

JOURNAL OF WILDLIFE REHABILITATION

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INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

THE *Journal of Wildlife Rehabilitation* is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered online and on-site in numerous locations, and its outreach to those in the profession, the IWRC works to disseminate information and improve the quality of the care provided to wildlife.



ON THE COVER:

Proboscis bats (*Rhynchonycteris naso*) on a tree trunk, Belize.

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LEFT:

Egyptian vulture (*Neophron percnopterus*) in India.

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INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

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INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

Providing evidence-based education and resources on wildlife rehabilitation to move the field of wildlife rehabilitation forward; to promote wildlife conservation and welfare; and to mitigate human-wildlife conflicts worldwide, through better understanding of wild animal ecology, behavior, and welfare.

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VOLUME 43, NUMBER 1, 2023

CONTENTS

PEER-REVIEWED PAPERS

7

Collaboration with wildlife rehabilitation centers to enhance bat care, research, and conservation
Rachel Handy and W. Douglas Robinson

17

Prediction factors for release of wildlife at an American Midwestern rehabilitation facility
Abigail E. Niswonger, Stormy Gibson, and Anna M. Young

DEPARTMENTS

Editorial 4
In the News 5
Selected Abstracts 29
Tail Ends 34
Submission Guidelines 35

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EDITORIAL

Knowledge Shared

Within this issue you'll find a collection of selected abstracts, a feature we provide in at least one JWR issue a year. As I was collecting abstracts, I read a lovely statement on the importance of collaboration in a paper on rehabilitation of the southern sea otter (*Enhydra lutris nereis*). Reflecting back on the other papers I'd just been reading, I noticed a theme of sharing knowledge.

The conclusion to the sea otter paper states,

> "For [Monterey Bay Aquarium] and other programs, increasing collaboration and partnerships continue to advance methods of rehabilitation, post-release monitoring, and analysis of impacts to wild populations, informing and improving conservation efforts into the future."

In addition to the benefits listed above by the Monterey Bay Aquarium, collaboration improves animal welfare, and that should always be at the forefront of what we do.

Other abstracts in this issue include findings that flying fox pups have a high prevalence of antimicrobial resistant *E. coli* before entering care; which point of care glucometer works in raptors; and SARS-CoV2 surveillance in Chilean wildlife centers. I also found additional abstracts that did not make it into this issue, such as one mapping head arteries in Eurasian red squirrels (*Sciurus vulgaris*) that noted the paper findings may improve protocols for this species in rehabilitation.

Research is not just a task for others. Sharing our observations and experiences is a task for all practitioners in the field of wildlife rehabilitation. *The Journal of Wildlife Rehabilitation*, NWRA's *Wildlife Rehabilitation Bulletin*, and numerous other publications are excellent places to submit case studies, post release-monitoring outcomes, and share new techniques. Remember, negative or null research results are just as important to share as positive outcomes.

I acknowledge that not all of us are ready to publish original research, but conferences and symposia—from local gatherings to global events—are other excellent ways to share information. With our broad and diverse community, we can all talk to one another, network, ask for help, and share our experiences.

—Kai Williams
Executive Director

Chilean Wildfire Threatens Multiple Species

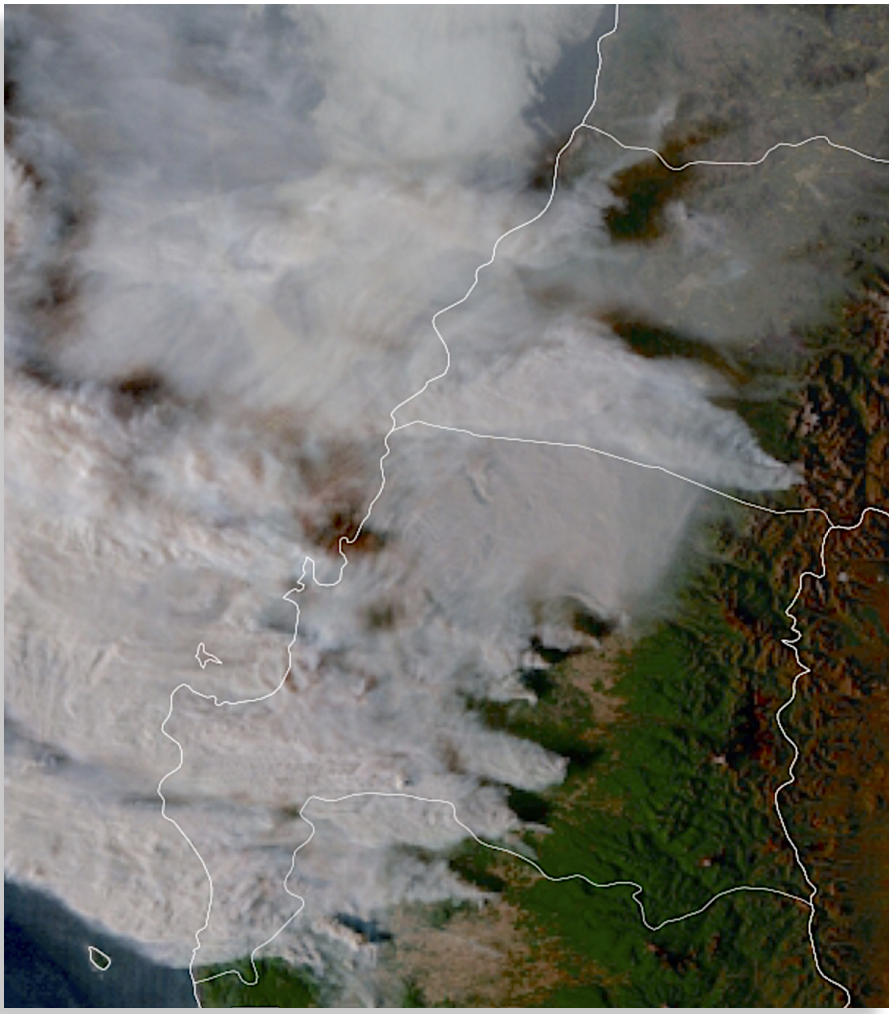
CHILLAN, CHILE *(February 9, 2023)*—Severe forest fires raging over 700,000 acres in Chile have affected humans, domestic, and wild animals. Reuters reports that the Ñuble Wildlife Rehabilitation Center along with Concepcion University are treating wildlife, including monito del monte *(Dromiciops gliroides)* and pudús (*Pudu puda*).

Avangrid Foundation Supports Wildlife Rehabilitation

ORANGE, CONNECTICUT USA *(February 7, 2023)*—The Avangrid Foundation, the primary philanthropic arm of sustainable energy company AVANGRID, Inc. (NYSE: AGR), today announced a record total of $136,000 in grants to 15 wildlife rehabilitation centers as part of its Wildlife Rehabilitation Program. This is the highest amount of grant funding ever given in the program's history. The funds will support operational capabilities and expand outreach to communities within the service area of the AVANGRID family of companies to improve knowledge and awareness of wildlife resources. Projects include avian influenza biosecurity, study of copper toxicity, shelter construction, nutritious food supply, and others.

"As a leading clean energy company, we acutely understand the importance of environmental stewardship," said Pablo Colón, Director of Corporate Citizenship and Executive Director of the Avangrid Foundation. "We are committed to wildlife protection, preserving healthy ecosystems and promoting biological diversity—all of which are essential for a sustainable future. This year's grantees are making impactful and lasting changes for the good of wildlife and our environment, all in unique ways. We're thrilled to support their efforts."

Now in its seventh year, AVANGRID's Wildlife Rehabilitation Program has given a total of more than $500,000 in grants to centers throughout the United States.



Wildfires in Chile, satellite image by NASA Feb 3, 2023. Click for video loop.

Animal Rescue Plan Research Initiative Includes Wildlife Rehabilitation

WASHINGTON, DC USA *(January 25, 2023)*—Dr. Mike Watson, Associate Administrator of the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) discussed research taking place under the American Rescue Plan for SARS-CoV-2, in partnership with the USDA Agricultural Research Service (ARS), on USDA Radio,

> "Ultimately, the tools and knowledge we gain from this work on SARS-CoV-2 will strengthen the nation's ability to respond to whatever the next disease is threatening animals, and possibly humans," said Watson. "Our collaboration with ARS is just a handful of the 17 projects we are currently conducting under the American Rescue Plan Act."

In 2021, USDA received $300 million in funding under the American Rescue Plan Act. APHIS is leveraging that funding to meet Congress' charge to conduct monitoring and surveillance of SARS-CoV-2 in susceptible animals. APHIS is uniquely positioned for this with their scientific expertise in animal health and animal diseases, including the ability to prepare for and respond to foreign animal disease outbreaks.

The work being done under the American Rescue Plan Act is aimed at

understanding how the SARS-CoV-2 virus behaves in different animals, how it moves between animals and people, and what can be done to interrupt the chain of transmission. It targets a wide range of animal groups for surveillance and to test for susceptibility, including farmed animals such as mink, companion animals like cats and dogs, free-ranging wildlife such as white-tailed deer, and wildlife in human care such as animals housed in zoos, aquariums, and animal rehabilitation centers.

"We are excited to harness the scientific expertise in USDA's research agency—ARS—to help us meet our goals," said Watson.

Wildlife Coexistence Bills Introduced in Maryland

MARYLAND, USA *(February 13, 2023)*—Maryland legislators have introduced three bills to improve wildlife management and coexistence in the state. These bills promote humane coexistence with black bears, increase the diversity of voices and scientific input in the state's wildlife policymaking process, and improve the procedure for reporting incidents involving pets, non-target wildlife, and other animals caught in traps and snares on public lands. The bills are scheduled for hearings on February 8, 15 and 17. All have bipartisan support and are supported by the Humane Society of the United States.

HB 378 would authorize grants for projects that reduce conflicts between black bears and humans, increase reimbursement for bear damage, and incentivize the creation of "bear-aware" communities using proven methods to prevent conflicts. Bears are extremely valuable to Maryland's ecosystems and economy, yet are confronted with habitat degradation, effects of climate change, and mortality from trophy hunting and human-caused conflicts.

HB 188 would add a requirement for broader citizen and scientist representation on the state's Wildlife Advisory Commission. Residents and visitors in Maryland who spend time outdoors without harming wildlife outnumber and outspend hunters and trappers by a wide margin. Historically, those constituents have had little say in policy decisions that affect Maryland wildlife. HB 188/SB 320 would acknowledge those stakeholders in the wildlife policy process.

HB 406 would require identification numbers on all traps, snares, and other devices designed to capture wildlife on Maryland public lands, and would encourage public reporting of non-compliant traps to the Maryland Department of Natural Resources. This would facilitate the reduction of accidental trapping and injury or death of pets, non-target wildlife, and other animals.

"We thank all of our bill sponsors for advancing measures that will promote humane and effective coexistence with Maryland's treasured wildlife," said Jennifer Bevan-Dangel, Maryland state director for the Humane Society of the United States. "These bills will help bring depth and diversity to wildlife management decisions in our state. Our wildlife is held in trust for the benefit of all our state's residents, and it's time that those residents have a say in how that wildlife is managed."

In 2021, an escaped zebra was found dead in an illegal snare trap in Prince George's County.

Born Free USA reports incidents of Maryland pets suffering in traps in recent years. Requiring better labeling of traps and more efficient reporting will help to protect Maryland's animals from such incidents.

People cause human–bear conflicts through actions such as leaving out unsecured trash, garbage, and bird feeders, which lure hungry black bears into neighborhoods. In rural areas, livestock feed, chickens, and bees attract bears. Residents can prevent conflicts and protect bears and property by blocking access with electric fencing.

Maryland's black bears provide significant benefits to their ecosystems. They spread more seed than birds and they break tree branches while feeding, which opens forest canopies, creating greater biological diversity on forest floors. They also indirectly protect gray foxes.

Black bears are as sentient as great apes and they spend up to two years raising their cubs, with whom they are closely bonded. The public appreciates their black bears, and HB 378 will encourage humane coexistence.

Infamous Islamabad Zoo Site to Become Wildlife Rehabilitation Center

ISLAMABAD, PAKISTAN *(January 30, 2023)*—The once infamous Islamabad Zoo, known broadly for animal welfare issues, closed in 2020. The facility is now in the process of becoming a wildlife education and rehabilitation center, tentatively named Margalla Wildlife Centre. Allocated to the project are 500 million Pakistani rupees via the 2022–2023 Public Sector Development Programme.

News outlets report that international non-governmental organizations (NGOs) involved in wildlife conservation have shown interest in partnering with the Islamabad Wildlife Management Board.

In an undated communication, Born Free Head of Policy, Dr. Mark Jones, stated, "We also applaud the stated intention to convert the site into a genuine rehabilitation centre and sanctuary for indigenous wild animals. However, for this ambition to be credible, the site will need to be developed and operated to internationally-recognised wildlife sanctuary criteria and standards, and not just turned into a sanitised version of the previous facility that continues to exploit animals for commercial purposes or public entertainment."

HPAI in South America

PARIS, FRANCE *(February 1, 2023)*—For the first time since 2002, seventy-five outbreaks of high pathogenicity avian influenza (HPAI) have been reported in nine countries in Central and South America. According to information shared by countries with the World Organisation for Animal Health (WOAH), these outbreaks have already led to the loss of nearly 1.2 million head of poultry.

CONTINUED ON PAGE 28

Collaboration with wildlife rehabilitation centers to enhance bat care, research, and conservation

Rachel Handy[1] **and W. Douglas Robinson**[1]

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Little brown bats (*Myotis lucifugus*).

Introduction

Bats are commonly misunderstood and feared by the public. Thought to be evil, flying rodents that get caught in one's hair, suck blood, and transmit diseases,[1,2,3] they garner mostly negative attention. Nevertheless, their important roles in ecosystems, remarkable behaviors, and conservation threats are increasingly studied and the subject of improved public outreach.[3]

Although bats face many threats such as habitat loss and degradation, roost disturbance, and persecution, new threats are emerging.[4,5] The development of alternative energy technologies, for example, has sometimes amplified previous threats, and has caused new problems such as barotrauma and direct mortality from collisions with wind turbine blades.[6] Diseases such as white-nose syndrome have caused bat populations in North America to plummet, in some cases more than 90%.[7] Climate change is a pervasive threat, reducing reproductive success and habitat availability through alteration of temperature regimes, and potentially from more frequent and severe wildfires.[8] Interactions with non-native species, such as domestic cats, also contribute to bat injuries and mortality.[9–12] As a result, wildlife rehabilitation centers (WRC) across North America are seeing larger numbers of bat admissions.[13,14]

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ABSTRACT: Bats are frequent patients at wildlife rehabilitation centers (WRCs) and pose unique challenges for their care. While they are taxonomically and ecologically diverse and face a wide variety of anthropogenic threats, their behavior, ecology, and animal husbandry requirements are poorly understood. Consequently, so are the best practices for their care and conservation. We review the available literature and summarize current opportunities and challenges for WRCs to collaborate with researchers, government agencies, academic institutions, community members, and other conservation organizations to enhance our knowledge of bats. Recognizing the opportunities WRCs offer by having wild bats under their care and by entering their data into national databases, collaborators could advance knowledge of bat biology rapidly. Collaborators, in turn, when recognizing the logistical constraints many WRCs face, could contribute to improvements to the rescue, care, and post-release survival of injured bats. We offer recommendations for collaborative opportunities and suggest potential research questions addressable with bats held at WRCs.

