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A Retrospective Analysis of Trends in Central Ohio Wildlife Health using Records from a Wildlife Rehabilitation Facility

Rachel B. Dalton
Otterbein University, rachel.dalton@otterbein.edu

A RETROSPECTIVE ANALYSIS OF TRENDS IN CENTRAL OHIO WILDLIFE HEALTH USING RECORDS FROM A WILDLIFE REHABILITATION FACILITY

Otterbein University

Department of Biology and Earth Science

Westerville, OH 43081

Rachel B. Dalton

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Anna M. Young, Ph.D. ______________________________
Project Advisor

Elizabeth V. Berkeley, Ph.D. ______________________________
Second Reader

John T. Tansey, Ph.D. ______________________________
Honors Representative

ABSTRACT

The analysis of records from wildlife rehabilitation facilities has shown great potential as a technique for monitoring health trends in local wildlife populations. We examined 45,668 records of animals admitted to a wildlife rehabilitation facility located in central Ohio, over a 10 year period (2005-2014). The objective was to examine how causes of admission for commonly admitted species may change over time and co-vary with seasonal patterns, with the goal of using fluctuations in wildlife admissions as a monitoring technique for population and ecosystem health. We assigned causes of admission to broad categories, such as “Collision with Non-Moving Object”, and a specific subcategory, such as “Collision with Window” or “Collision with Power Lines”. Reasons for admission were compared by species within years and across the 10 year period. We found that top specific causes for admission exhibited seasonal fluctuations that are consistent with annual biological patterns related to wildlife breeding and migratory seasons. This analysis suggests wildlife rehabilitation records do reflect phenomena occurring in local wildlife populations, supporting the use of wildlife rehabilitation facility data to monitor wildlife health, and potentially influence decision making for wildlife and ecosystem management.

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INTRODUCTION

In light of the pressures experienced by ecosystems worldwide due to habitat fragmentation, climate change, and other forms of human encroachment (Harvell et al. 1999, Wilson 1994, Oliver et al. 2015), effective wildlife monitoring techniques are becoming increasingly crucial. The rate of encroachment has continued to grow, resulting in declines of endemic species and ecosystem function (Brooks et al. 2002, Ibarra and Martin 2015, Oliver et al. 2015). Accurate data on the response of wildlife populations to these events is imperative for formulating effective conservation plans (Noss 2004, Cardillo et al. 2004). Wildlife population monitoring is also key for understanding annual ecosystem patterns and sources of human-wildlife conflicts (Suryanwashi et al. 2014), phenomena that can also be of notable conservation and public health significance. However, the relationships between wildlife population dynamics, human-wildlife conflicts, and wildlife health have not been extensively studied to date.

Wildlife health exerts significant influence on population dynamics; the ability of a population to maintain stability can be substantially hindered when individuals in that population are experiencing health stressors. Human activity and climate variability are significant sources of health stressors, and can influence global distributions of pathogens and subsequent infection of new vulnerable hosts (Harvell et al. 1999). This can have catastrophic levels of impact, resulting in mass mortality events that by definition involve over 90% population mortality, the loss of one billion individuals, and/or 700 million tons of dead organism biomass in an individual event (Fey et al. 2015). Recent examples of mass mortality events of particular conservation concern include chytridiomycosis associated with *Batrachochytrium dendrobatidis* in Central and South American frogs (Lips et al. 2006), and the loss of more than half of the global saiga (*Saiga tartarica*) population due to a *Pasteurella* spp. infection outbreak in 2015 (Milner-Gulland 2015).

Human-wildlife conflicts are comparable in magnitude to disease as causes of mortality and population decline (Collins and Kays 2011). Human development can result in significant biodiversity losses (Pidgeon et al. 2014, Brooks et al. 2002, Trombulak and Frissel 2000), and vehicle strikes have been implicated as a primary anthropogenic cause of mortality for many taxa (Trombulak and Frissell 2000, Clevenger et al. 2002). In the United States annually, free-ranging domestic cats are estimated to kill 1.3-4.0 billion birds and 6.3-22.3 billion mammals (Loss et al. 2013), and 1+ billion birds are killed as a result of mid-flight collisions with windows (Klem et al. 1990). Additionally, anthropogenic sources of ecological contamination have impacted populations of diverse taxa via toxicities, including some amphibian species (Townsend and Driscoll 2013), bald eagles (*Haliaeetus leucocephalus*) (Bowerman et al. 1998), and California condors (*Gymnogyps californianus*) (Kelly et al. 2014), and continue to exert pressure on wildlife populations and ecosystem function (Fox et al. 2001).

The relevance of wildlife health for human and domestic animal health has been increasingly recognized in recent years (Chomel et al. 2007). Interactions between humans and wildlife have become more frequent as a consequence of encroachment, resulting in an increase in the likelihood of human-wildlife conflict events and zoonotic disease transmission (Gnat et al. 2015). While educational programs encouraging appropriate coexistence between humans and wildlife have grown in popularity, human-wildlife conflicts are still a common occurrence (Baruch-Mordo et al. 2011) and present a concerning venue for disease transmission (Burton and

Doblar 1995). The majority of human emerging disease incidents that occur globally are zoonotic, and 71.8% of known zoonotic pathogens originate in wildlife (Jones et al. 2008). Wildlife species have been identified as reservoir populations for many zoonotic pathogens of concern for humans and domestic species, including enterohemorrhagic *E. coli* in wild cervids (Gnat et al. 2005), canine distemper virus in raccoons (Junge et al. 2007), avian influenzas in many waterfowl species (Miller et al. 2015, Hall et al. 2015), rabies in bats, skunks, and raccoons (Hirsch et al. 2013, Clark et al. 2015), and West Nile virus in corvids and raptors (Agenvoort et al. 2014, Saito et al. 2007).

Quantifying causes of morbidity and mortality in wildlife populations is often difficult, as there are significant logistical and animal welfare challenges associated with *in situ* studies of wildlife health (Spalding and Forrester 1993). When surveying live individuals, it may be difficult to access wildlife populations due to remote habitat or challenging terrain, capture of individuals is not always feasible, and it is common for wildlife to conceal clinical signs of disease to avoid predation (Ryser-Degiorgis et al. 2013). Opportunistic surveys of carcasses may only yield limited diagnostic information due to tissue degradation via post-mortem autolysis, and carcasses are difficult to recover prior to consumption by scavenger species (Ryser-Degiorgis et al. 2013). It can also be challenging to navigate the behavioral biology of wild populations in a minimally invasive manner; high stress events and capture myopathy are significant welfare risks to surveys of live individuals (Jacques et al. 2009). Mortality following release due to capture myopathy, physiological stress, or other injuries sustained in the capture event is not uncommon (Jacques et al. 2009). Continued innovation in developing wildlife health assessment methods with fewer logistical and welfare challenges is necessary (Ryser-Degiorgis

2013), and crucial to understanding the interconnections between wildlife, human, and ecological health.

