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IN THIS ISSUE:

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

On the cover:
An incoming Griffon vulture (*Gyps fulvus*) on a tether, a falconry technique that may improve raptor rehabilitation.

Left:
Orca whale and young (*Orcinus orca*), South Puget Sound, Tacoma, Washington.

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Patchwork: a conservation blanket of many patterns

It's an early autumn morning in Eugene, Oregon. I'm at my desk, sipping tea, and considering collaboration. I have a conference paper to present in a few weeks at the annual Aquarium and Zoological Association (AZA) Conference on the collaborative potentials between wildlife rehabilitation centers and zoos. After all, both of us have at the core of our missions a mandate to improve conservation outcomes and engage the public to care about wildlife.

There are abundant opportunities to work together, such as the scenario that gave me and my collaborator the idea to present a paper at AZA: using skilled animal keepers as volunteers to help during baby season, which provides the keepers with valuable hands-on experience for a potential critical emergency situation with a zoo baby. Such collaboration has occurred for years between the National Zoo and City Wildlife in Washington, DC.

Meanwhile, Bird Ally X, a California wildlife rehabilitation center, was deployed to the Klamath Basin National Wildlife Refuge complex to collaborate with the USFWS in response to a large avian botulism outbreak. A call for volunteers went out, to which several IWRC members responded, including board member Brooke Durham. Now a second outbreak in Nevada has Gold Coast Wildlife Rescue assisting the Nevada Department of Wildlife.

On North America's east coast, wildlife centers are braced for Hurricane Florence, which will of course be long gone by the time this Journal goes to press. I've talked to a few of the rehabilitators preparing for the expected storm and aftermath and have been impressed by their level of preparation and their immediate willingness to help any rehabilitator who needs aid. Facebook wildlife rehabilitation pages and groups are buzzing with conversations of assistance and planning.

On the business side, IWRC staff will be heading a few hours north for some tech support. Traction on Demand annually roadtrips from Vancouver, Canada to a large tech conference in San Francisco, becoming "Traction for Good" by making stops along the way to assist nonprofits with tech support and perform service projects like beach cleanups. This support has provided IWRC with 40 hours of *pro bono* tech help that lets us perform like a much larger organization. Along with Traction, IWRC collaborates with other tech firms and nonprofits. In fact, our database platform, "Salesforce.org Nonprofit Success Pack" is one enormous collaboration of nonprofits and tech companies—an open-source software project collaboration including corporations, small firms, and dozens of nonprofits which together create solutions we need and documentation to implement these solutions. I am *so* proud to be a part of this community alongside Soapbox Engage, Common Voyage, Traction on Demand, and many, many others.

As the last of my tea grows cold, I'll close by returning to the world of wildlife and some positive collaborations in the works: data-sharing between rehabilitation centers and researchers to alert researchers to possible population-level trends, while serving rehabilitators by modeling future events and intake levels; and community-building among rehabilitators in Brazil and Argentina to share knowledge and resources.

The lesson: learn to reach out to give and receive help. Whenever you feel like your work is too big to handle and everything is going sideways, remember the hugely positive interactions happening in communities across the world between citizens, wildlife rehabilitators, and governments — just like the botulism response in western North America.

—Kai Williams, Executive Director

Continued Medical Assessment for Endangered Southern Resident Orcas

PUGET SOUND, Washington, USA (August 20, 2018)—Biologists mobilized to assist an emaciated three-year-old killer whale (J50, a.k.a. Scarlet), from the critically endangered Southern Resident population. Scientists observing J50 agreed that she was in poor condition and may not survive. The response team included participants from National Oceanic and Atmospheric Administration (NOAA), The Center for Whale Research, Fisheries and Oceans Canada, University of Washington, King County Dept of Natural Resources and Parks, Lummi Nation, Sea World, SeaDoc Society, SR3, Vancouver Aquarium, Wild Orca, Soundwatch, Washington Department of Fish & Wildlife, and The Whale Sanctuary Project.

