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MORBIDITY AND MORTALITY OF REPTILES ADMITTED TO THE WILDLIFE CENTER OF VIRGINIA, 1991 TO 2000

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ABSTRACT: Medical records from 694 reptiles admitted to the Wildlife Center of Virginia (WCV; Waynesboro, Virginia, USA) from 1991 to 2000 were reviewed to determine causes of morbidity and mortality. Eighteen species were represented but the majority of cases were four species; eastern box turtle (*Terrapene carolina*) (66%), eastern painted turtle (*Chrysemys picta*) (11%), common snapping turtle (*Chelydra serpentina*) (10%), and rat snake (*Elaphe* sp.) (6%). There was a significant increase in reptile cases during the study period both in absolute number and in proportion to the total caseload. Trauma (74%) was the most frequent cause of morbidity and mortality followed by unknown or undetermined (13%), aural abscessation (7%), infectious diseases (2%), and one nutritional disorder (0.1%). In addition, 3% of the cases were healthy animals that had been removed from the wild and consequently brought to the WCV. Causes of morbidity and mortality differed between the four most numerous species. Impact with a motor vehicle was the most frequent cause of trauma for eastern box turtles, eastern painted turtles, and common snapping turtles; however, garden-equipment-related trauma was the most frequent cause for rat snakes. Aural abscessation was only seen in eastern box turtles. Eighty percent of cases occurred between May and September and 65% occurred within the five counties closest to the WCV. The majority of morbidity and mortality was the result of human activities. The expanding human population in Virginia likely will continue to have an impact on the health of wild reptiles.

Key words: Aural abscessation, common snapping turtle, eastern box turtle, eastern painted turtle, morbidity, mortality, trauma, rat snake, Virginia.

INTRODUCTION

Interest in wildlife as indicators of ecosystem health is increasing (Nielsen, 1995; Grasman et al., 1996; Pollock, 2001); for example, bald eagles (*Haliaeetus leucocephalus*) are used to monitor for the presence of organochlorine (OC) pesticides and polychlorinated biphenyls in the Great Lakes region of North America (Sikarskie et al., 1995). In addition, studies of morbidity and mortality of wildlife, especially raptors, admitted to wildlife centers and universities have provided insight into the health status of wild populations (Deem et al., 1998; Morishita et al., 1998; Gulland, 1999). However, similar studies of reptiles are few (Hartup, 1996). Reptiles, like amphibians, may be good indicators of ecological health as they are more dependent on the environment than mammals and birds for optimum physiologic function. We surveyed the causes of mortality and morbidity of the reptiles admitted to the Wildlife Center of Virginia, (WCV; Waynesboro, Virginia, USA) from 1991–2000, and identified species and diseases that may be used as indicators of ecological health.

MATERIALS AND METHODS

Original medical records of 732 reptiles admitted to the WCV (38°02′N, 78°55′W) between 1991 and 2000 were examined. Thirty-eight records were eliminated from the study because the reptiles were not native to the area, or had been held in captivity for longer than 2 wk prior to presentation (to exclude diseases acquired in captivity), or the medical records were incomplete. Relevant data from the remaining 694 records were organized into a computerized database (Microsoft Excel 97, Microsoft Corporation, Redmond, Washington, USA). Spatial distribution data were entered into a geographic information system program (ArcView 3.2, ESRI, Redlands, California, USA). Information collected included medical case identification number, species, admission date, county of origin, and clinical diagnosis.

Diagnoses were classified into morbidity and mortality categories that included trauma, infectious diseases, aural abscessation, nutritional disorders, and unknown or undetermined.

Trauma was subdivided into impact with motor vehicle, animal attack, human attack, garden-equipment-related trauma, fishing-equipment-related trauma, and unknown trauma. Causes of morbidity and mortality were based solely on primary diagnoses. Disorders acquired during hospitalization were not considered in this study.

Medical diagnoses were determined by the attending clinician and were based on the case history, physical examination findings, and any ancillary diagnostic tests. All cases received a complete physical examination. The diagnosis of trauma was based on case history and/or physical examination findings consistent with trauma. Garden-equipment-related trauma included any type of injury resulting from gardening machinery or material. Animal attack was defined as trauma caused by wild or domestic animals. Human attack consisted of any case of observed direct human-induced trauma, including assault with any type of weapon or object. Traumas of unknown origin were classified as unknown trauma. Diagnosis of infectious disease was based on clinical signs, history, diagnostic tests such as aerobic bacterial culture, and evidence of infective agents (suppuration, inflammatory cell infiltrates, mucopurulent discharges). Aural abscessation was diagnosed based on gross observation of a solid mass medial to the tympanum, either unilaterally or bilaterally, and when possible confirmed by surgical exposure of the necrotic material within the middle ear. Nutritional disorders were diagnosed based on clinical signs and complete blood cell counts and plasma total protein. Tentative clinical diagnoses were classified as unknown or undetermined. In addition, a number of animals had been removed from the wild and presented to the WCV that were otherwise healthy, and these were excluded from the above categories.