The analysis of records from admissions to wildlife rehabilitation facilities has great potential to be a useful technique for monitoring local wildlife population health and thus ecosystem health. The few such studies to date involving data from these institutions have identified common causes of morbidity and mortality for specific taxa, including raptors (Deem et al. 1998, Molina-Lopez et al. 2011), reptiles (Brown and Sleeman 2002), and black cockatoos (Le Souef et al. 2015), as well as across ecological niches (Wimberger and Downs 2010). However, analyses of these data sets could also provide insight regarding how causes of morbidity and mortality change over time— crucial information for epidemiological studies of disease and human-wildlife conflicts in wildlife populations (Harvell et al. 1999, Randall et al. 2012). This information can have direct implications for wildlife population management, ecosystem management, and conservation efforts, as well as human and domestic animal health (Spalding and Forrester 1993, Chomel et al. 2007). Additionally, this would be a method of wildlife health assessment that is not subject to the challenges of assessing the health of individuals in the field as described by Ryser-Degiorgis (2013) and Spalding (1993).

The purpose of this study was to use 10 years of records (2005-2014) from admissions to the hospital of a wildlife rehabilitation facility to assess trends in the occurrences of diseases and injuries of particular monitoring importance in local wildlife. This facility is an ideal candidate for this work as it admits approximately 5,000 animals annually from a wide variety of taxa, including rabies vector species, and has a substantial archive of hospital admissions records from its 30+ years of operation. These records have been the subject of little analysis prior to this study, and have the potential to lend significant insight to longitudinal trends in local wildlife health. As such, the objective of this study was to examine how causes of admission for commonly admitted species may change over time and co-vary with seasonal patterns, with the goal of using fluctuations in wildlife admissions as a monitoring technique for population and ecosystem health.

MATERIALS AND METHODS

This study utilized records from admissions to a wildlife rehabilitation veterinary hospital over a 10 year period (2005-2014), which included 45,668 individuals. This facility is located in a suburban context, with urban and rural areas in near proximity. Animals are regularly admitted from all three contexts. Each individual admitted is assigned a unique record entry, regardless of life stage or being admitted with conspecifics at the same intake event. Admissions records were recorded in a Microsoft Access database from 2005-2012, and in the Wildlife Incident Log/Database and Online Network (WILD-ONe) database from 2013-2014.

The two databases differed in how information was recorded, so consolidation of all records in the time span of this study necessitated reorganization, omission of irrelevant information, and standardization of how information was presented in order to facilitate analysis. This process involved standardizing species common names, unifying format of case number and patient identification numbers, standardizing life stage terminology, replacing database-specific abbreviations when not easily interpreted, and other miscellaneous modifications necessary for uniformity and ease of analysis. All reformatting efforts were concerning the organization of records content; the integrity of the original content was not compromised. Additionally, information types derived from existing information in the records were added that facilitated additional analyses. These additional information categories included taxonomic group, month and year of admission to the hospital, a broad cause of admission category**,** and a specific cause of admission subcategory.

Table 1: All information types – both originally included in the records and added based on existing information in the records – that were utilized in analysis for cases admitted to the wildlife rehabilitation facility from 2005-2014.

Item	**Definition**
Case Number	Number code specific to an individual and unique across all years
Patient ID	Number code unique to an individual within a single year
Species	Species common name
Taxon	Defined taxonomic category: mammals, raptors, reptiles, amphibians, songbirds + (included songbird taxa as well as corvids), gallinaceous, water/shorebirds, waterfowl
Admit. Life Stage	Adult, juvenile, hatchling, fledgling, nestling, egg, unknown
Other Location Info	Other information provided that related to where the animal was found
CoA Info 1-11	Information relevant to the animal’s cause for admission to the hospital that was recorded in Access database in up to eleven possible columns
WildOne CoA Info 1-2	Information relevant to the animal’s cause for admission to the hospital that was recorded in recorded in WILD-ONE database in up to two possible columns
CoA Broad Category	The assigned broad cause of admission category (Table 2)
CoA Specific Category	The assigned specific cause of admission subcategory (Table 2)
Admit Date	Full date on which the animal was admitted to the hospital
Admit Month	Month in which the animal was admitted to the hospital
Admit Year	Year in which the animal was admitted to the hospital
Disposition	Outcome of case: died, euthanized, released, self-released (escaped), transferred to another facility for permanent residency, returned to presenter for return to the wild
Disposition Date	Full date on which the final outcome of a case occurred.

Cause of Admission Categorization

Cause of admission information was recorded according to what the individuals presenting the animal to the wildlife rehabilitation facility stated, as well as being derived from physical examinations upon admission**.** Causes for admission are diverse and there was variation in how they were recorded by different individuals, so a categorization system was created to facilitate analysis (Table 2). The categorization system involves classifying cause of admission scenarios under broad categories and specific subcategories. For example, a songbird reported to have flown into a window would be classified under the broad category “Collision with Non-moving Object” and the specific category “Collision with Building/Window.” If an animal presented with multiple injuries, cause of admission was assigned based on the primary reason the animal was brought to the wildlife hospital. If an animal presented with both a disease state and an injury – for example, a raccoon that had been struck by a vehicle but also exhibited signs of canine distemper virus—the animal was categorized with the cause of admission categories corresponding to both the source of its injury and its disease.

Table 2: Recorded causes of admission were categorized under a broad category heading and a specific subcategory within that heading.