KEYWORDS: acoustic monitoring, bat, biotelemetry, Chiroptera, citizen science, post-release survival, wildlife rehabilitation, WILD-ONe database, zoonotic disease surveillance.

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Wildlife rehabilitation centers are playing an increasingly important role in bat conservation, particularly from the data collected at the centers and the vital role the centers play in public engagement and education. As one example, over a fifteen-year period (2005–2020), a total of 777 bats constituting seven species were admitted to the Ohio Wildlife Center in central Ohio, of which 33% were rehabilitated and released.[14] Because many WRCs receive bats, we argue that WRCs have an opportunity to expand their roles in bat research and conservation, as a wide variety of data can be collected from patients and shared with research communities. WRCs also have unique opportunities to engage the public in bat conservation. WRCs tend to focus on care of injured bats and can contribute basic knowledge about care and recovery. Because bats generally have low fecundity and relatively slow reproductive rates, WRCs may also have positive impacts on local bat populations under certain conditions, through successful rehabilitation and release of healthy animals back to the wild.[15] Simulation models showed a reduction of adult mortality via rehabilitation partially abated extinction risks for bats with small populations.[15] Despite the promise, the potential for WRCs to contribute to population-level effects needs further empirical evaluation.

Nearly all WRCs collect data valuable for improvement of our scientific understanding of basic biology and mortality risks faced by bats. With animals in hand, WRCs can contribute to pathogen surveillance, quantification and characterization of injuries, identification of sites where human disturbance of bats is frequent, and other emerging threats. In this article, we highlight opportunities for collaboration between WRCs, researchers, and conservationists interested in bats and their threats, building on the existing strengths of WRCs and revealing directions for enhancing their contributions to knowledge of bats.

Methods

We searched scientific databases for peer-reviewed scholarship, including Google Scholar, Researchgate.net, JSTOR, Web of Science, and the Oregon State University library search engine "1search." Keywords used to find relevant sources included: wildlife rehabilitation, wildlife management, wildlife database, bat conservation, bat rehabilitation, human–wildlife conflicts, biodiversity data, and conservation networking. Primary sources were included if they had direct application to bat research or rehabilitation. In addition, we supplemented information with personal observations and direct communications with rehabilitation facilities, including the Ohio Wildlife Center in Columbus, Ohio and the Lake Erie Nature and Science Center in Cleveland, Ohio.

Background of wildlife rehabilitation

Wildlife rehabilitation started as a grassroots movement in the 1970s with private citizens caring for injured, ill, and orphaned animals in their own backyards.[16,17] Since then, larger and more organized centers have become commonplace, many of which operate as non-profit organizations driven or dependent on volunteers. Regulation of these centers varies, frequently following care standards set by local, state, and federal government agencies, as is typical in the U.S. Although the mission of individual centers may vary, most wildlife centers follow the International Wildlife Rehabilitation Council (IWRC) definition of wildlife rehabilitation, "The treatment and temporary care of injured, diseased, and displaced indigenous animals, and the subsequent release of healthy animals to appropriate habitats in the wild."[16] Additionally, at least in the United States, WRCs are required to follow a set of minimum standards when intaking, treating, and caring for wildlife patients. This includes collecting information from the presenter such as name, contact information, circumstance of rescue including location, and health risks to the admitting person (e.g., were they bitten or scratched by the animal). Many WRCs contribute data to online databases such as WILD-ONe[14] The data collected from wildlife admissions by WRCs are increasingly used in scientific research.[12,18]

Spotlight on bat rehabilitation

Spurred by education and public relations efforts, an upswing in engaged citizens caring about the welfare of bats has emerged. When injured or distressed bats are found, people are better educated about how to help them—namely, bringing them to their local wildlife rehabilitation center. For example, in 2019 a total of 2,798 bats were admitted to WRCs in the United States and Canada, of which 40% were released.[14] Given that hundreds of similar facilities exist across the world, it is not unreasonable to assume that tens of thousands of bats are admitted to WRCs each year.

Once bats are admitted to these facilities, most centers rely on just three main information sources to determine best care practices. *Bats in Captivity* covers both Megachiroptera and Microchiroptera species, with a focus on bats staying in long-term captivity.[19] The "bible" of insectivorous bat care is authored by Amanda Lollar of Bat World Sanctuary. Their published care manual, *The Rehabilitation and Captive Care of Insectivorous Bats*, is the most thorough and detailed care guide for wildlife rehabilitators.[1] *Wild Mammal Babies: The First 48 Hours and Beyond* gives detailed instructions for infant care.[20] Along with presenter information (name, address where bat was obtained, hypothesized causes of admission), standard data collected upon initial intake during the physical exam includes species identification, weight, sex, age, and documentation of physical attributes, such as body condition, fractures or other injuries, and disease symptoms (R. Handy, personal observation).[14] Throughout the patient's time at the facility, daily records of treatments and observations may also be recorded. Most facilities also record the final disposition (released, held in long-term care, or euthanized) as well. With many WRCs encountering similar challenges treating and promoting recovery of individual bats, the development and sharing of effective practices with other WRCs and the research community provides opportunities for rapid advancement in knowledge.

Potential Opportunities

Bats are regularly listed as being among the most poorly known vertebrates. The World Conservation Union, for example, categorizes most bat species as Data Deficient and notes that more than half of bat species have no available data on population trends.[21] Because proactive approaches to conservation, which include gathering basic biological knowledge and documenting population trends and risk factors, are more effective than reactive strategies,[22] WRCs are well-positioned to contribute to bat conservation. The data collected from bats by WRCs during standard operations offer tremendous opportunities for research. In addition, having bats in hand provides unique opportunities to collect biological samples and to measure behavior difficult to observe in nature. The data collected by WRCs has the potential to reveal new or emerging threats from both anthropogenic and natural factors. The fact that many WRCs use digital databases as a source of record-keeping can facilitate rapid acquisition of information for researchers interested in collaborating with WRCs. Many rehabilitation centers in the U.S. use national databases which offer a way for wildlife health professionals to use their records. WILD-ONe, the Wildlife Incident Log/Database and Online Network created by the Wildlife Center of Virginia, is a free system WRCs can use for patient management and data management and analysis. Currently, at least 107 active organizations across five countries contribute data to this resource.[14] WILD-ONe provides conservation researchers a way to "obtain standardized incident data on injured and orphaned wildlife,"[14] offering opportunities to identify trends and characterize human impacts on bats that warrant attention.[12] Examples of observations that may be extracted from the database include pathogen occurrences,[23,24] domestic pet interactions,[10,18] window or building collisions, and vehicle strikes.[12] The consistency with which such information is included in patient records varies. To improve the value for research and improvement of best practices for bat care, we recommend the minimum information to record for each bat (Table 1). Adding details as to whether each type of information was confirmed or suspected will help researchers assess which subsets of data to include in their analyses.

TABLE 1. Recommended minimum information WRCs should record into WILD-ONe from admitted bats to improve the scientific value of the data collected and therefore the continued advancement of best care practices. For each value, "Confirmed" or "Suspected" should be added to improve data filtering by researchers. Relevant articles also include examples from other taxa that may be applied to Chiroptera.

	CRITICAL FACTORS	RELEVANT ARTICLES
ADMISSION	Species	(Long et al. 2020)[12]
	Rescue location	
	Date found	
	Circumstance of rescue (window collision, domestic pet interaction, etc.)	(Long et al. 2020, Demezas and Robinson 2021, Khayat et al. 2020)[12,18,65]
	Age/Sex/Weight	(Long et al. 2020, Demezas and Robinson 2021, Wund 2005)[12,18,38]
	Injury details	(Khayat et al. 2019)[65]
	White-nose syndrome status	(Turner et al. 2014)[27]
	Parasites (types, present vs. absent)	(Reeves et al. 2016, Graciolli et al. 2019)[66,67]
	Band or tag number, if applicable	(Norquay et al. 2013)[68]
CONCLUSION OF CARE	Disposition (i.e. end result of care; release, euthanasia, death, etc.)	(Long et al. 2020, Molina-López et al. 2013)[12,69]
	Date of disposition	(Molina-López et al. 2017)[70]
	Release location, if applicable	(Kelly et al. 2008, Ruffell et al. 2009)[40,71]

Collaboration/Partnerships

Stakeholders who may benefit from collaborating with WRCs include researchers and scientists, government agencies, policy-makers, students and teachers, and the public. Many stakeholders are interested in bat biology as well as the conservation issues they face. Because most conservation issues confronting bats, such as habitat loss, human disturbances, and climate change, are common across many organisms,[5,25] collaborations on studies of bats can have wide-reaching effects.[22,26]

Scientific researchers

Wildlife rehabilitation centers can contribute to scientific discovery (Table 2). When WRCs collect and place patient information into databases like WILD-ONe, they actively contribute to the potential for improving knowledge of bats. For instance, WILD-ONe is a nationwide database, so data deposited there can be used by researchers to detect and monitor wildlife health trends at large geographic scales. For example, Long et al. (2020)[12] reviewed 45,668 wildlife database records comprising over 280 wildlife species that were admitted to a WRC in Ohio over a 10-year time span. Their findings indicated the potential to learn about disease trends, human impacts at the local level, and what conservation topics would be most beneficial to emphasize in local outreach programs.[12] Expanding analyses from one center to many facilities across larger geographic areas could influence conservation efforts in many ways, such as promoting early detection of new diseases,[23,24,27] potentially quantifying occurrence of rabies and other known zoonotic diseases, characterizing widespread patterns of negative interactions with invasive species,[18,28] identification of periods of highest injury or mortality risk,[29,30] and identification of new injury or mortality sources as our environment changes.[31–33]

TABLE 2. Examples of potential research questions wildlife rehabilitation centers could help answer by collecting data in collaboration with academic researchers, science and management agencies and conservations groups. Decisions regarding involvement of particular bats should always be ethically considered.

QUESTION	POTENTIAL METHODS	MATERIALS NEEDED	RELEVANT ARTICLES
What are the most common injuries and sources of mortality for bats entering WRCs and how do they vary across landscapes?	Systematically search wildlife databases for circumstances of rescue.	Permission and access to WILD-ONe/other databases used by WRCs.	(Khayat et al. 2020, Long et al. 2020, Demezas and Robinson, 2021, Schenk and Souza 2014, Taylor-Brown et al. 2019, Duffy 2020)[11,12,18,72,73,74]
What are the physiological responses (e.g., cardiac activity, ventilation rate, body/tissue temperatures) bats exhibit during rehabilitation and/or artificial hibernation?	Use of biological sensors in the environment or attached to individuals in care; hormonal stress studies via blood samples or guano (ethically choosing which animals are suitable).	Biotelemetry and/or biologgers (sensor tags); fecal samples.	(Wilson et al. 2015, Kelm et al. 2016)[39,48]
What pesticides or other chemical toxins/pollutants are present in bats and do they vary by foraging strategy (i.e., insectivorous vs. nectivorous) or rescue location?	Depending on chemical of interest, various methods are available utilizing biomarkers to indicate pesticide and/or chemical levels.	Biological samples (i.e., fur, blood, guano, tissue).	(Bayat et al. 2014, Eng et al. 2019, Sandoval-Herrera et al. 2021, Wilcox et al. 2021)[47,75,76,77]
What emerging pathogen trends exist and how do they vary across geographic regions?	Various methods depending on pathogen of interest. Example, swabbing and using long wave UV light to detect the presence of white-nose syndrome.	Biological samples (i.e., fur, blood, guano, swabs).	(Randall et al. 2012, Camacho et al. 2016, Turner et al. 2014)[23,24,27]
How does development of echolocation behavior differ between orphaned, hand-reared bats, and wild post-natal bats?	Foraging test arena with trials of various amounts of "clutter" (i.e., open areas vs. artificial trees); see Wund 2005[38] for details.	Bioacoustics detector, recorder, and software, test arena, flying prey.	(Mukhida et al. 2004, Wund 2005)[37,38]
Do differing care and pre-release conditions (e.g., artificial hibernation, flight training, exposure to native prey) alter survival and behaviors of released bats?	Radio-tag bats prior to or upon being released from care to monitor behavior and track activities.	Radio-transmitters and telemetry equipment; artificial hibernation equipment (e.g., wine cooler protocol), native and/or flying prey, flight tent/arena.	(Serangeli et al. 2012, Kelly et al. 2008, 2012; McGuire et al. 2012, 2014; Jonasson and Guglielmo 2016, Krauel et al. 2018)[13,40,78–82]
What is the post-release survival rate of rehabilitated bats over the short- and long-term and how do those rates vary by species, injury type and geography?	Band bats prior to or upon being released from care. Would require follow-up mist-net surveys and band information entered into an accessible database.	Radio-transmitters and telemetry equipment, wild-caught individual(s) to act as a control; Bands or other permanent tagging options. High-speed video camera, software to analyze flight patterns.	(Serangeli et al. 2012, Kelly et al. 2008, 2012)[13,40,78]
What are the post-release behaviors of rehabilitated bats over the short- and long-term and how do these behaviors vary by species, age, injury type, pre-release conditioning protocols and release location?	Radio-tag bats prior to or upon being released from care and monitor for activity. Flight pattern study comparing healthy bats, bats with varying degrees of wing tears, and rehabilitated bats. Utilize software or could perform an observational study and create an ethogram of flight patterns. Radio-tag bats prior to or upon being released from care and track via MOTUS towers.	Radio-transmitters and telemetry equipment, wild-caught individual(s) to act as a control. Nanotags, MOTUS receiver.	(Serangeli et al. 2012, Kelly et al. 2008, 2012, Morningstar and Sandilands 2019, Bell et al. 2019, Monarchino et al. 2020, Clerc et al. 2021)[13,40,42,78,83–85]

Researchers can also benefit by gaining easier access to bats than might be possible under natural conditions, saving time and resources.[34,35] An example is the relatively new and growing trend at WRCs to house bats in wine coolers, which serve as less expensive versions of metabolic chambers. WRCs can mimic the winter environment bats seek during the hibernation portion of their annual life cycles, instead of keeping bats awake and active unnaturally (R. Handy, personal observation).[36] Maintaining bats appropriately in hibernation saves rehabilitation centers time and resources and also could provide researchers access to hibernating bats that might be difficult study in the wild. Consideration should be given by rehabilitation centers, however, for appropriateness of artificial hibernation, given suitable physiological conditions of bats. We encourage close monitoring by veterinary staff of all bats put in conditions that may induce torpor.[1] Furthermore, captive bats in suitable physical condition could be used in echolocation studies, such as Mukhida et al.'s[37] or Wund's[38] studies examining the echolocation calls of different species in spaces with different configurations of environmental clutter, thus revealing basic biological information about how bats navigate and interpret their environment. However, bats in a captive setting, such as a WRC, may not demonstrate the same behaviors exhibited in the wild, and this possibility should be considered carefully.

