JOURNAL OF WILDLIFE REHABILITATION

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IN THIS ISSUE:

The effects of captivity on behavior of barred owls

Utilizing rehabilitation data to understand threats to endangered South African vultures

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.



LEFT:

Tasmanian devil *(Sarcophilus harrisii)*, an endangered Australian marsupial whose extreme vulnerability to a facial tumor disease has caused major decline of a species already affected by human impact.

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ON THE COVER:

Cape and white-backed vultures at a buffalo feed (*Gyps coprotheres* and *Gyps africanus*).

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IWRC

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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EDITORIAL

Changing Strategies for a Changing Reality

Like so much of life, doctor appointments are mostly virtual these days. I recently watched my mother test out a new telemedicine technique with her Parkinson's physical therapist, Dr. Tara McIsaac. It reminded me that we are all innovating right now, as COVID-19 is an imposition on our normal lives; but it doesn't mean that the world stops. IWRC is not alone in adapting to helping people in our "new normal."

In preparation for my mother's appointment we cleared a space in the house and measured off ten feet with bright tape. We set up a chair and a few props. My brother ensured that the entire space would be viewable with the phone video camera. Observations of a patient walking; getting out of a chair; and other muscle movement, strength, and coordination activities are common techniques medical professionals use to assess a Parkinson's patient. While the tactile assessments, such as how much the person can push down against a doctor's arms, aren't possible, an amazing number of these techniques translate into a virtual environment. The successful practice session between my mother and her therapist will lead to safe, effective support of many Parkinson's patients.

I've spent many hours considering the execution of IWRC's mission in our COVID-19-restricted environment. As I wrote last issue, this pandemic illustrates the importance of wildlife rehabilitation; this is not a time to be on the sidelines. Yet safety must be our first priority.

There are nuances, but in essence we've created a twofold strategy:

1. Supporting the wildlife rehabilitation field at this critical and stressful time.

2. Ensuring our evidence-based courses are available without any compromise of quality or safety.

We've added Coffee & Tea Zoom chats to our usual virtual outreach via blog, website, newsletter, and social media. The best thing about this new addition is that it's an open but intimate conversation. The conversations within our chats are rarely, if ever, made public, providing a safe place for rehabilitators to discuss challenging issues. But notes are taken on the resources discussed and the ideas generated, and these are distributed to the attendees and to anyone else who finds them of interest. Meanwhile, these candid conversations are balanced by moderation and, at times, expert lectures (recorded!). I've been thrilled with the level of dialogue we've been able to achieve, binding people from six continents into one global community.

We've made, and are still working on, major upgrades to our online classes. Our once bare-bones recorded lectures and exams have been expanded with knowledge checks, activities, and lab kits. Some courses, like Wound Management, remain completely asynchronous and relatively self-paced; others, notably Basic Wildlife Rehabilitation, have a set schedule and combine synchronous lectures, labs, and Q&A sessions with asynchronous videos and forum discussions. Visit theiwrc.org to see what's currently available.

IWRC labs are going online as human medicine is using modern technology for successful virtual check-ups. What can wildlife rehabilitation do to further our mission safely during this global pandemic? Virtual medicine appointments with our vets? Video consultations to troubleshoot human–wildlife conflict? Long distance collaboration with subject matter experts?

It isn't easy, but we can function effectively in this new normal. I'm here if you ever need to reach out.

—Kai Williams
Executive Director
director@theiwrc.org

Yellow Fever in Brown Howlers

SALT LAKE, Utah, USA (August 12, 2020)—From 2007 to 2009, a devastating yellow fever virus outbreak nearly decimated Argentina's El Piñalito's howler monkey populations. The brown and black and gold howlers are extremely susceptible to the disease that enslavers introduced to the Americas. In the last few years, logging activity has progressively affected the howlers' habitat and brought humans closer to wildlife, increasing the risk of virus transmission from the loggers to the howlers. When laboratory analyses confirmed that the monkeys died from yellow fever, health authorities vaccinated human populations to prevent further transmission. By then, the damage was done.

"Our howler groups just disappeared from the park. We found almost no signs of a presence until 2014—six years after the outbreak," said Ilaria Agostini, biologist at the Instituto de Biología Subtropical of Argentina.

In a study led by the University of Utah, an international research team tested whether howler monkeys who survived the yellow fever virus outbreak had any genetic variations that may have kept them alive. The article was published online on June 25, 2020 in the *American Journal of Physical Anthropology*.

In 2017, Nicole Torosin, postdoctoral researcher at Rutgers University and then a doctoral student at the University of Utah, joined Agostini in El Piñalito to search for any living brown or black and gold howlers. They eventually counted nine brown howlers and two black and gold howlers. Torosin sequenced the genomes of liver samples that Agostini's team had collected from monkeys who died before the outbreak and right after the outbreak, and she extracted DNA from the poop of those who had survived.

"We saw many more dead black and gold howler monkeys than brown howlers after the outbreak," said Torosin, postdoctoral researcher at Rutgers University. "We wondered if there were genetic differences that may have helped the brown howlers survive somehow."



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Brown howler monkey with young *(Alouatta guariba clamitans*), Caratinga, Minas Gerais, Brazil.

The team found no genetic variants present at higher rates in the surviving monkeys than in the deceased ones. However, in comparing the two species, they found three mutations in the DNA sequence of the brown howler individuals. Two of these mutations result in amino acid changes in the part of the protein that detects the disease. In a companion study published in *Molecular Phylogenetics and Evolution,* Torosin found that the changes were positively selected in the brown howler population.

"With COVID-19, we've seen how a virus that originated in China can spread across the world. Here, humans brought a virus to primates that have evolved without exposure to it for tens of millions of years and it nearly wiped them out," said co-author Timothy Webster, anthropologist at the U. "We're interacting with species in new ways that are creating new immune

challenges, both for humans and for other species."—Lisa Potter, University of Utah.

District Court Judge Rules on 2017 MBTA Reinterpretation

NEW YORK (August 11, 2020)—"It is not only a sin to kill a mockingbird, it is also a crime." This quote from To Kill a Mockingbird is how Judge Valerie Caproni opens her 31 page ruling; the result of three separate cases against the US Department of the Interior. The cases—one by the state attorneys general of NY, CA, IL, MD, MA, NJ, NM, & OR; another by National Audubon Society, American Bird Conservancy, The Center for Biological Diversity, and Defenders of Wildlife; and the third by the Natural Resource Defence Council and National Wildlife Federation—were combined for the judgment.



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Mule deer doe *(Odocoileus hemionus).*

In the ruling, Judge Caproni notes that the M-Opinion is contrary to the law.

"In any event, Interior does not explain why the fact that the verb 'kill' associated with activity means that the phrase 'by any means or in any manner' should be rewritten to state 'by any means or in any manner of activity that is specifically directed at birds.' Killing a bird by firing a gun, setting a trap, dumping oil waste, or pressure washing nests from a bridge all fit within Interior's active sense of 'kill,' and yet the Jorjani Opinion concludes that the first two are prohibited by the MBTA while the latter two are not."

On August 11th the judge granted the plaintiffs' request to vacate the recent M-Opinion (M-37050/Jorjani). Her ruling is as unambiguous as the original Migratory Bird Treaty Act.

Cervid Adenovirus Outbreak in Northern California

SACRAMENTO, USA (August 3, 2020)—The California Department of Fish and Wildlife (CDFW) has confirmed outbreaks of adenovirus hemorrhagic disease in deer in several northern California counties.

"Providing attractants for deer—food, salt licks or even water—is against the law for good reason," said Dr. Brandon Munk, senior wildlife veterinarian with CDFW's Wildlife Investigations Laboratory. "Because these artificial attractants can congregate animals and promote the spread of disease, it's particularly imperative to leave wildlife alone during an outbreak. There is no cure or vaccine for this disease, so our best management strategies right now are to track it carefully, and to take preventative measures to limit the spread."

Beginning in May, CDFW began receiving increased reports of mortality in deer, both free-ranging and at fawn rehabilitation facilities. With the assistance of wildlife rehabilitation facilities and the California Animal Health and Food Safety Laboratory, CDFW confirmed cervid adenovirus 1 (CdAdV-1) as the cause of hemorrhagic disease outbreaks in Napa, Santa Clara, Sonoma, Tehama and Yolo counties.

The disease is typically fatal to deer and can be spread by animals in close contact with each other. The virus is not known to affect people, pets or domestic livestock.

CdAdV-1 was the cause of a 1993–1994 outbreak of hemorrhagic disease in black tailed deer and mule deer that spanned at least 18 California counties. Since then, CdAdV-1 has been identified as the cause of sporadic, often widespread, outbreaks of hemorrhagic disease in California and other western states. Deer fawns are at greatest risk, with high rates of mortality following infection. Yearlings and adult deer are more resistant but mortalities in these age groups occur as well. Outbreaks can be widespread and have significant impact on affected deer populations.

Affected deer are often found dead without any obvious symptoms. They may be found near water. Sick animals may have excessive salivation (drooling or foaming at the mouth), diarrhea, regurgitation or seizures.

In addition to removing food and other attractants, Californians can help wildlife veterinarians track and study the disease by reporting sightings of sick or dead deer. Anyone who observes a deer exhibiting symptoms, or encounters a deer that has died from unknown causes, can submit the information to CDFW through the department's online mortality reporting system.

New Wildlife Rehabilitation Center in Eastern Taiwan

TAIPEI (July 21, 2020)—The Council of Agriculture's (COA) Forestry Bureau on Monday signed a cooperation agreement with a local wildlife conservation society to jointly establish first ever large-scale wild animal rescue center in eastern Taiwan.

COA Deputy Minister Huang Chin-cheng, Forestry Bureau Director-General Lin Hwa-ching and WildOne Wildlife Conservation Association President Chi Meng-jou inked the agreement.

Huang said that the public and private sectors will work together to establish the wildlife rescue center and put it into operation on August 15th.

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A case study investigating the effects of rehabilitative captivity on neophobia and exploration in four barred owls (*Strix varia*)

Juliana M. Hitchcock

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AUTHOR AFFILIATIONS: MS in Biology (2019), University of Central Missouri. Coordinated with Raptor Rehabilitation Project, University of Missouri, Columbia, studying barred owls during captivity. Currently with Kindred Kingdoms Wildlife Rehabilitation Center, Central New York.

ABSTRACT: Exploration and neophobia are hypothesized to have a reciprocal relationship, each behavior influencing the expression of the other. Specifically, the possibility of exploration influencing the increase or decrease of neophobia is of concern for wildlife rehabilitators. Captivity has the potential to artificially alter the need for exploration due to the decrease in environmental variability, which may artificially change the expression of neophobia in captive patients. Changes in neophobic tendencies may impede survival rates of wildlife after release. I examined how functional neophobia changed within barred owls (*Strix varia*) during rehabilitation. Data suggests that as time spent in captivity increases, inhibition displayed towards novelty and during food retrieval decreases. This data potentially reflects a decrease in neophobic tendencies during traditional rehabilitation. However, auditory enrichment over the course of five days appears to prevent neophobia levels from drastically decreasing. If stable neophobia levels are of value and aid in survival after release, the inclusion of auditory enrichment during captivity might be a practical rehabilitation technique.

KEYWORDS: behavior, exploration, neophobia, release, survival rates, wildlife rehabilitation.

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Introduction

The purpose of this case study was to determine if the addition of a loudspeaker emitting the sound of leaves rustling while barred owls were feeding was beneficial for their recovery in wildlife rehabilitative captivity. The study addressed the following specific areas of concern: factors that could influence the expression of neophobia, the potential for a change in expressed neophobia to occur during captivity, and how rehabilitative captivity might affect live hunting abilities in barred owls. This case study included four individual barred owls undergoing rehabilitative captivity at the Raptor Rehabilitation Project (RRP), an affiliate of the University of Missouri, Columbia, Missouri.

Neophobia is defined as the fear or general avoidance of novel objects, spaces, or

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PHOTO © MATTHEW PAULSON. CC BY-NC-ND 2.0 LICENSE.

situations.[1,2] During the discovery of novel resources, neophobia serves to protect the individual by weighing the cost of exploration. Studies attempting to quantify neophobia in adult animals, specifically birds, indicate neophobia can be plastic, increasing or decreasing based upon the situation or repeated exposure to novelty.[3,4] Neophobia and exploration are often expressed in association with a novel stimulus[5,6] and appear to be correlated with foraging preferences of individual species.[7] In the wild, animals utilize neophobic and explorative behaviors to aid in survival.[8] Studies indicate neophobia and exploration are governed by independent motivational systems,[7,9,10] and a relationship where the expression of neophobia influences the expression of exploration, and vice versa, has been suggested.[1,11] Searches of primary literature have demonstrated that the expression of neophobia and exploration are correlated in some avian species but not in others, indicating that correlation of these behaviors might be species specific.[11,12,13] Studies suggest that the ecology and the environment of individual animals govern how they express neophobia and exploration. For example, studies comparing migratory birds and resident birds indicate migratory species possess higher neophobia levels than resident species.[7,11,13] This suggests that individuals living in stable environments, such as resident species of birds, would have lower neophobia levels than species living in more variable environments, such as migratory birds. This, however, poses the question of what specifically controls neophobia levels. Does the environment in which an animal resides dictate levels of neophobia expressed, or is neophobia selected for in individual species depending on its contribution to survival? Additionally, because neophobia can be plastic,[3,4] do levels of expressed neophobia fluctuate in response to a shift in an animal's environment, and do levels change to meet the needs of the animal in a new environment?

These questions are especially important for wildlife rehabilitators. Short-term captivity experienced by patients in wildlife rehabilitation creates a new static environment. Due to a lack of studies investigating the behavioral response of individuals in wildlife rehabilitation, it is important to ask if the creation of a new static environment may negatively affect patients. A negative impact on the expression of neophobia could reduce the survivability of rehabilitated patients in the wild. Of specific concern is the possibility that levels of neophobia can change and become ineffective in an animal's respective environment when faced with novelty. Ineffective neophobic expression can manifest through incurring increased risk of predation during exploration and obtaining food, or through a decrease in resources obtained.

Another factor that can influence the levels of expressed neophobia is stress. Gormally[14] suggests an increase in stress levels in

captive wild house sparrows (*Passer domesticus*) is correlated with an increase in expressed neophobia and results in more aggressive attainment of food. However, in Gormally's[14] study, cages housing house sparrows were rolled and tapped to produce a stress response. Stress response data collected by Gormally[14] may not accurately reflect the stress of patients in wildlife rehabilitation due to the differences in the stimulus invoking stress. Whether levels of expressed neophobia are influenced by stress caused through means as cited in Gormally[14] or a change in environment, a resulting change in levels of expressed neophobia could be detrimental upon release.

The lack of knowledge in how stress influences patients of wildlife rehabilitation leads to the focus of this case study. Does being placed in captivity during rehabilitation cause stress resulting in increased neophobia levels, or does experiencing a static environment affect a change in levels of expressed neophobia? Due to the breadth of this question, I chose to develop my hypothesis based solely on the possibility that a change to a static environment causes a change in levels of expressed neophobia. This question is being addressed due to the lack of primary literature involving this topic.