On August 3rd, the response team sampled J50's breath but were unable to diagnose the cause of morbidity. On August 9th, the team was able to do a visual exam and retrieve another breath sample. Antibiotics were administered, but only half the necessary dose was administered before the dart fell out. On August 12th, they experimented with additional treatment via a "live fish release," but could not confirm whether J50 ate any of the fish. The team tested fecal samples from the pod and from the pod's prey, which showed a high parasite load, *Contraceacum* spp, in at least one of the whales. Based on the last provided report, the team was preparing another dose of antibiotics and wormers for J50, and were discussing injection options. On September 4th, Dr. Haulena of the Vancouver Aquarium provided another dose of antibiotics via dart.

J50 has not been seen since September 11th, and search was called off September 15th. The West Coast Marine Stranding Network, researchers, and the general public are all on alert. If J50 is found alive attempts may be made to bring her into captivity for further treatment.

IN MEMORIUM

Helene Van Doninck, DVM *(May 24, 1966–August 10, 2018)*

By Lynn Miller, IWRC President Emeritus

The world became a little less sunny on August 10th, 2018. Helene Van Doninck—rehabilitator, veterinarian, educator, friend, and colleague—lost her battle with ovarian cancer.

Hearing the news, I tried to focus on the wonderful memories of the times we shared, but somehow that seemed rather impossible. I needed time to come to terms with her death, as did so many people. That we'd never share a laugh or a meal at some interesting restaurant again, as we did two years ago in Charlottetown, Price Edward Island, while attending a wildlife conference, is still sinking in slowly.

I started to remember trips she and I shared; for example, working together as members of the team that travelled to present the IWRC courses to many wonderful people in Johannesburg, South Africa. Helene was a superb educator. She taught the courses to a huge audience, while making sure everyone understood the materials—which was important, as many of the attendees' first language was not English. Helene, with her always-radiant smile, invited people to listen, because what she was saying was important, and she spoke to each person there. Once our teaching contract was done, it was time to play! And off to Kruger National Park we went. Birding, enjoying the scenery, and observing life there—Helene loved it all.

Other trips with Helene included the first IWRC Educational Symposium in Dallas, Texas. (She and I shared a room, and Helene found out margaritas were not her friend!) Always, there were laughter and smiles. Our time on the IWRC Board of Directors meant heading off to meetings, and sometimes sharing the road trip to reduce costs (because, after all, we were rehabbers and money always was an issue). We'd catch each other's eye at some of the rather longer sessions, and that smile showed she was enjoying the moment but looking forward to the downtime too.

Nothing seemed insurmountable. Just look at the huge impact Helene had on fishing practices in Nova Scotia and the shift away from the use of lead! I am very certain she won people over through her smile, her immense understanding of people, and her kindness, all combined with her firmness when she was right. Instead of simply telling anglers not to use lead fishing tackle, she replaced their lead gear with safer alternatives through a grant she obtained.

I still enjoy the memory of her joy in the Big Jeezley. Only Helene could have a magnificent eagle flight pen called the Big Jeezley! The building demonstrated how in tune she and her husband, Murdo, were with their patients and their needs to regain their strength and stamina before tackling life in the wild again. The flight pen is so well designed that it has habitats for several species to recuperate and prepare for release in the inner areas.

Oh, and her storage room also—that aspect of a rehabilitation facility you can never have enough of! It was all there, and so well planned and executed. Helene was very humbled by all the help and dedication of the people who helped her make her rehabilitation facility a reality. I was just so excited to see it in action—with four eagles hanging out there the day of my visit.

Every day, Helene's work as a veterinarian and wildlife rehabilitator gave her patients the very best chance to get on with their interrupted lives. We will miss her in so many ways. For me, simply being able to call and ask a question is the first of a long list of reasons to miss her, along with sharing meals and laughter, reminiscing, and discussing ideas and plans together. And, of course, I will miss her beautiful smile.

Thank you, Helene, for all the wonderful memories.

Maine Center Sees Intentional Injuries Double in 2018

CAPE NEDDICK, Maine, USA (August 19, 2018)—The Center for Wildlife in Cape Neddick, Maine, has observed an uptick in intakes due to purposeful human injury. According to a recent article in the *Sun Journal*, 8% of the center's intakes to date this year are from intentional harm, up from 4% in 2017.