When bat patients have been deemed healthy and fit for release back to the wild, appropriately trained researchers can band or radio-tag them. Such studies could promote our understanding of the short- and long-term success of rehabilitation treatments by monitoring survival and distances moved after release. Radio-tracking technology is continuously improving with size reductions of technology and implementation of passive antenna arrays listening for radio signals.[39] Kelly et al.[40] used a 14-day tracking period to monitor post-release survival of bats. This was useful in learning about the survival rates of released rehabilitated bats. Serangeli et al.[13] studied the habitat preferences of released rehabilitated bats via radio-telemetry. To track movements over much larger areas, scientists are using nanotags in combination with MOTUS towers to track the paths of migratory birds, and, in some cases, in collaboration with WRCs (T. Jasinski, personal communication). Such movement tracking helps determine not only where birds are going (including important migration stopover habitats), but also window and building collisions that may ultimately impact formation and implementation of conservation policies.[34,41] The same opportunities exist to use this technology to track bats, especially for migratory species whose movement patterns are poorly understood. For example, the MOTUS tower tracking system was used to track a Hoary Bat (*Lasiurus cinereus*) over 827 km in Ontario.[42] Using this technology can help scientists better understand migratory species' behaviors, which are highly vulnerable to anthropogenic factors such as collisions and barotrauma from wind turbines.[6,43–45] We are unaware of any published studies in collaboration with WRCs regarding radio-telemetry or nanotag and MOTUS studies of migratory bats.

Finally, WRCs have no shortages of biological materials useful for learning about bats. Fur, fecal material, blood, and tissues are typically discarded but offer many opportunities to improve knowledge of bats and their interactions with the environment and other species. Stable isotopes from tissues help scientists understand the environmental toxins bats encounter.[22,46] Sandoval-Herrera et al.[47] documented toxicity levels in insectivorous bats from blood samples; Richards et al.[35] describe methods to apply environmental monitoring via fur and feather samples; and Kelm et al.[48] utilized fecal glucocorticoid metabolite concentrations to monitor stress hormones in bats non-invasively. Feces are increasingly used to assess dietary composition by identifying DNA barcodes via eDNA studies.[49,50] The research opportunities using samples from bat patients at WRCs are abundant.



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Hoary bat (*Lasiurus cinereus*).

Education partners

By partnering with rehabilitation facilities, students at local universities can practice development and design of research projects. Many facilities regularly engage students as volunteers. In addition to training them to follow best practices for bat care, students learn the necessities for appropriate vaccinations and following safe handling protocols, and the complexities of daily work at WRCs. In turn, WRCs benefit from the availability of eager and enthusiastic assistance when staffing funds are in short

supply. Veterinary and veterinary technician students in particular make a great pairing, if WRCs have the time to invest in training these students.

Government agencies and policymakers

In the realm of wildlife rehabilitation, government agencies are typically responsible for regulating facilities via permitting, which can involve local, state, and federal levels. For example, Ohio rehabilitation facilities are required to obtain a permit to rehabilitate wildlife in the state, which is regulated by the Division of Wildlife within the Ohio Department of Natural Resources (ODNR).[51] Additionally, when federally endangered or state-sensitive bat species are presented, WRCs and rehabilitators are required to notify officials immediately so these rare species can be documented properly. Government agencies and other policymakers also assist with various wildlife protections, some of which may be influenced by what local non-governmental organizations (NGOs) and other conservation groups are doing. Bills like the Bird-Safe Buildings Act, H.R. 919, which helps both birds and bats,[52] are gaining public support as awareness grows.[41] For example, in 2019 after partnering with conservation groups such as the Ohio Bat Working Group, the Ohio government signed into law "National Bat Week" during the month of October.[53,54] When WRCs are on the front lines of this type of conservation, they have the opportunity to provide expert consultation directly to legislators,[34,55] especially given the large amount of data WRCs can provide about bats and their mortality sources. With collaboration between conservation groups and the support of our government leaders, public perception of bats and the importance of their conservation can improve.

TABLE 3. Recommendations for wildlife rehabilitators and their collaborators to advance bat biology and conservation.

WILDLIFE REHABILITATORS OR CENTERS	COLLABORATORS
1. Be open to opportunities to engage researchers and others in the mission of your rehabilitation center.	1. Be cognizant of the funding and staffing limitations most WRCs encounter and offer solutions when seeking collaborative opportunities.
2. Train personnel to accurately and completely enter data from bat admissions into databases such as WILD-ONe.	2. Proactively share new discoveries on bat behavior or health care needs from peer reviewed literature.
3. Seek collaborators who can help train personnel to gather and share accurate data.	3. Volunteer at your collaborating WRCs to care for the bats you are studying.
4. Encourage collaborators to volunteer at your center to improve their understanding of the challenges and constraints you face when caring for patients.	4. Get the appropriate animal care training and vaccinations completed prior to approaching WRCs with ideas for collaborations.
5. Ensure ethical practices are undertaken while providing bat care, especially when new methods or protocols are enacted.	5. Ensure bats are handled and studied ethically, keeping in mind that animal welfare is a main tenet of WRCs; utilize an ethics review process whenever possible.
	6. Follow through on commitments to make research or other information publicly available, giving appropriate credit to your WRC collaborators.

The Community

By offering the public opportunities to learn accurate information about bats and their biology, WRCs reach people through personal interactions (R. Handy personal observation),[56,57] educational programs,[12,31,58] and via activism and volunteerism.[34] WRCs can share information, trends, and protocols for care and handling of bats through formal and informal channels. As concerns for conservation of bats continue to grow, it seems to be increasingly important for WRCs to partner with other NGOs within their community, especially with those that share similar missions. WRCs typically have limited resources; therefore, collaborating with local NGOs allows for cooperation between organizations via shared data, advocacy,[57] public education, and even sharing of volunteers. Such cooperation can also improve development of best practice guidelines for bat care in WRCs across the nation.

As an example that WRCs might emulate, the Dubai Turtle Rehabilitation Project (DTRP) rehabilitates injured and ill sea turtles then releases them. Although their work has had positive effects on threatened turtle populations, they go a step further by satellite tracking released individuals and using that data to inform conservation efforts in the region.[33] Their data are uploaded to Movebank, a free, online database which assists animal tracking researchers by managing, sharing, analyzing, and archiving information.[59,60] As radio-tagging and tracking technologies continue to improve for use with bats, rehabilitators and fellow conservationists could follow in DTRP's footsteps to aid in various chiropteran conservation efforts.

Potential Pitfalls

When biodiversity data sources are freely and openly available, conservation efforts benefit.[61] Yet, the act of sharing data can present its own challenges. A lack of data collection method standardization can make using the data in reliable ways difficult. Furthermore, a lack of infrastructure within WRCs themselves can complicate their ability to share data.[12] This can be especially true when organizations utilize their own independent data platforms or still use paper instead of digital databases.[61]

While WRCs offer a wealth of bat data collected annually,[12] published articles based on WRC databases are still relatively rare.[62] Lack of standardization of databases, and variation in

data entry skills, can reduce data accuracy and uncertainty, discouraging researchers from using WRC data.[12,18,62,63] Even when accurately entered and curated, data may be incorrectly assessed at time of admission, being influenced by the reports provided by the rescuer.[62] Once admitted, bats pose challenges atypical of many other organisms. Determining the species and correct age of bats requires precise measurements such as forearm length and degree of bone ossification.[64] The limited number of trained staff and volunteers available at WRCs, let alone those who are rabies vaccinated, presents obstacles to accurate data collection. Furthermore, institutional resistance amongst organization leaders can hinder the progression of scientific integration, especially when the organization's existing framework lacks support.[22] Nevertheless, if these limitations can be addressed or even documented appropriately, researchers can recognize and handle such challenges during data analyses. We argue that the challenges are worth overcoming to promote the gain in useful knowledge of bat biology and conservation.

Summary

As human populations continue to grow, the number of bats getting injured or becoming ill due to anthropogenic reasons will likely also increase. Local and global bat conservation networks recognize risks faced by bats and strive to develop management plans, yet wildlife rehabilitation centers and their potential contributions are hardly considered.[25] Wildlife rehabilitation centers are well-positioned to be prominent voices in the chiropteran conservation conversation, despite intrinsic challenges they may face. Where possible, wildlife rehabilitation facilities can provide a valuable counterbalance to these threats by impacting the welfare of individual bats and potentially reducing severity of local population declines under certain conditions. On a broader scale, these centers can promote conservation by fostering relationships with other important stakeholders, such as researchers, scientists, academics, governing agencies, policymakers, and the community at large. To promote advancing knowledge of bat biology and conservation through opportunities presented by WRCs, we offer recommendations for WRCs and their collaborators (Table 3).

Wildlife rehabilitation centers can provide immense amounts of data and research opportunities to enhance chiropteran conservation. Improving and expanding partnerships between researchers and these facilities promises to further strengthen our knowledge of bats and the threats they face.

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Rachel Handy has dedicated her personal and professional pursuits to wildlife conservation including rehabilitation, field research, and educational outreach. She has her master's degree in Fisheries and Wildlife Administration and currently serves as an Academic Advisor in the Department of Integrative Biology at Oregon State University. She looks forward to further investigating how we can bridge gaps and bring people together to help save wildlife through expanding and sharing our knowledge.

W. Douglas Robinson is a Professor of Wildlife Science and has a longstanding interest in helping wildlife rehabilitation centers collaborate with research scientists. His typical research focus is on birds, but he has collaborated on projects involving small mammals including bats. He is especially interested in how we can learn more about sources of mortality in wildlife by studying data gathered by rehabilitation centers.

Prediction factors for release of wildlife at an American Midwestern rehabilitation facility

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Common mallard drake (*Anas platyrhynchos*).

Introduction

An increasing impact on wildlife populations by anthropogenic threats[1] has resulted in the field of wildlife rehabilitation becoming a common practice internationally.[2,3] Goals of the field include reducing animal suffering, releasing rehabilitated wildlife, monitoring the spread of wildlife diseases such as avian influenza, and educating the public.[1] Resources available to devote to rehabilitation are limited, so they must be used wisely.[4-6] Effective triaging is an important tool for directing resources to patients with the best prognostic outcome as well as preventing undue suffering of animals with a poor prognosis.

Continuing education for rehabilitators based on empirical research is necessary to improve best practices. Early assessments have focused on veterinary techniques[7-9] of caring for and treating specific species, such as Eastern cottontail rabbits (*Sylvilagus floridanus*),[7] and raccoons (*Procyon lotor*).[10] Several studies have been conducted on post-release survival using radio tracking,[11] which is a critical step in revealing the ultimate success of rehabilitation.[11,12] However, only those animals that are successfully rehabilitated can be included

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ABSTRACT: Wildlife rehabilitation is a large and internationally known field with thousands of wildlife rehabilitators around the world. Resources, such as time and money, are extremely limited in rehabilitation facilities, and not all animals are candidates for release due to injuries or illnesses that make them unlikely to survive in the wild. Understanding what factors predict release would be useful in focusing limited resources, but there has been little investigation previously. The purpose of this study is to determine what factors affect the survival of mammals and birds at an American Midwest wildlife rehabilitation center. It was found that animals admitted with trauma and fracture or injuries to the skull, hindlimb/pelvis, spine/tail, or nervous system had low rates of release. Weight was also a determining factor for the release of young mammals; animals that were below the average weight for their life stage were less likely to be released. This data may be of use in improving triage techniques in the American Midwest and abroad.

KEYWORDS: disposition, outcome, prediction factors, release rate, wildlife rehabilitation.

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in these evaluations. There is a dearth of research examining the rehabilitation potential of all animals admitted to wildlife rehabilitation centers, including those that do not survive.

The few studies that have been conducted often analyzed a single species like the European sparrowhawk (*Accipiter nisus*),[13] common kestrel (*Falco tinnunculus*),[14] hedgehog (*Erinaceus europaeus*),[15] wood pigeon (*Columba palumbus*),[16] or raptors in general,[17] and have mainly encompassed birds of prey.[18] One comprehensive study by Molony and colleagues was conducted to determine the factors that can predict release in native European wildlife including badgers (*Meles meles*), blackbirds (*Turdus merula*), hedgehogs (*Erinaceus europaeus*), red foxes (*Vulpes vulpes*), tawny owls (*Strix aluco*), European starlings (*Sturnus vulgaris*), house sparrows (*Passer domesticus*) and Pipistrelle bats (*Pipistrellus* spp.).[19] Potential factors were separated into two categories, intrinsic and extrinsic. Intrinsic factors included life stage, sex, and mass; extrinsic factors included time of day, season admitted, reason for admission, severity of injury or illness, and duration of care.[19] Despite intrinsic factors being commonly cited as the main determinants of release, Molony et al. found that severity of injury or illness was the best predictor.[19] A similar study by Molina-López et al. examined the primary causes of morbidity of 302 species in Spain.[20] Only the cause of admission was evaluated as a factor and it was found that trauma, metabolic or nutritional (i.e., low body condition or weakness), and infectious disease categories had the highest mortality rates. As with the Molony et al. study, they found that as the severity of injury or illness worsened, so did the mortality rate.[20] These data are valuable for European rehabilitation facilities; however, there have been few studies published outside of Europe.[21-24] A recent global meta-analysis by Cope et al. [25] found the reason for rescue and severity of diagnosis were commonly reported to affect the likelihood of survival to release.[25]

Expanded empirical studies are necessary to aid wildlife rehabilitators in triaging different species in other parts of the world; due to limited resources, such as time and money, it is impossible to rehabilitate every animal.[26] When the limits on resources, space, or capacity are reached, decisions are necessary about which animals to rehabilitate and which to humanely euthanize, after decisions have already been made from a welfare standpoint. Resources should be invested in the animals that are most likely to be released, proceed to survive, and eventually reproduce in the wild; empirical data can help elucidate the circumstances that will result in hopeful prognoses. Even with unlimited resources, wildlife unlikely to survive or be released should be humanely euthanized to minimize suffering.[18,27] Expanding research to include the American Midwest is valuable to determine if trends exist that are similar to those seen in European rehabilitation facilities.