Broad Category	Specific Subcategories
Collision with Moving Object	Hit by Vehicle Hit by Train Hit by Airplane Hit by Lawn Equipment Hit by Other Moving Object
Collision with Non-moving Object	Collision with Building/Window Collision with Natural Object/Structure Collision with Powerlines Collision with Wind Turbine Collision with Other Non-Moving Object
Domestic Animal Interaction	Cat Attack Dog Attack
Non-domestic Animal Interaction	Attack by Same Wildlife Species as Individual Attack by Different Wildlife Species than Individual
Projectile Injury	Gunshot BB/Airsoft Gun Paintball Gun Bow/arrow Non-weapon Projectile
Non-trap Entrapment/Entanglement	Entangled in Fishing Line Entangled in Other String Trapped in Sports Net Trapped in Other Net Trapped in Litter/Garbage Trapped in Pool Trapped in Building Trapped in Garbage Receptacle Trapped in Window Well Trapped in Vehicle

	Oil/Grease Saturation Trapped in Fence Trapped in Gutter Trapped in Mailbox Other Entrapment
Trap Entrapment/Entanglement	Trapped in Humane Cage Trap Trapped in Glue Trap Trapped in Leg-hold/Snare Trap Trapped in Mouse Trap Trapped in Mole Trap Trapped in Other Trap
Unspecified Entrapment	Unspecified Entrapment
Inappropriate Human Possession	Kept as Pet Taken from Wild with Intent to Rescue
Electrocution	Electrocution
Burn	Fire Other Burn Unspecified Burn
Orphaned	Orphaned
Weather Event	Precipitation Weather Event Extreme Temperature Weather Event Wind Weather Event Other Weather Event
Disease	West Nile Virus Canine Distemper Infection Mycoplasmal Conjunctivitis Avian Botulism Aspergillosis Rabies Unidentified Disease Neurologic Disease Other Disease
Toxicity	Lead Toxicity Landscaping Chemicals Rodenticide Toxicity Pesticide Toxicity Unspecified Toxicity
Injury Unspecified Cause	Bone Fracture Wounds/lesions Crop Injury Neck/spinal Injury Facial Injury Unspecified Neurologic Injury Other Injury
Unknown	Unknown

While the majority of records explicitly stated the reasons that individuals were admitted to the hospital and cause for admission categories were assigned accordingly, there were records where the circumstances that resulted in an animal's injury were either unknown by the individual who presented the animal, or were not recorded. If the presenting person did not know what had happened to the animal, it was possible in many instances to reasonably assign a cause for admission based on corroborating information. A frequently encountered example of this involved animals that had been found by the side of a road, but had not been observed being hit by a vehicle or were not recorded as having been hit by a vehicle. If a record noted that an individual was "found by road" and contained at least two other items of information (fractures, abrasions, contextual information, etc.) that would implicate a car strike, the individual was assigned the broad category of "Collision with Moving Object" and specific subcategory of "Hit by Vehicle." If a record stated an individual was "found by road" but there was not sufficient information to implicate a car strike, the individual was assigned the broad category of either "Unknown" if no other relevant information was included, or "Injury Unspecified Cause" and the appropriate subcategory if at least one injury was noted. Similar reasoning was applied to categorizing other scenarios where an individual's cause for admission to the wildlife hospital was not explicitly stated in the record. Of the 45,668 records in the timespan of this study, 98% contained sufficient information to be included in some level of analysis and 92% contained sufficient information to be assigned broad and specific cause of admission categories.

Statistical Analysis

This study examined overall admissions trends, as well as how occurrences of specific human-wildlife conflicts and diseases of particular monitoring importance change over time. The overall trends identified included mean cases admitted to the wildlife rehabilitation facility each month, the total number of each taxon admitted, the top 20 species admitted, the top 10 broad causes for admission, the top 10 specific causes for admission, and the top three specific causes for admission for each taxon similar to analyses by Wimberger and Downs (2010). Disease analyses focused on canine distemper virus, as it was the only disease with a degree of representation in the records that facilitated meaningful analysis. The mean cases of canine distemper virus admitted each month were examined, and a Chi-squared test was used to determine if canine distemper virus cases fluctuate significantly throughout the year. The human-wildlife conflict analyses examined cases admitted due to vehicle strikes and domestic animal attacks. The mean vehicle strike cases admitted throughout the year were assessed with a Chi-squared test, and the top 20 species admitted due to this human-wildlife conflict were identified. The mean cases of dog and cat attacks admitted throughout the year were examined, and the top three taxa impacted by each were identified. Disposition outcomes were also analyzed; taxa, specific causes of admission categories, and life stages with the highest release rates and mortality rates, where mortality included cases with outcomes of “died” and “euthanized”.

RESULTS

Overall Admissions Trends

A total of 45,668 cases were admitted to the wildlife rehabilitation facility from 2005-2014, with a mean of 4562.7 ± 226.51 cases admitted annually. The mean cases admitted each month fluctuated significantly throughout the year ($X^2 = 3467.74$, df = 11, $p < 0.001$). There was a substantial increase in cases admitted from March through May, with May being the peak month for total cases admitted (1083.5 ± 89.29). The month with the fewest cases admitted was December (65.9 ± 13.29) (Figure 1).

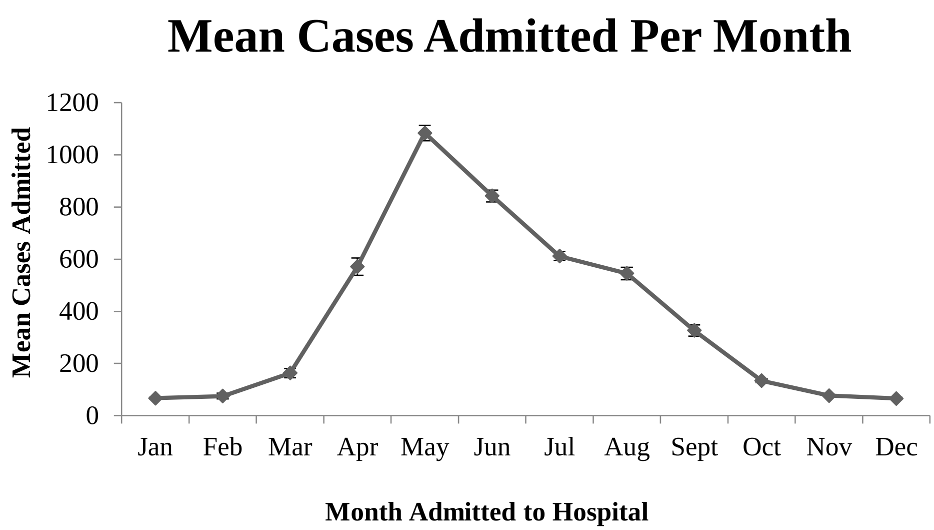


Figure 1: The mean ± SE cases admitted to the wildlife rehabilitation facility veterinary hospital each month from 2005-2014.

Of the eight defined taxonomic categories, mammals were the most frequently admitted, and gallinaceous birds were least frequently admitted. Species in the songbirds + category also accounted for a notable percentage of cases admitted, followed by waterfowl, raptors, and reptiles. Water/shorebirds, amphibians, and gallinaceous birds accounted for only a small portion of all cases admitted – 0.4% collectively (Figure 2).