Species were identified using the descriptions provided in Mitchell (1994). Differentiation between corn snakes (*Elaphe guttata*) and black rat snakes (*Elaphe obsoleta*) was not consistent in the medical records; therefore, the two species were combined and classified as rat snakes (*Elaphe* sp.). Differentiation was also not made between eastern kingsnakes (*Lampropeltis getula*) and mole kingsnakes (*Lampropeltis calligaster*), or between southern ringneck snakes (*Diadophis punctatus*) and northern ringneck snakes (*Diadophis punctatus*); therefore, they were identified as kingsnakes (*Lampropeltis* sp.) and ringneck snakes (*Diadophis* sp.) respectively.

All statistical analyses were performed using Microsoft Excel 97. Correlation coefficients were calculated and determined to be significant at $P<0.05$.

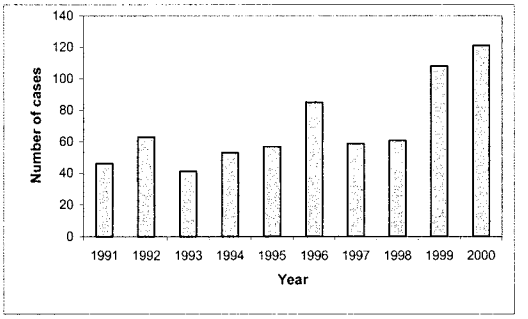

FIGURE 1. Total number of reptiles admitted each year to the Wildlife Center of Virginia, 1991 to 2000.

RESULTS

There was a significant trend ($r=0.78$, df=8) of increasing total number of reptiles presented each year to the WCV from 1991 to 2000 (Fig. 1). The proportion of reptile cases of the total caseload at WCV per year ranged from 2.0–4.0%. This also significantly increased ($r=0.71$, df=8) during the same time period.

We documented morbidity and mortality in 18 species of reptile during the study period (Table 1). Trauma (74% of the total reptile cases) was the most frequently observed cause of morbidity or mortality in this study (Table 2). Most cases of garden-equipment-related trauma involved lawnmowers or garden netting. Most cases of animal attack trauma were caused by a dog or cat. Cases of fishing-equipment-related trauma resulted from a swallowed or implanted fishhook.

Causes of morbidity and mortality varied among species (Table 3). Trauma was the most common cause observed in each of the four most frequently encountered species ($n>35$); eastern box turtles (*Terrapene carolina),* eastern painted turtles (*Chrysemys picta*), common snapping turtles (*Chelydra serpentina*), and rat snakes. However, there was some variation in subcategory of trauma between these species. In eastern box turtles, common snapping turtles, and eastern painted turtles impact

TABLE 1. Reptiles admitted to the Wildlife Center of Virginia, 1991 to 2000.

Species	Number	Percent of reptile cases
Eastern box turtle (*Terrapene carolina*)	458	66
Eastern painted turtle (*Chrysemys picta*)	78	11
Common snapping turtle (*Chelydra serpentina*)	68	10
Rat snake (*Elaphe* sp.)	38	6
Eastern garter snake (*Thamnophis sirtalis*)	20	3
Red-bellied turtle (*Pseudemys rubriventris*)	8	1
Eastern hognose snake (*Heterodon platirhinos*)	4	1
Yellowbelly slider turtle (*Trachemys scripta*)	4	1
Mud turtle (*Kinosternon subrubrum*)	3	0.4
Northern water snake (*Nerodia sipedon*)	2	0.3
Ringneck snake (*Diadophis* sp.)	2	0.3
Common musk turtle (*Sternotherus odoratus*)	2	0.3
Kingsnake (*Lampropeltis* sp.)	2	0.3
Other[a]	5	1
Total	694	100

[a] Includes one eastern milk snake (*Lampropeltis triangulum*), one five lined skink (*Eumeces fasciatus*), one timber rattlesnake (*Crotalus horridus*), one eastern river cooter turtle (*Pseudemys concinna*), and one wood turtle (*Clemmys insculpta*).