At the Ohio Wildlife Center, an American Midwestern wildlife rehabilitation facility, the decision to rehabilitate or euthanize is often a judgment call made by the veterinary staff based on the quality of life, predicted survival to release, and Ohio law. Experienced staff are well practiced at recognizing when an animal should be euthanized. However, to establish a consistent and efficient protocol, research should be completed to determine which animals are indeed likely to be released or more likely to be released than another. The goal of this study is to assess the factors that predict the release of wildlife at the Ohio Wildlife Center. Once this information is known, species-specific triage guidelines could be established to determine which animals to euthanize immediately due to low survival/release rates and which animals to attempt to rehabilitate. It is possible that this information could also be utilized by other rehabilitators in the American Midwest, especially smaller rehabilitators that do not have access to as many resources as larger facilities like Ohio Wildlife Center. Rehabilitators in other regions beyond the Midwest that receive the same predominant species of focus may also be able to implement these data into their practices.

Materials and methods

Study site

A retrospective study was completed in partnership with the Ohio Wildlife Center, an urban rehabilitation facility located in Columbus, Ohio. This facility manages one of the largest quantities of intakes in the state with approximately 4,500 patients per year consisting of 100 different species during the study period.[28] Since the conclusion, intake has increased to over 8,100 patients per year. The Ohio Wildlife Center is a Category II Rehabilitator, holds endangered species and rabies vector species permits from the Ohio Department of Natural Resources, and is a permitted Migratory Bird Rehabilitator by the U.S. Fish and Wildlife Service.

Data collection

Electronic intake records were available through data contributed to the WILD-ONe database (Wildlife Center of Virginia, Waynesboro, Virginia, USA; https://www.wild-one.org/), an online database for wildlife rehabilitators.[29] Records included information on the animal and on the presenter (the person who brought the animal to the hospital). Information on the animal included species, life stage, sex, number of individuals presented, location where it was found, when it was presented to the hospital, the circumstance of rescue (reason for presentation to the facility), anatomical site of injury, categorization of injury, weight, and disposition (died, euthanized, released, or transferred).

The data for the years 2015 and 2016 were extracted from a total of 8,900 records originating from the WILD-ONe database. Any record marked as active or missing an identification number was excluded, leaving 8,834 records for analysis. Any missing information such as number presented, sex, weight, and life stage was filled in from reviewing the paper records on hand at Ohio Wildlife Center. In instances where the electronic and paper records differed, the paper record was defaulted to.

Data configuration

To assimilate the data, all missing data were classified as undetermined and all weights were converted to grams. Any weight

that was greater than twice the average for the species-specific life stage was omitted to account for human error upon data entry (less than 1% of records). To facilitate analysis, the life stages newborn, pouch young, infant, hatchling, nestling, and fledgling were all recategorized as young.

To focus analyses, only species with greater than 100 records for mammals and 200 records for birds were considered. For the key descriptors—circumstance of rescue, anatomical site of injury, and categorization of injury—only categories with greater than 50 cases admitted were included. The circumstance of rescue was the reason the animal was presented to the rehabilitation facility. For example, *collision* indicated the animal collided with an object such as a car, lawn mower, window, etc. The category *electrocution* was not included because only two cases were admitted. The anatomical site of injury indicated where on the body the injury or ailment occurred. For example, *generalized* implied an injury or illness that was present throughout the entirety of the individual. Categorization of injury represented the type of injury sustained. Anatomical site of injury and categorization of injury were reconfigured due to overlapping categories (Tables 1 and 2). Descriptive statistics were applied to evaluate the data.

Percent Relative Weight (PRW) was calculated to account for varying typical weights for each species.

$$\text{Average Weight (g) for Life Stage} = \frac{\Sigma \text{ of all individual weights}}{\text{number of individual weights}}$$

$$\%\ \text{Relative Weight (PRW)} = \frac{(\text{Weight (g)} - \text{Average Weight (g) for Life Stage}}{\text{Average Weight (g) for Life Stage}} 100$$

Results

Six species of mammals and six species of birds with the most prevalent records were analyzed (Fig. 1a and 1b). Mammals made up 4,267 cases and included the Eastern cottontail rabbit, Eastern gray squirrel (*Sciurus carolinensis*), raccoon, Virginia opossum (*Didelphis virginiana*), house mouse (*Mus musculus*), and big brown bat (*Eptesicus fuscus*). Over one-third of the admitted mammals studied were Eastern cottontail rabbits and nearly a quarter were Eastern gray squirrels. Birds made up 2,319 cases and the number of cases for each species falls into two ranges. American robin (*Turdus migratorius*), mallard (*Anas platyrhynchos*) and house sparrow *(Passer domesticus),* were each in the 20–25% range. European starling, Canada goose (*Branta canadensis*), and mourning dove (*Zenaida macroura*) were each in the 10–15% range.

Of the 6,586 cases, 2,256 individuals died (34.25%), 1,693 were euthanized (25.71%), 2,580 were released (39.17%), and 57 were transferred (0.87%). Of the 12 species studied, big brown bats had the lowest release rate (23.3%), and mallards had the highest (65.72%). The highest unassisted mortality (those that were not euthanized) was associated with Eastern cottontail rabbits and the lowest was associated with raccoons (Fig. 2).

TABLE 1. Anatomical site of injury.

RECORDED ON RECORD	RECONFIGURED
Auditory	Auditory
Shell Carapace Plastron	Shell
Cardiovascular	Cardiovascular
Cavity Coelomic Abdominal Thoracic	Cavity
Clinically healthy	Clinically healthy
Died before exam Dead on arrival	Died before exam
Digestive system	Digestive system
Forelimb/wing/shoulder girdle	Forelimb/wing/shoulder girdle
Fracture	Changed to specific site; see **Categorization of Injury (Table 2)
Generalized Loss of body condition Thin Emaciation Hypothermia Hyperthermia/fever Dehydration Depression/lethargy	Generalized; see **Categorization of Injury (Table 2)
Hindlimb/pelvis	Hindlimb/pelvis
Integumentary	Integumentary
Musculoskeletal Joints/ligament tissue Muscles/tendon Skeleton	Musculoskeletal
Non-fracture*	
Ocular	Ocular
Nervous system CNS peripheral nerve CNS central/brain	Nervous system
Respiratory Lower respiratory tract Upper respiratory tract	Respiratory
Ribs/sternum	Ribs/sternum
Skull Facial bones Cranium	Skull
Spine/tail	Spine/tail
Undetermined	Undetermined
Urinary tract	Urinary tract

*Dispersed into other categories based on individual record comments.

TABLE 2. Categorization of injury.

RECORDED ON RECORD	RECONFIGURED
Abnormal behavior Abnormal imprint Mental	Abnormal behavior
Autoimmune/allergy*	
Bacterial Botulism Mycoplasma Chlamydia	Bacterial
Burns	Burns
Viral Rabies Canine distemper Viral/rabies West Nile virus Pox virus	Viral
Clinically healthy	Clinically healthy
Degenerative*	
Developmental/congenital/ inherited	Developmental/congenital/ inherited
Died before exam Dead on arrival	Died before exam
Parasitic Fleas Flies Ticks Lice Mites Trichomoniasis	Parasitic
Foreign substance	Foreign substance
Fungal	Fungal
Iatrogenic	Iatrogenic
Infectious*	
Inflammatory	Inflammatory
Noninfectious	Noninfectious
Nutritional Metabolic bone disease Inappropriate diet Metabolic	Nutritional
Trauma Physical injury External Internal	Trauma
Starvation Thin** Emaciation**	Loss of body condition**
Toxicity Rodenticides	Toxicity
Undetermined Idiopathic	Undetermined
	Fracture**
	Depression/lethargy**
	Hypothermia**
	Hyperthermia**

*Dispersed into other categories based on individual record comments.

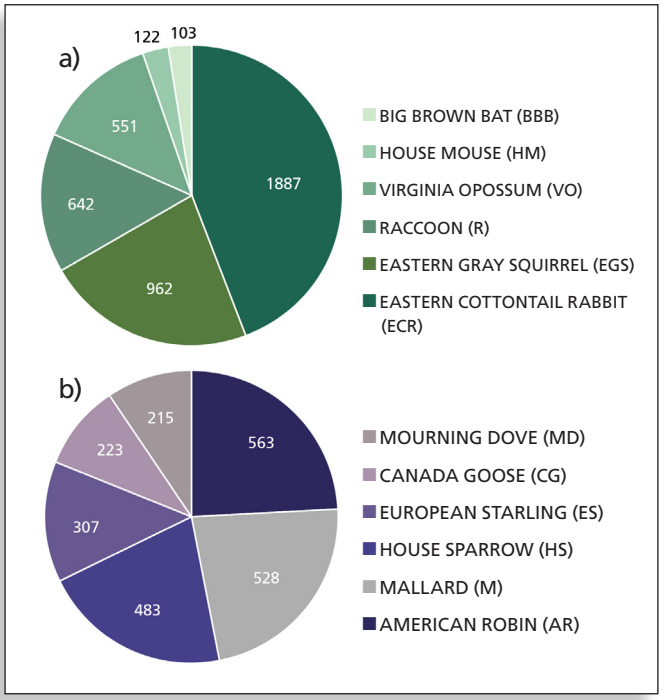


FIGURE 1. Number of cases for a) mammals and b) birds.

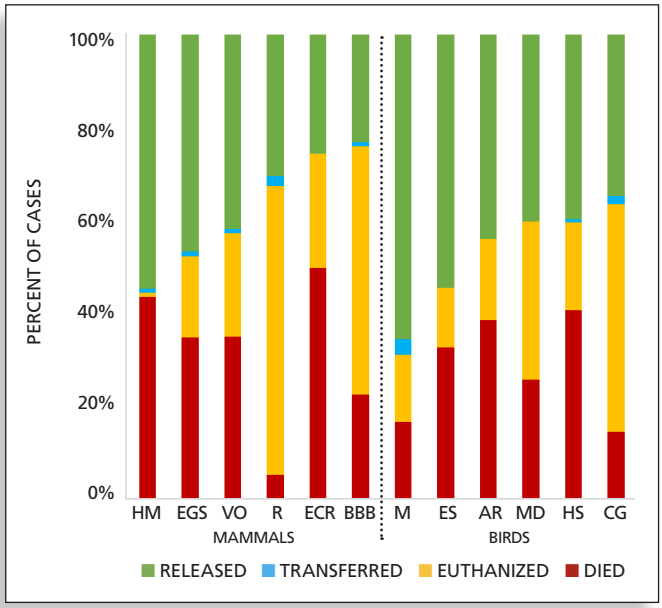


FIGURE 2. Final disposition for each of the twelve species studied. *Refer to Fig. 1 for key to abbreviations.*

Prediction Factors for Release

Circumstances of rescue

For both mammals and birds, Orphan accounted for the greatest percentage of circumstances of rescue, nearing 50% (Fig. 3a and 3b). Mammal admissions for animal interaction were greater than four times those of birds, and the percentage of mammal cases was twice that of birds. Eastern cottontail rabbits made up the majority of cases categorized as animal interaction. Survival of animals with different circumstances of rescue ranged from 24% to 52% (Fig. 4). The highest unassisted mortality (46% died) was a result of animal interaction. The lowest unassisted mortality (12%) was for failure

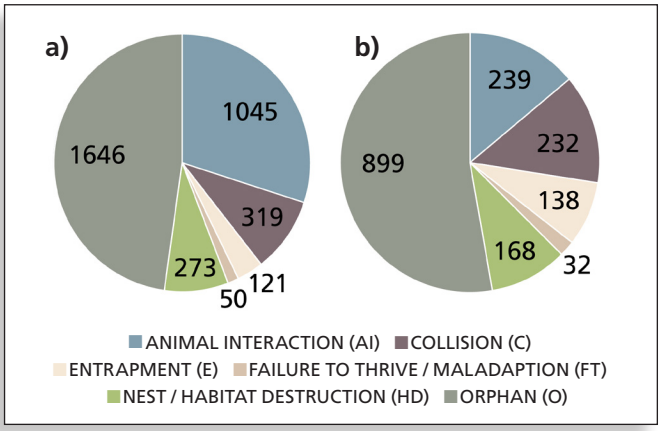


FIGURE 3. Top six circumstances of rescue for a) mammals, excluding undetermined (U) (n = 736), and b) birds, excluding undetermined (n = 552). Number of cases labeled.

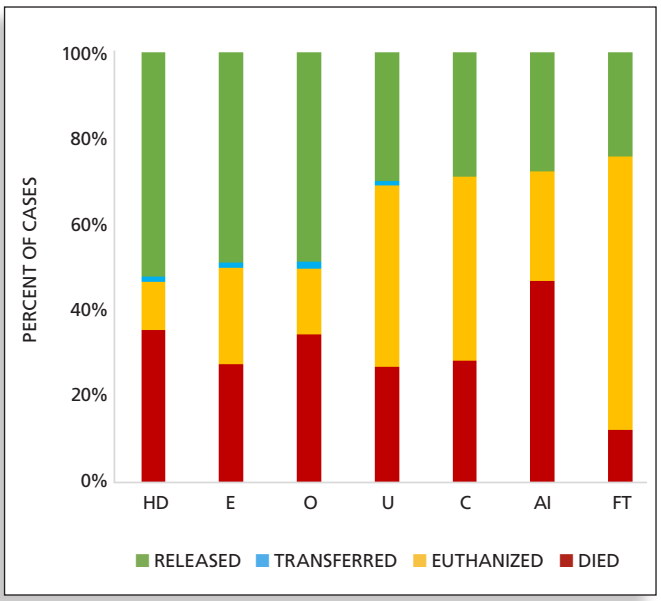


FIGURE 4. Top seven circumstances of rescue broken down by disposition for all twelve species studied. *Refer to Fig. 3 for key to abbreviations.*

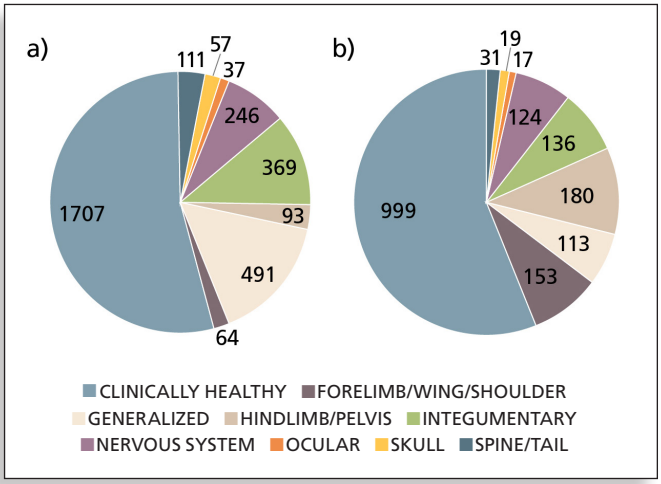


FIGURE 5. Top nine anatomical sites of injury for a) mammals, excluding undetermined (n = 939) and died before exam (n = 84), and b) birds, excluding undetermined (n = 469) and died prior to exam (n = 44). Number of cases labeled.