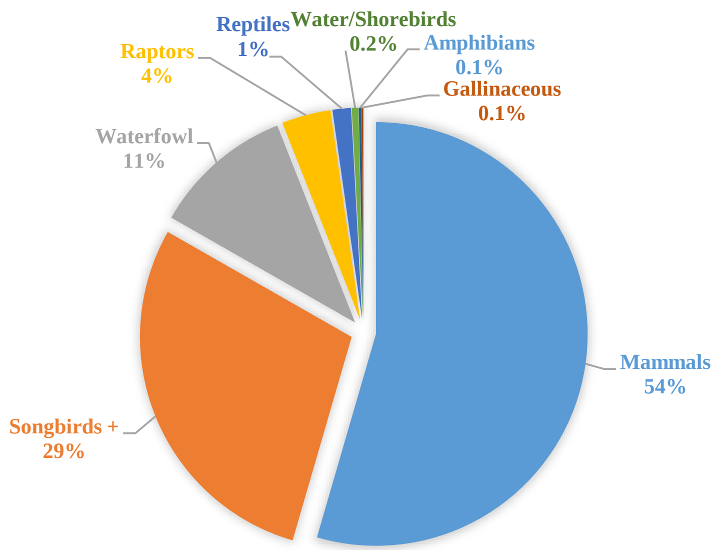


Figure 2: The percentage of admissions to the wildlife rehabilitation facility from 2005-2014 represented by each of the eight taxonomic categories.

The predominance of mammalian species in admissions is also reflected by the 20 species most frequently admitted, of which seven are mammals. These seven species – eastern cottontail rabbit, eastern gray squirrel, raccoon, Virginia opossum, big brown bat, striped skunk, and eastern chipmunk—collectively constitute 49.43% of all cases admitted. The most frequently admitted species was the eastern cottontail rabbit, which accounts for 23.5% of all cases admitted. The taxonomic categories of songbirds+, raptors, and waterfowl were also represented in the top 20 species admitted. Amphibian, reptile, water/shorebird, and gallinaceous bird species were not among the 20 most frequently admitted species (Table 3).

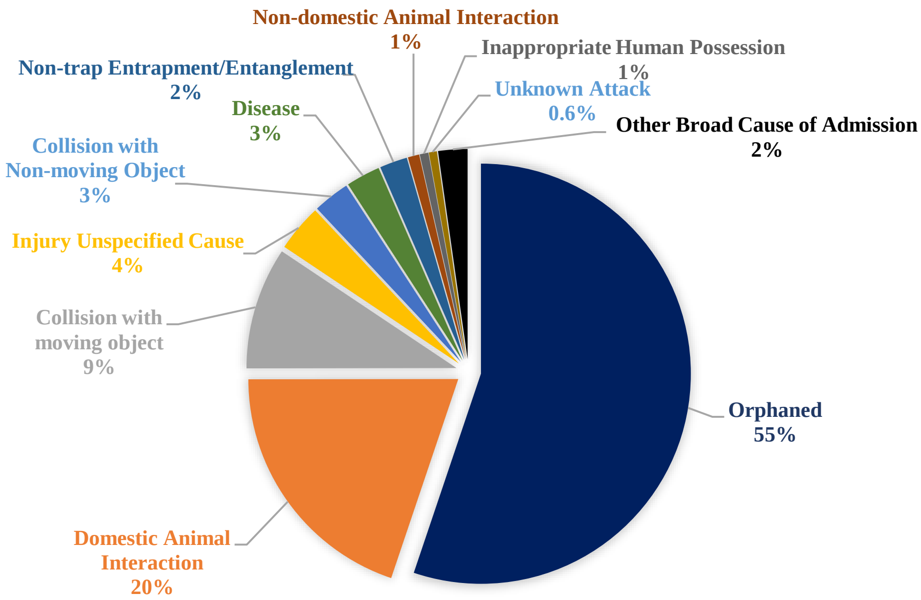
Species	Total Admitted	Percent of All Cases Admitted
Eastern Cottontail Rabbit (*Sylvilagus floridanus*)	10715	23.5%
Eastern Gray Squirrel (*Sciurus carolinensis*)	4831	10.6%
Mallard (*Anas platyrhynchos*)	3192	6.9%
Raccoon (*Procyon lotor*)	3109	6.8%
Virginia Opossum (*Didelphis virginiana*)	3105	6.8%
American Robin (*Turdus migratorius*)	2708	5.9%
House Sparrow (*Passer domesticus*)	1945	4.3%
European Starling (*Sturnus vulgaris*)	1443	3.2%
Mourning Dove (*Zenaida macroura*)	1307	2.9%
Canada Goose (*Branta canadensis*)	1184	2.6%
House Finch (*Haemorhous mexicanus*)	626	1.4%
Northern Cardinal (*Cardinalis cardinalis*)	561	1.2%
Red-tailed Hawk (*Buteo jamaicensis*)	537	1.2%
Big Brown Bat (*Eptesicus fuscus*)	417	0.91%
Common Grackle (*Quiscalus quiscula*)	416	0.91%
Striped Skunk (*Mephitis mephitis*)	407	0.89%
Goldfinch (*Spinus tristis*)	398	0.87%
Cooper's Hawk (*Accipiter cooperii*)	397	0.87%
Rock Pigeon (*Columba livia*)	386	0.85%
Eastern Chipmunk (*Tamias striatus*)	373	0.82%

Table 3: The 20 species most frequently admitted to the wildlife rehabilitation facility from 2005-2014.

