupying the entirety of the cornea (see Figures 3a and 3b).

Anterior (three bears, three eyes) and posterior (three bears, four eyes) synechiae were identified suggestive of previous corneal perforation or uveitis, respectively; however, aqueous flare was not witnessed in any bear (see Figure 5).

Cataract was one of the most commonly identified abnormalities, occurring in 28 eyes (17 bears). Cataracts ranged from incipient (two eyes) cortical cataract to immature (nine eyes), mature (two eyes), and hypermature (15 eyes). In 10 eyes (seven bears), there was obvious brunescence in conjunction with cataract. In two bears, hypermature cataracts had a Morgagnian brunescent nucleus, which moved to a ventral position within the lens capsule with alternate body positions of the bear (e.g., dorsal/sternal) according to gravity. (Figures 6A and 6B). The mean age of bears with brunescent cataracts was 12.1 (median 12, range 9–15) years, which was not statistically different from the mean of the examined population ($p = 0.33$), or all of those with cataract (mean 12.5, median 12.5, range 8–23 years, $p = 0.51$). Brunescence was also identified in conjunction with nuclear sclerosis (in absence of cataract formation) in one 9-year-old bear.

Lens luxation or subluxation was identified in 16 eyes (14 bears) (see Figures 7A and 7B). Vitreal prolapse into the anterior chamber was seen in seven bears, and an aphakic crescent in six bears. Lens luxation was confirmed on ultrasound in some cases where opaque ocular media made direct observation challenging. The mean age of bears with lens luxation or subluxation was 14.1 (median 13, range 9–23) years, which was not statistically significantly different from the mean age of bears with cataract ($p = 0.33$) or the whole population ($p = 0.57$). Lens luxation in combination with retinal detachment was documented in seven bears (nine eyes).

Retinal detachment in combination with cataract was identified by ocular ultrasound in 14 eyes (12 bears). Retinal detachment was identified in 29 eyes (21 bears), either on ophthalmoscopy or ocular ultrasonography, and including phthisical globes. The mean age of bears with retinal detachment was 12.5 (median 12, range 8–23) years, which was not statistically different from the

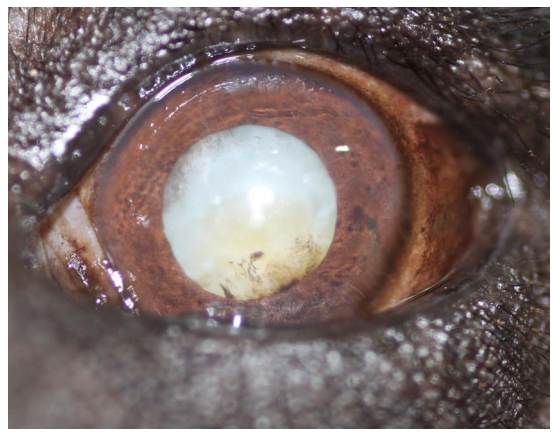

Figure 5. Hypermature cataract with iris rests and posterior synechia in a sloth bear: note the yellow discoloration of the lens nucleus along with pigmentation over the capsule at 9–12 o'clock and 4–6 o'clock positions (iris rests) along with a strand of iris adhesion from the pupil margin to the anterior lens capsule at 6 o'clock (posterior synechia).

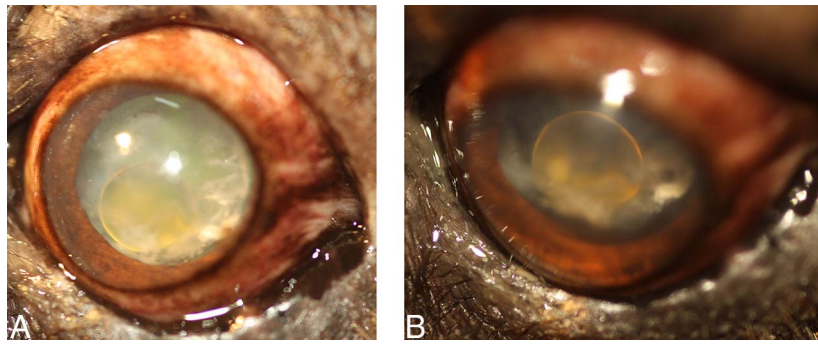

Figure 6. Cataracts noted in this sloth bear population. **A.** Hypermature cataract with Morgagnian brunescent nucleus in a sloth bear: note the yellow translucent spherical nucleus occupying the ventral lens capsule due to loss of lens material by phacolysis (hypermaturity) and gravity. **B.** Morgagnian brunescent nucleus seen by tangential observation demonstrating its spherical nature.

whole population ($p = 0.47$) or from those without retinal detachment ($p = 0.62$).

Retinal degeneration (from mild to total) was present in 19 eyes (16 bears) identified on ophthalmoscopy or electroretinography, not including phthisical globes. The mean age of the bears with retinal degeneration was 12.5 (median 12, range 8–23) years, which was not statistically different from the whole population ($p = 0.52$) or those without retinal degeneration ($p = 0.65$).