This study was conducted at the Raptor Rehabilitation Project, an affiliate of the University of Missouri in Columbia, Missouri. Preliminary data analysis of patient intake records revealed the barred owl as the most commonly admitted patient per year (2017 personal communication from Raptor Rehabilitation Project of unpublished data to me; unreferenced, see "Acknowledgments"). Therefore, barred owls were selected for this study. These owls are recorded as crepuscular, with documentation of partaking in diurnal hunting.[15] They possess an asymmetrical ear configuration which possibly equips the owls for nocturnal hunting and suggests a predominant dependence upon auditory stimuli during hunting.[16] A predominant dependence upon auditory stimuli during nocturnal hunting by barred owls could affect how a stimulus is perceived, potentially influencing neophobic reactions. Predominate dependence upon auditory stimuli was considered during the formulation of my hypothesis. Specifically, in this case study, I sought to determine if barred owls do primarily depend upon auditory stimuli during nocturnal hunting as well as to determine the effect an auditory stimulus has on neophobic reactions.

Five goals were identified and incorporated into the formulation of my hypothesis: First, to determine if a rapid shift to a static environment causes a change in the expression of exploration and neophobia. Second, to determine if neophobia and exploration are correlated in barred owls. Third, to measure if a decrease in the need for exploration causes an increase in neophobia. Fourth, to observe if there is a decrease in the efficiency of live hunting in barred owls after a period of not hunting due to rehabilitative captivity, and can it be attributed to a change in neophobia? Finally, do barred owls primarily depend on auditory stimuli during nocturnal hunting, and does this impact neophobic behaviors?

Based upon these goals, I hypothesized that a decrease in explorative need will increase neophobia. This increase in neophobia will negatively affect subjects during live hunting by increasing latency to approach prey. However, with specific auditory enrichment, explorative needs within the enclosure will increase, neophobia levels will remain stable, and live hunting abilities will not be significantly impeded. I further hypothesized that barred owls would utilize auditory cues over visual cues during nocturnal hunting, but that a novel visual stimulus would elicit a stronger neophobic reaction than a novel auditory stimulus. This is because a visual stimulus indicates a present danger, while an auditory stimulus suggests that danger may be near, but not necessarily present.

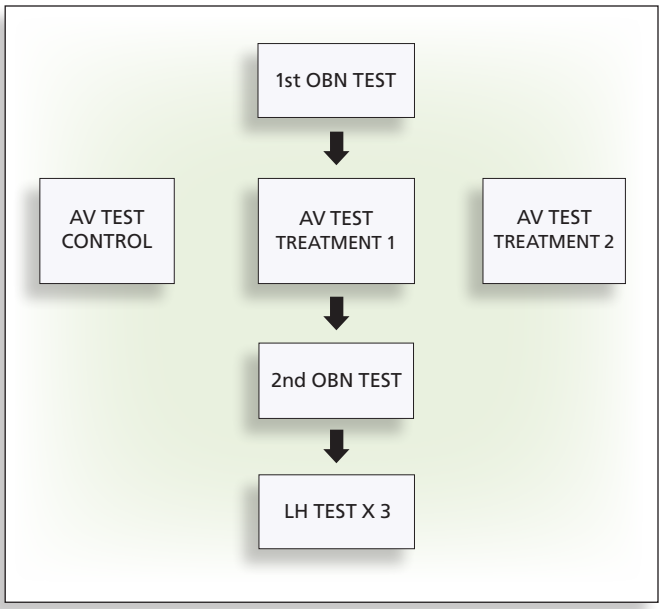


FIGURE 1. Flowchart depicting Experimental Design. Subjects were divided into three different groups (Treatment 1, Treatment 2, and Control) for Auditory/Visual (AV) testing. All subjects underwent three tests: two sessions of Object Neophobia (OBN) testing, five sessions of Auditory/Visual testing, and three sessions of Live Hunting (LH) testing.

Methodology

Overview

This study was conducted at the Raptor Rehabilitation Project (RRP), an avian wildlife rehabilitation facility, in conjunction with the University of Missouri, Columbia (MU). Methodology was approved by MU's chapter of the International Animal Care and Use Committee. Four barred owls were collected for this case study beginning 17 June 2018 through 29 October 2018. This case study ended 6 November 2018 after the last individual collected 29 October 2018 had completed testing. Despite maintaining a high rate of admittance, the majority of subjects died in captivity or were dead on arrival, resulting in a small sample size. Methodology was adapted from normal procedural events at RRP as well as from Mettke-Hofmann[11] and Guido.[17] An overview of the methodology is depicted in Figure 1. Barred owls used in this study had undergone traumatic injuries in the wild and were admitted to the University of Missouri, Columbia, Veterinary Hospital. Subjects underwent medical treatment between 17 to

TABLE 1. Each subject was randomly assigned a treatment. Depicted below are the individuals as they were assigned treatments, listed chronologically. Each subject was assigned a group (A or B) for organizational purposes. Each group contained up to one individual in each of the different treatments (Treatment 1, Treatment 2, and Control). Groups and treatment assignments are reflected in the subject's Testing ID (ex. Subject A1 belonged to Group A and was undergoing Treatment 1). Subjects were organized as such to perform cross-group statistical analysis had enough subjects been collected.

ADMIT DATE	*Strix varia* AS ADMITTED	RRP ID	GROUPS	TREATMENT	OWL TESTING ID
7/8/18	1st Individual	Beech	A	2 (Treatment 2)	A2
9/21/18	2nd Individual	Guthrie	A	1 (Treatment 1)	A1
9/22/18	3rd Individual	Ernesto	A	3 (Control)	A3
10/29/18	4th Individual	Kulgan	B	1 (Treatment 1)	B1

32 days. Upon discharge from the veterinary hospital, subjects were admitted to RRP and placed in mews. Following one day of acclimation, Object Neophobia (OBN) testing commenced establishing base levels of neophobia. Subjects underwent treatment (enclosures housing patients modified to produce an auditory stimulus during feeding) and Auditory/Visual (AV) testing for five days. Once treatment and AV testing had concluded, subjects again underwent OBN testing, followed by Live Hunting (LH) testing in flight cages.

Housing setup

Subjects were housed in one of two mews before being moved to one of two flight cages during testing. Mews were approximately 175 square feet and were constructed of wooden boards with approximately 0.5 inches of space between each board. Flooring consisted of a pea gravel and dirt mixture. Each mew contained a stump of roughly the same size, a natural tree branch reaching diagonally across the mew to provide roosting space, and a black rubber water dish. Flight cages were approximately 2,080 square feet and constructed of wooden boards with approximately 0.5 inches of space between boards. Like the mews, flooring consisted of a pea gravel and dirt mixture, with the ratio skewed towards pea gravel. Each flight cage had a variable amount of naturally growing plants inside as well as man-made stumps and natural tree branches reaching across the open space. Each flight cage also had a feeding box of approximately 25 square feet to contain mice during live hunting exercises. Exact dimensions and internal set up were not standardized for both mews and flight cages as modifying the internal structure was not permitted by the facility.

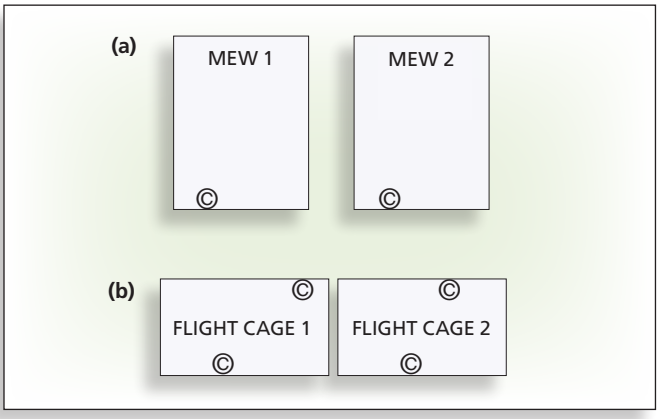


FIGURE 2. Relative placement for cameras (C) in mews (a) and in flight cages (b). Cameras were used to observe behavior elicited during Object Neophobia testing and Auditory/Visual testing in mews and Live Hunting testing in flight cages. Placement of cameras could not be standardized due to constraints of internal housing structure and length of cables running from cameras to the observations station.

Treatments and controls

The purpose of the treatments was to increase variability in the enclosures in which subjects were housed. Treatments consisted of enclosures modified to hide speakers that produced an auditory stimulus. The audio was a standardized recording of leaves rustling. An auditory stimulus was chosen as barred owls are believed to heavily rely on sound during nocturnal hunting.[16] Therefore, an auditory stimulus might be a more appropriate vehicle for introducing variation than a visual stimulus, and for this study, it was assumed to be more appropriate. The enclosures modified to produce sound were controlled for by housing one individual in an enclosure that was modified with a loudspeaker which did not produce an auditory stimulus. Treatments lasted for five consecutive days. The sound recording was played during feeding. The reason treatment was administered during feeding is that food serves as a motivational factor to prompt responses in behavioral studies.[17]

To determine if increasing variability using an auditory stimulus is appropriate for barred owls, two different treatments in which the source of sound was varied were applied. Treatment 1 consisted of the auditory stimulus source being presented in association with the food. Treatment 2 consisted of the auditory stimulus source being presented as separate from the food source. Of the four subjects collected, one was assigned to be rehabilitated in Control housing, two were assigned to be rehabilitated in Treatment 1 housing, and one was assigned to be rehabilitated in Treatment 2 housing (Table 1).

Object Neophobia testing

The purpose of Object Neophobia testing was to assess if levels of neophobia expressed by subjects changed in response to treatment. This was accomplished through recording levels of neophobia expressed in response to a novel object during feeding before and after treatment.

Object Neophobia testing was conducted in two sessions, Session 1 (before treatment) and Session 2 (after treatment). All OBN testing began at 2300 hours. One frozen-thawed brown mouse was placed inside the mew approximately 63 centimeters from the entrance, and the subject was left alone with the food. Once the subject pounced on the food and began to feed, the

investigator interrupted feeding by entering the mew and situated a novel object (Session 1: mop head, Session 2: seven-inch soccer ball) before exiting. Subjects generally responded by abandoning food and moving to a higher perch. Subjects were allowed 15 minutes to return to feeding, which was observed via a Lorex series LBV2711® security camera (Fig. 2). Subjects were allowed 900 s (15 m) to retrieve the food in the presence of the novel object. When the subject retrieved the food, or 900 s had elapsed, the novel object was removed. The resulting latency to return to the food in the presence of the novel object was used as a measurement of relative neophobia levels. If the subject had failed to consume the food in 900 s, a ceiling value was assigned to the session. If the food had been consumed by the subject before placement of the novel object, OBN testing was attempted for a second night.

Due to only four subjects being collected, robust statistical testing could not take place. However, a paired t-test was used to compare neophobia levels from the first and second sessions using R statistical program.[18] Length of stay in the veterinary hospital and initial levels of neophobia were plotted to determine if a correlation was present.

Auditory/Visual testing

To initiate the test for Treatment 1, the investigator placed a speaker emitting the standardized recording inside a brown box already in the enclosure (modification to hide the speaker). A frozen-thawed brown mouse was placed directly on top of the brown box. Once the door to the enclosure closed, the latency for the subject to retrieve the food was recorded. Once the subject had retrieved the food, the speaker was retrieved and turned off, thus ending the test. To initiate the test for Treatment 2, the investigator placed a speaker emitting the standardized recording into the brown box already in the enclosure. The frozen-thawed brown mouse was placed 56 cm away from the brown box, towards the center of the enclosure. Once the door was closed, the latency for the subject to retrieve the food was recorded. Once the food had been retrieved, the speaker was retrieved and shut off, ending the test. Individuals held in control enclosures were fed with the mouse placed on top of the brown box, without a speaker being placed inside.

Due to only four individuals being collected, robust statistical testing could not take place that would definitively assess if a true difference in latency to retrieve food existed between individuals in treatment enclosures and individuals in control enclosures. However, differences in latency to retrieve food between the treatments and the control were plotted to help visualize a difference.

Live Hunting testing

Live Hunting tests were conducted on all subjects placed in treatment and control enclosures. The purpose of this test was to determine if housing subjects in treatment enclosures influenced their abilities to efficiently hunt live prey. Testing began 45 m before sunset. Testing was initiated by the investigator entering the flight cage with the live brown mouse in a transportation carrier. Food and water for the mouse were placed in the center of the hunting box (25 square feet) before releasing the mouse. Mice were released from a central location on the side of the feeding box closest to the flight cage door. Upon the release of the mouse, the investigator exited the flight cage. The total time spent inside the flight cage by the investigator was no longer than two minutes. Time measuring latency to retrieve food began once the door to the flight cage had closed. Time ended once the subject had successfully caught the prey. Testing was observed via security cameras, the same model as used in OBN and AV testing (Fig. 2).

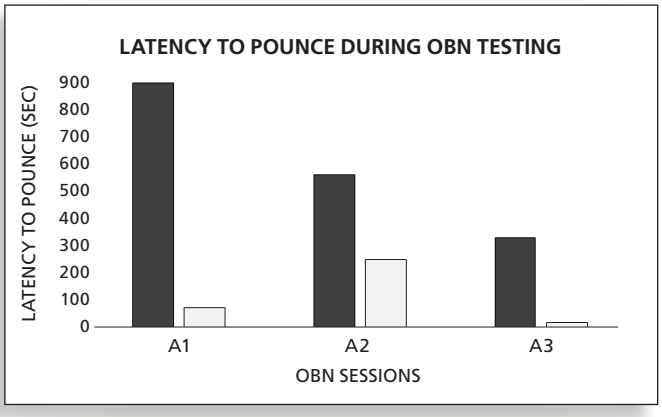


FIGURE 3. Differences in latencies to pounce (y-axis) between initial Object Neophobia (OBN) testing (black) and secondary testing (white) for each individual (x-axis). Individuals are listed by their Testing ID (Table 1). Subject A1 had the highest difference to pounce between sessions (825 seconds). Initial latency to pounce for the first OBN session (before) was 900 seconds. The latency to pounce for the second OBN session (after) was 75 seconds. Subject A2 had a difference to pounce between sessions of 310 seconds. Initial latency to pounce for the first OBN session was 561 seconds. The latency to pounce for the second OBN session (after) was 251 seconds. Subject A3 had the lowest difference to pounce between sessions (309 seconds). Initial latency to pounce for the first OBN session (before) was 330 seconds. Latency to pounce for the second OBN session (after) was 21 seconds. Data from the OBN test for subject B1 is not represented in this figure as data from the second session (after treatment) could not be obtained. Initial latency to pounce for the first OBN session was 150 seconds.

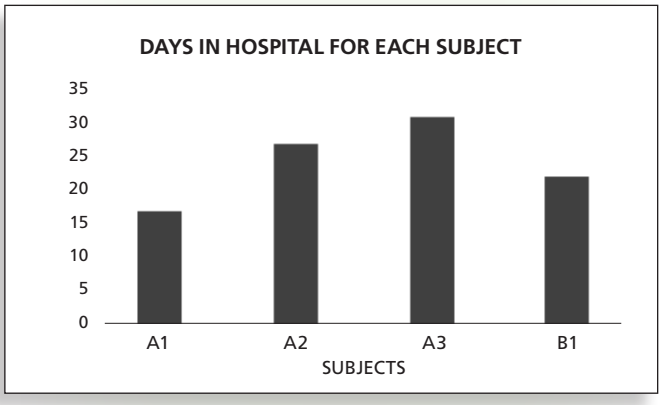


FIGURE 4. Days in hospital prior to admittance into the rehabilitation facility. Subjects (x-axis) are listed by their Testing IDs (Table 1). Days subjects spent in the hospital prior to admittance into Raptor Rehabilitation Project is plotted along the y-axis.