The top 10 most frequently assigned broad causes for admission categories (Figure 3a) account for 97.9% of all cases admitted, and the top 10 most frequently assigned specific causes for admission subcategories (Figure 3b) account for 92.2% of all cases admitted. The most assigned broad category and specific subcategory was “Orphaned” and encompassed 55% and 56% respectively of all cases admitted. Domestic animal interactions accounted for 20% of all cases admitted (Figure 3a), with cat attacks accounting for 11% of all cases admitted and dog attacks accounting for 9% (Figure 3b). Collisions with moving objects included 9% of all cases admitted (Figure 3a), with vehicle strikes accounting for 8% of all cases admitted and lawn equipment strikes accounting for 1% (Figure 3b). The broad category of “Injury Unspecified

Cause" was assigned to 4% of all cases admitted (Figure 3a), and individuals with bone fractures but no specified cause for admission accounted for 1% of all cases admitted (Figure 3b). Collisions with non-moving objects included 3% of all cases admitted (Figure 3a), with individuals that had collided with buildings/windows accounting for 2% of all cases admitted (Figure 3b). Disease cases accounted for 3% of all cases admitted (Figure 3a), with 1% of all cases admitted having canine distemper virus (Figure 3b). Interactions with non-domestic species accounted for 1% of all cases admitted (Figure 3a), with attacks by a wildlife species different than the victim (ex: predator and prey interaction) accounting for 1% of all cases admitted (Figure 3b). The remaining top 10 broad causes of admission categories included inappropriate human possession (1% of all cases), and attacks by an unknown domestic or non-domestic species (0.6%). The broad causes of admission outside of the top 10 most admitted collectively accounted for 2% of all cases admitted (Figure 3a). The specific causes for admission that were not among the top 10 most admitted accounted for 9% of all cases admitted (Figure 3b).

a).



b).

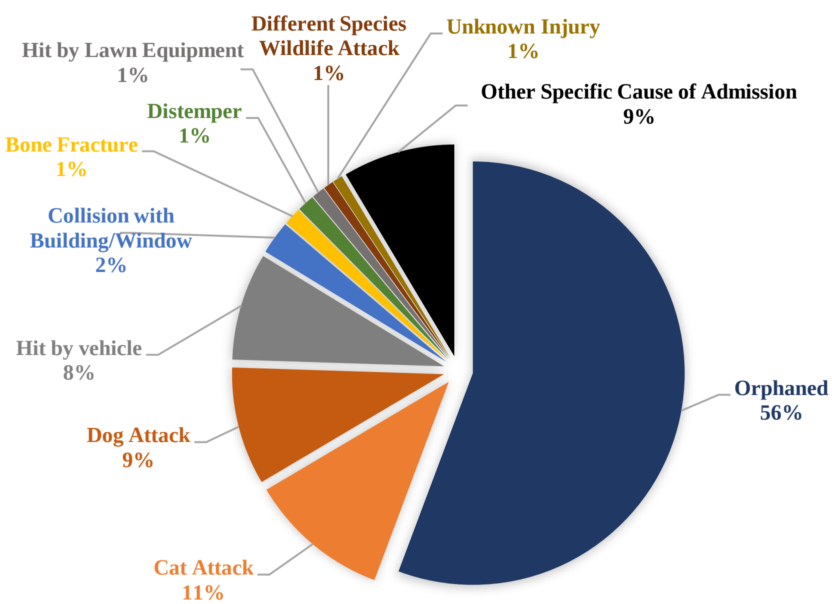


Figure 3: The 10 most frequently assigned broad causes for admission categories **(a)** and the 10 most frequently assigned specific causes for admission subcategories **(b)** for cases admitted to the wildlife rehabilitation facility from 2005-2014.

The most frequently observed specific causes for admission varied across taxa. Analyses of how taxa were impacted by causes for admission were modeled after Wimberger and Downs (2010). Mammals were admitted most frequently due to being orphaned (54.9%), dog attacks (13.1%), and cat attacks (10.4%). The top three specific causes of admission for songbirds+ were orphaned (47.4%), cat attacks (13.9%), and collisions with buildings/windows (6.7%). Waterfowl were most frequently admitted due to being orphaned (60.6%), vehicle strikes (14.4%), and bone fractures (1.9%). Reptiles were most admitted due to vehicle strikes (36.2%), being orphaned (16.5%), and dog attacks (4.5%). Water/shorebirds were most frequently admitted due to being orphaned (15.2%), vehicle strikes (11.7%), and bone fractures (10.4%). Amphibians were most admitted due to vehicle strikes (14.3%), bone fractures (7.1%), and being hit by lawn equipment (6.1%). Gallinaceous birds were most frequently admitted due to being orphaned (53.6%), vehicle strikes (17.9%), and cat attacks (7.1%) (Figure 4).

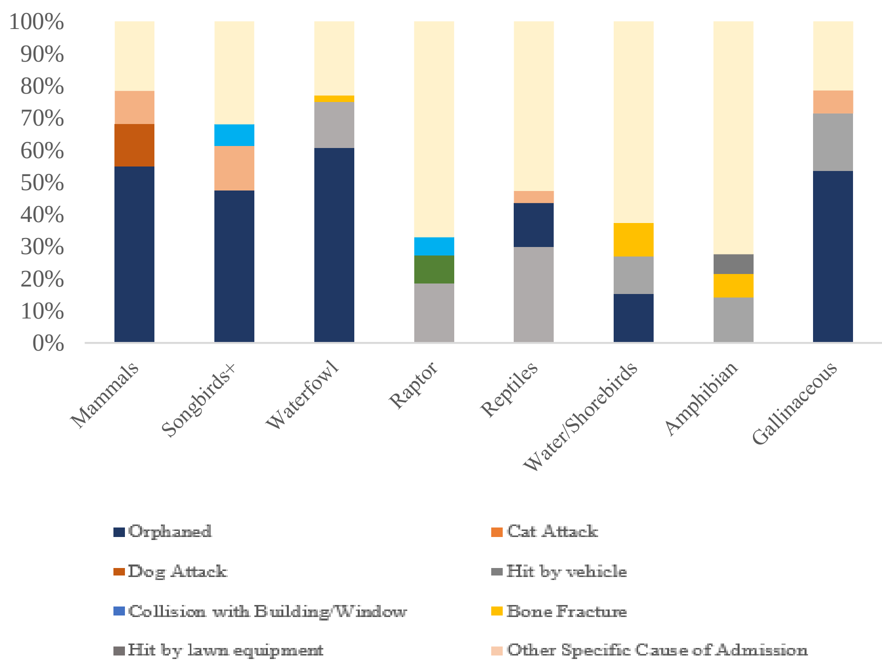


Figure 4: The top 3 specific cause of admission subcategories for each of the eight taxonomic categories admitted to the wildlife rehabilitation facility from 2005-2014, and the percentage of each taxon affected by them.

Disease Trends

Recorded disease cases accounted for 1018 (2.23%) of cases admitted from 2005-2014. Canine distemper virus was the most commonly recorded disease state of cases admitted from 2005-2014 (Figure 5), and 520 (94%) cases were observed in raccoons (*Procyon lotor*). The cases of canine distemper exhibited some fluctuation in frequency from month-to-month (Figure 2), but not to a statistically significant degree (X^2 = 3.376, df = 11, p = 0.985). Mycoplasmal conjunctivitis accounted for 8% of all disease cases admitted, and largely impacted house finches and goldfinches (89%). West Nile virus was recorded for 6% of all disease cases, botulism accounted for 4%, and other miscellaneous disease states accounted for 28% (Figure 5). Individuals testing positive for rabies only accounted for 0.3% of disease cases admitted (Figure 5), and 0.007% of all cases admitted to the wildlife rehabilitation facility during the examined time period.