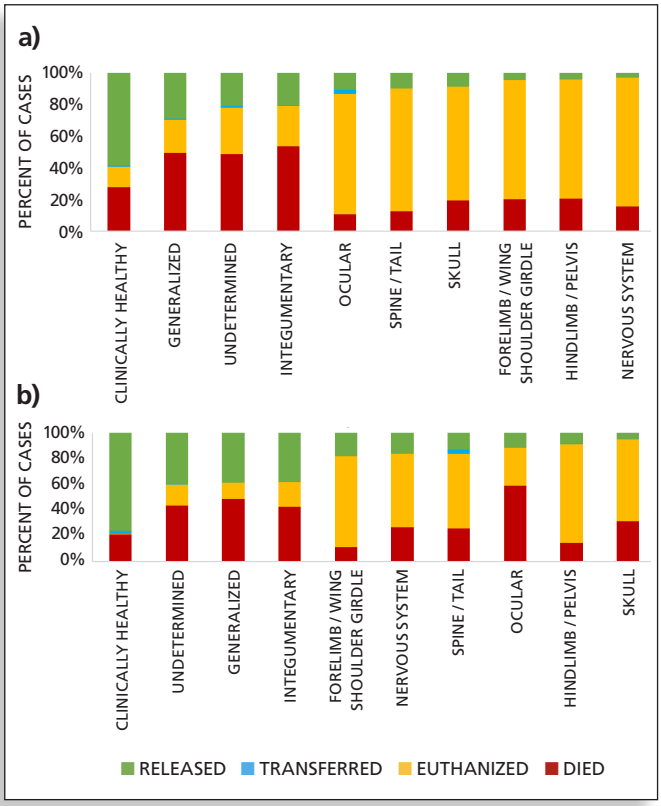


FIGURE 6. Top ten anatomical sites of injury for a) mammals and b) birds, excluding died prior to exam.

to thrive/maladaption; however, the same category had the highest combined mortality (75% died and euthanized).

Anatomical site of injury

The largest number of cases (>50%) were categorized as clinically healthy for both mammals and birds (Fig. 5a and 5b). Mammals were categorized as having generalized injuries greater than four times that for birds and the percent of cases is twice as great for mammals than birds. In contrast, birds sustained twice the number of both forelimb/wing/shoulder girdle and hindlimb/pelvis injuries than mammals. Release rates of mammals with varying anatomical sites of injury ranged from 3% to 58% (Fig. 6a) and 5% to 76% for birds (Fig. 6b). The top of the ranges for both mammals and birds was attributed to Clinically Healthy. Less than 10% of mammals with a spine/tail, skull, nervous system, hindlimb/pelvis, or forelimb/wing/shoulder girdle injury were released (Fig. 6a). Birds overall had higher survival for all anatomical sites of injury than mammals except for skull, which was 3.5% less (Fig. 6b). Most notably, survival of forelimb/wing/shoulder girdle and nervous system injuries was more than three times greater for birds. In contrast ocular injuries resulted in a 58% unassisted mortality rate for birds. The unassisted mortality rate for generalized injuries neared 50% for both mammals and birds (Fig. 6a and 6b).

Categorization of injury

As with anatomical site of injury, Clinically Healthy was the

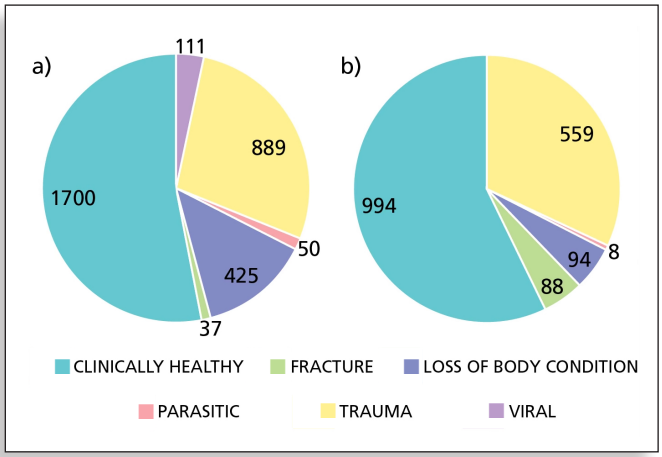


FIGURE 7. Top six categorizations of injury for a) mammals, excluding undetermined (n = 898) and died before exam (n = 89), and b) birds, excluding undetermined (n = 477) and died prior to exam (n = 46). Number of cases labeled.

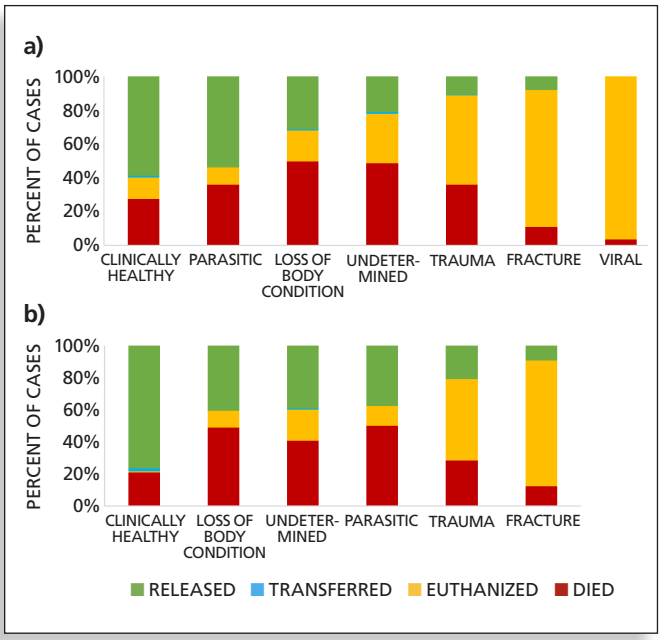


FIGURE 8. Top seven categorizations of injuries for a) mammals and b) birds, excluding died prior to exam.

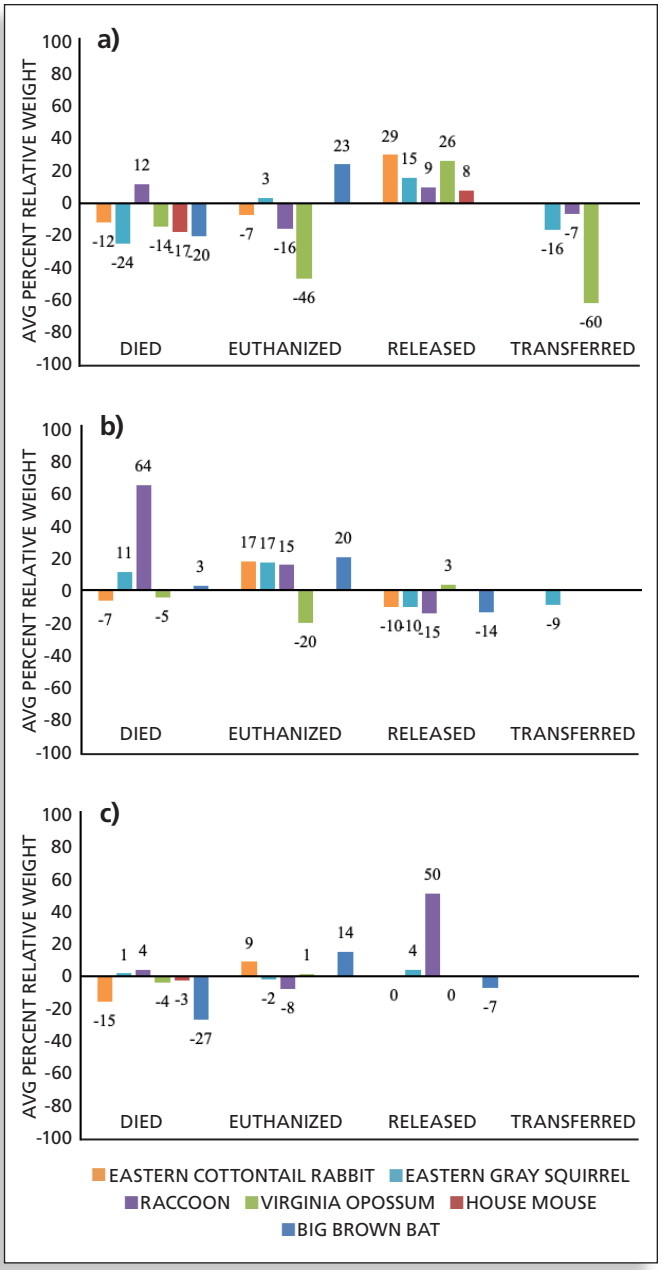


FIGURE 9. Average percent relative weight of all six species of mammals in comparison to disposition for a) young, b) juvenile, and c) adult.

largest category (Fig. 7a and 7b). Mammals suffered loss of body condition at more than twice the frequency of birds; however, nearly 30% of injuries sustained were trauma for both classes. There were no diagnosed cases of viral infections for birds. Release rates of mammals with varying categorizations of injury ranged from 0% to 58% and for birds release rates ranged from 9% to 76% (Fig. 8a and 8b). The upper end of the range is inflated by high release rates of clinically healthy individuals. Excluding viral, the lowest release rate for both classes was due to fracture; however, this category also had the lowest unassisted mortality rate. The release rate of birds with trauma was nearly twice that of mammals; yet both were low at 20% and 11% respectively.

Weights

Percent relative weight (PRW) is the percentage over or under the average weight for the life stage of a specific species. For example, in Figure 9, average PRW for young Eastern cottontail rabbits that died was –12%. This indicates that, on average, young Eastern cottontail rabbits that died were 12% under the average weight of all young Eastern cottontail rabbits.

Young for all studied species of mammals (no data for bats) that were released, had average PRWs above zero (Fig. 9). Young that died for all mammal species, except raccoons, had average PRWs below zero. Juvenile raccoons, Eastern gray squirrels, and big brown bats that died had average PRWs above zero. No trends

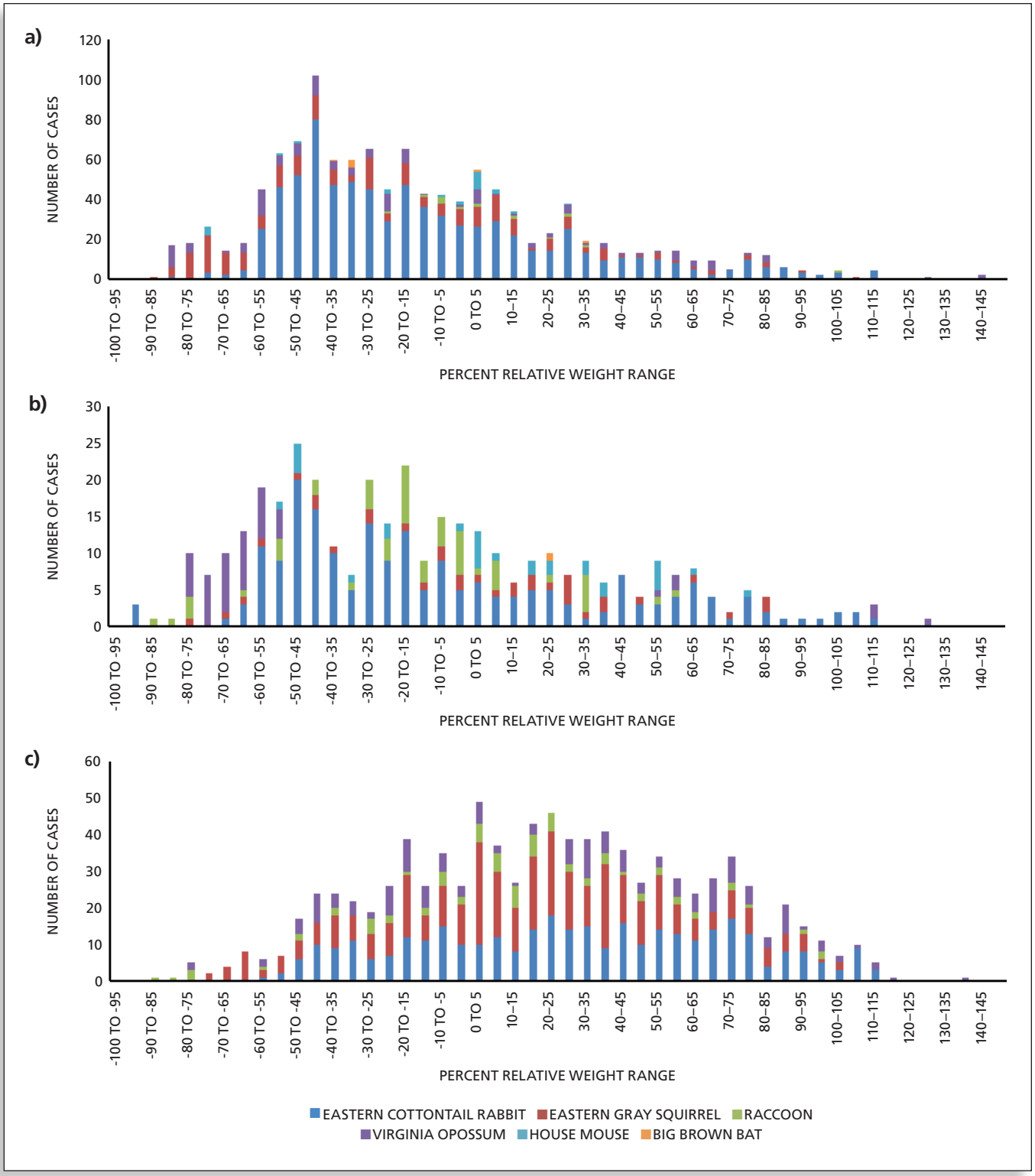


FIGURE 10. Distribution of percent relative weight in young mammals for a) died, b) euthanized, and c) released. Note differing y-axis ranges.

were seen for adults. When the trends for young mammals are examined more closely (Fig. 10) it can be seen that the PRWs for both died and euthanized peaked around –50% and were skewed right. PRWs for released young mammals peaked around 15% and appeared normally distributed.