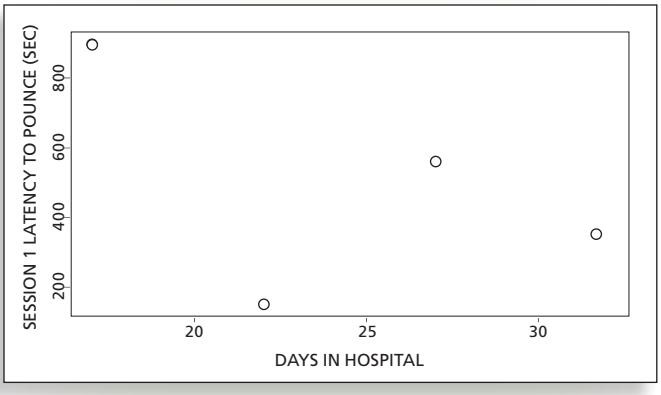


FIGURE 5. The number of days spent in veterinary hospital prior to admittance into the rehabilitation facility at Raptor Rehabilitation Project correlated with latency to pounce during the first Object Neophobia (OBN) session. As days in hospital (x axis) increase, latency to pounce decreases during the first OBN session (y axis).

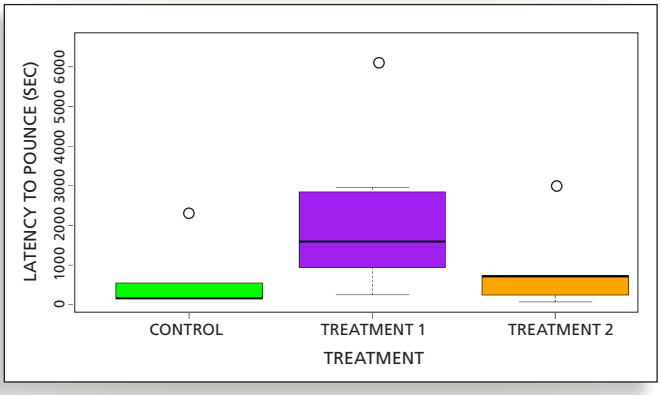


FIGURE 6. Differences in latency to pounce between treatments during Auditory/Visual testing. The different treatments individuals underwent is plotted on the x-axis. Control (green) is mouse and no sound. Treatment 1 (purple) is mouse and sound together. Treatment 2 (orange) is mouse and sound separate. The y-axis is the latency to pounce measured in seconds. For visual purposes, outliers recorded on 11 July 2018 and 1 November 2018 were excluded from the boxplot but were included in actual data analysis.

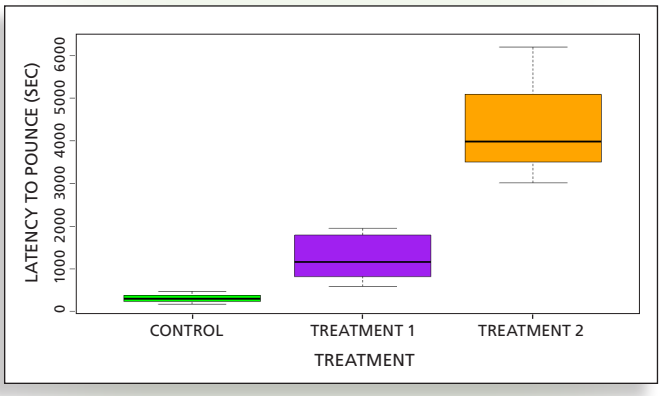


FIGURE 7. Differences in latency to pounce between treatments during Live Hunting testing. The different treatments individuals underwent is plotted on the x-axis. Control (green) is mouse and no sound. Treatment 1 (purple) is mouse and sound together. Treatment 2 (orange) is mouse and sound separate. The y-axis is the latency to pounce in seconds. Differences in latency to pounce were not significant.

Results

Object Neophobia testing

Differences in latency to pounce between Session 1 (before treatment) and Session 2 (after treatment) during OBN testing were not significant (t_2 = -2.6815, P-value > 0.05) (Fig. 3). Plotting time spent by test subjects in the veterinary hospital prior to beginning rehabilitation (x axis) against levels of neophobia expressed during Session 1 of OBN testing (y axis) illustrates the potential correlation (Figs. 4 and 5).

Treatment, Auditory/Visual testing, and Live Hunting testing

During Auditory/Visual testing, individuals in Control housing experienced the shortest latency to retrieve food, followed by individuals in Treatment 2 housing and individuals in Treatment 1 housing, respectively (Fig. 6). During Live Hunting testing, individuals in Treatment 2 had the longest latency to retrieve food while the control had the shortest latency to retrieve food (Fig. 7). It is recommended this test be repeated with a larger number of subjects for this study and a linear regression mixed effects model used to analyze data.

Discussion

Three tests were conducted during this case study, which are discussed later in detail. During these three tests, my original hypothesis was not supported. However, results indicate that playing an auditory stimulus during the feeding of barred owls in wildlife rehabilitative captivity has the potential to be beneficial for patients post-release.

Object Neophobia testing

Object Neophobia Testing (OBN) sought to determine if the treatment (enclosures housing patients modified to produce an auditory stimulus during feeding) produced a difference in levels of neophobia expressed in subjects as a response. A decrease in latency to feed in the presence of a novel object was present across all subjects after treatment except for one, indicating levels of expressed neophobia decreased during captivity (Fig. 3). Increasing stress could account for the decrease in latency to retrieve food over the course of this study. It is possible that the observed decrease in latency to feed in the presence of a novel object is a manifestation of stress due to captivity. With increased stress, subjects appear to take greater risks in obtaining food, resulting in the decreased latency to retrieve food.[14] The reasoning behind why subjects would take larger risks during exploration and foraging in a stressful environment is that the benefits of foraging outweigh the benefits of remaining stationary.[19] This postulation could explain why there was a negative correlation (not significant) between the length of stay in hospital and initial OBN scores (Figs. 4 and 5). Individuals that stayed the longest in the veterinary hospital prior to being moved to the rehabilitation facility most likely were under the most stress from their extended stay and therefore would have the shortest latency to retrieve food in the presence of a novel

object. Studies have shown that captivity can induce chronic stress in wild pigeons.[20] Chronic stress could lead to heightened stress levels post-release, resulting in the partaking of larger risks to feed in the wild. Future studies investigating the correlation between length of time in veterinary hospitals and expressed neophobia should include more than four individuals in order to perform robust statistical analysis and incorporate assessments of expressed neophobia post-release.

Treatment and Auditory/Visual testing

Treatment consisted of modifying enclosures to produce an auditory stimulus during feeding of the subjects. The purpose of the auditory stimulus in treatment enclosures was to increase variability inside the enclosures. There were two treatments used to determine if barred owls primarily used auditory cues during nocturnal hunting. During Treatment 1 the auditory stimulus was presented as associated with food given during feeding (the sound and the food were presented in the same location). During Treatment 2 the auditory stimulus was presented as unassociated with the food during feeding (the sound and the food were presented in separate locations inside the mew). Control enclosures were not modified and did not produce an auditory stimulus when subjects were given food for feeding. Control enclosures controlled for the enclosures themselves as well as the modification required for sound production. Initially, my hypothesis predicted individuals in Treatment 1 would have the shortest latency to retrieve food, followed by individuals in Control housing and finally individuals in Treatment 2. Minor differences in latencies to retrieve food between initiating tests (placing the food in the mew) and retrieval of food by the subject exist between all treatments and the control. However, results do not support that barred owls predominately depend upon auditory cues during nocturnal hunting. If auditory cues are predominately used during nocturnal hunting, then subjects in Treatment 1 would have experienced the shortest latency to retrieve food due to both auditory and visual cues guiding the test subject toward the same location. Conversely, individuals in Treatment 2 would experience the longest latency to retrieve food due to auditory cues guiding the subject away from the food. Results show the individual in Control housing displaying the shortest latency to retrieve food, followed by the individual in Treatment 2 housing and individuals in Treatment 1 housing. The auditory stimulus was possibly perceived to be threatening. Subjects in Treatment 1 (mouse and speaker together) may have refrained the longest from food retrieval because the unfamiliar sound could not be avoided during feeding. On the other hand, the individual in Treatment 2 (mouse and speaker separate) most likely retrieved food more quickly because the owl could avoid the potentially threatening sound. The individual in the control had no inhibitions on food retrieval as no sound was present to presumably induce a neophobic response. This also indicates auditory cues elicit a stronger neophobic reaction than visual cues. Further studies should test whether barred owls utilize sound frequencies to avoid predators while hunting.

I maintain that adding a sound stimulus to the enclosures during feeding would be beneficial to patients in captivity. The auditory stimulus would assist in keeping the cost/benefit ratio in favor of remaining stationary or proceeding with caution instead of immediately feeding as a potential reaction to stress. Behavior that does not favor caution could be dangerous when foraging or feeding in the wild. There is potential that upon release, subjects who undergo traditional rehabilitation without auditory enrichment (i.e. auditory stimulus while feeding) would still be experiencing decreased inhibitions while exploring or foraging without regard for potential dangers, decreasing chances of survival. Further research is required to determine if auditory enrichment for barred owls is beneficial during rehabilitation and reacclimation into the wild.

Live Hunting testing

Live Hunting (LH) testing was universal for all subjects after the conclusion of treatment. Subjects were placed in a flight cage, and live prey was released during feeding to test subjects' ability to hunt. This test was utilized to determine if the treatment had an impact on live hunting abilities in subjects. Results from LH testing indicate individuals that had not undergone treatment in the control housing before being moved to a flight cage had the shortest latency to retrieve live food overall. Individuals who had undergone treatment in Treatment 1 housing had the shortest latency to pounce between the two treatments (Treatment 1 and Treatment 2). Data suggests that the decreased inhibitions observed in the control during OBN testing and AV testing appear to carry over into live hunting. Conversely, auditory enrichment appears to assist with increasing inhibitions during live hunting. However, results could be skewed due to the small sample size and individual personality types of subjects. Future studies should use larger sample sizes to definitively assess if a decrease in inhibition or decrease in functional neophobia can influence live hunting ability.

Management implications

The overall goal of this case study was to examine if housing barred owls in enclosures with increased auditory variability would aid in keeping explorative needs similar to needs in the wild and aid in maintaining stable levels of expressed neophobia. What was gleaned from this case study is that an increased amount of time in captivity potentially increases stress and decreases neophobia levels expressed. Chronic stress has been observed in pigeons undergoing captivity,[20] and there is a possibility barred owls may also continue experiencing stress once released. Experiencing decreased levels of neophobia has the potential to leave these owls vulnerable to risks from predators or humans due to a decrease in inhibition.

For wildlife rehabilitators, allowing patients with decreased inhibitions to be released into the wild will potentially decrease survival rates, rendering the effort put into rehabilitation futile. However, during this case study, there appears to be some evidence indicating the use of an auditory stimulus during feeding aids in increasing the length of time to retrieve food during live hunting

testing. It is unknown if this increased latency reflects neophobia levels or the increasing of inhibitions, but utilizing this tool during rehabilitation could potentially increase post-release survival rates for barred owls and other species with critical conservation status.

Further research is required to determine if sound enrichment for barred owls is beneficial during rehabilitation and reacclimation into the wild. In addition, testing should incorporate physiological analysis to determine levels of stress in subjects, either through manual inspections for physical signs of stress or analysis of glucocorticoids in the bloodstream. Examination of naturally occurring neophobia levels in the wild should also be studied to determine how neophobia levels change in subjects after being brought into captivity. Post-release studies on subjects should also be conducted to determine the survivability of patients.

Acknowledgments

I would like to thank Raptor Rehabilitation Project for the use of their facilities and their patient intake data in this project. Patient intake data is unpublished data collected by Raptor Rehabilitation Project. This data was sent to me in a personal communication with the intent for me to use it in determining which species of raptor to collect for testing.

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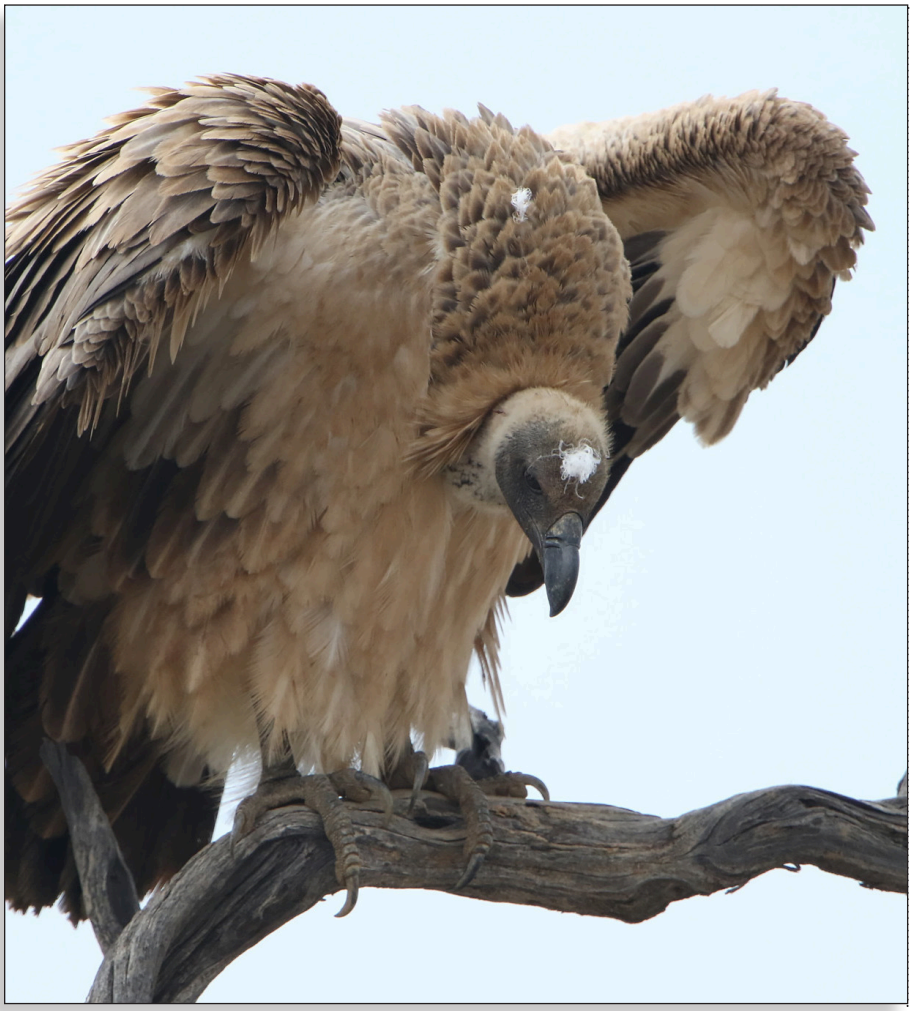
About the Author

Juliana M. Hitchcock has a BS in Biology (2016) from Stephens College, and an MS in Biology (2019) fron the University of Central Missouri. She has worked in wildlife rehabilitation since 2017. She completed a 200+ -hour internship with Sarvey Wildlife Care Center, Arlington, Washington. Hitchcock coordinated with the Raptor Rehabilitation Project, University of Missouri, Columbia, studying behavioral changes in barred owls during captivity (2018–2019), and is currently with Kindred Kingdoms Wildlife Rehabilitation Center in Central New York.

