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Survey of ophthalmic disorders among captive pinnipeds in Japan

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ABSTRACT. Pinnipeds have evolved enlarged ocular bulbs to catch fish in the dark. However, their large protruding eyes are easily damaged, which increases the risk of blindness and death in these animals. In captivity, ophthalmic disorders, manifested as keratitis and cataracts, are common among pinnipeds. In this study, we investigated symptoms of ophthalmic disorders in pinniped species using a questionnaire distributed to 32 zoos and aquariums throughout Japan. We conducted this study in cooperation with the Japanese Association of Zoos and Aquariums. The survey included 295 pinnipeds from four otariid species, five phocid species, and one odobenid species. Of these, 43.1% of the pinnipeds had diseases affecting the lens, cornea, and/or other eye parts. Age was positively associated with lens disorders in California sea lions, South American sea lions, and spotted seals. Conflicts and public appearances were also associated with corneal and/or lens disorders in California sea lions. Treatments were evaluated as effective for corneal disorders and conjunctivitis. The results of this study indicate that ophthalmic disorders in pinnipeds are related to the conditions of their captive environment. Aquariums and zoos should be encouraged to share information regarding optimal maintenance practices to improve the living conditions of pinnipeds.

KEY WORDS: aquarium, eye disease, pinniped, survey, zoo

Pinnipeds, which include over 30 species of phocids, otariids, and odobenids, live in the water for feeding and come up onto land and water surfaces to rest. Pinnipeds dive to various water depths for feeding. The normal depth depends on the species; dives to depths of 75 m are normal for California sea lions, whereas 21-m depths are normal for Stellar sea lions, with greater depths possible [15]. The eye functionality of pinnipeds has evolved for feeding under low-light, cold-temperature conditions in the water; thus, eyeball size in pinnipeds is three-fold that of humans, allowing them to collect light more efficiently. In general, the eyes of onshore mammals cannot adapt to underwater use. The refractive indices of the cornea and water are almost the same, and the lens should be round and dense for normal underwater vision [9, 11]. However, an animal with an underwater-adapted eye lens likely experiences near-sightedness on land due to the higher refractive index of the lens. To prevent this issue, the pinniped eye has a specific corneal structure. The eyes of California sea lions have a flat surface on the nasal side of the cornea that adjusts the refractive index to land or underwater conditions [13]. In addition, pinnipeds have a thermal system to warm the eyeballs to minimize retinal light sensitivity [14]. Thus, pinnipeds retain a sophisticated vision system both on land and underwater [9, 11]. Ophthalmic disorders (OpDs) in pinnipeds increase their risk of death, due to the inability to adequately hunt for fish. In the wild, 4.3% of gray seals had eye disease-related conditions in a population of 4,000 seals in the Gulf of St. Lawrence [10]. Captive animals housed in artificial conditions different from those in the wild may also be affected by OpDs. Colitz *et al.* reported that eye disorders were prevalent in captive pinnipeds in the Bahamas and United States, as well as otariid keratitis in animals housed in captivity in North America, the Bahamas, and Germany [1, 2]. However, similar surveys have not been conducted in zoos and aquariums in Japan. We conducted a large-scale survey of OpDs in pinniped species using a questionnaire distributed to zoos and aquariums throughout Japan.

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MATERIALS AND METHODS

Questionnaire

We conducted a survey of pinniped OpDs at 32 facilities nationwide in Japan under the authorization of the Japanese Association of Zoos and Aquariums (JAZA). Answers were collected from veterinarians in each facility. The contents of the questionnaire were related to signalments, tank conditions, symptoms of eye disease, and putative causes of disease. From the answers to these questions, we aimed to identify the factors that affect OpDs in the animals, such as individual behaviors, facility-related causes, rearing conditions, and nutrition. A question about parental OpDs was included to analyze any factors for OpD inherited from parents. Vision was categorized into three levels: normal vision, poor vision (animals losing their ability to follow an object and needing additional time to find objects), and visual loss (animals had lost the ability to follow or find objects). The vision level was judged by veterinarians, but the referring keeper's comments were not prohibited.