Young for all studied species of birds, except Canada geese, that were released had average PRWs slightly above zero (Fig. 11). Young birds that died had average PRWs below zero, except Canada geese and European starlings. An acute but similar trend was seen for adult birds and the opposite trend is apparent for juveniles. When the trends for young birds are examined more closely, it is more difficult to distinguish the distribution patterns

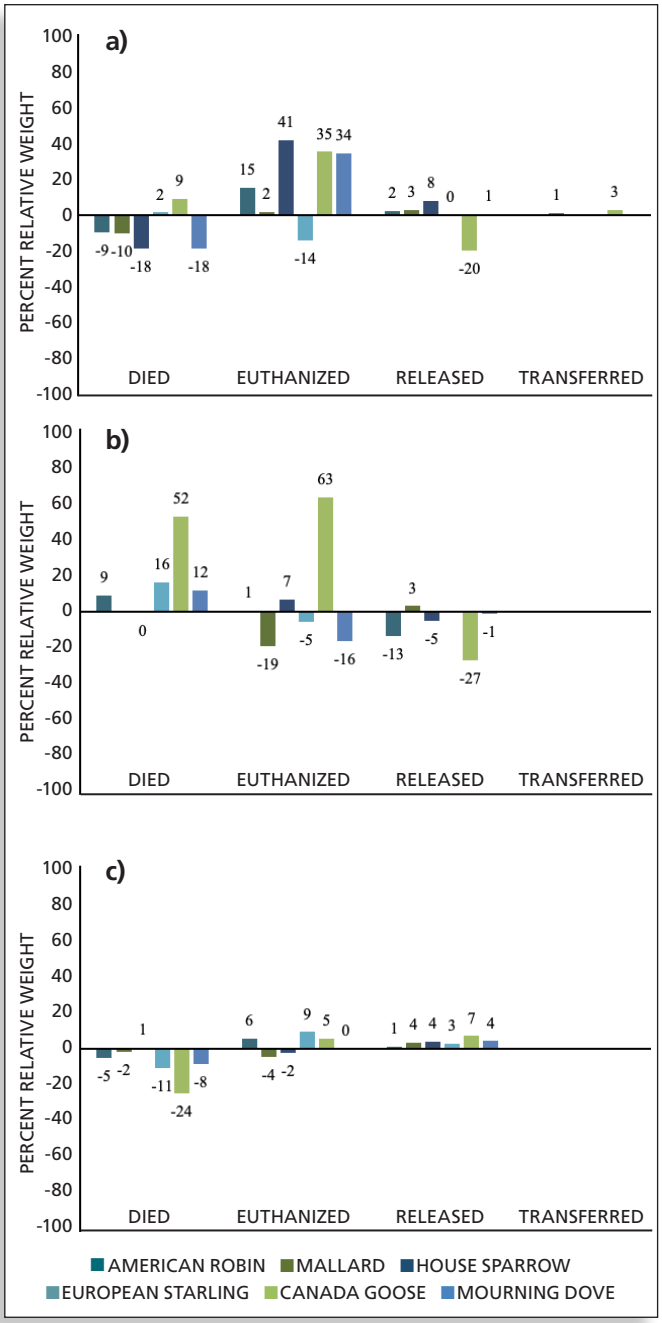


Figure 11. Average percent relative weight of all six species of birds in comparison to disposition for a) young, b) juvenile, and c) adult.

from that of mammals (Fig. 12). Died and released appear bimodal; there are not enough instances of euthanized young to distinguish a trend for euthanized.

Discussion

One of the main goals of wildlife rehabilitation facilities is to release healthy individuals back into the wild.[20] Triage helps to avoid unnecessary suffering and stress for animals that are not likely to be released.[26] However, knowing which animals are likely to survive rehabilitation requires analysis of factors that predict release. The current study aimed to help fill the gap in the literature for rehabilitation of common wildlife species in the Midwestern United States.

The overall release rate of 39% for the 12 most commonly admitted mammal and bird species is comparable to the 39% reported by Molony et al.,[19] the 42% reported by the British Wildlife Rehabilitation Council,[30] and the 40% reported by Grogan and Kelly.[18] However, the release rate was lower than the 63% reported by Molina-López et al.[20] No national average could be found for the United States. Two species overlapped with Molony et al., house sparrows and European starlings. Release rates for those two species were slightly higher for Ohio Wildlife Center, 40% for house sparrows and 54% for European starlings as compared to 33% and 36% respectively reported by Molony et al.[19]

The species with the second lowest release rate (25%) at Ohio Wildlife Center was also the one with the highest intake of all species, the Eastern cottontail rabbit. With high intakes and low survival, considerable time and resources are being devoted to a species with the conservation status of least concern. With almost 50% of Eastern cottontail rabbits dying on their own, it may be cost effective and reduce suffering to establish a weight cutoff for young Eastern cottontail rabbits. Procedures could be modified to only attempt rehabilitation of young individuals that do not have a PRW of less than 50%, as supported by data from Figure 10.

Nearly 50% of mammals and birds were admitted with orphan as their circumstance of rescue. Many of these animals may not have been truly orphaned at all; it is well documented that young animals are often misperceived as orphaned when their mothers are feeding nearby.[26] Despite orphaned animals sustaining no known injuries, 34% of them still died on their own. This is a reminder of how important it is for the staff at wildlife rehabilitation facilities to educate their communities about when it is appropriate to bring an animal in for rehabilitation.[12,31]

For circumstances of rescue, the highest percentage (46%) of animals with unassisted mortality were a result of animal interaction. Mammals were admitted due to animal interaction at over twice the rate than that of birds. This high admittance could be due to the interaction being more lethal to birds than mammals, precluding birds being presented to rehabilitation facilities as often. Alternatively, mammals may have generated more public sentiment than birds, so the public might be more likely to present a mammal to a rehabilitation facility. Eastern cottontail rabbits also made up a large percentage of animals with animal interaction as their circumstance of rescue. This may factor into the decision to rehabilitate one animal over another when one was admitted due to orphan status versus one that was admitted due to animal interaction. These findings also support the importance of educating the public on the impact of domestic animals on wildlife.[12,31]

The large number of orphan animals has likely contributed to the large number of clinically healthy animals in the data from the anatomical sites of injury and categorizations of injury. Injuries to skull, spine/tail, nervous system, forelimb/wing/shoulder girdle and hindlimb/pelvis resulted in low release rates for both classes, while birds overall displayed a higher release rate (48%) than mammals (34%). Around 20% of animals with those injuries

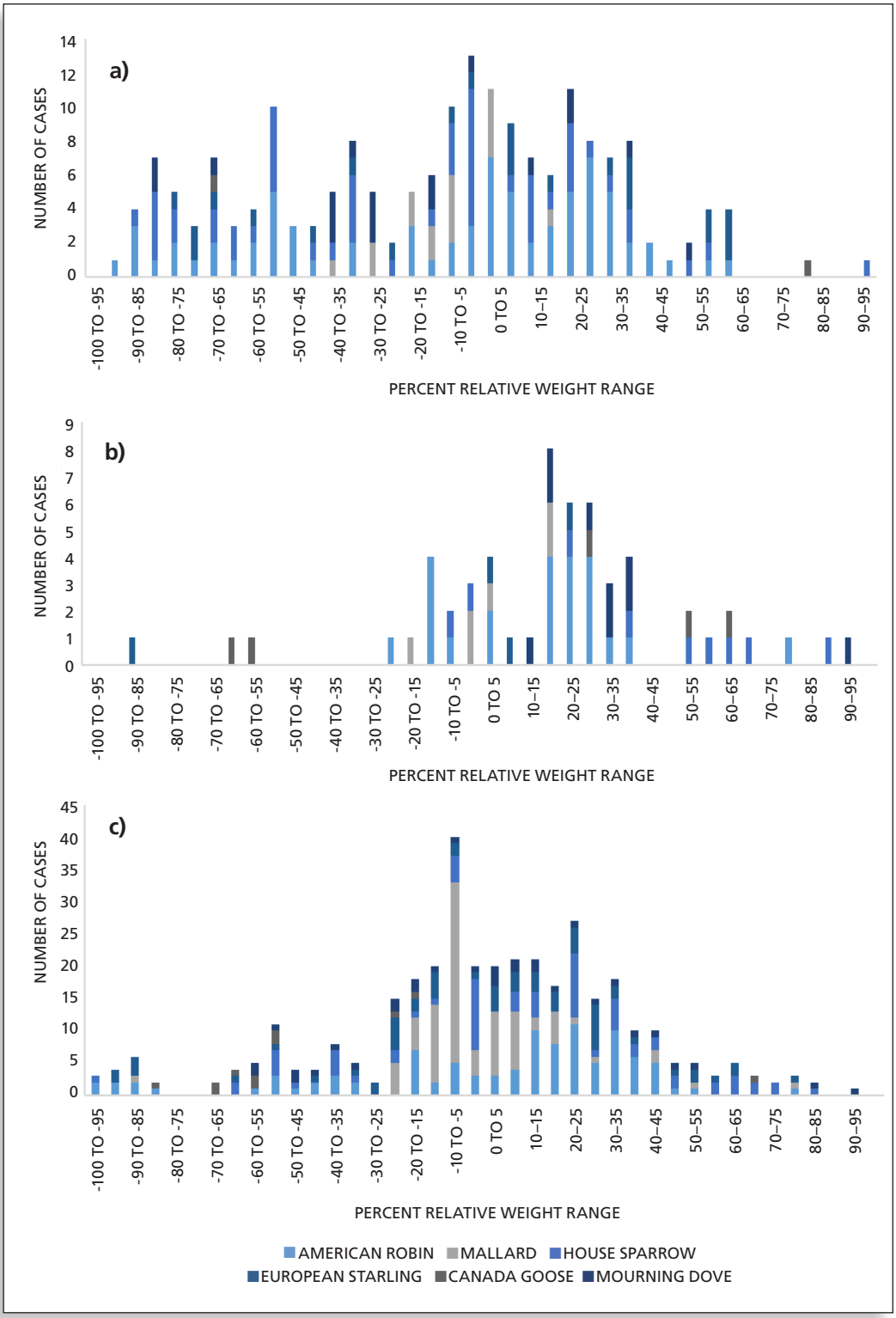


FIGURE 12. Distribution of percent relative weight of young birds for a) died, b) euthanized, and c) released. Note differing y-axis ranges. Outliers over 100 PRW were omitted.

died on their own and the rest were euthanized. A 2015 study by Molina-López et al.[32] also found nervous system injuries to be associated with higher mortality (40.5% total mortality) in raptors during the first week of hospitalization, while total mortality for birds with nervous system injuries at Ohio Wildlife Center was 83%.[32] In the future it would be important to be mindful of mortality rates from nervous system injury when deciding which animals to attempt to rehabilitate.

Low release rates for fracture and trauma as categorization of injury were seen for both birds and mammals. To compare with Molony et al.,[19] who found severity of injury as the best predictor of release, in our study, fracture and trauma could be considered as more severe injuries than Clinically Healthy or Loss of Body Condition, for example. Our findings also support Molina-López et al.,[20] who found trauma to be associated with mortality for most species studied in Spain, although an average percentage was not reported.

Contradictory to Molony et al.,[19] mass did appear to be a contributing factor to mortality for young mammals and birds. For example, except for raccoons, all young mammals that died had average PRWs below zero. A similar but much less pronounced trend was seen for young birds. In the future it may be possible to establish a weight cutoff for rehabilitation of each species of mammals and birds using the histograms in Figures 10 and 12. Additional data should be collected for juveniles and adults to determine if a trend is present in those life stages. The inconclusive findings on juvenile birds are consistent with a 2013 study by Haynes et al. on juvenile American robins, which did not find weight to be a conclusive predictor of outcome for juveniles.[33] Life stage does appear to be a predictor of release rate for mammals, amphibians, and birds.

One important caveat to note is that Ohio Wildlife Center only accepts infant raccoons from Franklin and Delaware counties; infants admitted from other counties are euthanized. In addition, most infant raccoons with closed eyes are automatically euthanized due to a low chance of survival and maladaptive behavior. Per Ohio law, nuisance adults and nuisance progeny of raccoons and opossums are not to be rehabilitated.[34] These policies may have skewed the data to include more euthanasia for raccoons and opossums that were not due to factors related to the wellness of the animal. The existing protocols for raccoons explain why the average PRW for young raccoons that died was above zero; because eyes-closed raccoons are euthanized automatically, the larger young are the only ones for whom rehabilitation is attempted (Fig. 9). It is not possible to filter out records that were euthanized due to policy reasons, because the data available does not indicate whether the individual had eyes closed or open on presentation.

Identifying factors that predict release is crucial to prevent unnecessary suffering of wildlife admitted to rehabilitation centers.[20] Because the proportion of unassisted deaths to humane euthanasias was high, there is a further need for evidence-based triage to both prevent unnecessary suffering and free up resources for those with better prognoses. Animals with a poor chance of release should be humanely euthanized as soon as possible.[5,16] In the present study, this would include animals with trauma or nervous system injuries and individuals with relative weights extremely below average, for example –50 PRW for Eastern cottontail rabbits. Not only is welfare an issue, but time, resources, and capacity are limiting factors for many rehabilitation facilities.[30] Resources should be devoted towards the animals that are most likely to survive and be released so as to improve overall effectiveness of rehabilitation.[19] When developing triage protocols, data from this study, or other similar studies, should be considered. However, it is up to the individual rehabilitation center's staff to determine what works best for them. It is possible that other rehabilitation facilities in North America, or elsewhere, with similar predominant species may utilize this data as well to redistribute resources effectively.

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Over the past years, avian influenza and has proven to be devastating for poultry flocks and wildlife in Africa, Asia, Europe, and North America. The disease is a global threat to animal health, food security, and livelihoods. Affecting primarily both domestic and wild birds, it can occasionally transmit to humans and other mammals. A highly contagious disease, avian influenza is caused by viruses, whose genetic characteristics can rapidly evolve. Numerous subtypes of HPAI viruses have circulated in diverse domestic and wild bird populations on a wide geographical scale during the past several years.