Injuries, mortality rates, and release rates of endangered vultures admitted to a rehabilitation center in South Africa

Alexandra Howard,[1] Maggie Hirschauer,[1] Ara Monadjem,[2,3] Neil Forbes,[4] and Kerri Wolter[1]

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African White-Backed vulture (*Gyps africanus*).

Introduction

Vultures are economically, ecologically, and culturally important, as they provide irreplaceable ecosystem services.[1] As the only obligate avian scavengers on Earth, ecological consequences of their demise would include increased disease risks to livestock and humans; decrease in their populations has been observed to lead to increase of disease vectors in the form of mammalian scavengers and to drastic changes in ecological community compositions.[1,2] Almost two-thirds (61%) of all African vulture species are currently threatened, with some populations declining by over 80% over the last three decades.[3] This "African Vulture Crisis" is caused by unintentional and intentional poisoning, collisions and electrocutions with electrical infrastructure, habitat degradation, lack of safe food resources, and unsustainable traditional cultural use of vulture parts.[1, 4, 5, 6, 7]

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ABSTRACT: African vultures are at serious extinction risk due to a number of anthropogenic factors, including negative interactions with electrical energy infrastructure. VulPro, a vulture rehabilitation facility in South Africa, has admitted 692 vultures and released 302 of these since its inception in 2007. Using VulPro records between 2007 and 2018, we compiled admission and release data for two endangered species—the African white-backed (*Gyps africanus*) and Cape (*Gyps coprotheres*) vultures to determine the causes of injury and their effect on the probability of successful release. We categorized admissions by cause of injury, age at admission, and days in rehabilitation. Electricity powerlines were the predominant cause for admission across species and years, followed by poisoning for African White-backed vultures and weather-related injuries for Cape vultures. Individuals of either species admitted with weather-related injuries had the highest release rates, while individuals admitted because of powerline interactions had the lowest release rates. Overall, 27% of admitted African White-backed vultures and 47.5% of admitted Cape vultures were eventually released, emphasizing the importance of rehabilitation in the conservation of endangered vultures.

KEYWORDS: African White-backed vulture, Cape vulture, mortality rates, release rates, rehabilitation, South Africa

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Identifying the causes of morbidity and mortality is critical to addressing threats and implementing conservation strategies for drastically declining vulture populations.[8,9]

One method for identifying the causes and scale of threats is the use of data from rehabilitation centres.[10,11] Long-term datasets of standardised records are invaluable for measuring rescue incidences, rehabilitation success, release probability, and and frequency of each threat causing injury or mortality. Furthermore, these data may be inferred to apply to wild populations so as to understand the forces that drive species declines.[8,9,10] Although the conservation value of wildlife rehabilitation is debated, there is empirical evidence that the release of additional individuals may assist population recovery in critically endangered species.[9,12] Rehabilitation centres and their associated data records are steadily being recognised as a conservation tool for endangered species, with urgent calls for research based on these broad datasets.[11,13,14]

The impacts of electrical infrastructure on the survival of African vultures are poorly known, and have been identified as research priorities for African white-backed (*Gyps africanus*) and Cape vultures (*Gyps coprotheres*).[15,16] Using VulPro's longitudinal data set of rehabilitation cases from 2007 to 2018 (see Methods, below), we aim to determine the cause of injury and its effect on the probability of successful release in African white-backed and Cape vultures. Interaction with electricity infrastructure appears to be an important source of severe injury to vultures, at least in South Africa, from which the birds are unable to make a full recovery.[13] Therefore, we hypothesize that birds with injuries due to powerline collisions and electrocutions will have the lowest probability of successful rehabilitation for release, based on the severity of injuries resulting from such interactions.

Materials and methods

Study site and species

Data presented here were obtained from VulPro, a vulture conservation organization focusing on rehabilitation, conservation breeding, and research, located in North-West Province, South Africa. The facility is within 75 km of extant and extinct Cape vulture colonies in the Magaliesberg Mountain Biosphere Reserve.[17,18] We report data for Cape and African White-backed vultures (Accipitriformes: Accipitridae) as they constituted the majority of VulPro's rehabilitation cases during the study period.

The Cape vulture is listed as "Endangered" with a global breeding population estimated at 4,700 pairs.[19, 20] This *Gyps* species is a slow-maturing, wide-ranging, social cliff-nesting vulture endemic to southern Africa, with a body mass of ca. 9 kg.[21,22,23] The African White-backed vulture is listed as "Critically Endangered" with an estimated 3,700 breeding pairs remaining in South Africa, although the species ranges over much of sub-Saharan Africa.[24,25] This is a tree-nesting species with age of first annual breeding at four years and body mass of ca. 6 kg.[21,26]

Data collection

We assembled all VulPro's rehabilitation admissions between 01 January 2007 and 31 December 2018 and recorded the following details: date; species; body condition; age; injury type(s); and probable cause of injury, based on available information. All data were recorded at the time of admission and entered immediately into the RaptorMed medical records software program.[27] Admissions were classified according to a single main cause of injury based on available evidence. Reported mortalities without admission to the facility and individuals that died upon arrival were excluded from the analysis.

Data analysis

The causes of injury and outcomes (whether the bird was released, died, or was euthanized) were tabulated, and descriptive statistics calculated to allow for comparisons between the two species; age cohorts within each species; and release status (i.e. released or not released).[28,29] Age classes, based on Mundy et al.,[21] were defined as "nestling" (less than 6 months); "juvenile" (6 months to 1 year); and "mature" which included immature (2 to 4 years), sub-adult (5 to 6 years) and adult (more than 6 years) birds. Causes of injury were divided into seven categories: i) "powerlines": interactions with electrical powerlines, such as collisions and electrocutions; ii) "weather": weather-related conditions, such as heat stroke causing grounding or dehydration; iii) "poison": unintentional or intentional poisoning; iv) "other": other anthropogenic causes, such as nest disturbance, captures, shootings, and fence entanglements; v) "natural": naturally-occurring factors, such as nutritional (e.g. calcium) deficiencies, near-drowning, bee-stings, and hard landings; and vii) "unknown": unknown causes.

Release rate was measured as the proportion of the number of birds released each year compared with the total number admitted yearly. Releases typically occurred after an acclimation period in in an off-site release enclosure, located 60 km from VulPro, at the Nooitgedacht Cape vulture colony and vulture restaurant in the Magaliesberg Mountains.[17] Each bird was assessed for release readiness by examination of its body condition and flight capability.[9,30] The number of days in rehabilitation was calculated from the admission date to the date of release. Mortality rates were measured as the proportion of total yearly mortalities compared with total yearly admissions for each injury category.

We applied generalized linear models (GLM) using the Package lme4[31] in the program R version3.6.2[32] to ascertain whether release and mortality rates of vultures admitted into the rehabilitation facility (our two response variables) were influenced by the cause of injury, number of days in rehabilitation, age class of the bird, or species. We fitted our data to a binomial distribution. We compared models based on their Akaike's Information Criterion (AIC) values obtained through the AIC tab function in the R package AICcmodavg.[33] We considered all models within 2 AIC points of the top model as competing models. We evaluated beta estimates of variables at 95% confidence intervals (CI) in competing models and considered those that did not include 0 to be relevant.

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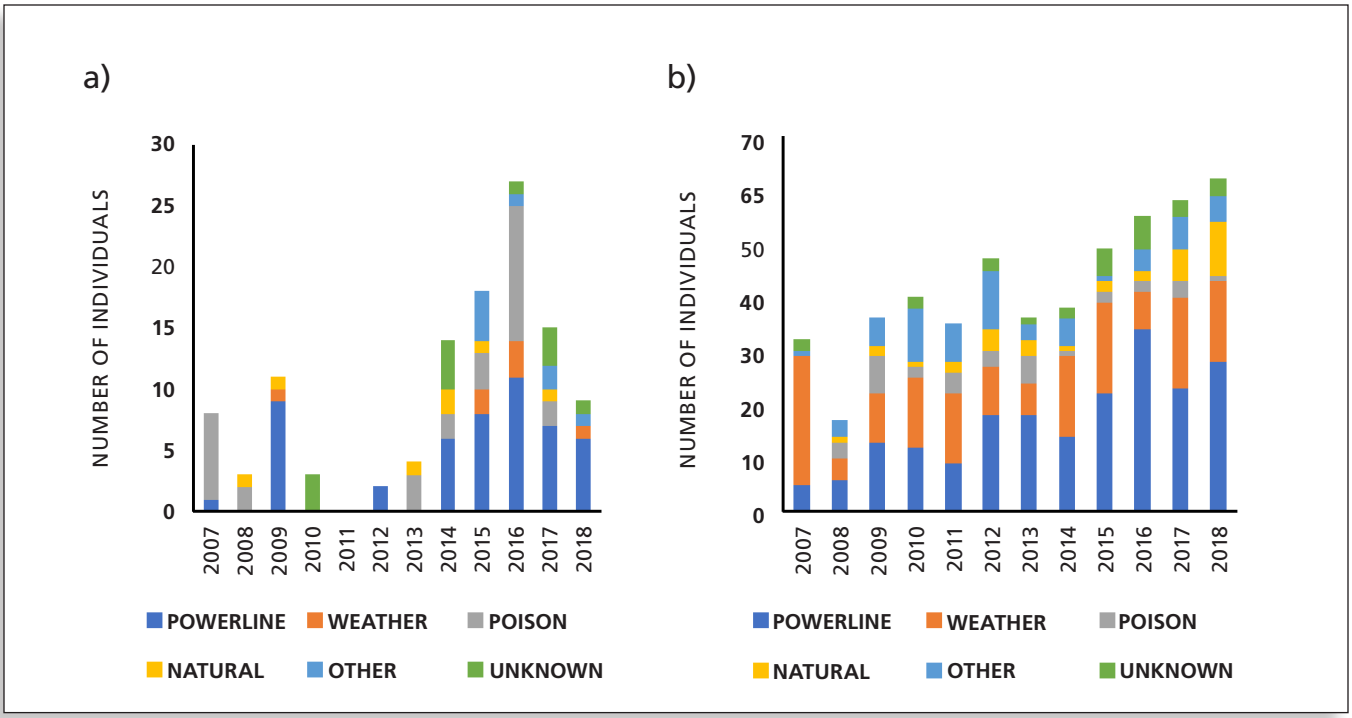


FIGURE 1. Number of: a) African White-backed vultures; and b) Cape vultures, admitted and categorized by cause of injury and year. See Methods for definition of the various causes of injury. *Legend colour key:* Powerlines = Dark blue. Weather = Orange. Poison = Grey. Natural = Yellow. Other = Light blue. Unknown = Green.

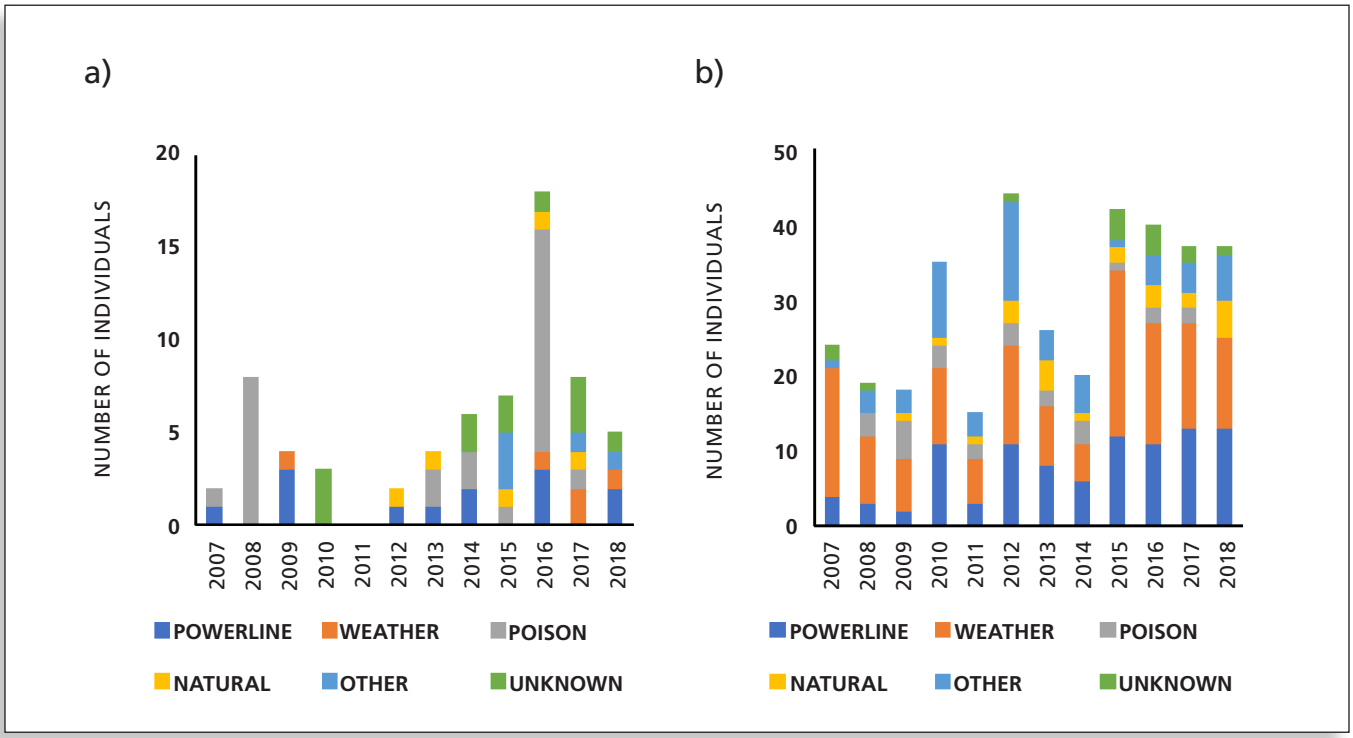


FIGURE 3. Number of birds released of a) African White-backed vultures and b) Cape vultures, categorized by cause of injury and year. Legend colour key: Powerlines = Dark blue. Weather = Orange. Poison = Grey. Natural = Yellow. Other = Light blue. Unknown = Green.

TABLE 1. The number of admitted and released Cape and African White-backed vultures 2007–2018 by age and cause of injury with their associated release rate.

INJURY	OTHER			NATURAL			POISON			POWERLINE			UNKNOWN			WEATHER		
	Admitted	Released	Rate (%)	Admitted	Released	Rate (%)	Admitted	Released	Rate (%)	Admitted	Released	Rate (%)	Admitted	Released	Rate (%)	Admitted	Released	Rate (%)
AFRICAN WHITE-BACKED VULTURE	**9**	**1**	**11**	**8**	**2**	**25**	**33**	**18**	**55**	**55**	**4**	**7**	**15**	**3**	**20**	**12**	**8**	**67**
Mature	4	0	0	2	0	0	15	6	40	16	0	0	3	0	0	2	0	0
Juvenile	3	1	33	6	2	33	18	12	67	39	4	10	12	3	25	10	8	80
Nestling	2	0	0	0	0		0	0	0	0	0	0	0	0		0	0	
CAPE VULTURE	**68**	**41**	**60**	**43**	**27**	**63**	**34**	**19**	**56**	**229**	**45**	**20**	**28**	**5**	**18**	**158**	**129**	**82**
Mature	8	5	63	2	1	50	14	11	79	65	15	23	15	2	13	13	11	85
Juvenile	59	36	61	41	26	63	20	8	40	164	30	18	12	3	25	145	118	81
Nestling	1	0	0	0	0		0	0	0	0	0	0	1	0	0	0	0	
TOTAL	**77**	**42**		**51**	**29**		**67**	**37**		**284**	**49**		**43**	**8**		**170**	**137**	

TABLE 2. The number of admitted and deceased Cape and African White-backed vultures 2007–2018 by age and cause of injury with their associated mortality rate.

