Distribution and outcome of ocular lesions in snakes examined at a veterinary teaching hospital: 67 cases (1985–2010)

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Objective—To determine the distribution and clinical outcome of ocular lesions in snakes.

Design—Retrospective case series.

Animals—67 snakes with ocular lesions.

Procedures—Signalment, lesion duration, diagnosis, treatment, and clinical outcome were recorded for all snakes with ocular lesions that were examined at a veterinary teaching hospital from 1985 to 2010.

Results—71 ocular lesions were detected in 67 of 508 (13%) snakes examined. Affected snakes were of the families Boidae, Pythonidae, Colubridae, and Viperidae. The distribution of ocular lesions did not vary by taxonomic family, age, or sex; however, snakes from the genus Epicrates with ocular lesions were overrepresented in the population. The most commonly diagnosed ocular lesions were retained spectacle (n = 41), pseudobuphthalmos or subspectacular abscess (13), trauma (8), and cataracts (4). Pseudobuphthalmos or subspectacular abscess developed more frequently in Colubridae than in non-Colubridae snakes. Of the 16 snakes with retained spectacles for which data were available, the lesion recurred once in 4 snakes and multiple times in 5 snakes.

Conclusions and Clinical Relevance—Results indicated that retained spectacle was the most common ocular lesion diagnosed in snakes. Compared with other snakes with ocular lesions, snakes of the genus Epicrates had a higher than expected frequency of ocular lesions in general and snakes of the family Colubridae had a higher than expected frequency of pseudobuphthalmos or subspectacular abscess. (J Am Vet Med Assoc 2013;243:252–260)

The eyes of snakes have several functional and anatomic differences that make them distinct from the eyes of other reptiles.1–5 The most clinically relevant of those differences are the presence of a spectacle, lack of a lacrimal gland but presence of a well-developed Harderian gland that secretes tears into the subspectacular space, lack of scleral cartilage, and accommodation by means of indirect pressure changes exerted by the ciliary muscles onto a yellow pigmented lens via the vitreous.1–4,6–8 It is believed that the eyes of snakes are unique because snakes evolved from burrowing lizards that had vestigial eyes.1–3 Ocular disease is not uncommon in snakes.6,7,9,10 and retained spectacle; pseudobuphthalmos; subspectacular abscess; trauma; cataracts; exophthalmos; bacterial and fungal infections of the spectacle, cornea, and globe; congenital defects; and neoplasia have been diagnosed in various species of snakes.7,9,11–15 However, most reports9,11–13 regarding ocular lesions in snakes are single case reports or small case series. To our knowledge, a large case series of snakes with ocular lesions has not been retrospectively examined and reported; therefore, the purpose of the study reported here was to describe the distribution and clinical outcome of ocular lesions in snakes that were examined at a single veterinary teaching hospital during a 25-year period.

Materials and Methods

Case selection—The keywords snake, boa, python, rattlesnake, and copperhead were used in a computerized search to identify medical records of snakes examined at the University of California-Davis William R. Pritchard Veterinary Medical Teaching Hospital between April 1, 1985, and October 1, 2010. The medical records for all snakes examined during the reference period were reviewed by an investigator (JCH) to determine whether each snake had evidence of an ocular lesion. A snake was classified as having an ocular lesion if the clinical diagnosis field included the terms retained spectacle, pseudobuphthalmos, subspectacular cyst, bullous spectacleopathy, exophthalmos, ocular trauma, traumatic spectaculitis, cataract, lenticular opacity, corneal defect, or corneal edema or if the physical exami...
nation findings field included descriptions of lesions or abnormalities involving any ocular tissues. A snake was excluded from the study if information in the medical record was insufficient to determine whether it had an ocular lesion.

Medical records review—Species, sex, age, and clinical diagnosis were recorded for all snakes (ie, those with and without ocular lesions). Additionally, body weight, clinical signs, duration of clinical signs, physical examination findings (including whether the ocular condition was unilateral or bilateral and the presence of nonocular disease), results of diagnostic tests performed (including a description of subspectacular fluid analysis and necropsy results, when available), suspected or proven etiology, clinical diagnosis, treatment, outcome, time to outcome, number of recurrences, and duration of follow-up were recorded for all snakes with ocular lesions. Family, genus, and species were determined on the basis of common names provided by the owners and verified by the attending clinicians. The duration of clinical signs prior to initial examination at the teaching hospital was determined on the basis of the recorded history obtained from the owner by the attending clinician. Each subspectacular fluid sample was classified as an exudate (evidence of inflammation or bacteria), hemorrhage (evidence of RBCs), or transudate (clear fluid without evidence of exudate or RBCs) on the basis of gross and cytologic examinations. Outcome was classified as complete resolution, improvement without resolution, or no response of ocular clinical signs to treatment. Recurrence was defined as diagnosis of the same ocular lesion after it was considered resolved, or worsening of the ocular lesion after initial improvement in response to treatment. A single telephone call was made to all owners to obtain follow-up data about the patient’s response to treatment, final outcome, and the time to resolution or recurrence of the ocular lesion.