Follow-up clinical records since examination demonstrate 37 of the 43 bears examined are no longer alive. Postmortem and antemortem tests revealed 24 of the 43 bears are or were positive for tuberculous *Mycobacteria* (TB) (MycoPac dual kit™, CisGen Biotech Discoveries Private Ltd., Chennai, India). This test kit utilizes immune chromatographic/lateral-flow technology and has a reported sensitivity of 94% in sloth bears.[23] Of these 24 animals, only two remain alive. A further two bears had equivocal results with initially positive results and subsequent negative results.

Individual causes of death (other than TB) identified by postmortem were recorded as: pneumonia and bronchiectasis, suppurative bronchopneumonia, nephropathy and cystitis, chronic renal disease and cardiomyopathy, chronic renal disease, multi-organ failure, infectious canine hepatitis (canine adenovirus infection), hepatic failure, hepatic carcinoma, adenocarcinoma, bronchioalveolar carcinoma, and 'senility' in two bears.

DISCUSSION

The population examined in this study, with the exception of two bears, were selected due to

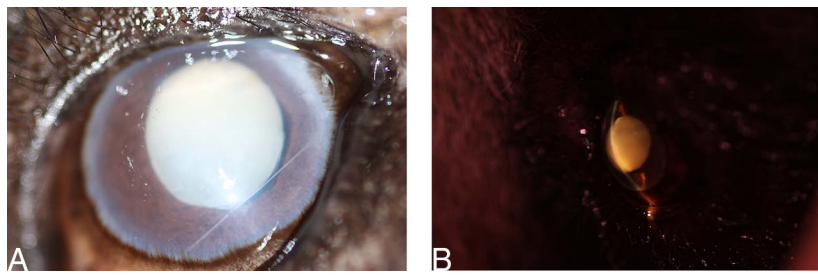

Figure 7. Lens luxation and subluxation in this sloth bear population. **A.** Arcus senilis with subluxated mature cataract in a sloth bear: note the perilimbal white-gray hazy opacity (arcus senilis) with finger like projections of superficial pigmentation. Note also the aphakic crescent at 2–6 o'clock denoting the subluxated nature of this mature (white) cataract and a white fibrotic strand running from the endothelium close to the iridocorneal angle across the anterior chamber from 3–7 o'clock (presumed secondary to chronic uveitis). **B.** Anteriorly luxated cataract in a sloth bear viewed by slit lamp biomicroscopy: note the white-yellow ovoid cataractous lens sitting in front of the pigmented iris that is highlighted by the slit beam dorsal and ventral to the luxated lens. Note also the slit beam that highlights the corneal surface is very close to the beam highlighting the anterior lens capsule of the lens denoting the lens' extremely close proximity to the corneal endothelium (i.e., anteriorly luxated).

perceived ocular abnormalities and therefore measurements (STT, IOP, axial globe, and lens diameters) might be expected to be different from an ophthalmologically normal population. In order to mitigate this, those bears with grossly hydrophthalmic or phthisical eyes were excluded for mean axial globe diameter or IOP calculations, and cataractous lenses were excluded for mean axial lens diameter measurements. The two ophthalmoscopically normal bears had STT, IOP, and B mode ultrasound measurements (axial globe and lens diameters) matching the mean for the population.

A previous study of eight brown bears (*Ursus arctos*) used as Turkish dancing bears also reported a high incidence of phthisis bulbi (5/7 that could be closely examined under anesthesia) in which the authors concluded that blunt force trauma by a 'correction' stick was the most likely cause.[21] Phthisis bulbi was also common in this current population of bears (12/43 bears) and could reflect blunt trauma from disciplinary beatings as described by Stades et al. Other causes such as end-stage uveitis or glaucoma secondary to infectious or inflammatory systemic disease could not be excluded. One bear with bilateral phthisis bulbi had no observable lens in either eye on B mode ultrasonography, suggestive of globe rupture and loss of the lens at each trauma. Congenital aphakia is extremely rare across a wide range of species so was considered less likely.

TB is common in humans in India, with incidence of 210 per 100,000 capita reported in 2021 by the World Health Organization (WHO). Under-nutrition has been reported as a critical contributory factor in the development of active TB disease in humans. TB has been reported in this population of bears at both sanctuaries.[13,18,19,22] It has been suggested that this is likely to represent a reverse zoonosis with bears contracting *Mycobacterium tuberculosis* from their unnatural habitat in human environments, which are often also poverty-stricken.[24] Approximately 10 million people worldwide were infected with TB in 2018 according to the WHO, and 27% of the global TB cases were from India.[24] India also accounted for 27% of the worldwide burden of rifampicin-resistant TB in 2019.[25]. The incidence of TB was highest in the 15–24 years age group in India, with rates in men, women, and children reported as 60%, 34%, and 6%, respectively.[12]