INJURY	OTHER			NATURAL			POISON			POWERLINE			UNKNOWN			WEATHER		
	Admitted	Deceased	Rate (%)	Admitted	Deceased	Rate (%)	Admitted	Deceased	Rate (%)	Admitted	Deceased	Rate (%)	Admitted	Deceased	Rate (%)	Admitted	Deceased	Rate (%)
AFRICAN WHITE-BACKED VULTURE	**9**	**4**	**44**	**8**	**4**	**50**	**33**	**11**	**33**	**55**	**17**	**31**	**15**	**8**	**53**	**12**	**0**	**0**
Mature	4	3	75	2	2	100	15	7	47	16	5	31	3	2	67	2	0	0
Juvenile	3	0	0	6	2	33	18	4	22	39	12	31	12	6	50	10	0	0
Nestling	2	1	50	0	0	0	0	0		0	0		0	0		0	0	
CAPE VULTURE	**68**	**18**	**27**	**43**	**9**	**21**	**34**	**7**	**21**	**229**	**66**	**29**	**28**	**12**	**43**	**158**	**18**	**11.4**
Mature	8	2	25	2	0	0	14	0	0	65	13	20	15	6	40	13	2	15.4
Juvenile	59	16	27	41	9	22	20	7	35	164	53	33	12	5	42	145	16	11.0
Nestling	1	0	0	0	0		0	0		0	0		1	1	100	0	0	
TOTAL	**77**	**22**		**51**	**13**		**67**	**18**		**284**	**83**		**43**	**20**		**170**	**18**	

Results

Admissions

Across the study period, a total of 692 vultures were admitted to the facility, of which 560 were Cape vultures and 132 African White-backed vultures. Combining all years, powerlines were the cause of most admissions, followed by poisoning for African White-backed vultures (Fig. 1a), and weather-related injuries for Cape vultures (Fig. 1b). Powerline injuries, including both collisions and electrocutions, constituted the greatest proportion of the total annual admissions each year for Cape vultures, apart from 2007 and 2011 when weather-related injuries were higher (Fig. 1b).

CONTINUED ON PAGE 20

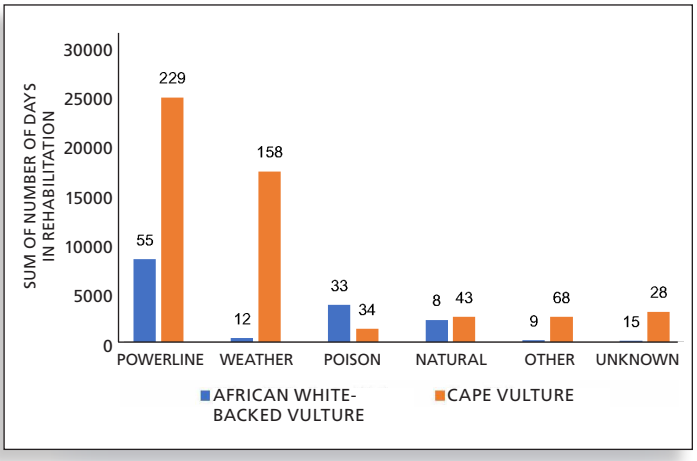


FIGURE 2. The average number of days in rehabilitation of Cape and African White-backed vultures between 2007-2018, by cause of injury. The total number of admissions in each category is indicated above each bar. African White-backed vultures indicated in blue and Cape vultures indicated in orange.

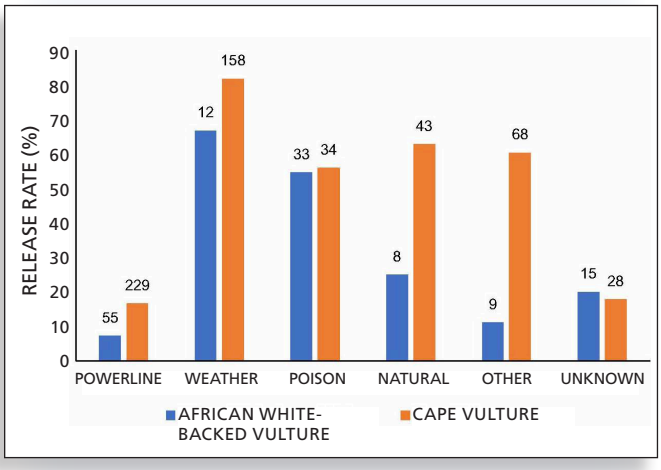


FIGURE 4. Release rates of African White-backed and Cape vultures from 2007 to 2018, categorized by cause of injury. The total number of admissions in each category is indicated above each bar. African White-backed vultures indicated in blue and Cape vultures indicated in orange.

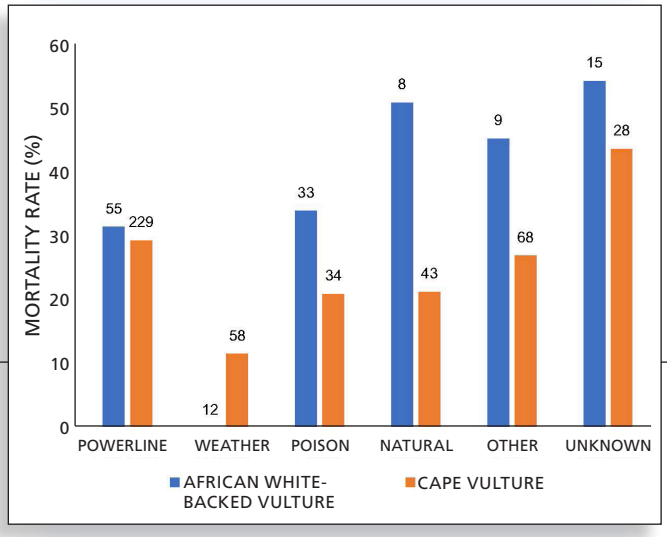


FIGURE 5. Mortality rates of African White-backed and Cape vultures between 2007 and 2018. The total number of admissions is indicated above each bar. African White-backed vultures indicated in blue and Cape vultures indicated in orange.

TABLE 3. Results from GLM investigating whether release rates of vultures admitted into the rehabilitation facility were influenced by cause of injury, number of days in rehabilitation, age class of the bird, or species. The number of estimated parameters is indicated by 'n'. The models are arranged from best (top of table) to worst (bottom) based on the corrected Akaike's information criteria (AICc). Included is the difference in AICc from the best model (delta AICc), and the weight of each model (AICc weights).

MODEL	N	AICc	DELTA AICc	AICc WEIGHTS
Global	9	610.9830	0.0000	0.9262
Cause & Days	7	616.0428	5.0599	0.0738
Days & Species	3	709.5805	98.5975	0.0000
Days & Age	3	719.4778	108.4949	0.0000
Days	2	719.7064	108.7235	0.0000
Cause & Species	7	722.7293	111.7764	0.0000
Cause	6	732.5971	121.6141	0.0000
Cause & Age	7	734.1589	123.1759	0.0000
Species	2	911.9929	301.0100	0.0000
Age	2	920.3575	309.3746	0.0000
Null	1	929.0852	318.1022	0.0000

TABLE 4. Results from GLM investigating whether survival rates of vultures admitted into the rehabilitation facility were influenced by cause of injury, number of days in rehabilitation, age class of the bird or species. The number of estimated parameters is indicated by 'n'. The models are arranged from best (top of table) to worst (bottom) based on the corrected Akaike's information criteria (AICc). Included is the difference in AICc from the bestmodel (delta AICc), and the weight of each model (AICc weights).

MODEL	N	AICc	DELTA AICc	AICc WEIGHTS
Global	9	659.5958	0.0000	0.5776
Cause & Days	7	660.2221	0.6263	0.4224
Days & Species	3	693.8905	34.2946	0.0000
Days	2	700.9000	41.3041	0.0000
Days & Age	3	701.7191	42.1232	0.0000
Cause & Species	7	713.0998	53.5040	0.0000
Cause	6	714.0609	54.4651	0.0000
Cause & Age	7	715.2739	55.6781	0.0000
Species	2	726.9921	67.3963	0.0000
Null	1	731.3107	71.7149	0.0000
Age	2	733.3063	73.7104	0.0000



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White-backed vulture in flight.

The number and causes of African White-backed vulture admissions were more variable, with poisoning constituting the greatest proportion of admissions in 2007, 2008, and 2013; but there were no poisoning admissions in 2011 (Fig. 1a). The overall number of yearly admissions increased from 20 to 40 birds in 2007 and 2008, to over 70 birds in 2016, 2017, and 2018 (Fig. 1a and 1b).

Days in rehabilitation

African White-backed vultures admitted due to natural causes had the longest rehabilitation time, averaging 291 days, while powerline-related injuries and poisoning required an average of 156 days and 117 days recovery time, respectively (Fig. 2, page 19). Unknown causes had the shortest average time to release of just 11 days (Fig. 2). The longest rehabilitation period for Cape vultures was due to unknown causes, weather, and powerline-related injuries, with an average range of 110–114 days (Fig. 2). Poisoning and "other" causes had the shortest average time in rehabilitation for Cape vultures, with 39 and 42 days, respectively (Fig. 2). However, when both species were combined, birds admitted with powerline-related injuries had the longest time in rehabilitation, averaging 119 days (Fig. 2).

Releases and release rate

Across the study period, a total of 302 vultures were released, of which 266 were Cape vultures and 36 African White-backed vultures. Of the African White-backed vultures released, the single most predominant cause for admission was poisoning, whereas for Cape vultures it was weather-related injuries (Fig. 3, page 17). An average of 22 vultures were released per year, with the highest number released in 2016. The greatest number of releases of African White-backed vultures occurred in 2016, the majority of which were from poisoning cases (Fig. 3a). Weather-related admissions and the "other" category equally contributed 13 Cape vulture individuals for release of 44 total birds released, making 2012 the most successful year (Fig. 3b). Individuals admitted with injuries due to adverse weather had the highest release rate for both African white-backed and Cape vultures, at 66.7% and 81.7%, respectively (Table 1, Fig. 4). The lowest release rates for both African white-backed and Cape vultures were caused by powerline collisions and electrocutions, with only 7.3% of 55 African White-backed vultures and 16.7% of the 229 Cape vultures released with these injuries (Table 1, Fig. 4). The mean release rate across all years and for both species for all causes was 43.6%.

The global model that included all factors (cause of injury, days in rehabilitation, age, species) was the best-performing model for the probability of release (Table 3). Within this top model, the following variables did not have CI crossing zero and were deemed relevant: causes of injury as "natural", "poison", "weather", and "other"; the number of days in rehabilitation; and species. However, the "unknown" category cause of injury and age class of the bird had CIs crossing zero, and were therefore not deemed as relevant variables. There were no competing models, with the second-best model having a delta AICc >5.

Mortality rate

Injuries due to "unknown" resulted in the highest mortality rate for both African white-backed and Cape vultures, at 53.3% and 42.9%, respectively (Table 2, Fig. 5). The lowest mortality rates for African white-backed and Cape vultures were those associated with injuries by adverse weather conditions, with 0% and 11.4%, respectively, of the 158 admitted vultures (Table 2, Fig. 5).

Higher mortality rates for mature African White-backed vultures were observed in all injury categories in comparison with juvenile and nestling age classes (Table 2). Conversely, higher mortality rates in Cape vultures were observed in juveniles due to natural factors (22.0%), poisoning, powerline-related injuries, and unknown causes of injury, while mortality rates were higher in adults for weather-related (15.9%) and "other" (25.0%) causes of injury (Table 2, Fig. 5). The best model was the global model that included all the variables (cause of injury, age class of the bird, days in rehabilitation, species) (Table 4). Within the top model, the following variables did not have CI crossing zero and were

therefore deemed relevant: causes of injury as "poison", "weather" and "other"; the number of days in rehabilitation; and species. However, the "unknown" and "natural" causes of injury and age class of the bird had CIs crossing zero and were therefore not deemed as relevant variables. There was one competing model (delta AICc < 0.7) that included the cause of injury and days in rehabilitation (Table 4). The same variables were again deemed relevant as for the top model, except for species.

Discussion

Electrical powerline-related injuries had the lowest release rate and highest number of admissions, while the highest release rates were injuries due to weather-related events or poisons, with rates >55% for Cape and African White-backed vultures. Although we did not differentiate between the types of powerline-related injuries, these results are supported by the findings of Naidoo et al.[13] that the major cause of preventable injuries in South African vultures is collision with electrical infrastructure, causing skeletal and soft tissue damage. Furthermore, since the Naidoo et al.[13] study was based on data from the same rehabilitation facility as this one, our current study demonstrates that electrical infrastructure remains one of the most important threats to vultures in this region.

Our observations also broadly match those reported by Thompson et al.,[14] at another rehabilitation centre in South Africa, but differ in one major aspect; they reported collisions with vehicles as a major cause of injury to raptors generally, whereas this was not the case for vultures in this study. This suggests that vultures may be less prone to collisions with vehicles, perhaps because they have an aversion to scavenging along roads as compared with other raptors, like owls.[34]

The single most important cause of injury of vultures (41.0%) admitted to VulPro over the 12-year study period was negative interactions with electrical infrastructure. Rehabilitation centers across the globe have reported increasing admissions from collisions with resulting traumatic injuries,[10, 28,35,36] although most previous studies have not described the type of infrastructure causing the collision injury (which may include collisions with vehicles). For example, all vehicle and infrastructure collisions were reported as one injury category, which was also the most frequent cause of admission for raptors, in the the Canary Islands (>2,600 admissions).[36] Interestingly, they also noted an increase in collision-related cases over the 10-year study period, with only 44.4% of their cases released, which compares to the 43.6% release rate of this study.[36] Our powerline-related injury release rate of 43.6% is notably higher than that reported by Punch[28] as 27% for 104 falcons and owls admitted to an Australian Veterinary Hospital from 1994–1998. However, Komnenou et al.[35] had a higher post-collision release rate of 56.9% (n = 402) of all rehabilitated raptors compared to this study; but this figure only included fourteen Eurasian griffon vultures (*Gyps fulvus*) during a 3-year period.

We ascribe the large difference in release rates between African white-backed (11.1%) and Cape vultures (60.3%) in the "other" category due to the difference in sample sizes (9 versus 68, respectively) and large variety in types of injuries. The African White-backed vultures were injured mostly as a result of colliding with fences, whereas a large proportion of the Cape vultures were admitted after being trapped or captured. The difference in sample sizes between species and specific injuries may also explain the large discrepancy between the release rates of birds suffering from natural causes (25.0% versus 62.8% in African white-backed and Cape vultures, respectively). Developmental problems and injuries sustained in the nest before fledging affected eight African White-backed vultures, prolonging rehabilitation and release, as compared to calcium deficiencies, lack of experience, bee stings, and rescues from water reservoirs, which affected 43 Cape vultures.