Data analyses and statistics

We analyzed the data after aggregation and tabulation of the collected answers. Logistic regression analysis was used to identify the factors (wild/captive-born, feeding competition, conflict with pool mate, indoor/outdoor living, parental OpD history, sex, shade on the pool, and show attendance) affecting each OpD among all animals and in each animal. The same analysis was also applied to determine the association between each OpD and vision level, between each OpD and its prevalence in eyes, and between treatments and their effects. Fisher's exact test with a Holm adjustment was used to analyze the differences between all/each OpD development and each animal species. The same test was also used for analyzing the differences between vitamin administration and OpD development, and between sex and OpD development. Multi-way ANOVA was used to analyze the differences in age and weight averages among OpDs for each animal species. Statistical analyses were performed using R ver. 3.5.2 software (R Foundation, Vienna, Austria). All P-values <0.05 were considered to indicate statistical significance.

RESULTS

We conducted a questionnaire survey of pinniped OpDs in animals housed in 32 captive facilities registered with JAZA. Four otariid species—California sea lion (*Zalophus californianus*), Steller sea lion (*Eumetopias jubatus*), South American sea lion (*Otaria flavescens*), and South American fur seal (*Arctocephalus australi*); five phocid species—spotted seal (*Phoca largha*), harbor seal (*Phoca vitulina*), Baikal seal (*Phoca sibirica*), Caspian seal (*Phoca capsica*), and ringed seal (*Pusa hispida*); and one odobenid species—walrus (*Odobenus rosmarus*), were represented in the survey.

Types of OpD, prevalence, and vision levels

The aggregated data are summarized in Table 1. Of 295 animals, 43.1% had diseases affecting the lens, cornea, and/or other eye parts. Among the animals with disease, 97 had disorders in both eyes, and 27 in one eye. Regarding lens diseases, there was a significantly larger number of animals with both eyes affected than animals with one eye affected (P=0.04). Seven disease types were recorded: lens disorder (e.g., cataract, lens luxation), corneal disease (e.g., keratitis, corneal abscess), glaucoma, blepharitis, uveitis, and conjunctivitis. Thirteen animals had disorders in both lenses and corneas. Regarding vision, 39.4% of animals had normal vision and 60.6% had poor vision or visual loss. Among 73 animals that only had lens disorders, 14 had normal vision, 35 had poor vision, and 24 had visual loss. Among 25 animals that only had corneal diseases, 18 had normal vision and seven had low vision or visual loss. There were no differences in OpD prevalence across pinniped species, and no relationships between vision and OpD type.

Correlation between OpD and sex/age/weight

Among the animals with OpDs, 53 were male (41.7%) and 74 were female (58.3%). There was no correlation between the presence of eye disorders and sex. In California sea lions, South American sea lions, and spotted seals, the mean ages of animals with lens diseases were significantly higher than those of animals without lens disease (P=0.002, 0.015, 0.00002, respectively). In spotted seals, there was a tendency (P=0.056) for animals with lens disease to have higher weights compared to animals without lens disease.

Effects of parental OpD status, birthplace, or related diseases

There were 50 wild-born animals without parental information, and information on eye diseases was not available or supplied for 77 captive-born animals. We were also unable to obtain usable information on the eye disease histories of the parents. In spotted seals, significantly more wild-born than captive-born animals had corneal disorders (P=0.016). Most of the facilities reported that there were no related diseases; however, some facilities indicated that there was evidence of cataracts, keratitis, partial alopecia, and Malassezia infections.

Effects of rearing facilities, facilities with or without shade, tank water type, and public performances

Of all captive pinnipeds, 63% were reared outside in the open, and 68.5% of the facilities provided shade. There was no correlation between OpD prevalence and the presence/absence of shade or indoor/outdoor rearing. Three types of tank water were used in the animal facilities: salt water (sea water or artificial sea water), fresh water (tap water, river water, or well water), and

Table 1. Summary of ophthalmic disorders (OpDs) in pinnipeds in 32 Japanese zoos and aquariums