Tasmanian Devil Faces Another Cancer Threat

SOUTHHAMPTON, UK (August 15, 2018)—A new study suggests that the Tasmanian devil (*Sarcophilus harrisii*) is under severe threat from a newly emerged contagious cancer, Devil Facial Tumour 2 (DFT2), which could jeopardize its future in the wild. The study, "The newly-arisen Devil Facial Tumour Disease 2 (DFT2) reveals a mechanism for the emergence of a contagious cancer," is published in *eLife*.

In 2014, scientists discovered that DFT2 was circulating in a small number of animals. However, new research led by University of Southampton researcher Dr. Hannah Siddle suggests that this cancer type has the potential to cause as much, if not more, damage to the already weakened population of Tasmanian devils.

For over two decades, the species has been suffering from Devil Facial Tumour Disease (DFTD), which causes close to 100% mortality in the world's largest remaining marsupial carnivore. The Tasmanian devil is listed as endangered, with a global population reduced by more than 60% in the past 10 years due to DFTD. The facial cancer spreads by bite wounds and kills those affected in a matter of months.

Every mammalian cell has on its surface a molecule called major histocompatibility complex (MHC) that allows the immune system to determine whether a cell is friend or foe. If the cell is foreign and a potential threat, MHC triggers an immune response.

Siddle's study found evidence that these cancerous cells may be losing their MHC, thereby reducing the ability of the host's immune system to identify the threat. This increases the likelihood that the cancer will be able to spread rapidly, causing more population crashes in an already vulnerable species.

Siddle added that while this could be very bad news for the Tasmanian devil, researchers are in a better position compared to when the first contagious cancer emerged in order to develop captive management strategies.

Challenging Year for California Seabirds

FAIRFIELD, California, USA (August 14, 2018)—It has been another tough year for California's seabirds, and for International Bird Rescue, whose mission is to balance the natural world by rescuing waterbirds in crisis. One example of many are the hungry and exhausted young common murres (*Uria aalge*) inundating IRB's Northern California wildlife hospital. Over 100 murres have been admitted into intensive care at the San Francisco Bay–Delta Wildlife Center. They arrive starving and many of them, including chicks, have contaminated feathers that require delicate washing.

Though the IRB is currently seeing an uptick in murres, they have experienced an overall increase in intakes. So far in 2018, the organization has treated 2,500 waterbirds at its two California wildlife centers.

Giving these seabirds a second chance is expensive, and the IRB is asking for public contributions to help pay for their care. An anonymous donor generously donated USD $50k in matching funds (https://www.givinggrid.com/emurregency).

Reptile Skin Microbiome May Aid Understanding of Fungal Disease

URBANA, Illinois, USA (August 14, 2018)—Scientists at the University of Illinois Urbana–Champaign Wildlife Epidemiology Lab have published their findings on a review of the skin microbiome on free-ranging, eastern Massasaugas rattlesnake (*Sistrurus catenatus*). This endangered species is susceptible to *Ophidiomyces ophiodiicola*, a keratinophilic fungus that causes Snake Fungal Disease (SFD).

The report states that, based on an analysis of 144 skin swabs collected from 44 snakes in 2015 and 52 snakes in 2016, researchers determined that SFD infection altered the bacterial and fungal diversity of the skin microbiome, even at locations on the body far from the infection sites.

Marine Mammals Have Fewer Defenses Against Pesticides

PITTSBURG, Pennsylvania, USA (August 9, 2018)—The University of Pittsburgh School of Medicine published a report in *Science* that suggests that marine mammals do not have the ability to make a protein that defends terrestrial mammals, including humans, from the neurotoxic effects of a popular man-made pesticide.

The implications of this finding led researchers to call for increased monitoring of waterways to learn more about the impact of pesticides and agricultural run-off on marine mammals, including dolphins, manatees, seals, and whales. The research may also shed further light on the function of the gene encoding this protein in humans.