As in our study, European rehabilitation datasets have also reported unknown causes as representing the largest percentage of admissions in the long term.[10,29] Therefore, we suggest investment in diagnostic techniques and veterinary resources, to address the identification of causes of injury, should be a priority for African rehabilitation centers that deal with vultures and other large and endangered birds. The lack of avian orthopedic professionals and specialized facilities needed to perform invasive procedures required to treat the severe dislocations, fused fractures and broken bones caused by collisions is arguably the main reason for the low release rate from powerline injuries reported in this study.[37]

Time spent in rehabilitation was a significant factor in the statistical models predicting the release and mortality rates of Cape and African White-backed vultures, as the cause of injury greatly influences the recovery period (Tables 3 and 4).[9, 38]

Our survival rates are lower than those reported for Australian rehabilitated raptors (50%);[28] this study also reported the lowest release rates for individuals suffering from collisions, again corroborating our results. However, much lower release rates from poisoning cases (6.9% and 3.0%) were observed by Greek and Canary Island rehabilitation centers, respectively, than reported here.[35,36] This may be due to the numerous different types of poisoning methods being used in Africa as compared with Europe, such as intentional persecution; unintentional poisoning resulting from predator control efforts, livestock and veterinary drugs; as well as sentinel poisoning, whereby illegal hunters contaminate carcasses to conceal illicit activities of ivory and rhino poaching.[3,7,39] Unfortunately, there is limited information on the types of poisons used, with the majority of cases being organophosphate substances in this study (K. Wolter, pers. obs.).

Retrospective and long-term datasets of rehabilitation centers are proving invaluable to identifying threats to wild populations. For example, the United States Geological Survey (USGS) National Wildlife Health Centre database was instrumental in identifying the scale of fatal electrocutions and collisions associated with powerlines for bald and golden eagles in the USA.[8] In a similar light, the outcomes of this study should be used to advise energy infrastructure companies in South Africa and neighboring

states on the importance of bird-safe technologies and mitigation of powerlines for the conservation of endangered vulture species.[40]

In conclusion, our results demonstrate that release rates are highest for vultures injured by weather-related events or poisons, with rates >55% for both species. This should be considered when investing resources and targeted training at avian rehabilitation centers. Electrical powerline-related injuries had the highest number of admissions coupled with the lowest release rates, thus highlighting the importance of field mitigation measures with wildlife-friendly infrastructure. Our study also demonstrates that the successful rehabilitation and release of birds with certain types of injuries is not only feasible, but a critical tool for conserving endangered species.

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The establishment of the center is of great importance for Taiwan's promotion of wildlife conservation because the eastern area is home to a wide variety of wildlife species, Huang noted.

None of the seven existing government-designated wildlife rescue centers in Taiwan are located in the east. They are in Taipei, Nantou, Taichung, the outlying island county of Penghu, and in the south, according to the association.

In the past few years, when wild animals were injured in eastern Taiwan, they had to be sent to either a wildlife rehabilitation facility set up by National Pingtung University of Science and Technology (NPUST) in southern Taiwan or Taipei Zoo in the north, Huang said, adding that the establishment of the new center will help boost Taiwan's successful rescue rate for wild animals.

According to Forestry Bureau statistics, a total of 576 endangered pangolins and wild animals on the verge of extinction have been rescued around Taiwan over the past five years, and 304 of them have been returned to the wild after being treated.

In the past five years, the number of rescued animals in Hualien and Taitung in the east rose from 143 in 2015 to 319 in 2019, the data showed.

Commenting on the public–private partnership operational model of the new center, Lin said that it is adopted by learning from the experience of advanced countries. Chi said that public–private collaboration will make people jointly care about the ecology.



PHOTO © TIM MCFARLANE, CC 2.0.

A subtle detail of the Gothic entryway at the Penn Mutual Tower in Philadelphia.

Decentralizing Rapid Response Wildlife Disease Screening

ST LOUIS, USA (July 10, 2020)—Writing in the journal "Science" this month, a group of authors including FPI leadership and researchers from the USA, Germany, the UK, and Australia advocate for large-scale, proactive wildlife pathogen screening.

Of particular concern are the human–wildlife interfaces where people commonly come into direct contact with wildlife. This may occur when animals are hunted for sustenance, but the risk is amplified at places such as wildlife markets, where many different species are often kept in close proximity with poor biosecurity and limited health and safety standards.

Presently, most wildlife disease testing is done reactively after an outbreak, and often the advanced laboratories used for molecular analysis exist far from where spillovers are most likely to occur. The authors note that the overwhelming majority of existing reference labs for animal pathogens do not exist at zoonotic hotspots where EID risk is greatest, such as Southeast Asia, Africa, and Central and South America. However, this no longer needs to be the case, as the technologies used for detecting pathogens via genome sequencing have become affordable and practical for use in even remote locations. In situ training programs for field lab protocols can rapidly produce competent technicians, opening avenues for local control over public health and research priorities.

"Portable sequencing technology with low power requirements and small footprints has become affordable today, unlike ten years ago right after the H1N1 pandemic," said Mrinalini Watsa, senior scientist at Field Projects International. "We have demonstrated in prior projects that this technology can be utilized in tropical rainforest requirements, and training provided to competent local scientists, of which there is no scarcity. Simply providing access to technology reduces inequity and increases participation in biosurveillance methods."

A decentralized approach to biosurveillance not only allows for a greater volume of data to be collected, but it is also resistant to the shifting socio-political climates that affect funding priorities for more expensive centralized efforts.

"We are not implying that our model is better than what others have been doing up to this time. COVID-19 has made it clear where the gaps are, and our vision for global biosurveillance can address those gaps, namely, that the majority of the world, and especially locals in zoonotic hotspots, do not have the resources to participate in spillover surveillance," commented Gideon Erkenswick, co-Founder of FPI and Post Doctoral Researcher in the Infectious Diseases Division of the Washington University in St. Louis School of Medicine. "Anyone can be trained to collect sequence data that is shared and analyzed instantaneously in the 'cloud.'" This will allow all stakeholders to be in the loop, from the grassroots and up.

In addition, the authors recommend that international biosecurity standards

for managing wildlife trade also be established based on taxa-specific disease risks. However, they emphasize that this must be implemented carefully to avoid stigmatizing certain animals and triggering fearful human behaviors that threaten species welfare and survival. One of the goals of increased pathogen screening for wildlife (along with complimentary human testing programs) is to inform conservation efforts by detecting threats to nonhuman populations as well.

Fundamentally, the authors advocate for a strategy of wildlife disease surveillance that is in line with the "One Health" concept focusing on interactions and equilibrium among human and natural systems. Public health is inextricable from animal health and ecological function, necessitating a multidisciplinary approach to manage risks to each. The proposed disease monitoring network also depends on the enhanced agency and participation of under-resourced localities that are most at-risk, underscoring a necessary social justice component to this framework.

UPenn Leads US Research into Bats and COVID

PHILADELPHIA, USA (July 8, 2020)—COVID-19 is a zoonotic disease. For the 200+ bats currently in wildlife rehabilitation facilities across Pennsylvania, this presents a threat. Eman Anis, a microbiologist with Penn Vet's New Bolton Center, is leading a study to test for the presence of SARS-CoV-2 in North American bats, work being done with associate professors Lisa Murphy and Julie Ellis and Pennsylvania Game Commission biologist Greg Turner.

Because the School of Veterinary Medicine and the Pennsylvania Game Commission began collaborating in 2019 on the Pennsylvania Wildlife Futures Program to address wildlife health problems, they were able to shift quickly to COVID-19 research. Now, the team is developing a rapid diagnostic test using bat guano sent from local wildlife rehabilitation centers.

The researchers' goal is to verify that bats held over the winter in rehab facilities will not transmit disease. "When you do these tests, you're trying to ask questions," says Murphy. "Can bats harbor it? Do bats in Pennsylvania harbor it?"

Testing the guano of North American bats for COVID-19 ties into Penn Vet's One Health focus, which recognizes that human, animal, and environmental health are interrelated and that an adverse event in any one of these areas may also adversely impact the others, Murphy says. "With disease, humans, animals, and the environment can all play key roles in transmitting and maintaining harmful pathogens. Identifying the role that each plays can be the first step in understanding how to stop or prevent further harm," she says.



PHOTO ©BLM: LISA MCNEE. CC BY

Biologists search Oregon's Derrick Cave for bat guano.

There is no evidence that North American bat populations currently harbor COVID-19 or other beta-coronaviruses like MERS and SARS, but there is a possibility that humans could transmit disease to bats, Anis says. This would present a public health risk and is one of the impacts her study will mitigate. "We don't want have another reservoir where they can transfer it back to humans," she says.

Pennsylvania is home to nine species recognized as resident breeding bats, according to the Game Commission. As bats are able to be a reservoir for most coronavirus strains, they are likely to contract COVID-19 if exposed, Turner says. While the animals are generally able to survive a dormant coronavirus, many North American bats are already stressed due to white-nose syndrome. This presents the risk that the virus would become active and cause an additive mortality factor on top of white-nose syndrome, which has decimated many bat species.

The New Bolton Center team began work on this project at the end of April, and Anis says the team is "very confident that we'll be able to complete and validate the test and have it up and running soon. Our first goal is to help the rehab populations to release their overwintered bats, and we hope to expand beyond that."

While the current study is targeted to a very specific population and need, it has larger implications, says Murphy. "Why does this matter now? We have an immediate need," she says. Most wildlife rehabilitation facilities are staffed with volunteers and funded via donations. During the pandemic, most are operating with a skeleton crew and limited financial resources, continuing to feed and care for overwintered bats that are ready to be released into the wild. "To the specific populations of bats in Pennsylvania and people who are caring for them, it really does matter, it matters now, and we have no data" to inform their decisions, Murphy says. "We're going to address a very specific need, but, in terms of where it can go from there, the ramifications and the benefits, this is only the first step."

"In terms of thinking about what animal species may be susceptible to this

virus, it doesn't just stop with bats," she says, citing evidence that weasels and ferrets are able to contract COVID-19, as can other animals. "This disease is going to be with us, and is going to be a question and a concern for human and animal health for quite some time," she says.

—Kristina García, UPenn

$214,000 Granted to Western Australia Wildlife Rehabilitators

PERTH, Australia (July 2, 2020)—The McGowan Government has announced the successful recipients of the Wildlife Heroes Wildlife Rehabilitation and Emergency Response Grants 2020.

Environmental Minister Stephen Dawson notes, "By investing in this program, we are providing licensed rehabilitators with the opportunity to expand their knowledge and resources to ensure sick and injured native animals receive the care they need to hopefully return back to the wild."

The one-year grant will see 38 licensed wildlife rehabilitators share in $214,000 (AUD) to provide care for sick and injured native wildlife for release back into the wild.

Recipients may use funds for relevant items, such as to purchase specialist equipment, animal food, first aid supplies, veterinary support, reference materials and development and implementation of training courses. ■

SELECTED ABSTRACTS

Singing in a silent spring: Birds respond to a half-century soundscape reversion during the COVID-19 shutdown

EP Derryberry, JN Phillips, GE Derryberry, MJ Blum, and D Luther. *Science*, 24 Sep 2020: eabd5777. https://doi.org/10.1126/science.abd5777

Actions taken to control the coronavirus disease 2019 (COVID-19) pandemic have conspicuously reduced motor vehicle traffic, potentially alleviating auditory pressures on animals that rely on sound for survival and reproduction. Here we evaluate whether a common songbird responsively exploited newly emptied acoustic space by comparing soundscapes and songs across the San Francisco Bay Area prior to and during the recent statewide shutdown. We show that noise levels in urban areas were dramatically lower during the shutdown, characteristic of traffic in the mid-1950s. We also show that birds responded by producing higher performance songs at lower amplitudes, effectively maximizing communication distance and salience. These findings illustrate that behavioral traits can change rapidly in response to newly favorable conditions, indicating an inherent resilience to long-standing anthropogenic pressures like noise pollution.

PHOTO © CINDY MC. CC BY-NC 2.0 LICENSE.



White-crowned sparrows (*Zonotrichia leucophrys*) have been known to sing throughout the night.

Towards a more effective model of wildlife care and rehabilitation: A survey of volunteers in New South Wales, Australia

R Haering, V Wilson, A Zhuo, and P Stathis. *Australian Zoologist*, 2020:40(4),605–627. https://doi.org/10.7882/AZ.2019.018

The provision of wildlife rescue and rehabilitation services in New South Wales (NSW) relies heavily on the volunteer sector. The NSW Government regulates the sector and is responsible for identifying measures for its support and delivery of services. To inform this process, we undertook an extensive review of the sector. We report here on the results from our survey of NSW volunteer wildlife rehabilitators, who have collectively reported over 1,000,000 rescues of sick and injured free-living wildlife over the past 16 years. The survey provided a unique insight into the demographics of the sector, the challenges faced, and the value of their contribution to wildlife rehabilitation. Volunteers' views on the operation of wildlife rehabilitation providers cover five key areas: governance, training, standards of care, service capacity and reporting, as well as the support received from other stakeholders, NSW Wildlife Council (the peak body for the sector), veterinary professionals and government. We found that the volunteer wildlife rehabilitation sector in NSW provides a significant public good that is of high value to the environment, community and government. We make recommendations for investment and strategic improvements to the capacity of the sector to continue to deliver services including transitioning wildlife rehabilitation providers towards a system of accreditation in the future.

Characterizing trends in human–wildlife conflicts in the American Midwest using wildlife rehabilitation records

RB Long, K Krumlauf, and AM Young. *PLoS ONE*, 2020:15(9):e0238805. https://doi.org/10.1371/journal.pone.0238805

Human–wildlife conflict is difficult to measure, but the analysis of records from wildlife rehabilitation facilities has shown potential as a

technique for characterizing human impacts on wildlife. To examine the value of wildlife rehabilitation records for characterizing local human–wildlife conflicts and prevalence of select wildlife diseases, we reviewed 45,668 records representing over 280 species admitted to a wildlife rehabilitation facility over a 10-year period (2005–2014). We identified the most frequently recorded causes of admission for commonly admitted species, and evaluated how causes of admission may vary across taxa throughout the year. Our analyses support the value of wildlife rehabilitation facility data for characterizing some pressures from human-wildlife conflict and select disease trends for certain taxa, as well as utility for informing topics to emphasize in local conservation education efforts. For example, orphaned neonatal wildlife accounted for the largest proportion of admissions to this facility, and highlights a opportunity for conservation education regarding when wildlife is truly orphaned and requires professional intervention. Additionally, domestic dog attack cases accounted for a proportion of admissions comparable to that of domestic cat attacks, demonstrating a need for the conversation surrounding the impact of domestic pets on local wildlife to expand to include dogs in addition to cats.

Evolutionary dynamics in the Anthropocene: Life history and intensity of human contact shape antipredator responses.

B Geffroy, B Sadoul, BJ Putman, O Berger-Tal, LZ Garamszegi, AP Møller, and DT Blumstein. *PLOS Biology*, 22 Sept 2020. https://doi.org/ 10.1371/journal.pbio.3000818

Humans profoundly impact landscapes, ecosystems, and animal behavior. In many cases, animals living near humans become tolerant of them and reduce antipredator responses. Yet, we still lack an understanding of the underlying evolutionary dynamics behind these shifts in traits that affect animal survival. Here, we used a phylogenetic meta-analysis to determine how the mean and variability in antipredator responses change as a function of the number of generations spent in contact with humans under 3 different contexts: urbanization, captivity, and domestication.



PHOTO © JOHN PEARCE, USGS. PUBLIC DOMAIN.