	All	Cal SL	Steller SL	Otaria	South A FS	Walrus	Spotted S	Harbor S	Baikal S	Caspian S	Ringed S
OpD n/total	43%	41%	40%	39%	17%	60%	22%	53%	80%	50%	57%
	127/295	34/82	10/25	9/23	2/12	3/5	51/117	9/17	4/5	1/2	4/7
Lens disorder	73%	68%	90%	78%	-	-	75%	100%	100%	100%	75%
	93/127	23/34	9/10	7/9	-	-	38/51	9/9	4/4	1/1	3/4
Corneal disorder	32%	32%	20%	-	100%	100%	29%	22%	100%	-	25%
	41/127	11/34	2/10	-	2/2	3/3	15/51	2/9	4/4	-	1/4
Glaucoma	6%	3%	10%	-	-	-	10%	-	-	-	-
	7/127	1/34	1/10	-	-	-	5/51	-	-	-	-
Conjunctivitis	4%	-	-	-	-	-	10%	-	-	-	-
	5/127	-	-	-	-	-	5/51	-	-	-	-
Uveitis	2%	-	-	-	-	-	2%	11%	25%	-	-
	3/127	-	-	-	-	-	1/51	1/9	1/4	-	-
Other symptoms	each	BLP/VO	FD	-	-	-	OM	-	-	-	EBEL
Reaction to light	each	-	WR/PPH (2 cases)	-	-	-	PPH (2 cases)	-	-	-	-
Male	53/127	11/34	5/10	2/9	1/2	1/3	25/51	5/9	1/4	1/1	1/4
Female	74/127	24/34	7/10	7/9	1/2	2/3	26/51	4/9	3/4	-	3/4
Mean age (years)	18.9 ± 8.6	19.7 ± 8.4	18.1 ± 7.1	20.6 ± 3.3	5.5 ± 2.1	14.7 ± 5.9	18.8 ± 10.0	23.0 ± 3.0	22.8 ± 2.9	21.0	10.0 ± 8.9
Mean weight (kg)[1)]	-	96.9 ± 46.9	369.5 ± 243.2	88.1 ± 9.8	33.5 ± 2.1	768 ± 206.6	92.5 ± 21.5	105.3 ± 16.0	64.2 ± 8.5	47.5	44.3 ± 7.6
OpD eye											
Right	10%	15%	10%	11%	50%	-	10%	-	-	-	-
	13/127	5/34	1/10	1/9	1/2	-	5/51	-	-	-	-
Left	11%	6%	40%	22%	-	33%	8%	-	25%	-	-
	14/127	2/34	4/10	2/9	-	1/3	4/51	-	1/4	-	-
Both sides	79%	82%	70%	67%	50%	67%	82%	100%	75%	100%	50%
	100/127	28/34	7/10	6/9	1/2	2/3	42/51	9/9	3/4	1/1	2/4
Vision											
Normal vision	39%	68%	30%	56%	100%	100%	24%	-	50%	-	-
	50/127	23/34	3/10	5/9	2/2	3/3	12/51	-	2/4	-	-
Poor vision	38%	32%	60%	33%	-	-	35%	56%	25%	100%	25%
	48/127	11/34	6/10	4/9	-	-	19/51	5/9	1/4	1/1	1/4
Visual loss	23%	3%	30%	-	-	-	37%	44%	25%	-	75%
	29/127	1/34	1/10	-	-	-	19/51	4/9	1/4	-	3/4
Treated	65%	71%	80%	56%	50%	67%	65%	44%	75%	100%	75%
	83/127	24/34	8/10	5/9	1/2	2/3	33/51	4/9	3/4	1/1	3/4
Effective	39%	29%	30%	20%	-	100%	42%	25%	100%	-	33%
	31/83	7/24	3/10	1/5	-	2/2	14/33	1/4	3/3	-	1/3
Not effective	31%	46%	10%	-	100%	-	30%	-	-	100%	67%
	26/83	11/24	1/10	-	1/1	-	10/33	-	-	1/1	2/3
Undetermined	31%	25%	80%	80%	-	-	27%	75%	-	-	-
	26/83	6/24	8/10	4/5	-	-	9/33	3/4	-	-	-
Vitamin supplement	85%	97%	80%	100%	100%	100%	80%	44%	100%	100%	100%
	108/127	33/34	9/10	9/9	2/2	3/3	41/51	4/9	4/4	1/1	4/4
Tank water											
Salt water[2)]	76%	68%	100%	67%	50%	100%	88%	100%	-	-	100%
	96/127	23/34	10/10	6/9	1/2	3/3	45/51	4/4	-	-	4/4
Fresh water[3)]	13%	35%	-	-	50%	-	-	-	100%	-	-
	17/127	12/34	-	-	1/2	-	-	-	4/4	-	-
Brackish water[4)]	8%	-	-	11%	-	-	12%	-	-	100%	-
	10/127	-	-	(3)/9	-	-	(6) 4/51	-	-	1/1	-
Rearing area											
Outdoor	64%	59%	100%	11%	-	33%	82%	56%	-	100%	50%
	81/127	20/34	10/10	1/9	-	1/3	42/51	5/9	-	1/1	2/4
Indoor	30%	32%	-	78%	100%	-	16%	44%	100%	-	50%
	38/127	11/34	-	7/9	2/2	-	8/51	4/9	4/4	-	2/4
In- & out-door	6%	12%	-	11%	-	67%	2%	-	-	-	-
	8/127	4/34	-	1/9	-	2/3	1/51	-	-	-	-
Shade	69%	85%	30%	100%	100%	100%	59%	56%	50%	100%	100%
	88/127	29/34	3/10	9/9	2/2	3/3	30/51	5/9	2/4	1/1	4/4
Feeding competition	15%	6%	60%	-	-	-	22%	-	-	-	-
	19/127	2/34	6/10	-	-	-	11/51	-	-	-	-