Data analysis—Ocular lesions were assigned to 1 of 5 categories: retained spectacle, pseudobuphthalmos or subspectacular abscess, ocular trauma, cataракти, or other ocular lesions. Snakes were considered to have pseudobuphthalmos or subspectacular abscess if the clinical diagnosis field included the terms pseudobuphthalmos, subspectacular cyst, bullous spectaculopathy, or subspectacular abscess. Snakes with pseudobuphthalmos or subspectacular abscesses were considered as a single category because in many instances, those diagnoses were difficult to distinguish on the basis of information provided in the medical records as a result of variations in the diagnostic tests performed on the subspectacular fluid. Ocular lesions were classified in the other ocular lesions category if they did not fit into 1 of the other 4 categories. Snakes with 2 ocular lesions believed to be unrelated were represented in both ocular lesion categories. For all statistical comparisons, values of P < 0.05 were considered significant. Exact $\chi^2$ tests were used to compare snakes with and without ocular lesions in regard to taxonomic family, genus, and sex. Within a study classification group (ie, snakes with or without ocular lesions), a taxonomic family or genus with an observed-to-expected ratio > 2 was considered over-represented in that classification group, whereas a family or genus with an observed-to-expected ratio < 0.5 was considered underrepresented in that classification group. A Kruskal-Wallis test was used for the following comparisons: age of snakes with and without ocular lesions, age of snakes by ocular lesion category, and duration of ocular clinical signs before initial examination at the teaching hospital by ocular lesion category (for snakes with ocular lesions). The frequency distributions of snakes within each taxonomic family, lesion location (unilateral or bilateral), and the presence of additional clinical signs were compared among the ocular lesion categories with the exact $\chi^2$ test.

Results

Between April 1, 1985, and October 1, 2010, 71 ocular lesions were detected in 67 of 508 (13%) snakes that were examined at the veterinary teaching hospital. The median duration of follow-up for snakes with ocular lesions was 0.7 months (range, 1 day to 256 months). Of the 67 snakes with ocular lesions, 23 were sexually intact males, 27 were sexually intact females, and 17 had an unstated sex. According to medical records, 50 were still alive, 7 had died, and 10 had been euthanized by the end of the study period. Of the 441 snakes without ocular lesions, 141 were sexually intact males, 147 were sexually intact females, and 153 had an unstated sex. The sex distribution for snakes with ocular lesions did not differ significantly ($P = 0.76$) from that for snakes without ocular lesions. Age was not available for all snakes; however, for the snakes for which age was available, the median age at initial examination for snakes with ocular lesions (4 years; range, 0.03 to 24 years; $n = 53$) did not differ significantly ($P = 0.33$) from that for snakes without ocular lesions (3 years; range, 0.008 to 25 years; 291).

Taxonomic family was identified for all 67 snakes with ocular lesions. There were 27 snakes of the family Boidae (1 Argentine boa [Boa constrictor occidentalis], 6 boa of unidentified species, 3 boa constrictors [Boa constrictor], 2 rainbow boas [Epicrates cenchria], 3 Brazilian rainbow boas [Epicrates cenchria cenchria], 2 Columbian rainbow boas [Epicrates cenchria mausi], 6 Columbian red tail boas [Boa constrictor constrictor], 1 Kenyan sand boa [Gongylophis colubrinus or Eryx colubrinus loveridgei], 1 Puerto Rican boa constrictor [Epicrates inornatus], 1 rosy boa [Charina trivirgata, formerly Lichanura trivirgata], and 1 Solomon Island boa [Candoia carinata], 27 of the family Pythonidae (18 ball pythons [Python regius], 3 blood pythons [Python brongersmai or Python curtus], 5 Burmese pythons [Python molurus bivittatus], and 1 reticulated python [Python reticulatus]), 12 of the family Colubridae (1 African brown house snake [Lampropeltis fuliginosus], 1 Baird’s rat snake [ Pantherophis Bairdi, formerly Elaphe Bairdi]), 1 king snake [Lampropeltis sp], 1 Florida king snake [Lampropeltis getula floridana], 2 California king snakes [Lampropeltis getula californicae], 2 corn snakes [Pantherophis guttatus], 1 eastern indigo snake [ Drymarchon corais couperi], 1 garter snake [Thamnophis sp], and 2 rat snakes [Elaphe sp or Pantherophis sp]), and 1 of the family Viperidae (copperhead [Agkistrodon
Classification by genus was possible for 61 of 67 snakes with ocular lesions and 394 of 441 snakes without ocular lesions. The 27 snakes in the family Boidae with ocular lesions included 8 of the genus Epicrates; 10 of the genus Boa; 3 of the genera Candoia, Charina, or Gongylophis (or Eryx) or other genera; and 6 of unknown genera. The 149 snakes in the family Boidae without ocular lesions included 7 of the genus Epicrates; 80 of the genus Boa; 36 of the genera Candoia, Charina, or Gongylophis (or Eryx) or other genera; and 26 of unknown genera. Within the family Boidae, the distribution of snakes with and without ocular lesions varied significantly ($P < 0.001$) among genera, and the genus Epicrates was significantly overrepresented (observed-to-expected ratio, 3.65) in the group of snakes with ocular lesions. Of the 15 snakes that belonged to the genus Epicrates, 8 (2 rainbow boas, 3 Brazilian rainbow boas, and 1 Puerto Rican boa constrictor) had ocular lesions, which included retained spectacles ($n = 6$), pseudobuphthalmos (1), and bilateral corneal edema (1). Within the Colubridae ($P = 0.74$) and Pythonidae ($P = 0.21$) families, the distribution of snakes with and without ocular lesions did not vary significantly among genera.