Recent study suggests the effects of human contact upon fear of predators in wildlife is predictable and measurable.

We found that any contact with humans leads to a rapid reduction in mean antipredator responses as expected. Notably, the variance among individuals over time observed a short-term increase followed by a gradual decrease, significant for domesticated animals. This implies that intense human contact immediately releases animals from predation pressure and then imposes strong anthropogenic selection on traits. In addition, our results reveal that the loss of antipredator traits due to urbanization is similar to that of domestication but occurs 3 times more slowly. Furthermore, the rapid disappearance of antipredator traits was associated with 2 main life-history traits: foraging guild and whether the species was solitary or gregarious (i.e., group-living). For domesticated animals, this decrease in antipredator behavior was stronger for herbivores than for omnivores or carnivores and for solitary than for gregarious species. By contrast, the decrease in antipredator traits was stronger for gregarious, urbanized species, although this result is based mostly on birds. Our study offers 2 major insights on evolution in the Anthropocene: (1) changes in traits occur rapidly even under unintentional human "interventions" (i.e., urbanization) and (2) there are similarities between the selection pressures exerted by domestication and by urbanization. In all, such changes could affect animal survival in a predator-rich world, but through understanding evolutionary dynamics, we can better predict when and how exposure to humans modify these fitness-related traits.

Associated article in *Science News*: "**Animals lose fear of predators rapidly after they start encountering humans.**" https://www.sciencedaily.com/releases/2020/09/200922144323.htm

Using wildlife carer records to identify patterns in flying-fox rescues: a case study in New South Wales, Australia

M Mo, M Roache, R Haering, and A Kwok. *Pacific Conservation Biology*, 2020. https://doi.org/10.1071/PC20031

Injured flying-foxes (*Pteropus* spp.) are frequently taken into care in eastern Australia. In particular, the grey-headed flying-fox (*P. poliocephalus*), a vulnerable species, is affected by several threats, which are partly mitigated through rescue and rehabilitation. This study examined patterns in flying-fox rescues in New South Wales (NSW) between 2011–12 and 2016–17 using annual reporting data from wildlife rehabilitation organisations. Specifically, we examined (1) species and demographic patterns in flying-foxes rescues; (2) the geographical distribution of flying-fox rescues; (3) reported causes of injury; and (4) release rates of rehabilitated flying-foxes. *P. poliocephalus* accounted

for the largest proportion of flying-fox rescues. Most rescues occurred in coastal regions, with more than one-third of *P. poliocephalus* rescues occurring in the Sydney region and more than one-third of black (*P. alecto*) and little red (*P. scapulatus*) flying-fox rescues occurring on the NSW Far North Coast. A broad range of factors was involved in flying-foxes coming into care, the main ones being entanglements, heat stress, orphaned pups, and electrocutions. Release rates of rehabilitated flying-foxes were high, especially in pups and juveniles. These results demonstrate the potential conservation value of flying-fox rehabilitation. High proportions of injuries caused by entanglements, heat stress and electrocutions highlight the importance of ongoing threat mitigation efforts.

Survival and conflict behavior of American black bears after rehabilitation

CD Blair, LI Muller, JD Clark, and WH Stiver. *Jour. Wild. Mgmt.*, 2020:84:75–84. doi:10.1002/jwmg.21783

Wildlife agencies face difficult situations when orphaned or injured American black bear (*Ursus americanus*) cubs (<12 months old) or yearlings (≥12 and <24 months old) are captured. One option is bear rehabilitation, the care and feeding of cubs or yearlings in a semi-natural environment, followed by release. Unfortunately, the survival and movements of bears released from rehabilitation facilities are often poorly documented and the ultimate reasons for success or failure poorly understood. Our goal was to assess survival and post-release conflict of orphaned bear cubs and yearlings following release from a rehabilitation facility, Appalachian Bear Rescue (ABR), in Townsend, Tennessee, USA, from 2015–2016. We predicted that rehabilitated bears would survive at similar rates, die from similar causes, and engage in similar conflict behavior to wild conspecifics. We equipped 42 black bear cubs and yearlings from ABR with global positioning system-collars and released them in Great Smoky Mountains National Park or Cherokee National Forest, Tennessee and North Carolina, USA. Estimated annual survival using known-fate methods for all released bears was 0.93 ± 0.06 [SE]). Survival for 13 bears released as cubs was 0.64 ± 0.14, whereas none of the bears released as yearlings died within 1 year after release (n = 29). Survival of rehabilitated bears was similar to or higher than published rates for wild conspecifics. Three of 42 bears (7.1%) released from ABR engaged in conflict behavior up to 1 year following release, and those had spent time involved in conflict behavior with their mothers (e.g., approaching humans) prior to being orphaned. Despite not having the typical post-natal experience with their mothers, the bears in our study appeared to behave and survive similarly to their wild conspecifics. Rehabilitation is effective for managing orphaned or injured bears. Best survival occurred for bears released as yearlings; however, managers can maximize cub survival through fall releases when plentiful wild foods are available.



PHOTO © VALERIE. CC BY-NC-ND 2.0 LICENSE.

American black bears (*Ursus americanus*).

Pododermatitis in raptors admitted in a wildlife rehabilitation centre in central Spain

C Rodríguez Díez, F González, I López, L Suárez, V Moraleda, and C Rodríguez. *Preventive Veterinary Medicine*, 2020:175:104875. ISSN 0167-5877. https://doi.org/10.1016/j.prevetmed.2019.104875

Pododermatitis is a chronic and progressive bacterial infectious disease of birds´ footpads, especially associated with captivity, which could represent an important problem in wildlife rehabilitation centres, delaying the release of the birds to the environment and harming their conservation. The objectives of the present study were i) to estimate the incidence rate of pododermatitis, ii) to analyse the influence of environmental, physiological, and pathological factors which may influence the onset of the infection in raptors after their admission to a rehabilitation centre, and iii) to follow up the evolution and macroscopic characteristics of the lesion. An observational retrospective study was carried out on clinical cases of raptors (n = 2004) admitted in a rehabilitation centre in central Spain from 2009 to 2015. The proportion of pododermatitis was 6.9%, with an incidence density of 6.8 cases/100 bird-years at risk. Our results showed that the disease was more likely to occur in birds staying longer ($P < 0.001$). According to Cox analysis, the variables 'raptor family' ($P < 0.001$) and 'age' ($P = 0.002$) may have significant effects on pododermatitis development. Raptors from the Falconidae and Strigidae families were less likely to develop pododermatitis than those from the Accipitridae family, with a hazard ratio (HR) of 0.31 and 0.13, respectively. Regarding age, fully feathered raptors had a three-fold higher risk of having pododermatitis than non-fully feathered birds.

Survival analysis of time of pododermatitis development revealed significant differences associated with the variables 'raptor family' ($P < 0.03$); 'age' ($P < 0.001$) and 'cause of admission' ($P = 0.001$). Duration of the pathology ($P < 0.05$) and lesion location ($P < 0.001$) seemed to be phylogenetic dependent. Injuries were primarily located in the toes area or the whole footpad of birds belonging to the Accipitridae or Falconidae families, respectively ($P = 0.003$).

Identifying the stressors impacting rescued avian wildlife

K Janssen, C Marsland, MO Barreto, R Charalambous, E Narayan. *Animals.* 2020; 10(9):1500.

Stress evaluation in wildlife is valuable tool for rehabilitation and injury prevention. This pilot study investigated categories of stress in rescued birds. We determined three categories of stressors (preliminary, primary and secondary) using clinical data of rescued birds from Adelaide, South Australia. It was discovered that birds are highly susceptible to impact injuries (e.g., flying into a building window) and vehicle-related injuries as preliminary stressors, which often result in hospitalisation of birds. Immobility and abnormal behaviour represented the most common primary stressor, while the most common secondary stressors included trauma and fracture. Furthermore, the most common outcome in clinics due to exposure of birds to these three stressor categories was euthanasia.

Eco-virological preliminary study of potentially emerging pathogens in hedgehogs (*Erinaceus europaeus*) recovered at a wildlife treatment and rehabilitation center in northern Italy

M Delogu, C Cotti, D Lelli, E Sozzi, T Trogu, A Lavazza, G Garuti, MR Castrucci, G Vaccari, MA De Marco, and A Moreno. *Animals*, 2020:10(3),407. https://doi.org/10.3390/ani10030407

The Western European hedgehog (*Erinaceus europaeus*) is one of the four hedgehog species belonging to the genus Erinaceus. Among them, *E. amurensis* is extant in East Asia's areas only, whereas *E. europaeus, E. roumanicus* and *E. concolor* are mainly found in Europe. *E. europaeus* is endemically distributed from western to central and southern Europe, including Italy. Western European hedgehogs' ecological and feeding habits, along with their high population densities, notable synanthropic attitudes, frequent contacts with sympatric wild and domestic species, including humans, implicate the possible involvement of E. europaeus in the ecology of potentially emerging viruses, such as coronaviruses, influenza A and influenza D viruses, canine distemper virus, pestiviruses and Aujeszky's disease virus. We examined 24 *E. europaeus* individuals found injured in urban and rural areas of Northern Italy. Of the 24 fecal samples collected and tested for the above-mentioned pathogens by both PCR-based and virus isolation methods, 14 were found PCR-positive for betacoronaviruses belonging to lineage C and related to the known *Erinaceus* coronaviruses (EriCoVs), as determined by partial sequencing of the virus genome. Our findings suggest that hedgehogs could be considered natural reservoirs of CoVs, and also act as chronic shedding carriers of these potentially emerging RNA viruses.

Prevalence of box turtle adenovirus in Eastern box turtles (*Terrapene carolina carolina*) presented to a wildlife rehabilitation Center in Virginia, USA

D Franzen-Klein, L Adamovicz, D McRuer, SA Carroll, JFX Wellehan, and MC Allender. *Journal of Zoo and Wildlife Medicine,* 9 January 2020:50(4),769–77. https://doi.org/10.1638/2018-0238

Eastern box turtles (*Terrapene carolina carolina*) are a native North American species with a declining population trend that may be attributable to habitat fragmentation, vehicle collisions, and disease. Adenoviral infections can cause significant morbidity and mortality in captive reptile populations. Adenoviruses have been documented in box turtles, but their occurrence and impact in wild populations are unknown. A disease survey was performed at The Wildlife Center of Virginia, USA, to assess the prevalence of box turtle adenovirus (BTAdV) in wild eastern box turtles and evaluate potential associations with clinical disease. Swabs from the oral cavity, including the choanal slit, and the cloaca were collected from 106 eastern box turtles from July 2015 through June 2016. The quantitative polymerase chain reaction (qPCR) primer detected both ornate box turtle adenovirus 1 and eastern box turtle adenovirus. The resulting qPCR adenovirus prevalence was 55.7% (n = 59). Most animals (99.3%) that tested positive for BTAdV had fewer than 100 viral copies/ng DNA. This study did not find a statistically significant association between cause of admission, age, sex, outcome, and BTAdV qPCR status. However, the probability of BTAdV detection was 1.5 times higher in rehabilitation turtles compared with wild turtles ($P = 0.01$). Albumin was significantly lower in qPCR BTAdV-positive turtles ($P = 0.007$). Hypoalbuminemia is not generally associated with adenovirus infections in other species, and no obvious clinical cause for this abnormality was identified. The results of this study suggest that eastern box turtles may harbor BTAdV infections at low levels and that infection is rarely associated with clinical disease, potentially identifying BTAdV as a host-adapted pathogen. Future studies should focus on this pathogen's ability to induce clinical disease and its potential impact on recovery efforts for this species.

Merging metagenomics and spatial epidemiology to understand the distribution of antimicrobial resistance genes from Enterobacteriaceae in wild owls

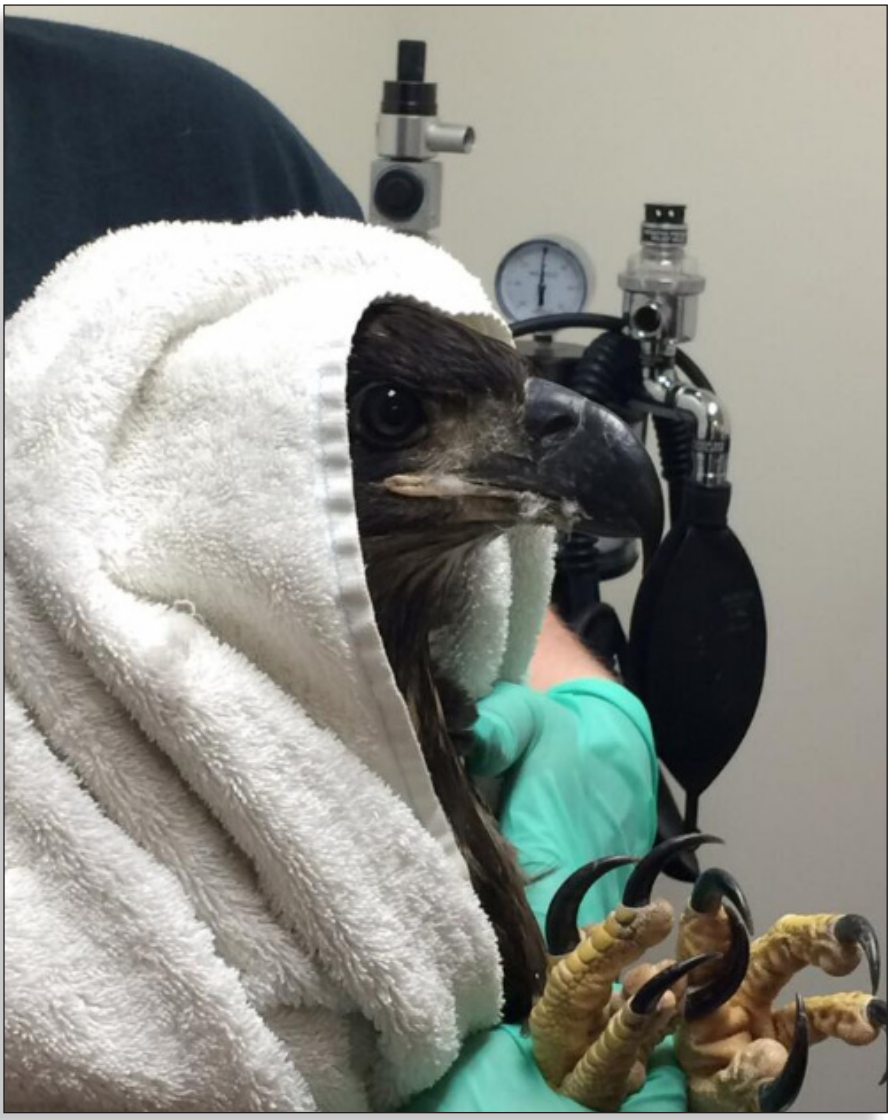
EA Miller, JB Ponder, M Willette, TJ Johnson, and KL VanderWaal. *Applied and Environmental Microbiology*, Oct 2020:86(20),e00571-20. http://doi.org/10.1128/AEM.00571-20

Antimicrobial resistance (AMR) is a well-documented phenomenon in bacteria from many natural ecosystems, including wild animals. However, the specific determinants and spatial distribution of resistant bacteria and antimicrobial resistance genes (ARGs) in the environment remain incompletely understood. In particular, information regarding the importance of anthropogenic sources of AMR relative to that of other biological and ecological influences is lacking. We conducted a cross-sectional

study of AMR in great horned owls (*Bubo virginianus*) and barred owls (*Strix varia*) admitted to a rehabilitation center in the midwestern United States. A combination of selective culture enrichment and shotgun metagenomic sequencing was used to identify ARGs from *Enterobacteriaceae*. Overall, the prevalence of AMR was comparable to that in past studies of resistant *Enterobacteriaceae* in raptors, with acquired ARGs being identified in 23% of samples. Multimodel regression analyses identified seasonality and owl age to be important predictors of the likelihood of the presence of ARGs, with birds sampled during warmer months being more likely to harbor ARGs than those sampled during cooler months and with birds in their hatch year being more likely to harbor β-lactam ARGs than adults. Beyond host-specific determinants, ARG-positive owls were also more likely to be recovered from areas of high agricultural land cover. Spatial clustering analyses identified a significant high-risk cluster of tetracycline resistance gene-positive owls in the southern sampling range, but this could not be explained by any predictor variables. Taken together, these results highlight the complex distribution of AMR in natural environments and suggest that both biological and anthropogenic factors play important roles in determining the emergence and persistence of AMR in wildlife.