Table 1. Continued

	All	Cal SL	Steller SL	Otaria	South A FS	Walrus	Spotted S	Harbor S	Baikal S	Caspian S	Ringed S
Conflict with others	31%	32%	50%	-	-	-	37%	44%	50%	-	-
	40/127	11/34	5/10	-	-	-	18/49	4/9	2/4	-	-
Show attendance	35%	62%	80%	100%	-	-	22%	-	-	-	-
	45/127	21/34	8/10	9/9	-	-	11/51	-	-	-	-
Parents' OpD history											
Parents with OpD	12%	3%	67%	-	-	100%	70%	100%	-	-	25%
	15/127	1/34	2/3	-	-	1/1	7/10	3/3	-	-	1/4
Parents without OpD	82%	91%	33%	89%	100%	67%	80%	67%	100%	-	75%
	104/127	31/34	1/3	8/9	2/2	2/3	41/51	6/9	4/4	-	3/4
Related diseases	4%	4%	30%	-	-	-	2%	-	25%	-	-
	4/96	1/28	3/10	-	-	-	1/41	-	1/4	-	-
Related diseases UK	9%	18%	-	17%	-	-	11%	-	-	-	-
	11/127	5/28	-	1/6	-	-	5/46	-	-	-	-
Wild-born	40%	29%	40%	89%	50%	33%	39%	-	100%	100%	50%
	51/127	10/34	4/10	8/9	1/2	1/3	20/51	-	4/4	1/1	2/4
Frozen food fish	98%	100%	100%	100%	100%	100%	96%	100%	100%	100%	100%
	125/127	34/34	10/10	9/9	2/2	3/3	49/51	9/9	4/4	1/1	4/4
Frozen & raw food (fish)	2%	-	-	-	-	-	4%	-	-	-	-
	2/127	-	-	-	-	-	2/51	-	-	-	-

Cal, California; South A, South American; FS, fur seal; S, seal; SL, sea lion, Otaria, South American sea lion. OpD, ophthalmic disorder; BLP, blepharitis; VO, vitreous opacity; FD, fibrin deposition; OM, opaque media; EBEL, eyeball enlargement; WR, weakened reflex; PPH, photophobia; UK, unknown. 1) No weight information was available for four California sea lions and two spotted seals. 2) Includes sea water, artificial sea water, salt water, and fresh water. 3) Includes well water. 4) Numbers in brackets indicate instances when both salt and brackish water was used.

brackish water. Of all captive pinnipeds, 80.3% were reared in salt water, and all Baikal seals were kept in fresh water. Of the captive pinnipeds, 35.4% had participated in at least one performance or show. In California sea lions, significantly more animals that had participated in public performances or shows had corneal or lens disorders compared to animals that had not (P=0.038 and 0.037, respectively).

Effects of conflict and feeding competition

Of all animals, 31.5% experienced conflict with pool mates, and of these, 35% were male. In California sea lions, significantly more animals with a history of conflict had corneal disorders than did animals with no such history (P=0.039). Feeding competition was not associated with the occurrence of other eye diseases.

Effects of food type and vitamin supplements and treatment efficacy

All animal facilities fed the animals frozen fish, with a few adding raw fish as a supplement. In addition, 83.4% of pinnipeds were administered vitamin supplements. There were no significant relationships between vitamin administration and OpD prevention. Of the diseased pinnipeds, 66.4% received treatment, and 37.8% exhibited improvement post-treatment. The other animals exhibited little or no improvement. For corneal disorders and conjunctivitis, the treatments were evaluated as effective by veterinarians (P=0.003 and 0.016, respectively), but not for the other diseases.