Clinical signs of TB in sloth bears were reported as ill-thrift, weight loss, cachexia, anorexia, dullness, pale mucous membranes, respiratory distress, and cough.[13,15,18,19] Ocular signs were not reported in any of these studies. Ocular tuberculosis in humans has been described as manifesting with anterior uveitis and/or choroiditis, and/or choroidal tubercle formation, retinal detachment, and retinal vasculitis.[17] The development of chronic hypotony and secondary phthisis bulbi has also been reported with ocular TB. One study reported almost 24% of chronic hypotony cases were secondary to tuberculosis in a referral hospital setting in India.[12] Further studies are required to identify if tuberculosis could be implicated in phthisis development in this population. Further work could consider genetic sequencing for TB organisms in formalin-fixed paraffin-embedded ocular tissue (FFPE globes), as this has recently been shown to be possible on archived samples.[1,20]

Retinal degeneration was identified in 19 bears as tapetal hyperreflectivity and vascular attenuation with non-recordable or low ERG wave response to flash light stimulation. Causes of retinal degeneration could include secondary to uveitis (and in particular secondary to systemic tuberculosis), glaucoma, age-related and nutritional.[9] Retinal lipofuscinosis has been described on histopathology of the globe of an Asiatic black bear (Dubielzig unpublished data), which is perhaps suggestive of vitamin E deficiency. This population of bears rescued from the dancing trade lived with the impoverished Kalander community; therefore, it is likely that malnutrition was present both in the humans and bears of this community. One bear examined had been raised from a cub to adulthood at the sanctuary (on balanced diet) and this bear showed no signs of retinal degeneration. Retinal degeneration has been described in other species due to photopic damage.[5,8,22] Exposure to sunlight or bright light in the early neonatal period has been hypothesized as a cause of retinal degeneration as in the wild neonates live inside the dark deep caves for more than three months with their mother and are rarely exposed to light. Even when they come out with their mother, it is only at night. The one bear raised from a cub to adulthood at the sanctuary with no signs of retinal degeneration might argue against this hypothesis. However, this bear was one of the youngest examined (8 years old) and it is possible degeneration would have been evident later in life.

Cataract and lens luxation were seen frequently in this population. Cataract causes might include chronic uveitis, nutritional, senile, and traumatic. Chronic uveitis is likely to be present in this population based on the prevalence of phthisis bulbi, even in the absence of demonstrable aqueous flare. It has been noted that aqueous flare is rarely encountered in other bear species, despite other indications of intraocular inflammation (synechia, cataract).[10] It is notable that this population of bears were kept in

close proximity with humans and were generally fed scraps and leftovers of human food. It seems likely that bear cubs might develop nutritional cataracts similar to other species, but this has not been proven. In other captive bear populations, cataract formation has also been described, where correction sticks were perhaps less frequently used (caged bears on bile farms), but these were reported in different bear species (Asiatic black bears, Malayan sun bears, Eurasian brown bears, and a Tibetan brown bear), so direct comparison is not possible.[10]

Brunescence within cataracts and nuclear sclerosis was prominent in this population of bears ($n = 8$). Although brunescence has been associated with ageing in people and other species, these bears were not the oldest of those examined and not statistically different from the mean of the population.[11,15] The accumulation of chromophores within the lens are responsible for the increasing yellow to brown discoloration associated with lens brunescence. Protein s-thiolation has been associated with lens brunescence in humans and has been linked to ageing but also ultraviolet (UV) and visible light exposure as well as exposure to other oxidants (such as hyperbaric oxygen).[10] Wild sloth bears live in a variety of dry and moist forests and in some tall grasslands, where shelter is provided by boulders, scattered shrubs and trees. It is conceivable that this population of bears may have been exposed to increased UV light exposure compared to their wild counterparts; however, the rate of lens brunescence in the wild population is unknown.

Lens luxation causes might include chronic uveitis, secondary to hydrophthalmos, secondary to blunt force trauma, or a primary zonular abnormality (such as is reported in dogs but also presumed in a case report of a Matshchie's tree kangaroo).[14] Lens luxation has also been reported in other captive bear populations (particularly Asiatic black bears and Malayan sun bears), where blunt force trauma might be expected to be less common (e.g., bile farming industry, where bears are kept in crates, rather than by means of a nose-rope with a correction stick).

Both cataract and lens luxation have been described in captive pinnipeds.[2] Risk factors for lens luxation, cataracts, or both included age $\geq$15 years, a history of fighting, a history of ocular disease, and insufficient access to shade. In this study, the age of the bears with lens luxation was not different from those without, within this population. However, the examined population was selected for those with ophthalmic disease (only 2/43 without ocular disease). The sanctuary population was typically aging as the last bear was rescued from the dancing trade in 2009. Bear cubs confiscated from the pet trade were joining; however, ocular disease in this group was reportedly low.

CONCLUSIONS

Blinding ocular disease was common in this population, in particular phthisis bulbi, retinal degeneration and retinal detachment. Retinal detachment and phthisis bulbi may relate to blunt force ocular trauma prior to rescue but ocular TB cannot be excluded and retinal degeneration could result from a poor diet prior to rescue. Future studies include nanosequencing of FFPE ocular tissue to identify or exclude ocular TB.

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