Recently, the disease has also encroached on several new countries in Central and South America. Bolivia, Colombia, Costa Rica, Ecuador, Honduras, Panama, Peru, and Venezuela have detected the presence of HPAI for the first time. Chile, which had been free of HPAI for 20 years, has also reported new cases of the disease. In addition, the speed of HPAI spread has been raising some concerns, reaching all these countries in only four months. While most cases have been reported in poultry, wild species have also been impacted by this disease, including the Peruvian pelican (*Pelecanus thagus*) and the brown pelican (*Pelecanus occidentalis*), among others.

In response to the recent cases in the region, WOAH and the Food and Agriculture Organization of the United Nations (FAO) created a Standing Group of Experts on Avian Influenza within the context of their joint initiative, the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs). This group aims to provide guidance on preventive actions, preparedness and emergency response to avian influenza in the region. Their first meeting took place 13 December 2022 where together they agreed on a list of recommendations.

In addition to poultry farms, the recommendations also focus on wild birds, including the need for surveillance programmes and enhanced biosecurity measures to avoid direct or indirect contact between domestic and wild birds and thus, the potential further spread of the disease.

WOAH Reference Laboratories specialised in avian influenza can support national laboratories in the diagnoses of their samples, as needed by countries who are encouraged to share any relevant information pertaining to their disease situation in order to stop its spread and ensure a healthier world for all.

CITES 19th Conference of Parties (World Wildlife Conference)

PANAMA CITY, PANAMA *(November 27, 2023)*—The European Union and 183 countries are Parties to the Convention, and every three years take part in a meeting of the Conference of the Parties (CoP). This is the 19th time the CoP has met in the 50 years since the Convention was adopted in 1973. Representatives of more than 160 governments—Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)—reaffirmed their commitment to address the biodiversity crisis by adopting proposals to regulate international trade in more than 500 new species.

The CoP adopted a total of 46 proposals of the 52 put forward. This will bring species of sharks, lizards, turtles, fish, birds, frogs, and more than a hundred tree species under CITES regulations designed to ensure the sustainability of these species in the wild, while allowing their international trade and contributing to the conservation of ecosystems and global biodiversity.

The CoP also reached a record number of 365 decisions as they worked to safeguard threatened wildlife species, while at the same time allowing the international trade that underpins human well-being and contributes to conservation efforts. The decisions will shape CITES' work for the years to come.

The contribution that CITES can make to reducing zoonotic diseases will also be investigated.

In welcoming the decisions made by the Parties, the Secretary-General of CITES, Ivonne Higuero, pointed out that they come at an important time,

> "The Parties to CITES are fully aware of their responsibility to address the biodiversity loss crisis by taking action to ensure that the international trade in wildlife is sustainable, legal and traceable. Trade underpins human well-being, but we need to mend our relationship with nature. The decisions coming from this meeting will serve the interests of conservation and wildlife trade, that doesn't threaten the existence of species of plants and animals in the wild, for future generations."

A first for the meeting was the adoption of a resolution on gender, to try to address inequality as it relates to the trade in wildlife. The meeting learned that women are likely to lose out on the benefits of wildlife trade, and work will now be done to suggest ways to tackle this issue.

The meeting also addressed the need for a more inclusive forum by increasing the number of languages included in key meetings. Future CoPs are likely to include Arabic, Chinese, and Russian in addition to the current working languages of Spanish, French, and English.

CoP19 has taken place at a crucial moment. This year has seen a number of significant scientific reports which have highlighted the need to halt—and reverse—biodiversity loss if our planet and human well-being are to be sustained. The three main threats to wild plants and animals are habitat loss, climate change, and overexploitation. ■

SELECTED ABSTRACTS

Tetracycline resistance genes in wild birds from a wildlife recovery centre in central Italy

Di Francesco A, Salvatore D, Bertelloni F, Ebani VV. *Animals* 2023:13(76). DOI: 10.3390/ani13010076.

Wild animals are less likely to be exposed directly to clinical antimicrobial agents than domestic animals or humans, but they can acquire antimicrobial-resistant bacteria through contact with humans, animals, and the environment. In the present study, 254 dead free-living birds belonging to 23 bird species were examined by PCR for the presence of tetracycline resistance (*tet*) genes. A fragment of the spleen was collected from each bird carcass. A portion of the intestine was also taken from 73 of the 254 carcasses. Extracted DNA was subjected to PCR amplification targeting the *tet*(L), *tet*(M), and *tet*(X) genes. In total, 114 (45%) of the 254 birds sampled belonging to 17 (74%) of the 23 bird species tested were positive for one or more *tet* genes. The *tet*(M) gene showed a higher frequency than the other tested genes, both in the spleen and in the intestine samples. These results confirm the potential role of wild birds as reservoirs, dispersers, or bioindicators of antimicrobial resistance in the environment.

Antimicrobial resistance patterns of bacteria isolated from chicks of Canarian Egyptian vultures (*Neophron percnopterus majorensis*): A "one health" problem?

Suarez-Perez A, Corbera JA, Gonzalez-Martín M, Tejedor-Junco MT. *Comparative Immunology, Microbiology and Infectious Diseases* 2023:92(101925).

Antimicrobial resistance in Gram-negative bacteria isolated from cloacal samples of chicks of Canarian Egyptian vultures was investigated. Prevalence of *Salmonella* was also studied. Forty-seven isolates, obtained from 23 animals, were analysed. *Escherichia coli* (n = 29), *Proteus mirabilis* (n = 17) and *Salmonella* spp. (n = 1) were identified using API 20E system. Antimicrobial susceptibility to 13 antibiotics included in nine different categories was determined using disk-diffusion technique. The higher percentages of susceptible *E. coli* isolates were found for aminoglycosides and cefoxitin, and the lower ones were found for ampicillin, enrofloxacin and tetracycline. *Proteus mirabilis* isolates were susceptible to most of antimicrobials tested. Multidrug resistance patterns were found in 13 *E. coli* and four *Proteus mirabilis*. *Salmonella* spp. was detected in one chick (4.37%), and the isolate was also resistant to ampicillin and tetracycline. Thirteen *E. coli* isolates and four *Proteus* isolates showed a multidrug-resistance pattern, being resistant at least to one antibiotic in three or more different antimicrobial categories. This high level of antibiotic resistance in chicks of an endangered bird may be a limitation for possible treatments of infections in this species, as well as representing a source of resistant bacteria for animal care staff and for other animals in wildlife recovery centres. A "One Health" approach to this problem is necessary to reduce the levels of antimicrobial resistance in wild birds.

A retrospective study of native wild birds and reptiles admitted to three New Zealand wildlife hospitals due to predation by cats

Gartrell BD, Jolly M, Tissink K, Argilla LS, and Esam F. *New Zealand Veterinary Journal* 2023. DOI: 10.1080/00480169.2022.2152889.

Aims: To investigate the types of wildlife affected and outcomes of hospitalisation for native wild birds and reptiles admitted to three wildlife hospitals in New Zealand following predation by cats.

Methods: We reviewed hospital records of three wildlife hospitals (Wildbase Hospital (WBH) in Palmerston North; The Wildlife Hospital – Dunedin (DWH); and The Nest Te Kōhanga (TNTK) in Wellington) for cases of native species with a submission history or diagnosis of predation by cats over the period 2006–2022. Frequency analysis and cross tabulation of the data was carried out using the factors wildlife hospital, animal order, species, and case outcome.

Results: Native wildlife (n = 639) presented following predation by cats to the three wildlife hospitals comprised 598 (93.6%) birds from 31 species and 41 (6.4%) reptiles from eight species. The mortality rate of these patients combined was 61.8% (395/639), with the other 38.2% (244/639) being released from hospital to rehabilitation facilities, released to the wild, or, for a small number, put into permanent captive placements. The most common species of birds admitted due to predation by cats were tūī (*Prosthemadera novaeseelandiae*; n = 173), silvereyes (*Zosterops lateralis*; n = 142), sacred kingfishers (*Todiramphus sanctus*; n = 100) and kererū (*Hemiphaga novaeseelandiae*; n = 70). There was an overall trend to increasing numbers of wildlife admitted for predation by cats over the period of this review, but the different operating periods of the three hospitals should be considered. Each of the three hospitals saw a different mix of species, with Wellington's TNTK seeing the widest diversity of species affected.

Conclusions: Predation by cats was a common cause of native birds and reptiles being admitted to all three wildlife hospitals and a diversity of urban and rural wildlife were affected.

The fitness consequences of wildlife conservation translocations: A meta-analysis 1

Gross IP, Wilson AE, and Wolak ME. *BioRxiv* January 2023. https://doi.org/10.1101/2023.01.14.524021.

Conservation translocation is a common strategy to offset mounting rates of population declines through the transfer of captive-reared or relocated organisms to imperiled populations. However, these programs have been criticized for low success rates and husbandry practices that produce individuals with genetic and performance deficits. We assessed the disparity in post-release performance of translocated organisms relative to wild-resident conspecifics through a meta-18 analysis of 826 performance comparisons from 172 studies representing nine animal classes (101 species). We found that translocated organisms have 70% decreased odds of out-performing their wild-resident counterparts, supporting published claims



PHOTO © ROBIN GWEN AGARWAL. CC BY-NC-ND 2.0 LICENSE.

Southern sea otter (*Enhydra lutris nereis*).

of systemic issues hampering conservation translocation. Pre-release animal enrichment significantly reduced performance disparities, whereas our results suggest no overall effects of captive generation time or the type of fitness surrogate measured. Conservation managers should consider evaluations of post-release performance using sympatric (resident-control) and allopatric (true-control) wild-reference groups to ensure translocated animals contribute to recipient population growth and viability.

Bald eagle mortality and nest failure due to clade 2.3.4.4 highly pathogenic H5N1 influenza-a virus

Nemeth NM, Ruder MG, Poulson RL, Sargent R, Breeding S, Evans MN, Zimmerman J, Hardman R, Cunningham M, Gibbs S, and Stallknecht DE. *Scientific Reports* 2023:13(191).

The bald eagle (*Haliaeetus leucocephalus*) is a culturally and ecologically vital species in North America that embodies conservation success but continues to face threats that include emerging pathogens. The introduction of A/goose/Guangdong/1/1996 lineage highly pathogenic (HP) clade 2.3.4.4b H5N1 influenza A virus (IAV) in North America in late 2021 resulted in high rates of mortality among bald eagles. Here we show an alarming rate of bald eagle nest failure and mortality attributed to HP IAV. We documented fatal, systemic HP IAV infection in breeding adult and nestling bald eagles along the southeastern U.S. coast. Concurrently, annual bald eagle nest surveys in Georgia and Florida revealed a precipitous drop in success in coastal counties compared with previous years, portending negative impacts on population recruitment. As an apex predator and efficient scavenger, it is likely that bald eagles become infected through consumption of infected waterfowl. These results and similar reports of raptor mortality in Europe, Asia, and Africa, indicate a clear threat to raptor health. The possible long-term persistence of HP H5N1 IAV in North America poses an impending threat to bald eagle populations not only related to direct mortality but also decreased recruitment and warrants continued efforts to understand these potential impacts.

Prevalence of mortality in mammals: A retrospective study from wildlife rescue center of Nepal

Adhikari B, Baral K, Bhandari S, Kunwar RM, and Subedi SC. *Conservation Science and Practice* 2022:4(10),e12799.

To assess threats to the population of native mammals and their survival, we performed a retrospective study utilizing a rescue and rehabilitation database from Nepal. Based on a total number of 1013 cases involving six taxonomic families of mammals admitted over five years, the outcome (mortality and survivability) differed significantly among six taxa (χ^2[df = 5, N = 1013] = 65.08, p .001). The mortality rate was highest in Felidae (74%), followed by Herpestidae (69%), Viverridae (62%), Bovidae (50%), Cervidae (50%), and Cercopithecidae (38%). The outcome also differed significantly among the causes of admission (χ^2[df = 9, N = 1013] = 241.48, p .001). The prevalence of mortality was highest in the cases of gunshot and poisoning, followed by collision with a vehicle, diseases/infection, entanglement/trapped, injured by dogs/cats, abandoned/orphaned, injured by humans, unknown causes, and domestic/captivity issues. Multiple logistic regression analysis showed the significant influence of taxonomic family, age group, and cause of admission on the likelihood of mortality of the rescued mammals. The odds ratio of mortality was higher for carnivore taxa, and juveniles were more likely to succumb to death than adults. Our study provides important information associated with the mortality of rescued mammals, thereby assisting in the development and formulation of strategies for threat mitigation and an efficient rehabilitation process. View at https://conbio.onlinelibrary.wiley.com/doi/10.1111/csp2.12799.

Microplastics ingestion and chemical pollutants in seabirds of Gran Canaria (Canary Islands, Spain)

Navarro A, Perez Luzardo O, Gomez M, Acosta-Dacal A, Martínez I, Felipe de la Rosa J, Macías-Montes A, Suarez-Perez A, and Herrera A. *Marine Pollution Bulletin* 2023:186(114434).

Plastic pollution constitutes an environmental problem in the Canary Islands nowadays. Nevertheless, studies evaluating the impact of plastics on its avifauna are still scarce. Gastrointestinal tracts of 88 birds belonging to 14 species were studied for the presence of plastics. Moreover, their livers were analyzed for the determination of bromodiphenyl ethers (BDEs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides (OCPs). Among

Cory's shearwaters (n = 45), the frequency of occurrence of plastic ingestion was considerably high (88.89 %). This species had the highest mean value of items (7.22 ± 5.66) and most of them were compatible with lines derived from fishing gear. PCBs and PAHs were detected in all of the samples and OCPs in the great majority of them (98.86 %). Our results highlight the problems that plastic debris (mainly for seabirds) and organic pollutants pose to these species.

Clinical examination and necropsy findings of a mountain hawk-eagle (*Nisaetus nipalensis*) that died during rehabilitation

Ushine N, Michishita M, Machida Y, Enomoto T, Sakai T, Kato T, and Hayama S. *Journal of Veterinary Medicl Science* 2023:85(1):88–91. doi: 10.1292/jvms.22-0333.

We examined the clinical signs and necropsy findings of a mountain hawk-eagle (*Nisaetus nipalensis*) that died during rehabilitation. The bird was rescued and treated for open fracture of the right forearm. During rehabilitation, the bird could not stand up or fly. Part of the right secondary and left and right primary feathers were removed during rehabilitation; additional fracture was found in the right tibiotarsus and treated. However, the bird died 92 days after rescue and necropsy was performed. Severe hepatic lipidosis and capture myopathy were confirmed by histopathological examinations. These lesions may be associated with the cause of death of this animal. Accumulation of information is expected to contribute to the improvement of effective rehabilitation techniques for raptors.

Monitoring the spatiotemporal patterns of wildlife health using rehabilitation databases

Kanankege K, Wilette M, Jenni P, Ponder J, Schott R, Bueno I, Muellner U, Muellner P, and VanderWaal K. 2022. Retrieved from the Data Repository for the University of Minnesota, https://doi.org/10.13020/6a7p-hz87.