with motor vehicle was the most frequently observed subcategory of trauma. The most common subcategory in rat snakes was garden-equipment-related trauma. Cases of garden-equipment-related trauma in rat snakes were more likely to involve entrapment in garden netting, while in the other three major species it most frequently resulted from a lawnmower. Garden-equipment-related trauma was the most frequently reported subcategory in eastern garter snakes (*Thamnophis sirtalis*) (29% of trauma cases). Fishing-equipment-related trauma was observed in common snapping turtles, eastern painted turtles, and rat snakes. Animal attack occurred in each of the three most common turtle species, but not in the rat snakes. The second most common cause of mortality or morbidity in the eastern box turtle was aural abscessation (11%) and unknown or undetermined causes (11%). Aural abscessation was not seen in any of the other species examined in this study. Unknown or undetermined was the second most frequent category for eastern painted

TABLE 2. Morbidity and mortality of reptiles presented to the Wildlife Center of Virginia, 1991 to 2000.

Morbidity/mortality category	Number	Percent of reptile cases	Percent of trauma cases
Trauma	515	74	
Impact with motor vehicle	340		66
Unknown trauma	71		13
Garden-equipment trauma	46		9
Animal attack	43		8
Fishing-equipment trauma	11		2
Human attack	4		1
Unknown/undetermined	92	13	
Aural abscessation	50	7	
Infectious disease	15	2	
Nutritional disorder	1	0.1	
Healthy animals held in captivity	21	3	
Total	694	100	

TABLE 3. Morbidity and mortality in the most frequently encountered species at the Wildlife Center of Virginia, 1991 to 2000.

Morbidity/mortality category	Eastern box turtle (*Terrapene carolina*)	Eastern painted turtle (*Chrysemys picta*)	Common snapping turtle (*Chelydra serpentina*)	Rat snake (*Elaphe* sp.)
Trauma[a]	335 (73)[b]	64 (82)	53 (78)	23 (61)
Impact with a motor vehicle	232 (69)	42 (66)	40 (76)	10 (44)
Unknown trauma	46 (14)	7 (11)	6 (11)	0 (0)
Garden-equipment trauma	30 (9)	2 (3)	1 (2)	11 (48)
Animal attack	26 (8)	7 (11	1 (2)	0 (0)
Fishing-equipment trauma	0 (0)	6 (9)	3 (5)	1 (4)
Human attack	1 (0.3)	0 (0)	2 (4)	1 (4)
Unknown/undetermined	50 (11)	10 (13)	11 (16)	10 (26)
Aural abscessation	50 (11)	0 (0)	0 (0)	0 (0)
Infectious disease	14 (3)	0 (0)	0 (0)	1 (3)
Healthy animals held in captivity	9 (2)	4 (5)	4 (6)	4 (11)
Total	458 (100)	78 (100)	68 (100)	38 (100)

[a] Subcategories of trauma are listed as percent of total cases of trauma.
[b] Number of cases by species; percent for each species.

turtles, common snapping turtles, and rat snakes.

The 15 cases of infectious diseases included two respiratory tract infections, nine cases of conjunctivitis, and four animals with both conjunctivitis and respiratory tract infection. Fourteen of these were eastern box turtles and one was a rat snake. No etiologic agents were isolated by routine aerobic bacterial culture. One case of general malnutrition was found in a king snake.

Eighty percent of all reptile cases in the study period were admitted between May and September (Fig. 2). The largest number of cases was in June, followed by July and September. No difference in temporal distribution was observed between the four most numerous species.

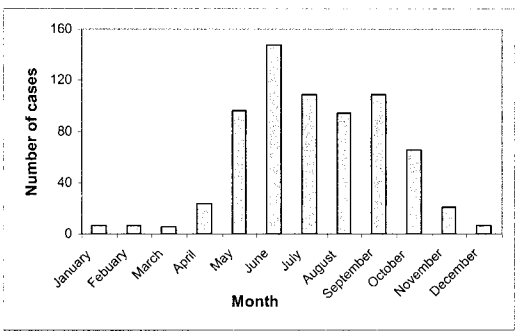

FIGURE 2. Monthly distribution of reptile cases presented to the Wildlife Center of Virginia, 1991 to 2000.

Reptiles were admitted to the WCV from 42 counties in Virginia. Sixty-five percent of the total caseload originated from five counties closest to WCV (Albemarle, Augusta, Nelson, Rockbridge, and Rockingham). Spatial distribution was similar between the four species most frequently admitted to the WCV.