DISCUSSION

In this study, we aggregated data from questionnaires distributed to 32 zoos and aquariums in Japan to find factors that affect pinniped OpDs.

Among the pinnipeds surveyed, the most prevalent eye disease was lens disease. In humans and dogs, the most common lens disease is cataracts, which are associated with genetics, nutrition, toxins, radiation, infections, parasites, and geriatric issues [5]. Lens dislocation occurs due to congenital, traumatic, secondary, and genetic causes [4, 5]. Geriatric factors might have been the main reason that lens disorders were more prevalent in both eyes equally. Corneal diseases are attributable to infections, allergies, irritation, and dry conditions [4]. In otariid species, otariid keratitis is the most common form of progressive keratitis [1]. Otariid keratitis cases have been recorded over a broad age range in California sea lions, Steller sea lions, and South African fur seals [1]. The corneal disorders in this study probably included this disease.

OpDs can progress to more complicated disorders if left untreated [5]. Corneal disorders can lead to uveitis and subsequently, cataracts and lens dislocation [5]. It is difficult to pinpoint the causes of specific disorders with the questionnaire administered in this study. However, it is important to screen for systematic diseases (such as endocrine and neoplastic disorders) that may induce OpDs.

The frequency of conflict differs between intact males and females and castrated males [2]. In this study, differences in frequency

were not attributable to sex, and no neutered animals were included in the survey.

The lifespan of pinnipeds is 14–30 years for otariid species, 40 years for odobenid species, and 12–35 years for phocid species [15]. Most of the captive pinnipeds were probably adults over the age of 10 years, based on the questionnaire results. The typical lens disease, cataracts, can be classified into four categories according to the age of the animal with the disease: congenital, neonatal, juvenile, or geriatric [5]. In humans, in early-onset cases, cataracts can occur from the age of 40 years, with most people having developed cataracts by the age of 80 years. Nuclear sclerosis is often misdiagnosed as cataracts due to the milky blue color of the lens [4, 5]. Colitz *et al.* reported that captive pinnipeds in the United States exhibited age-related lens disorders, with 100% of animals aged 26 years or older exhibiting this type of disorder [2]. Similarly, lens disorder prevalence was correlated with age in this study, further suggesting that this disorder is age-related. Otariid keratitis, a progressive keratitis in otariid species, is classified into three categories according to severity, with Stage 1 representing the mildest cases that occur even in young animals [1]. Generally, young animals are more inquisitive and more active than older animals, and as such, they tend to be more susceptible to eye damage from being active (e.g., collisions with the tank wall). This may be the reason that corneal disorders are more prevalent in the young, as opposed to age-related lens disorders.

Obesity in pinnipeds is probably caused by excessive feeding resulting from winning food competitions or acquiring food from visitors. Other reasons include a lack of activity and seasonal fat accumulation. Under captive conditions, each individual's food amount is calculated; however, sometimes the amount consumed differs from the desired feeding amount due to group-rearing conditions. In the wild, animals suffering OpDs have less success in hunting fish, which probably leads to the animals losing weight. In this study, there was no association between weight and OpD prevalence.

Wild-born animals were introduced to many zoos and aquariums in the country before Japan ratified the CITES treaty. Thus, there are many wild-born pinnipeds in Japanese captive facilities. Our survey results indicate that an animal's genetics (i.e., wild-born versus captive-born) are associated with the prevalence of corneal disorders.

Previous studies have shown that the prevalence of lens diseases is correlated with that of other eye diseases [2]. Lens disorders are commonly complicated by additional diseases as a cause or effect. For example, there is a link between uveitis and cataract progression, based on an eluted denatured protein from the cataractous lens; also, glaucoma can lead to eyeball atrophy [4]. In this study, veterinarians in some facilities might have established more detailed diagnoses with veterinary ophthalmologists. Collaborative diagnostics are required to increase the diagnostic accuracy for some minor diseases and/or difficult-to-diagnose diseases.