Of the 67 snakes with ocular lesions, the primary reason for initial evaluation at the hospital was ocular disease for 27 (40%) snakes. Nonocular clinical signs were noted in 47 of the 67 (70%) snakes with ocular lesions. Thirty-nine (58%) snakes had clinical signs that were considered likely associated with an ocular lesion even though those clinical signs were not necessarily specific to the ocular system; those included 22 snakes with dysecdysis at a nonocular site, 8 with stomatitis, and 9 with facial or oral swelling. The median duration of ocular clinical signs prior to initial examination at the veterinary teaching hospital was 1.5 weeks (range, 1 day to 156 weeks; $n = 29$).

Seventy-one ocular lesions were identified in 67 snakes and were categorized as follows: retained spectacles ($n = 41$ [58%]), pseudobuphthalmos or subspectacular abscess (13 [18%]), ocular trauma (8 [11%]), cataracts (4 [6%]), and other (5 [7%]). Four snakes each had 2 concurrent ocular lesions: 2 had retained spectacles and cataracts, 1 had ocular trauma and cataracts, and 1 had pseudobuphthalmos and a retained spectacle. Of the 71 ocular lesions detected, 35 (49%) were unilateral and affected 31 snakes, whereas 36 (51%) were bilateral and affected 34 snakes. For 2 of the snakes that had 2 concurrent ocular lesions, 1 lesion was present bilaterally and the other lesion was present unilaterally.

The distribution of ocular lesions did not vary significantly ($P = 0.14$) among the taxonomic families represented in the study population (Table 1). However, pseudobuphthalmos or subspectacular abscess was significantly ($P = 0.006$) more likely to be detected in Colubridae (affected snakes included 1 African brown house snake, 2 California king snakes, 1 corn snake, 1 eastern indigo snake, and 1 rat snake) than in non-Colubridae snakes.

Descriptive data for snakes within each ocular lesion category were summarized (Table 2). Age ($P = 0.30$) and duration of ocular clinical signs before examination ($P = 0.06$) did not vary significantly among the ocular lesion categories. Conversely, lesion location (unilateral or bilateral; $P = 0.006$) and the presence of additional clinical signs ($P < 0.001$) varied significantly among the ocular lesion categories.

### Retained spectacle

Retained spectacle was the most common ocular lesion diagnosed, affecting 41 of 67 (61%) snakes, and it was generally diagnosed as an isolated ocular condition, although 3 snakes with retained spectacle had concurrent bilateral cataracts and 1 snake had concurrent pseudobuphthalmos. Snakes with retained spectacle were affected bilaterally (61%) more often than unilaterally (39%; Table 2). Among the snakes with the various ocular lesions, snakes with retained spectacle were significantly ($P < 0.001$) more likely to have concurrent dysecdysis and significantly ($P = 0.004$) less likely to have concurrent facial or oral swelling. The suspected etiology was recorded for 32 (78%) snakes with retained spectacle and was always associated with husbandry. Specific recommendations were made for 36 snakes for the improvement of husbandry, which included increasing cage humidity, increasing frequency of soakings, and providing an appropriate substrate within the cage to assist with skin shedding. Various treatments were administered to snakes with retained spectacle and included systemic antimicrobials for ocular disease.

### Table 1—Number of ocular lesions by taxonomic family for 67 snakes that were examined at a veterinary teaching hospital between April 1, 1985, and October 1, 2010.

<table>
<thead>
<tr>
<th>Taxonomic family</th>
<th>Retained spectacle</th>
<th>Pseudobuphthalmos or subspectacular abscess</th>
<th>Ocular trauma</th>
<th>Cataract</th>
<th>Other</th>
<th>Total lesions</th>
<th>No. of affected snakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boidae</td>
<td>18</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Colubridae</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Pythonidae</td>
<td>19</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>Viperidae</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>13</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>71</td>
<td>67</td>
</tr>
</tbody>
</table>

Snakes with 2 concurrent ocular lesions ($n = 4$) are represented in each ocular lesion category in which they were affected.
2 snakes), systemic antimicrobials for nonocular disease (18), lubricating eyedrops (5), antimicrobial eyedrops (2), attempted removal of the retained spectacle (8), supportive treatment (eg, fluids, vitamins, or tube feeding; 15), and other nonspecified treatment of nonocular disease (7).