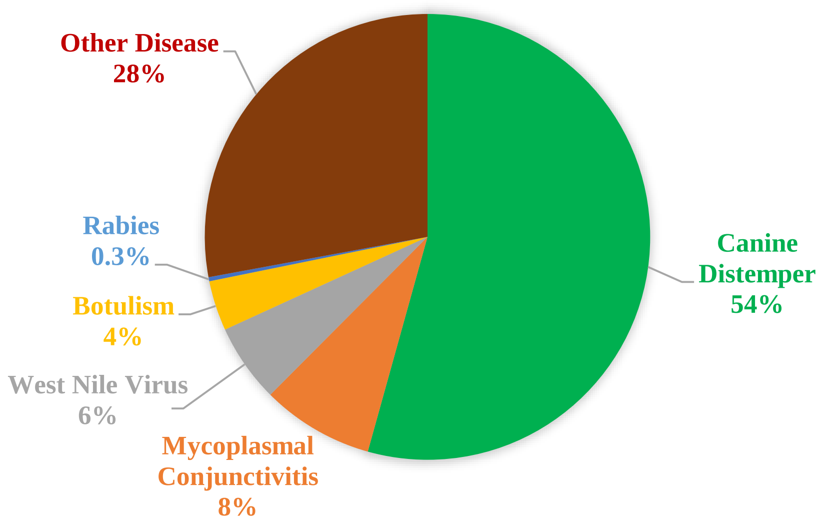


Figure 5: The disease cases admitted to the wildlife rehabilitation facility from 2005-2014.

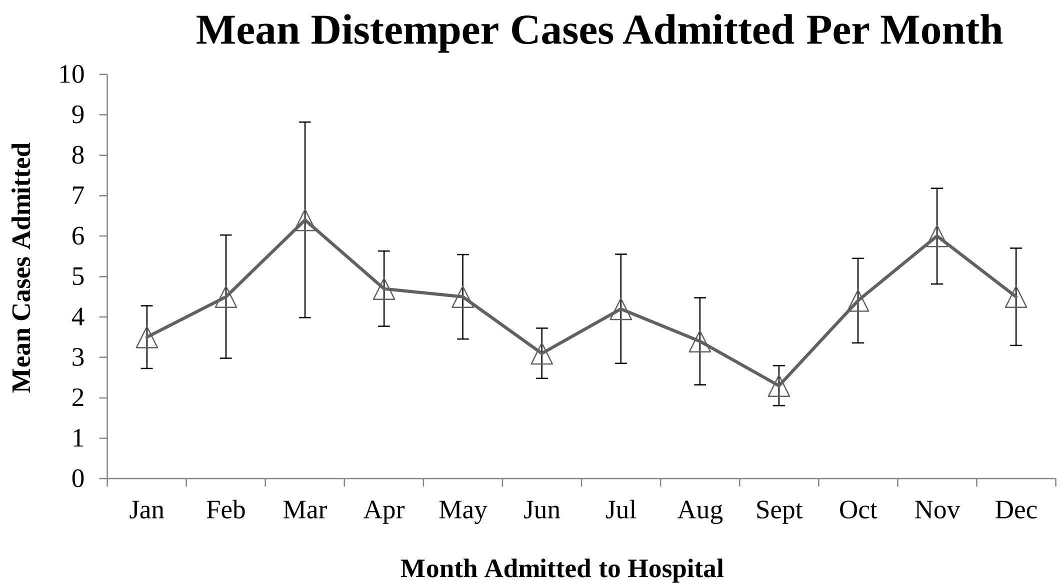


Figure 6: The mean ± SE cases of canine distemper virus admitted to the wildlife rehabilitation facility per month from 2005-2014.

Human-Wildlife Conflicts

Vehicle Strikes

Vehicle strikes represented 8% of all cases admitted to the wildlife hospital. Diverse taxa were admitted due to vehicle strike cases, with Canada geese (*Branta canadensis*), Virginia oppossums (*Didelphis virginiana*), eastern cottontail rabbits (*Sylvilagus floridanus*), mallards (*Anas platyrhynchos*), and eastern gray squirrels (*Sciurus carolinensis*) being the five most admitted species (Table 9). The mean “hit by vehicle” case admissions varied significantly across months per a Chi-squared test ($X^2 = 115.48$, df = 11, $p < 0.001$). The peak month for cases admitted due to vehicle strikes occurred in May, and the months with the fewest vehicle strike cases were December and January (Figure 3).

Table 4: The 20 species most frequently admitted to the wildlife rehabilitation facility from 2005-2014 due to having been struck by a vehicle and assigned the specific subcategory of “hit by vehicle”.

Species	Cases Admitted
Canada Goose	398
Virginia Opossum	367
Eastern Cottontail Rabbit	366
Mallard	266
Eastern Gray Squirrel	244
Raccoon	184
Red-tailed Hawk	179
Robin	135
Cooper's Hawk	78
Snapping Turtle	63
House Sparrow	62
Mourning Dove	60
Eastern Box Turtle	60
Rock Pigeon	55
European Starling	54
Northern Cardinal	52
Woodchuck	46
Barred Owl	44
Eastern Screech Owl	44

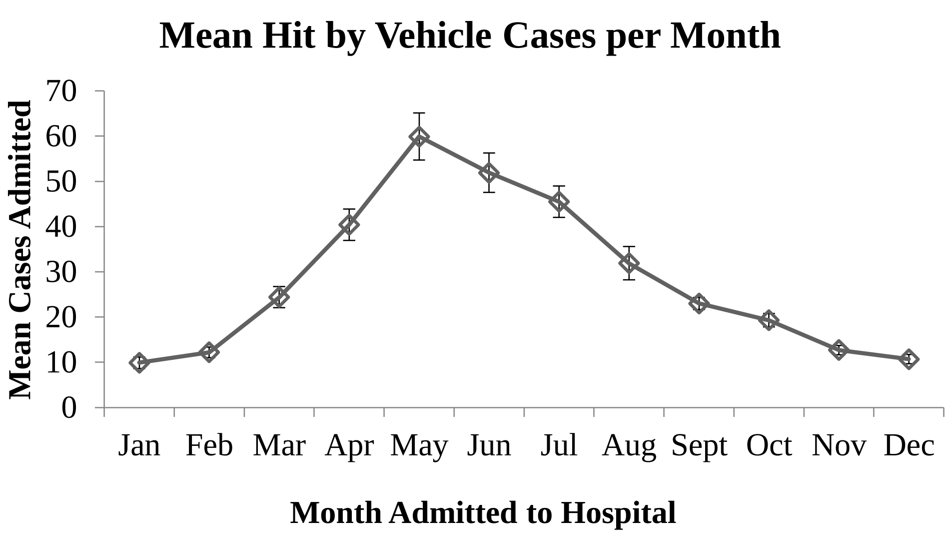


Figure 3: The mean ± SE vehicle strike cases admitted to the wildlife rehabilitation facility per month from 2005-2014.