The pinnipeds reared outdoors were exposed to UV light longer than were indoor animals, most likely increasing the chances of developing a cumulative lens disorder over time. Reflected light from artificial objects, such as a painted tank wall or bottom, is also a potential risk factor [2, 7]. Colitz *et al.* reported that the existence of shade affected lens disorders under captive conditions [2]. Solar irradiation conditions and light intensity depend on the environment, such as the heights of objects and color and depth of the tank. Thus, additional information would be needed in the questionnaire to properly evaluate the light conditions experienced by the animals surveyed. Pinnipeds rest on the shore and usually do not open their eyes under strong sunlight. Thus, a captive pinniped reared outdoors has a higher risk of developing a UV-related OpD compared to those brought up in the wild [16]. Public appearances also affect their eyes, in that their eyes are open for longer periods of time, both on land and underwater. For outdoor animals, there is a risk of being reared in a brighter tank [7]. Pinniped eyes are affected by continuous rearing in fresh-water conditions, resulting in frequent damage [6–8]. However, there are fewer eye diseases in pinnipeds housed in water without chemical additives [7, 8]. Thus, there is the possibility that adding chemicals, such as chlorine, may affect the prevalence of eye disorders. Colitz *et al.* also noted that osmotic pressure differences and chlorine levels may affect the eyes of sea mammals in fresh-water conditions, although statistical evidence for this has yet to be reported [2]. In the questionnaire, specific items related to the addition of chemicals or chlorine levels were not included. Thus, in future research, the antiseptic chemicals used should be examined more closely, in terms of the chemical types and concentration levels. In addition, bacterial and viral levels in tank water should also be considered.

Of note, the mean age of animals that made public appearances was 21.6 years, in contrast to those that did not make appearances (mean age, 17.8 years). Thus, age might have confounded the results regarding public appearance as a factor. However, the animals that made public appearances had a much lower prevalence of corneal disorders compared to the other animals. This result may be because these animals are often reared in individual cages, which reduces the chances of incurring physical damage due to the proximity of other pinnipeds.

Previous reports noted that conflict or fighting can lead to damage in pinniped eyes, particularly due to their large size [1, 2]. Colitz *et al.* reported that lens disorder prevalence and conflict occurrence are correlated [2]. Conflict or fighting may result in direct damage to the eye surface (cornea), with subsequent development of keratitis and blindness in the animal [4]. In this survey, conflict appeared to be a factor in California sea lions. Food competition was also a risk factor, as the larger eyes of pinnipeds can be damaged by the nails, whiskers, and/or teeth of other animals. In this study, food competition and eye disorders were not associated, which differed from a previous survey [2]. Blunt damage to eyes can progress to delayed lens displacement [4]. Blunt damage or secondary infection should also be included as a lens disorder complication in future surveys. The damage caused by conflict or competition should not be excluded from the causes of the high prevalence of lens disorders.

Feeding raw fish to pinnipeds is desirable; however, almost all zoos and aquariums provide frozen fish to these animals, due to storage issues or as a way of minimizing parasitic infections. Unfortunately, hydrosoluble vitamins, such as thiamine and ascorbic acid, are lost when seafood is frozen; additionally, there are less tocopherols in frozen food after thawing [3, 12]. Most facilities supplement the food with vitamins via oral administration. Ascorbic acid antioxidants exhibit some effectiveness with regard to preventing age-related cataracts in humans, and likely have a similar function in mitigating cataract development in pinnipeds

[17]. In this study, >80% of the animals were given vitamin supplements, probably for eye disease prophylaxis. However, vitamin supplements should be carefully selected to optimize their effectiveness and minimize undesired interactions among the vitamins used. The survey results indicate that treatment had some effect on corneal disorders and conjunctivitis compared to the other eye disorders. Corneal disorders and conjunctivitis are easy to diagnose and treat because the lesions appear on the eye surface. Other diseases, such as lens disorders, are more difficult to detect because the lesions are inside the eye. Furthermore, lens disorders, such as cataracts, are difficult to treat using medication, and normally, lens replacement is required. Thus, the diagnosis and treatment of lens diseases takes time. The pupils of pinnipeds tend to be narrow, making examination of the inner areas of the eye, such as the lens and retina, more difficult [13]. Atropine-epicatechin ophthalmic solution appears to help with its mydriatic action [13]. Another consideration is that group-rearing conditions may complicate treatment administration.

We surveyed OpDs in captive pinnipeds in Japan with the cooperation of 32 facilities. Further participation by additional facilities is expected to provide more accurate information. However, our results provide useful data for managing eye diseases and enriching the environmental habitats of pinnipeds in captivity.

CONFLICT OF INTEREST. The authors declare no conflict of interest.

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