Information to assess treatment response was available for 25 of the 41 snakes with retained spectacles. Treatment of the retained spectacle resulted in complete resolution in 17 snakes, improvement and partial resolution in 3 snakes, and no response in 5 snakes (Table 3). Manual removal of the retained spectacle was attempted in 8 snakes, of which 7 had complete resolution of the ocular lesion immediately (n = 6) or within 3 weeks (1) after spectacle removal; the remaining snake's retained spectacle could not be completely removed manually. One snake was euthanized immediately after successful spectacle removal because of the

Table 2—Descriptive data for the snakes from Table 1 that had various ocular lesions.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Retained spectacle</th>
<th>Pseudobuphthalmos or subspectacular abscess</th>
<th>Ocular trauma</th>
<th>Cataract</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)*</td>
<td>4 (0.17–24)</td>
<td>2.25 (0.03–15)</td>
<td>7 (4–22)</td>
<td>22 (5–24)</td>
<td>5 (2–6)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lesion location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unilateral</td>
<td>16</td>
<td>10</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>25</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Duration of ocular clinical signs before examination (wk)†</td>
<td>1.75 (0.71–16)</td>
<td>4 (0.29–52)</td>
<td>0.21 (0.14–2)</td>
<td>—</td>
<td>81 (6–156)</td>
</tr>
<tr>
<td>Additional clinical signs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concurrent ocular lesion</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Nonocular disease</td>
<td>33</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Dysecdysis</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Stomatitis</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Facial or oral swelling</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Values reported are number or median (range).

Table 3—Response to treatment and clinical outcome for the ocular lesions in the snakes of Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Retained spectacle</th>
<th>Pseudobuphthalmos or subspectacular abscess</th>
<th>Ocular trauma</th>
<th>Cataract</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response to treatment*</td>
<td>17</td>
<td>7</td>
<td>3</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Resolved</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Time to treatment (wk)†</td>
<td>0 (0–31.3)</td>
<td>0 (0–0.29)</td>
<td>2</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>No. with 1 recurrence</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>No. with multiple recurrences</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Time to recurrence or reexamination for recurrence (wk)§</td>
<td>30 (3.5–106)</td>
<td>0.93 (0.57–32)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Discharged</td>
<td>31</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Died</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Euthanized</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Duration of follow-up (mo)</td>
<td>0.7 (0.03–227)</td>
<td>0.47 (0.03–41)</td>
<td>0.6 (0.03–82)</td>
<td>0.13 (0.03–41)</td>
<td>2.1 (0.5–256)</td>
</tr>
</tbody>
</table>

Values reported are number or median (range).

*Data available for only 25 snakes with retained spectacles, 10 snakes with pseudobuphthalmos or subspectacular abscess, 5 snakes with ocular trauma, 3 snakes with cataracts, and 4 snakes with other ocular lesions.
†Data available for only 11 snakes with retained spectacles, 7 snakes with pseudobuphthalmos or subspectacular abscess, 1 snake with ocular trauma, 0 snakes with cataracts, and 1 snake with other ocular lesions.
‡A time of 0 indicates that the lesion resolved immediately following spectacle removal; the remaining snake's retained spectacle could not be completely removed manually. One snake was euthanized immediately after successful spectacle removal because of the

See Table 1 for remainder of key.
severity of its concurrent nonocular disease. Extended follow-up information was available for 16 snakes, of which 4 had recurrence of retained spectacle once and 5 had multiple recurrences of retained spectacle (range, 1 to 5 recurrences). The owner of 1 snake reported that the patient had 4 to 5 episodes of retained spectacle. Necropsy was performed on 9 snakes with retained spectacle. Necropsy findings revealed that 1 snake had hyphema in the right eye and 1 had mild heterophilic dermatitis of the spectacle, whereas the remaining 7 snakes had no clinically relevant ocular abnormalities.

**Pseudobuphthalmos and subspectacular abscess**—The second most common ocular lesion diagnosed was pseudobuphthalmos or subspectacular abscess (Table 1) and affected 13 of 67 (19%) snakes, of which 1 snake also had a retained spectacle and generalized dyscyclysis. Snakes with pseudobuphthalmos or subspectacular abscess were affected unilaterally (77%) more often than bilaterally (23%; Table 2). Among all study snakes, snakes with pseudobuphthalmos or subspectacular abscesses were significantly ($P = 0.005$) more likely to have concurrent facial or oral swelling and significantly ($P = 0.006$) less likely to have dyscyclysis. Six snakes with pseudobuphthalmos or subspectacular abscess had concurrent signs of nonocular diseases, which included ventral erythema, maxillary swelling, irregular heartbeat, lingual sheath abscess, pneumonia, ulcerative stomatitis, and encephalitis. Analysis of a subspectacular fluid sample resulted in the fluid being classified as a transudate for 7 snakes and an exudate for 3 snakes; fluid analysis was unreported in 1 snake. Bacteriologic culture of the subspectacular fluid sample was performed for 1 snake prior to treatment and resulted in the growth of a coagulase-negative *Staphylococcus* spp.