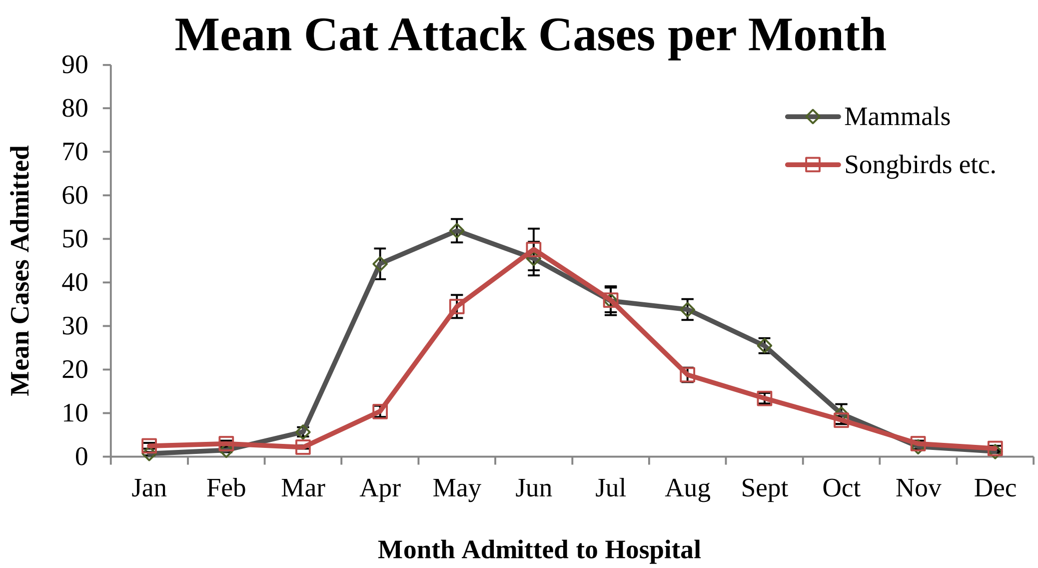
Domestic Animal Attacks

Cat attacks and dog attacks account for comparable percentages of all cases admitted to the wildlife hospital (9.8% and 8.2% respectively). Mammals, songbirds+, and waterfowl were the taxa most impacted by cat attacks, and mammals, songbirds+, and reptiles were most impacted by dog attacks. Cat attacks impacted 1,413 more songbirds+ individuals than dog attacks, and dog attacks impacted 682 more mammals than cat attacks. The peak month for mammal cases admitted due to either cat or dog attacks was May, and the peak month for songbirds + cases admitted due to either cat or dog attacks was June (Figure 4).

Table 5: A comparison of the total cat attack and dog attack cases admitted to the hospital from 2005-2014, and the top three taxa impacted by each.

Cat Attacks			**Dog Attacks**		
Mammals	Songbirds +	Waterfowl	Mammals	Songbirds +	Reptiles
2580	1816	64	3262	403	29
Total: 4490			Total: 3755		
Percentage of all cases admitted: 9.8%			Percentage of all cases admitted: 8.2%		

a).



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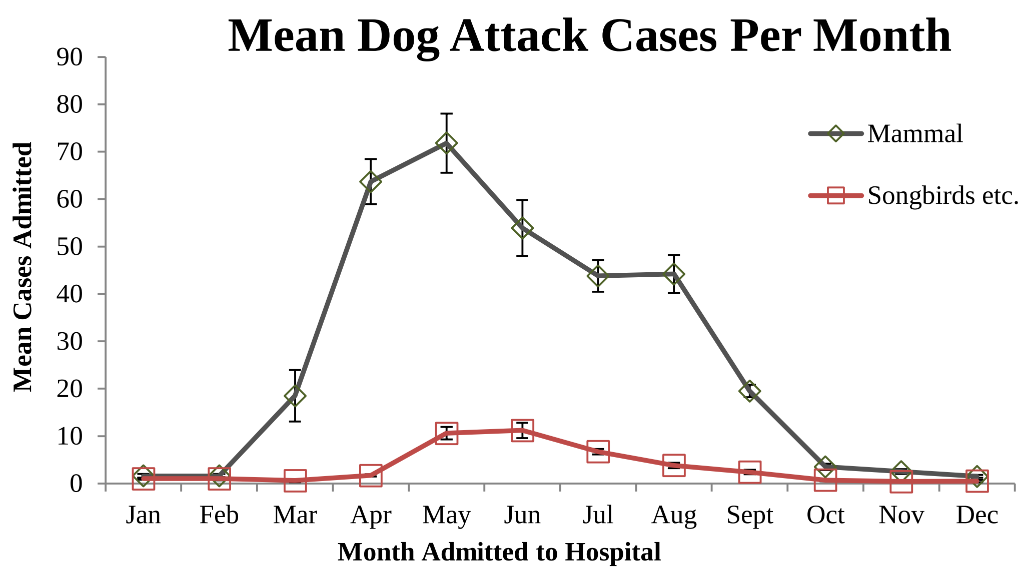

Figure 4: The mean ± SE cat attack cases **(a)** and mean ± SE dog attack cases **(b)** admitted to the wildlife hospital per month from 2005-2014 for the top two most impacted taxa: mammals and songbirds+.