Wildlife health surveillance is challenging. An alternative is to use wildlife rehabilitation data as potential sentinels, where anomalies in the pattern of submissions may indicate an underlying event that deviates from the baseline and warrants further investigation. Such anomalies may affect multiple species, leading submissions to be clustered in a certain area or time period. To determine spatiotemporal submission patterns and the feasibility of identifying anomalies potentially associated with underlying events, we aggregated databases from two major wildlife rehabilitation centers in Minnesota, drawing on 66,472 submissions from the 2015–2019 period, and pertaining to 29 "species groups" and 12 "circumstances" associated with submission. The infants and juveniles of wildlife, including fledglings, hatchlings, and after-hatch year birds (Baptor-specific), submitted as a group from the same location on the same day were grouped and considered as one submission. Hence, the number of records included in the spatiotemporal cluster analysis was 49,352. The multivariate multinomial space-time model of the scan statistic was used to identify statistically significant spatiotemporal clusters of either wildlife species groups or circumstances, simultaneously (Cluster: an area capturing 10% of the submissions aggregated within a maximum radius of 30 km during a maximum temporal window of 3 mo). This repository contains the data arranged to be used for the spatial cluster analysis.

Southern Sea Otter Rehabilitation: Lessons and Impacts from the Monterey Bay Aquarium

Konrad L, Fujii JA, Hazan S, Johnson, AB, Mayer KA, Murray MJ, Nicholson TE, Staedler MM, and Young C. *Journal of Zoological and Botanical Gardens* 2022;3(4):641–52. https://doi.org/10.3390/jzbg3040047.

As biodiversity continues to decline across the globe, conservation of wildlife species and the ecosystems they inhabit is more important than ever. When species dwindle, ecosystems that depend on them are also impacted, often leading to a decrease in the life-giving services healthy ecosystems provide to humans, wildlife, and the global environment. Methods of wildlife conservation are complex and multi-faceted, ranging from education and advocacy to research, restoration, and rehabilitation. Here, we review a conservation program focused on helping recover the federally listed threatened southern sea



PHOTO © MIKE MAGUIRE. CC 2.0 LICENSE.

Bald eagle with nest (*Haliaeetus leucocephalus*).

otter (*Enhydra lutris nereis*) population. We describe the development of unique rehabilitation methods and steps taken to advance the program's conservation impact. Understanding this evolution can inform conservation efforts for other vulnerable species and their ecosystems.

Using wildlife rehabilitator surveys to identify threats: a case study of koalas in Victoria, Australia

Ashman KR, Watchorn DJ, and Whisson DA. *Australian Zoologist* 2022:42(1):130–145.

Identifying threats and their regional occurrence across a species' range is increasingly valuable for prioritising threat-specific interventions and achieving effective conservation outcomes. We surveyed registered wildlife rehabilitators to identify (i) threats faced by the koala across Victoria and (ii) their perceptions on koala population trends and potential threat mitigation actions. Wildlife rehabilitators identified habitat loss, fragmentation, and degradation as the biggest threat to koalas, while vehicle collisions, heatwaves and wildfire were also identified as key threats. Accordingly, reducing the clearing of native vegetation was considered the most effective threat mitigation action, while creating of wildlife corridors, planting of more food trees, and educating communities living in koala occupied areas were also considered appropriate mitigation strategies. Finally, 89% of wildlife rehabilitators believed that koala numbers are declining in their region.

Pathogen spillover driven by rapid changes in bat ecology

Eby P, Peel AJ, Hoegh A, et al. *Nature* 2023:613,340–344. https://doi.org/10.1038/s41586-022-05506-2.

During recent decades, pathogens that originated in bats have become an increasing public health concern. A major challenge is to identify how those pathogens spill over into human populations to generate a pandemic threat. Many correlational studies associate spillover with changes in land use or other anthropogenic stressors, although the mechanisms underlying the observed correlations have not been identified. One limitation is the lack of spatially and temporally explicit data on multiple spillovers, and on the connections among spillovers, reservoir host ecology and behaviour and viral dynamics. We present 25 years of data on land-use change, bat behaviour and spillover of Hendra virus from Pteropodid bats to horses in subtropical Australia. These data show that bats are responding to environmental change by persistently adopting behaviours that were previously transient responses to nutritional stress. Interactions between land-use change and climate now lead to persistent bat residency in agricultural areas, where periodic food shortages drive clusters of spillovers. Pulses of winter flowering of trees in remnant forests appeared to prevent spillover. We developed integrative Bayesian network models based on these phenomena that accurately predicted the presence or absence of clusters of spillovers in each of the 25 years. Our long-term study identifies the mechanistic connections between habitat loss, climate and increased spillover risk. It provides a framework for examining causes of bat virus spillover and for developing ecological countermeasures to prevent pandemics.

Using wildlife rehabilitation and postmortem data to identify key causes of morbidity and mortality impacting the health and welfare of free-living wild animals in Canada

King M, Giacinti J, Dubois S, Lair S, Parmley EJ, and Jardine CM. *Journal of Wildlife Diseases* Jan 17 2023. *doi: 10.7589/JWD-D-21-00178. Epub ahead of print.*

The health and welfare of wild animals are of increasing concern, yet there are very few large-scale data syntheses examining how causes of wildlife morbidity and mortality vary across time, space, and taxa. Records for 18,540 animals submitted to the Canadian Wildlife Health Cooperative (CWHC) (2009–19) and 144,846 animals admitted to 19 wildlife rehabilitation centers (WRCs) (2015–19) were evaluated to 1) identify the main causes of morbidity and mortality for Canadian wildlife and 2) assess the utility and complementarity of these two data sources to further our understanding of wildlife health. The CWHC cases (mortality) were examined by pathologists and grouped by the presence or absence of five diagnostic categories: trauma, emaciation, infection or inflammation, toxicity, and other. These CWHC animals were also classified as "killed due to real or perceived human–wildlife conflict" based on finder history. The WRC admissions were categorized by health issue (according to intake records) and based on reported or observed situational reasons for admission: parental loss, unsafe or unsuitable location, nest or habitat disturbance, illegal possession, and abnormal behavior. For both datasets, the main reason for submission or admission was trauma (44 and 48%, respectively), especially vehicle collisions (7 and 11%) and window or building strikes (5 and 7%). Many other WRC admissions were due to parental loss (28%), cat attacks (6%), and immature animals being found in unsafe or unsuitable locations (6%). Most other CWHC mortalities were caused by infections (27%) and emaciation (23%). Relatively few birds, amphibians, and reptiles submitted to CWHC were killed due to human-wildlife conflict, but 22% of mammals were killed for this reason, highlighting the taxonomic differences in the perceived threat of wildlife to finders, and therefore their response. Together, these data sources highlight key issues impacting the health and welfare of wild animals in Canada.

Corticosterone, lactate, and injury severity as short-term and long-term prognostic indicators in eastern box turtles (*Terrapene carolina carolina*) with traumatic injuries admitted to a wildlife rehabilitation clinic

Tucker-Retter EK, Lewbart GA. *Journal of Herpetological Medicine and Surgery* 2022:32(4):281–290. https://doi.org/10.5818/JHMS-D-22-00022

The hypothalamic–pituitary–adrenal axis is often disregulated during critical illness or following traumatic injury, and both elevated and reduced glucocorticoid levels have been associated with poor prognoses in multiple species. In eastern

box turtles (*Terrapene carolina carolina*), hyperlactatemia has been identified as a negative prognostic indicator, prompting the question of whether glucocorticoids become elevated in this species during hospitalization. This study examines the role of corticosterone in relation to lactate, other blood-based parameters, and triage scores during hospitalization of eastern box turtles with traumatic injuries on survival at 24 h, 1 wk, and 1 month. Eastern box turtles with higher triage scores had lower survival at 24 h and at 1 month, and lactate concentration at admission was associated negatively with survival at 24 h. Turtles in which plasma corticosterone levels increased in the first 24 h were more likely to die in the first week than turtles in which corticosterone decreased or remained the same, but this was not statistically significant. The results of this study demonstrate the potential role of the hypothalamic–pituitary–adrenal axis in survival of eastern box turtles with traumatic injuries.

Molecular surveillance of potential SARS-CoV-2 reservoir hosts in wildlife rehabilitation centers

Mena J, Hidalgo C, Estay-Olea D, Sallaberry-Pincheira N, Bacigalupo A, Rubio AV, Peñaloza D, Sánchez C, Gómez-Adaros, Valeria Olmos J, et al. *Veterinary Quarterly* Jan 2023;43(1):1–10. doi: 10.1080/01652176.2023.2164909

The COVID-19 pandemic, caused by SARS-CoV-2 infection, has become the most devastating zoonotic event in recent times, with negative impacts on both human and animal welfare as well as on the global economy. Although SARS-CoV-2 is considered a human virus, it likely emerged from animals, and it can infect both domestic and wild animals. This constitutes a risk for human and animal health including wildlife with evidence of SARS-CoV-2 horizontal transmission back and forth between humans and wild animals.

Aim: Molecular surveillance in different wildlife rehabilitation centers and wildlife associated institutions in Chile, which are critical points of animal–human interaction and wildlife conservation, especially since the aim of wildlife rehabilitation centers is to reintroduce animals to their original habitat.

Materials and Methods: The survey was conducted in six WRCs and three wildlife associated institutions. A total of 185 samples were obtained from 83 individuals belonging to 15 different species, including vulnerable and endangered species. Each specimen was sampled with two different swabs: one oropharyngeal or nasopharyngeal according to the nostril diameter, and/or a second rectal sample. RNA was extracted from the samples and two different molecular assays were performed: first, a conventional RT-PCR with pan-coronavirus primers and a second SARS-CoV-2 qPCR targeting the N and S genes.

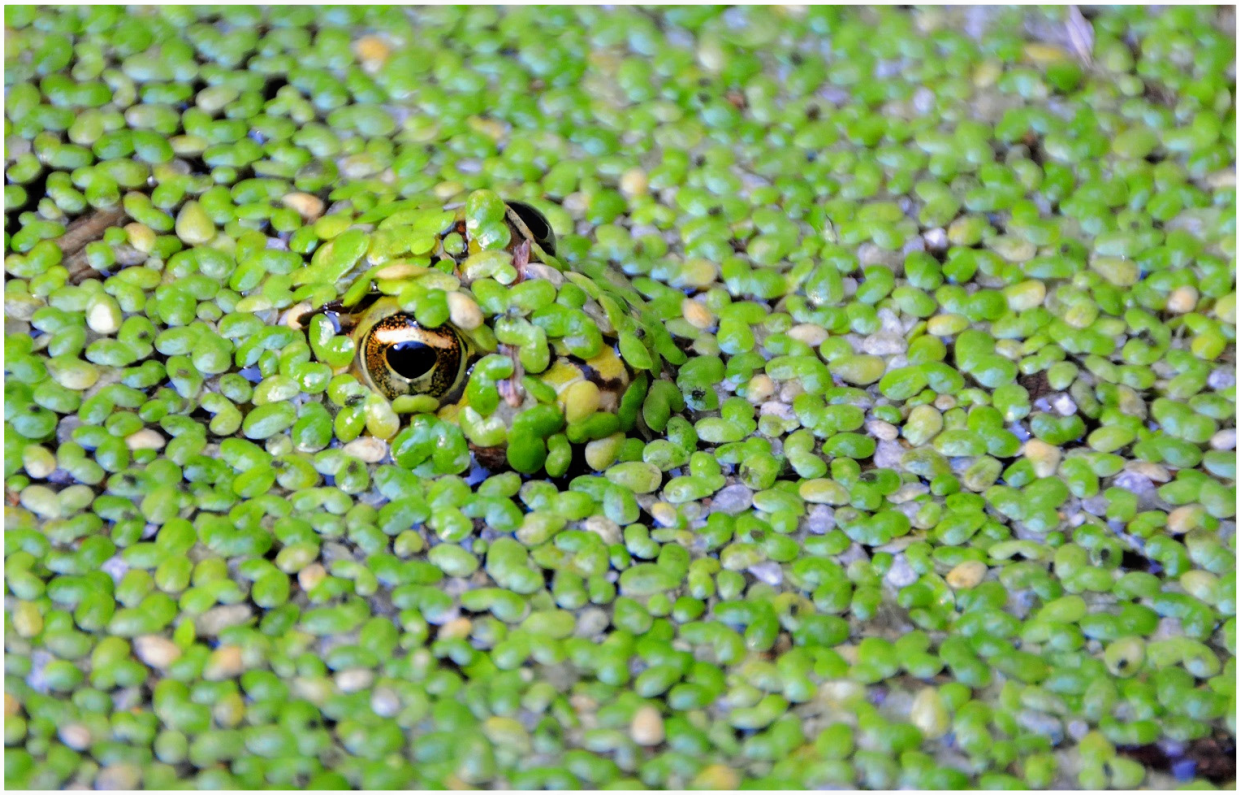
Results: All 185 samples were negative for SARS-CoV-2.

The wolf and the city: insights on wolves conservation in the anthropocene

Zanni M, Brogi R, Merli E, Apollonio M. *Animal Conservation* 15 February 2023. https://doi.org/10.1111/acv.12858

After a long period of human persecution that led it to extinction in most of its distribution range, the wolf is undergoing a fast recovery. Despite being described as an elusive species only living in remote areas, wolves are recently occupying also human-dominated landscapes, increasing the frequency of direct contacts with humans. Nevertheless, it is unclear whether this situation is only caused by a numerical increase or partially facilitated by a higher tolerance of wolves with respect to human proximity. We focused on a European region offering an abundant, widespread and long-term monitored wolf population to analyse wolf pack distribution and its relationship with human presence across areas recolonized across four different time periods (1972, 1996, 2005 and 2016). Throughout areas recolonized during different periods, wolves were initially located in mountains and hills, occupying plains only in the recent past. Although they consistently tended to be located as far as possible from urban settlements, especially from those with over 5000 inhabitants, in 2016, 70% of packs included at least one urban settlement within the expected home range. Moreover, the distance kept by wolves from the nearest urban settlement was more constrained in areas of recent recolonization (2005 and 2016) and in the mountainous altitudinal range, likely due to a reduced availability of territories. We showed that wolves tend to keep as far away as possible from humans, but they can also permanently occupy human-dominated landscapes to cope with the lower availability of space induced by their remarkably successful recolonization. Our results shed light on an upcoming scenario for the conservation of large carnivores ■

TAIL ENDS



Yes, I'm ready for my closeup.

Clicking stream frog
Stongylopus grayii

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