Treatments administered to and management interventions recommended for snakes with pseudobuphthalmos or subspectacular abscesses included husbandry changes ($n = 3$), systemic antimicrobials for ocular disease ($5$), systemic antimicrobials for nonocular disease ($2$), NSAIDs ($2$), lubricating eyedrops ($1$), supportive treatment ($5$), other nonspecific treatment of nonocular disease ($1$), and surgery ($7$). After treatment, analysis of a subspectacular fluid sample revealed a change in color or degree of opacity, compared with that of the sample analyzed before treatment, in several snakes. For 3 snakes, bacteriologic culture of a subspectacular fluid sample obtained after surgery to reconstruct the lacrimal duct yielded *Salmonella arizonae* ($n = 2$) or *Pseudomonas aeruginosa* ($1$). The suspected etiology for the pseudobuphthalmos or subspectacular abscess was recorded as congenital ($n = 3$), neoplastic ($1$), traumatic ($1$), traumatic or congenital ($1$), occult stomatitis ($1$), retrobulbar mass ($1$), or unrecorded ($5$). The 3 snakes with congenital pseudobuphthalmos or subspectacular abscess were born from the same clutch, and all were bilaterally affected.

Information to assess treatment response was available for 10 of the 13 snakes with pseudobuphthalmos or subspectacular abscess. Overall, the condition progressed in 1 snake, resolved with medical management in 1 snake, and never fully resolved in 2 snakes; 6 snakes initially improved with surgery. Three snakes received only medical treatment, and the lesion resolved within 2 days for 1 snake, improved but did not resolve for 1 snake, and progressed despite treatment for 1 snake. The snake in which the lesion improved but did not resolve with medical treatment had been administered intralesional chemotheraphy for a suspected neoplasia that was obstructing the lacrimal duct. Surgical drainage of the subspectacular fluid was performed in 7 snakes via subspectacular fluid aspiration ($n = 3$), subspectacular fluid aspiration and lancing of the oral opening of the lacrimal duct ($1$), wedge resection of the spectacle ($1$), or lacrimal duct reconstruction ($2$). Following surgery, 6 snakes initially had complete resolution of pseudobuphthalmos or subspectacular abscess, and 1 snake had improvement but the lesion did not completely resolve. Of the 6 snakes that had complete resolution of the lesion with surgical drainage, 1 had a single recurrence and 4 had multiple recurrences of pseudobuphthalmos or subspectacular abscess. In 1 snake, the subspectacular space was initially drained by oral manipulation; however, when the lesion recurred, surgical aspiration of the subspectacular fluid was performed. In another snake, surgical aspiration of the subspectacular fluid was performed initially, and when the lesion recurred, fluid drainage was obtained by a single incision through the spectacle, which had to be reopened multiple times. The snake that initially had the opening of the lacrimal duct lanced subsequently underwent lacrimal duct reconstruction surgery. All 3 snakes that had surgery performed on the lacrimal duct or its orifice developed surgical complications that included septicemia, loss of the tubing or suture, loss of patency of the new canal, and subspectacular infection. Necropsy was performed on 4 snakes with pseudobuphthalmos or subspectacular abscess, the results of which revealed that 1 snake had a nasal adenocarcinoma, 1 had a squamous cell carcinoma of the lingual sheath, 1 had septicemia, and 1 had microphthalmia or anophthalmia.

**Ocular trauma**—Eight of 67 snakes had ocular trauma; 1 of those snakes had a concurrent cataract in the contralateral eye, and 4 snakes had evidence of nonocular disease that included bite wounds to the body, a fractured mandible, anorexia, or sepsis. Snakes with ocular trauma were affected unilaterally (88%) more often than bilaterally (12%; Table 2). The ocular trauma was recorded to have resulted from the feeding of live prey in 6 snakes and was unknown or unrecorded in 2 snakes. Treatments administered to snakes with ocular trauma included husbandry changes ($n = 3$), systemic antimicrobials for ocular disease ($2$), systemic antimicrobials for nonocular disease ($2$), antimicrobial eyedrops ($3$), supportive treatment ($2$), and other nonspecified treatment of nonocular disease ($2$). Information to assess treatment response was available for 5 of 8 snakes with ocular trauma; the lesion resolved in 3 snakes, improved but did not resolve for 1 snake, and did not respond to treatment in 1 snake. The snake that did not respond to treatment developed a scar on the spectacle. Of the 4 snakes that responded at least partially to treatment, 1 had trauma to the spectacle as the result of a bite wound with concurrent swelling around that eye, 2 had superficial abrasions to the spectacle,
and 1 had a full-thickness laceration of the spectacle without evidence of trauma to the underlying tissues. Necropsy was not performed on any snake with ocular trauma.