DISCUSSION

The apparent relative increase in annual admissions of reptiles (both in absolute numbers and in proportion to the total caseload) may reflect an increase in reptile morbidity and mortality in Virginia over the time period studied. However, it may also indicate increased public concern for the health and welfare of reptiles resulting in more submissions of animals to the WCV. In addition, undetermined environmental factors and changes in reptile population densities may influence the number of admissions.

The high prevalence of traumatic injuries is consistent with one previous study (Hartup, 1996). Like our study, the most common subcategory of trauma was also

impact with a motor vehicle, although snakes in our study appear more prone to garden-equipment-related trauma. This difference is probably the result of the different natural histories of these species that results in exposure to different types of human activities. However, studies involving admissions to wildlife centers are probably biased towards human-related causes of morbidity and mortality (Spalding and Forrester, 1993). A study comparing the prevalence of the different causes of morbidity and mortality in areas of high human activity versus low human activity would assist in identifying any sampling bias.

Deliberate human-related causes of morbidity and mortality were uncommon, although it was assumed that impact with motor vehicle and garden-equipment-related trauma was not malicious. This could be a result of low human abuse towards reptiles compared with other species. However, illegal interactions with reptiles may be under reported and therefore under-represented, especially if the animals died and were not recovered for examination.

The second highest category of morbidity and mortality was unknown or undetermined. This is probably due to the lack of ancillary diagnostic tests performed in some cases and lack of information on the diseases of free-living reptiles (Mader, 1996).

Aural abscessation was the third most frequent cause of morbidity and mortality. This was only observed in eastern box turtles. A previous study by Holladay et al. (2001) showed significant association between hepatic levels of organochlorine (OC) compounds and lower serum and hepatic vitamin A with squamous metaplasia and aural abscesses in eastern box turtles. In another study, aural abscessation in eastern box turtles from New York (USA) was not associated with seropositivity for *Mycoplasma* spp. (Calle et al., 1998). If OC compounds cause these metabolic and pathologic changes then the presence of aural abscessation in eastern box turtles may serve as an indicator of OC contamination in the environment. Eastern box turtles are abundant and widely distributed throughout Virginia. They have a relatively small home range, are easy to identify, a convenient size, and relatively long-lived (Mitchell, 1994) making them an ideal candidate as an indicator species (Pokras and Major, 1995; Heaton-Jones et al, 1997). The causal relationship between body burdens of OC compounds and aural abscessation as well as the epidemiology of this condition merits further investigation.

The cases of infectious disease consisted of upper respiratory tract infections or conjunctivitis in which no etiologic agent was found from routine aerobic bacterial culture. Organochlorine body burdens may also be the underlying cause of these conditions seen in wild eastern box turtles. Tangredi and Evans (1997) speculated that OC body burdens caused immunosuppression in eastern box turtles from Long Island, New York which resulted in upper respiratory tract infections. Further studies are needed to accurately determine this relationship and demonstrate its mechanism.

The majority of reptile cases were presented in late spring, summer, and early fall. This is consistent with the natural history of the reptiles in this study (Mitchell, 1994). A lower prevalence of reptiles was observed during the period between December and March during which most of the reptiles in Virginia hibernate. The peak in May and June is indicative of the natural period of breeding and nesting for the species in this study. The second peak in September probably represents an increased activity prior to hibernation (Mitchell, 1994). Information campaigns to increase public awareness of reptile health issues and prevent human-induced trauma should occur in late spring and summer.

The majority of the cases admitted to the WCV originated from counties located in close proximity to the hospital. People

from counties close to the WCV are more likely to bring an animal to the center because it requires less time commitment, effort, and expense. Residents of these counties are also more likely to know that the WCV exists and make use of its services. These data indicate the geographical bias associated with retrospective analysis of cases presented to a wildlife center.

In conclusion, the majority of the known causes of morbidity and mortality of reptiles in this study was the result of both direct and indirect human activities, although the possibility of underlying disorders exists. This indicates that human activities are having an adverse effect on the health of wild reptiles, although the effects on the reptile populations in Virginia cannot be determined from this study. Prospective studies are necessary to more accurately evaluate relationship between expanding human populations, associated human encroachment into the environment, and incidence of morbidity and mortality in reptiles.

Evaluating morbidity and mortality of wildlife admitted to wildlife centers can provide useful information on the health of wild populations and the environment. However, retrospective studies are dependent on historic medical data and the trends observed should be further investigated through prospective studies to reduce bias and strengthen conclusions. Continued monitoring is also necessary to follow trends and observe any variations.

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