Case Outcomes

Broadly speaking, mortality as defined by the sum of “died” and “euthanized” outcomes was more prevalent than release. The top three taxa with the highest release rates were gallinaceous birds, waterfowl, and reptiles (Table 6), and the top three taxa with the highest mortality rates were waterbirds/shorebirds, raptors, and songbirds (Table 7). The specific causes for admission categories with the highest release rates were “orphaned”, “unknown injury”, and “different species wildlife attack” (Table 6), and those with the highest mortality rates were “bone fracture”, “hit by vehicle”, and “cat attack” (Table 7). The lifestages at which individuals were admitted with the highest release rates were fledglings, nestlings, and hatchlings (Table 6), and those with the highest mortality rates were adults, juveniles, and infants (Table 7).

Table 6: The three taxa, top specific causes of admission, and life stages associated with the highest release rates for cases admitted to the wildlife rehabilitation facility from 2005-2014.

Variable	Release Rate
Taxon	
Gallinaceous	44.60%
Waterfowl	41.10%
Reptile	38.70%
Specific CoA	
Orphaned	46.60%
Unknown Injury	35%
Different species wildlife attack	32.10%
Lifestage	
Fledgling	45.20%
Nestling	44.80%
Hatchling	44.30%

Table 7: The three taxa, top specific causes of admission, and life stages associated with the highest mortality rates for cases admitted to the wildlife rehabilitation facility from 2005-2014.

Variable	Mortality Rate
Taxon	
Water/shorebirds	76.10%
Raptors	64.70%
Songbirds	57.20%
Specific CoA	
Bone Fracture	79.80%
Hit by Vehicle	74.40%
Cat Attack	67.40%
Lifestage	
Adult	72.10%
Juvenile	56.60%
Infant	48.40%

DISCUSSION:

The value of wildlife rehab facility records for monitoring pressures on local wildlife populations was demonstrated. Top specific causes for admission exhibit seasonal fluctuations that are consistent with annual biological patterns related to wildlife breeding and migratory seasons. This supports the capability of wildlife rehabilitation records to effectively monitor what is happening in local wildlife populations. These findings provide support for speculation in other literature regarding the potential value of wildlife rehabilitation records for wildlife health monitoring (Stitt et al. 2007, Randall et al. 2012, Molina-Lopez et al. 2011).

Both human-wildlife conflicts demonstrated significant month-to-month fluctuations in cases admitted to the wildlife hospital, likely corresponding with seasonal changes in the biology of local wildlife related to habitat use (Althoff et al. 1997, Burke and Capitano 2011), breeding seasons (Arzel et al. 2006), migration (Arzel et al. 2006, Malecki et al. 2001), and range size (Bond et al. 2001, Trent and Rongstad 1974). The significant fluctuations observed in hit-by-vehicle cases during a mean year do not correlate with annual traffic volume changes in the central Ohio area; peak traffic volume actually occurs from December – March for both rural and urban areas (Ohio Department of Transportation Division of Planning 2015), and peak months for hit by vehicle cases were April through August. As such, this pattern is more likely due to annual changes in dispersal and home range sizes inherent to the biology of local wildlife vs. changes in traffic loads. Domestic animal attack cases exhibited similar seasonality; it is likely this is due in large part to similar changes in activity level, breeding seasons, and home range sizes, as well as the annual influx of wildlife offspring from March-August in the northern hemisphere. It is also worth noting that during the months of April-August in the northern hemisphere, domestic animals maintained as household pets may be more likely to spend more time outside and thus have a greater likelihood of encountering wildlife. As such, this may highlight a time of year where it is particularly important to emphasize supervising pets outdoors to decrease the frequency of domestic animal attacks on wildlife.

The findings of this study also suggest that the current conversation regarding the impact of domestic animal attacks on wildlife needs to expand. Most of the existing literature related to this human-wildlife conflict focuses on the impact of domestic cat predation on songbird taxa, but dog attacks exert pressure comparable to cats, accounting for 8.2% of all 45,668 cases admitted with cat attacks accounting for 9.8%. This study certainly found support the previously demonstrated magnitude with which domestic cat predation impacts songbird and mammalian taxa (Loss et al. 2013, Beckerman et al. 2007). However, dog attacks are likely another source of anthropogenic pressure on wildlife that should be addressed in conservation education efforts, and accounted for in conservation decision-making for songbird and mammalian taxa.

This study also highlighted the ongoing need for public education regarding legitimately orphaned wildlife. Orphaned neonates account for the largest source of admissions to this facility (Figure 3), and it is possible that a significant portion of the neonates admitted as orphans were not actually orphaned. This facility has protocols to help screen for neonatal wildlife that may not actually be orphaned, but as they mostly entail conversational questioning, are dependent on the honesty and existing knowledge of the members of the public presenting the animals to the hospital. Thus, increasing the rigor and/or consistency of these screenings may be useful to some degree, but increasing public understanding of the biology of local neonatal wildlife and discerning whether found neonates are legitimately orphaned would likely be the more ultimate solution.

While the mean canine distemper virus cases admitted per month were not found to fluctuate to a statistically significant degree, Figure 6 indicates there is some degree of fluctuation and may implicate some value for wildlife rehabilitation records for disease monitoring. As noted by Randall et al., resources available for diagnostic testing and relatively low rates of diseased individuals being admitted may limit the ability of wildlife rehabilitators to discern small fluctuations in disease occurrences locally (2015). Inconsistencies in recording diseased individuals may contribute to this as well. However, in the event of significant spikes in disease prevalence in local populations, it is likely that wildlife rehabilitation facilities would be among the first to detect it via abnormal increases in cases admitted. This would corroborate speculation in other literature regarding the potential value of wildlife rehabilitation records for wildlife health monitoring (Stitt et al. 2007, Randall et al. 2012, Molina-Lopez et al. 2011), and subsequent implications for conservation and wildlife management.

A standardized system of record keeping may optimize effectiveness of rehabilitators as a wildlife health monitoring resource. While wildlife rehabilitation facilities have great potential to contribute to these efforts, there is a need for cohesiveness between organizations and public health agencies regarding data collection and management in order to accomplish this (Stitt et al. 2007). Some of the most significant challenges for wildlife health surveillance are related to the lack of confirmed cases, underreporting of confirmed cases, and lack of infrastructure to facilitate assembling records for surveillance (Stallknecht 2007). This infrastructure would reduce recording error due to inconsistent formats, as well as the subsequent loss of useful information and potential for analysis. It would also facilitate more uniform, cohesive monitoring of disease occurrences and human-wildlife conflicts nationally and internationally, and potentially enable wildlife rehabilitation facilities to contribute to wildlife health monitoring on a global scale. This would have significant value for identifying specific conservation needs, as well as contributing to One Health initiatives concerning the relevance of wildlife health for public health and domestic animal health (Daszak et al. 2007).

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