**Cataracts**—Four of 67 snakes had cataracts, and 3 of those had additional ocular lesions (2 snakes had concurrent retained spectacles, and 1 had concurrent ocular trauma to the contralateral eye). Snakes with cataracts were significantly ($P = 0.004$) more likely to have concurrent ocular disease than snakes with other ocular lesions (Table 2). None of the snakes were administered specific treatments for their cataracts, but treatments administered for concurrent disease included husbandry changes ($n = 1$), systemic antimicrobials for ocular disease ($n = 1$), systemic antimicrobials for nonocular disease ($n = 1$), antimicrobial eyedrops ($n = 1$), supportive treatment ($n = 2$), and other nonspecified treatment of nonocular disease ($n = 1$).

**Other ocular lesions**—Five of 67 snakes had ocular lesions that were classified in the other ocular lesions category: 2 snakes had protrusion or swelling of the conjunctiva, 1 snake had corneal edema and spectacle deformation, 1 snake had a unilateral 1-mm corneal opacity, and 1 snake had corneal dehydration and concurrent generalized dyscecyis suspected to be the result of poor husbandry. None of these 5 snakes had concurrent ocular conditions. One of the snakes with conjunctival swelling had concurrent oral and facial swelling. Treatments administered to snakes within the other ocular lesions category included husbandry changes ($n = 4$), systemic antimicrobials for ocular disease ($n = 1$), systemic antimicrobials for nonocular disease ($n = 2$), lubricating eyedrops ($n = 1$), antimicrobial eyedrops ($n = 1$), supportive treatment ($n = 2$), and surgery ($n = 1$). Information regarding treatment outcome was available for all 5 snakes in this category. An abscess was lanced in one of the snakes with conjunctival and facial swelling, and the conjunctival swelling resolved within 1 week after the abscess was lanced. That snake subsequently developed a retained spectacle that also resolved following treatment. For the snake with corneal edema and spectacle deformation, the corneal edema resolved but the spectacle deformation did not. The snake with corneal dehydration improved, but the condition never completely resolved. The other snake with conjunctival swelling and the snake with the corneal opacity did not respond to treatment. Necropsy was not performed on any of the snakes with other ocular lesions.

**Discussion**

Results of the present study indicated that snakes examined at the University of California-Davis William R. Pritchard Veterinary Medical Teaching Hospital most commonly belonged to the Pythonidae and Boigidae families, and the most common genera of snakes examined were *Python* and *Boa*. These results are consistent with a study performed at the same institution that evaluated skin disease in reptiles. Interestingly, an ocular abnormality was not the primary reason that the majority ($40/67 \ [60\%]$) of snakes with ocular lesions in the present study were examined. Only 27 of the 67 ($40\%$) snakes were examined at the teaching hospital specifically because of ocular abnormalities. In addition, 47 of 67 ($70\%$) snakes with ocular lesions had clinical signs of nonocular disease, such as anorexia, lethargy, melena, ventral erythema, burns, wounds, dehydration, abnormal breathing, stomatitis, edema, and petechiae. Thus, it is important to thoroughly examine the eyes of snakes with systemic disease because those snakes may have ocular lesions that remain unnoticed by their owners.

For snakes in the present study, the ocular lesion most frequently identified was retained spectacle ($41/67 \ [61\%]$), and this finding was consistent with results of other studies. Embryologically, the spectacle is formed by fusion of the eyelids, and it is regularly shed with the rest of the skin during ecysis. A retained spectacle is defined as a spectacle that fails to shed properly. Retained spectacle is generally associated with low humidity or dry environments, however, other factors, such as poor nutrition, other skin disease, or systemic disease may also contribute to the development of retained spectacle. In the present study, snakes with retained spectacle were often affected bilaterally, and the diagnosis was frequently associated with dyscecyis. The high prevalence of retained spectacle in snakes of the present study suggested that snake owners often failed to provide adequate husbandry and emphasize the need for veterinarians to educate owners about proper husbandry practices for captive snakes.

In the present study, snakes belonging to the genus *Epicrates* of the family Boigidae had a higher than expected frequency of ocular lesions. The reason for this was unclear; however, because most of those snakes had retained spectacles and the natural habitat for snakes of that genus is the tropical regions of Central and South America, it is possible that snakes of the genus *Epicrates* require higher humidity than do other snakes. Tropical species usually require a humidity of 80% to 90%. The humidity in California is generally much lower than that, which may have contributed to the number of snakes with retained spectacles that belonged to the genus *Epicrates* and were examined at this particular veterinary teaching hospital. The frequency of retained spectacles in snakes examined at other institutions in more humid environments may differ from that of the present study, although for captive snakes that are housed indoors, the ambient humidity inside their enclosures may be more relevant to the development of retained spectacles than is the humidity outdoors.