Importance: Antimicrobial resistance (AMR) is a multifaceted problem that poses a worldwide threat to human and animal health. Recent reports suggest that wildlife may play an important role in the emergence, dissemination, and persistence of AMR. As such, there have been calls for better integration of wildlife into current research on AMR, including the use of wild animals as biosentinels of AMR contamination in the environment. A One Health approach can be used to gain a better understanding of all AMR sources and pathways, particularly those at the human-animal-environment interface. Our study focuses on this interface in order to assess the effect of human-impacted landscapes on AMR in a wild animal. This work highlights the value of wildlife rehabilitation centers for environmental AMR surveillance and demonstrates how metagenomic sequencing within a spatial epidemiology framework can be used to address questions surrounding AMR complexity in natural ecosystems.

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Pre-fledge bald eagle (*Haliaeetus leucocephalus*) under observation.

A schematic sampling protocol for contaminant monitoring in raptors

S Espín, J Andevski, G Duke, et al. *Ambio*, 2020. https://doi.org/10.1007/s13280-020-01341-9

Birds of prey, owls and falcons are widely used as sentinel species in raptor biomonitoring programmes. A major current challenge is to facilitate large-scale biomonitoring by coordinating contaminant monitoring activities and by building capacity across countries. This requires sharing, dissemination and adoption of best practices addressed by the Networking Programme Research and Monitoring for and with Raptors in Europe (EURAPMON) and now being advanced by the ongoing international COST Action European Raptor Biomonitoring Facility. The present perspective introduces a schematic sampling protocol for contaminant monitoring in raptors. We provide guidance on sample collection with a view to increasing sampling capacity across countries, ensuring appropriate quality of samples and facilitating harmonization of procedures to maximize the reliability, comparability and interoperability of data. The here presented protocol can be used by professionals and volunteers as a standard guide to ensure harmonised sampling methods for contaminant monitoring in raptors.



Importance of taxonomic group, life stage and circumstance of rescue upon wildlife rehabilitation in Ontario, Canada

G Kelly and J delBarco-Trillo. *Journal for Nature Conservation*, 2020:57(125897), ISSN 1617-1381. https://doi.org/10.1016/j.jnc.2020.125897

Wildlife rehabilitation is an increasingly important and global practice, aiming towards advancements in animal welfare and species conservation. Although there are ongoing discussions on the benefits and limitations of wildlife rehabilitation, there is a general agreement on the importance of wildlife rehabilitation on improving the welfare of wild animals and identifying threats to wildlife. Determining which factors lead to a successful outcome of rehabilitation can allow wildlife rehabilitation centres to best focus their resources to benefit animals with the greatest chance of a successful release. In this study, three factors affecting the success of rehabilitation were evaluated: taxonomic group, life stage and circumstance of rescue. We used a large database of patients' records (9561 animals from 198 species) from Sandy Pines Wildlife Centre (Ontario, Canada) over a three year study period (from 2015 to 2018). We found that reptiles had a higher rate of release (63.6 %), compared with mammals (42.1 %) and birds (48.3 %), although released reptiles spent longer in the centre than birds and mammals. Animals arriving to the centre in poor condition were less likely to be rehabilitated and spent longer in the centre than animals arriving in good condition. Overall, preadults were more likely to be released than adults, although the number of days spent at the centre did not differ by life stage. Animals suffering active damage (e.g. 'collision' and 'projectile') were less likely to be rehabilitated than animals suffering passive damage (e.g. arriving to the centre as 'orphan' or due to 'habitat destruction'); however, when only considering those animals that left the centre, the number of days spent at the centre did not differ between animals suffering passive or active damage. The analysis of patients' records can provide relevant information to rehabilitators about factors influencing rehabilitation efforts, which can be used to implement strategies that maximise release rates, given limited resources.

NSAIDs detected in Iberian avian scavengers and carrion after diclofenac registration for veterinary use in Spain

M Herrero-Villar, R Velarde, PR Camarero, MA Taggart, V Bandeira, C Fonseca, I Marco, and R Mateo. *Environmental Pollution*, 2020:266 Part 2;115157. ISSN 0269-7491. https://doi.org/10.1016/j.envpol.2020.115157

Despite the now well-recognised impact of diclofenac on vultures across the Indian subcontinent, this non-steroidal anti-inflammatory drug (NSAID) was registered in 2013 for livestock treatment in Spain, Europe's main vulture stronghold. We assessed the risk of exposure to diclofenac and nine other NSAIDs in avian scavengers in the Iberian Peninsula (Spain and Portugal) after the onset of diclofenac commercialization. We sampled 228 livestock carcasses from vulture feeding sites, primarily pig (n = 156) and sheep (n = 45). We also sampled tissues of 389 avian scavenger carcasses (306 Eurasian griffon

vultures, 15 cinereous vultures, 11 Egyptian vultures, 12 bearded vultures and 45 other facultative scavengers). Samples were analysed by liquid chromatography with mass spectrometry (LCMS). Seven livestock carcasses (3.07%) contained NSAID residues: flunixin (1.75%), ketoprofen, diclofenac and meloxicam (0.44% each). NSAID residues were only detected in sheep (4.44%) and pig (3.21%) carcasses. Fourteen dead avian scavengers (3.60%) had NSAID residues in kidney and liver, specifically flunixin (1.03%) and meloxicam (2.57%). Flunixin was associated with visceral gout and/or kidney damage in three (0.98%) dead Eurasian griffons. To date, diclofenac poisoning has not been observed in Spain and Portugal, however, flunixin would appear to pose an immediate and clear risk. This work supports the need for well managed carrion disposal, alongside appropriate risk labelling on veterinary NSAIDs and other pharmaceuticals potentially toxic to avian scavengers.

"Self-fumigation" of nests by an endangered avian host using insecticide-treated feathers increases reproductive success more than tenfold

F Alves, N Langmore, R Heinsohn, and D Stojanovic. *Anim Conserv*, 2020. http://doi.org/10.1111/acv.12627

Parasites can cause great fitness cost to their hosts; however, their impact on host populations is often unknown. In healthy populations, parasites are not expected to cause declines, but they can be devastating to small and/or declining populations. Nest ectoparasites can have detrimental impacts on the breeding output of their hosts and are emerging as a threat to several endangered bird species. Therefore, finding cost-effect ways to reduce the impact of parasites on endangered hosts is crucial. Although "close-order" management techniques available to manage nest parasites are effective, they are often expensive and might not be suitable for species that are intolerant of intensive manipulation. We tested a low cost, "close-order" management technique to control parasites and boost nest productivity in an endangered passerine. The endangered forty-spotted pardalote *Pardalotus quadragintus* is exploited by an ectoparasitic fly *Passeromyia longicornis*, an obligate subcutaneous parasite of nestling birds. We offered adult pardalotes the opportunity to 'self-fumigate' their nests by supplying feathers treated with insecticide with which to line their nests and tested whether this boosted nest productivity. Pardalotes readily incorporated the experimental feathers in nest building, and survival of hatchlings was significantly higher in nests lined with treated feathers (95%) compared to nests lined with control feathers (8%). This represents a substantially greater improvement in reproductive success than in previous experimental studies, offering the strongest evidence yet that self-fumigation is a highly effective, simple and low cost "close-order" management technique for defending endangered birds against ectoparasites.



PHOTO © NOAA PHOTO LIBRARY. CC BY 2.0 LICENSE.

Beaked whales (family Ziphiidae) have been increasingly involved in mass strandings.

Investigating cat predation as the cause of bat wing tears using forensic DNA analysis

ROS Khayat, RA Grant, H Ryan, et al. *Ecol Evol.* 2020:10(8368–8378). https://doi.org/10.1002/ece3.6544

Cat predation upon bat species has been reported to have significant effects on bat populations in both rural and urban areas. The majority of research in this area has focussed on observational data from bat rehabilitators documenting injuries, and cat owners, when domestic cats present prey. However, this has the potential to underestimate the number of bats killed or injured by cats. Here, we use forensic DNA analysis techniques to analyze swabs taken from injured bats in the United Kingdom, mainly including *Pipistrellus pipistrellus* (40 out of 72 specimens). Using quantitative PCR, cat DNA was found in two-thirds of samples submitted by bat rehabilitators. Of these samples, short tandem repeat analysis produced partial DNA profiles for approximately one-third of samples, which could be used to link predation events to individual cats. The use of genetic analysis can complement observational data and potentially provide additional information to give a more accurate estimation of cat predation.

Body weight as an indicator of vulnerability to domestic cat predation for juveniles of three species of cottontail rabbits (*Sylvilagus* spp.) in Colorado: Implications for release criteria

GC Paul and DG Friend. *Journal of Wildlife Diseases*, 2020: In-Press. https://doi.org/10.7589/JWD-D-20-00036

Cottontail rabbits (*Sylvilagus* spp.) are frequently admitted to wildlife rehabilitation facilities due to predation by domestic cats (*Felis catus*). Our retrospective study (2015–19) of three species (*Sylvilagus audubonii,*

Sylvilagus floridanus, and *Sylvilagus nuttallii*) indicated that once juveniles reached a weight over 220 g, they were unlikely to present due to domestic cat interactions. This information should be incorporated into release criteria for these species.

Advances in research on the impacts of anti-submarine sonar on beaked whales

YB de Quirós, A Fernandez, RW Baird, RL Brownell, N Aguilar de Soto, D Allen, M Arbelo, M Arregui, A Costidis, A Fahlman et al. *Proc. R. Soc. B*., 2019:28620182533. http://dx.doi.org/10.1098/rspb.2018.2533

Mass stranding events (MSEs) of beaked whales (BWs) were extremely rare prior to the 1960s but increased markedly after the development of naval mid-frequency active sonar (MFAS). The temporal and spatial associations between atypical BW MSEs and naval exercises were first observed in the Canary Islands, Spain, in the mid-1980s. Further research on BWs stranded in association with naval exercises demonstrated pathological findings consistent with decompression sickness (DCS). A 2004 ban on MFASs around the Canary Islands successfully prevented additional BW MSEs in the region, but atypical MSEs have continued in other places of the world, especially in the Mediterranean Sea, with examined individuals showing DCS. A workshop held in Fuerteventura, Canary Islands, in September 2017 reviewed current knowledge on BW atypical MSEs associated with MFAS. Our review suggests that the effects of MFAS on BWs vary among individuals or populations, and predisposing factors may contribute to individual outcomes. Spatial management specific to BW habitat, such as the MFAS ban in the Canary Islands, has proven to be an effective mitigation tool and mitigation measures should be established in other areas taking into consideration known population-level information.

A neural correlate of sensory consciousness in a corvid bird

A Nieder, L Wagener, and P Rinnert. *Science,* 25 Sep 2020:369:(6511);1626-1629. http://doi.org/10.1126/science.abb1447

Humans have tended to believe that we are the only species to possess certain traits, behaviors, or abilities, especially with regard to cognition. Occasionally, we extend such traits to primates or other mammals—species with which we share fundamental brain similarities. Over time, more and more of these supposed pillars of human exceptionalism have fallen. Nieder et al. now argue that the relationship between consciousness and a standard cerebral cortex is another fallen pillar (see the Perspective by Herculano-Houzel). Specifically, carrion crows show a neuronal response in the palliative end brain during the performance of a task that correlates with their perception of a stimulus. Such activity might be a broad marker for consciousness. Subjective experiences that can be consciously accessed and reported are associated with the cerebral cortex. Whether sensory consciousness can also arise from differently organized brains that lack a layered cerebral cortex, such as the bird brain, remains unknown. We show that single-neuron responses in the pallial endbrain of crows performing a visual detection task correlate with the birds' perception about stimulus presence or absence and argue that this is an empirical marker of avian consciousness. Neuronal activity follows a temporal two-stage process in which the first activity component mainly reflects physical stimulus intensity, whereas the later component predicts the crows' perceptual reports. These results suggest that the neural foundations that allow sensory consciousness arose either before the emergence of mammals or independently in at least the avian lineage and do not necessarily require a cerebral cortex.

Related article, *Stat News (online news site)*: "Brainiacs, not birdbrains: Crows possess higher intelligence long thought a primarily human attribute," by Sharon Begley.

"Good" and "Bad" Urban Wildlife (in Problematic Wildlife II)

G Perry, C Boal, R Verble, and M Wallace. (2020) In: F Angelici, L Rossi (eds), Problematic Wildlife II, pp 141–70. Springer, Cham. https://doi.org/10.1007/978-3-030-42335-3_5

Urban environments offer habitat for many species of animals. Although some of those are ubiquitous and/or undesirable, others are native and in some cases, of conservation value. In many cases, urban wildlife populations are a source of enjoyment for human residents, who sometimes invest considerable amounts in attracting them to yards and public spaces. Their presence there can serve an important educational role that helps protect non-urban habitats and species. Nonetheless, urban wildlife must survive what has been termed a "landscape of fear." Although some of the urban wildlife that do well in this environment are benign, other populations–sometimes of a species that, in other locations, is iconic and desirable–can become problematic. Some species can serve as vectors that carry important zoonosis, such as the plague or diseases that affect other wildlife. Others can create noise or olfactory nuisances and degrade structures or usability of public spaces. Some pose hazards at busy airports, whereas still others may present an envenomation or predation risk on unwary humans. Here, we review the role that reptiles, birds, and mammals play in urban environments and discuss how urban wildlife rehabilitation centers help address some related issues. We close by looking ahead and trying to predict how global patterns such as increased urbanization and population growth may affect urban wildlife and its value for conservation.

Articles of interest:

"Armed with new research, ranchers rethink depredation"

By Kendra Chamberlain, *New Mexico Political Report*, September 22, 2020.

"Mountain Lion Cub Rescued From California Wildfire"

By Mary Jo DiLonardo. *Treehugger*, October 2, 2020. (Online news site).

"Tasmanian devils released into sanctuary north of Sydney in step towards 'rewilding'"

The Guardian, US edition.

Conference proceedings:

The Wildlife Society Annual Conference presentations, Sept 28–Oct 1, 2020. Online access is time-limited.

- Contributed Papers
- Contributed Posters

TAIL ENDS



I like our walks, Harry, but remind me next time not to do the buffet.

Turkey vultures (*Cathartes aura*).
PHOTO © KATHERINE DEVLIN. USED WITH PERMISSION.

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Carrion crow *(Corvus corone Linnaeus 1758)* playing with a leaf.
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