Husbandry changes were recommended for the treatment of 36 of 41 (88%) snakes with retained spectacles in the present study. Conservative management (eg, increasing ambient humidity and providing coarse-textured environmental substrate) is generally recommended for the initial treatment of retained spectacles so that the spectacles can be shed normally before manual removal is attempted. However, retained spectacles must be addressed in a timely manner because they can cause other health issues. The current recommended procedure for retained spectacle removal is to moisten the spectacle directly by application
of saline (0.9% NaCl) solution, lubricating eyedrops, or acetylcysteine or by soaking the entire snake. A moistened cotton-tipped applicator can be used to remove the retained spectacle once it is well hydrated, and this is considered the safest method. Manual removal of a retained spectacle with forceps may result in damage to the underlying newly formed spectacle. Only small sections of a spectacle can be removed and regenerate. In the present study, successful manual removal of a retained spectacle was achieved in 6 of 8 snakes, and retained spectacle recurred in many snakes, regardless of the method used to remove the retained spectacle initially.

Pseudobuphthalmos or subspectacular abscess (13/67 [19%]) was the second most common ocular lesion identified in snakes of the present study. Pseudobuphthalmos develops when the lacrimal duct, which travels from the subspectacular space to the vomeronasal organ and drains into the oral cavity, becomes obstructed and fluid produced by the Harderian gland accumulates in and distends the subspectacular space. Obstruction of the lacrimal duct can result from ulcerative stomatitis, oral or nasal neoplasia, granulomas, oral burns, scarring, cysts, and congenital blockage or can be idiopathic. In the present study, only 2 of 13 snakes with pseudobuphthalmos or subspectacular abscess had concurrent stomatitis. The fact that snakes with pseudobuphthalmos or subspectacular abscess were more frequently affected unilaterally rather than bilaterally suggested that the underlying etiology for this condition is generally focal in nature. Additionally, snakes with pseudobuphthalmos or subspectacular abscess often had facial or oral swelling. Two of the 5 snakes with pseudobuphthalmos and concurrent facial or oral swelling had a nasal or oral neoplasia confirmed during necropsy. Another snake with pseudobuphthalmos or subspectacular abscess had clinical signs and radiographic changes consistent with a mass causing exophthalmos, but no further diagnostic testing was performed. The use of diagnostic imaging techniques may be beneficial for the identification of abnormal cranial masses in snakes with pseudobuphthalmos or subspectacular abscess and concurrent facial or oral swelling. The 3 snakes that had bilateral pseudobuphthalmos or subspectacular abscess were congenitally affected and born in the same clutch. The condition was believed to be heritable. A necropsy was performed on 1 of those 3 snakes, and the results revealed either microphthalmia or anophthalmia under the fluid accumulation, both of which have been described in snakes.

Infection of the subspectacular space can result from a penetrating wound, retrograde contamination from the mouth along the lacrimal duct, or hematogenous spread. In many snakes with pseudobuphthalmos, evaluation and culture of subspectacular fluid has yielded various bacteria, fungi, or flagellated protozoans. For snakes of the present study, most subspectacular fluid samples obtained during the initial examinations were classified as either a transudate (7/13) or exudate (5/13). Bacteriologic culture of the subspectacular fluid was performed on only 1 sample obtained during initial examination and on 3 samples (ie, 3 snakes) obtained following lacrimal duct reconstruction and yielded growth of a coagulase-negative Staphylococcus sp (n = 1), S arizonae (2), and P aeruginosa (1). Pseudomonas spp are commonly isolated from skin, ocular, and oral tissues of reptiles. The presence of S arizonae in the subspectacular fluid of 2 snakes following surgery was not unexpected because reptiles can carry Salmonella spp, which can lead to disease, particularly if their immune system has been otherwise compromised. Because culture was not performed until after surgery in those 2 snakes, it is unknown whether the Salmonella infection was present at initial examination or was the result of contamination of the subspectacular space from the oral cavity or skin during surgery. Regardless, these findings suggested it would be prudent to perform bacteriologic culture on subspectacular fluid obtained from snakes with pseudobuphthalmos during initial examination to determine whether a concurrent infection exists and for comparison purposes should an infection of the subspectacular space subsequently develop.

In addition to elimination of the underlying cause of lacrimal duct obstruction, surgical treatment of pseudobuphthalmos involves methods such as a 30° wedge resection, circumferential incision in the spectacle, or a conjunctivoralostomy. The wedge resection is also used for the treatment of subspectacular abscesses. These procedures facilitate draining, flushing, and medicating the subspectacular space before the spectacle reforms. In the present study, 5 of 7 snakes that underwent surgical intervention for pseudobuphthalmos or subspectacular abscess had a recurrence of the lesion. This high likelihood for recurrence should be discussed with owners prior to surgery. In the present study, removal of subspectacular fluid was more frequently accomplished by aspiration with a needle than with a wedge resection. All 3 snakes that underwent a wedge resection in the present study were lost to follow-up, but recurrence of pseudobuphthalmos after wedge resection is commonly reported. The snake in the present study, in which subspectacular fluid drainage was achieved with a single incision through the spectacle, had to have that incision reopened multiple times, and, at 1 point, air bubbles were present under the spectacle. Three snakes in the present study had surgery to construct new drainage canals from the subspectacular space to the mouth. These canals were created with 25-gauge needles and kept patent by the placement of 3-0 suture or latex tubing through the newly created canal. One of the 3 snakes died of suspected septicaemia 2 days after the procedure and the other 2 snakes had postsurgical complications that included loss of the suture or tubing, loss of canal patency, and infection of the subspectacular space. Although the same surgical procedure used to reconstruct the lacrimal duct of the snakes in the present study resulted in the successful treatment of a blood python, the procedure is difficult to perform and may be accompanied by serious and sometimes fatal complications.

In the present study, snakes of the family Colubridae had a higher than expected frequency of pseudobuphthalmos or subspectacular abscess. Pseudobuphthalmos and subspectacular abscess have been described in

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several species of snakes. Results of a study conducted to evaluate the shape and depth of the subspectacular space in 4 snake species (corn snake, California king snake, gopher snake [Pituophis melanoleucus], and ball python) indicate that there is no difference in the mean spectacle thickness, corneal thickness, or depth of the subspectacular space among the 4 species. However, the mean horizontal spectacle diameter, anterior chamber depth, and axial globe length of ball pythons are greater than those of California king snakes. Although a reason for the higher than expected frequency of subspectacular disease in Colubridae snakes was not evident in the present study, these findings suggested that research into anatomic differences or other factors that predispose Colubridae to lacrimal duct obstruction is warranted.

In snakes, ocular trauma is generally caused by feeding live prey, although it can also be caused by foreign bodies, inappropriate handling, and overcrowding. Ocular trauma can also be caused by attempts to manually remove a retained spectacle, which was the reason 1 snake in the present study was referred to the veterinary teaching hospital. In the present study, live prey was fed to 6 of 8 snakes with ocular trauma, which supports the recommendation that only dead prey should be fed to snakes.

Cataracts have been described in several snake species, even though examination for cataracts can be difficult because of the small size of the eyes and difficulty pharmacologically dilating the pupil in many snakes. In the present study, 3 of 4 snakes with cataracts had concurrent ocular disease. This finding may indicate that cataracts in snakes generally remain undetected unless the eye is examined for other reasons or that ocular disease may predispose snakes to cataract development. In snakes, the cause of cataracts is often unknown; however, on the basis of knowledge about cataracts in other vertebrate species, some hypothesized causes of cataracts in snakes include age-related changes, development secondary to uveitis, hereditary, or nutritional insufficiency.

Limitations of the present study are those inherent in any retrospective study and include the lack of availability and completeness of medical record information, reliance on histories obtained from owner recall, and the variable duration of patient follow-up. To our knowledge, this is the largest case series study of snakes with ocular lesions, and despite a 25-year observation period, which suggests that many owners need education regarding basic snake husbandry. Snakes of the genus Epicrates had a higher than expected frequency of ocular lesions in general, and snakes of the family Colubridae had a higher than expected frequency of pseudobuphthalmos or subspectacular abscess. Most of the snakes with ocular trauma had a history of being fed live prey; therefore, this practice is not recommended.

References
Effect of underwater treadmill exercise on postural sway in horses with experimentally induced carpal joint osteoarthritis

Melissa R. King et al

Objective—To evaluate the effect of underwater treadmill exercise on static postural sway in horses with experimentally induced carpal joint osteoarthritis under various stance conditions.

Animals—16 horses.

Procedures—On day 0, osteoarthritis was induced arthroscopically in 1 randomly selected middle carpal joint of each horse. Beginning on day 15, horses were assigned to either underwater or overground treadmill exercise at the same speed, frequency, and duration. Two serial force platforms were used to collect postural sway data from each horse on study days –7, 14, 42, and 70. Horses were made to stand stationary on the force platforms under 3 stance conditions: normal square stance, base-narrow placement of the thoracic limbs, and removal of visual cues (blindfolded) during a normal square stance. The mean of 3 consecutive, 10-second trials in each condition was calculated and used for analysis.

Results—Displacement of the center of pressure differed significantly depending on the stance condition. Among horses exercised on the underwater treadmill, postural stability in both the base-narrow and blindfolded stance conditions improved, compared with findings for horses exercised on the overground treadmill. Horses exercised on the overground treadmill were only successful at maintaining a stable center of pressure during the normal square stance position.

Conclusions and Clinical Relevance—Variations in stance position had profound effects on the mechanics of standing balance in horses with experimentally induced carpal joint osteoarthritis. Underwater treadmill exercise significantly improved the horses’ postural stability, which is fundamental in providing evidence-based support for equine aquatic exercise. (Am J Vet Res 2013;74:971–982)

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