Nathan L. Clark, Ph.D., associate professor at the university's Department of Computational and Systems Biology, and lead author Wynn K. Meyer, Ph.D., a postdoctoral associate in Clark's laboratory, knew from previous research that some genes connected to olfaction and gustation (smell and taste, respectively) lost their function during marine mammal evolution. To further examine this, they set out to see what other genes that are conserved in land-dwelling mammals had lost function in marine mammals.

Analyzing DNA sequences from five species of marine mammals and 53 species of terrestrial mammals, the team identified Paraoxonase 1 (*PON1*) as the gene that best matched the pattern of sensory loss in marine mammals. In humans and other terrestrial mammals, *PON1* reduces cellular damage caused by unstable oxygen atoms. It also offers protection from organophosphates, some of which are pesticides that kill insects—which lack

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Case study: the use of falconry techniques in raptor rehabilitation

Kristin Madden[1,2] and Matthew Mitchell[1]

Use of a traditional falconry hood on a prairie falcon (*Falco mexicanus*).

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ABSTRACT: We predicted that certain falconry techniques would decrease stress and the time required to pre-condition raptors for release. Between 2008 and 2014, we alternated use of traditional rehabilitation procedures with falconry techniques on 45 raptors. Twenty-seven birds were alternately restrained using either a towel or a falconry hood. Results from t-tests showed significant decreases in stress with the use of falconry hoods vs. towels. Twenty-six accipiters and falcons were either held in pet carriers or hooded and perched on falconry blocks. All 14 tethered birds retained excellent feather and cere condition. Of the 12 birds kept in pet carriers, none were in excellent condition and eight showed more than one category of damage. Twenty-eight birds were either provided with the traditional cage flight conditioning, flown on a creance, or conditioned through specialized strength building exercises called "Jump-Ups." An additional three birds were conditioned using a combination of Jump-Ups and creance flight. Cage flight alone required considerably, though not statistically significant, more conditioning time before release in most cases. Creance flight and Jump-Ups were similar in time required for conditioning when used alone. However, a combination of creance and Jump-Ups for three birds required far more time than either method alone.

KEYWORDS: conditioning, creance, falconry, raptors, rehabilitation, wildlife rehabilitation

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Introduction

Thousands of raptors are raised, rehabilitated, and released annually throughout the world. While some published guidelines for treatment, housing, and pre-release criteria exist,[1] most raptor rehabilitators rely on traditional methods that allow them the greatest benefit for the lowest cost and greatest convenience. Wildlife rehabilitators are typically volunteers, using their own funds or relying on donations to fund their facilities. In addition, they can receive large numbers of young, ill, or injured raptors in short periods of time. This requires time and space that may be in short supply at certain times of the year. As a result, time-honored methods such as the use of pet carriers for housing; towels for restraint, warmth, and visual insulation; and large,

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often square or rectangular outdoor enclosures for pre-release conditioning are commonly used.

Birds that no longer require temperature regulation, frequent treatment, or restricted activity due to bandaging, are moved to large outdoor enclosures, known as cages or mews, for pre-release conditioning. While some rehabilitation centers and individuals have experimented with cage designs, the vast majority of

A tethered Harris's hawk (*Parabuteo unicinctus*) on a falconry block at a demonstration.

pre-release enclosures provide little to challenge a bird during conditioning. Cage flight alone is often insufficient for certain species and birds recovering from multiple injuries.[1,2,3] Creance flight, and other falconry techniques, have been recommended for assessment and improvement of injured raptors for decades.[4] It has also been suggested that raptors conditioned for release with falconry techniques have greater fitness than raptors conditioned in cages and may have improved success rates after release.[3]

Due to concerns over the inadequacy of cage flight alone in conditioning raptors for release, falconry techniques in raptor rehabilitation have become more prevalent, particularly in the last decade. More raptor rehabilitators are taking advantage of regulations that allow a temporary transfer of a raptor to a Master Falconer for purposes of pre-release conditioning (50 CFR §21.31). The Minimum Standards reference,[1] used by many rehabilitators, encourages rehabilitators to alter techniques to provide greater benefit to animals in rehabilitation.

While the potential benefits of combining falconry techniques and standard raptor rehabilitation methods have been suggested for many years, few studies have been conducted to quantify these benefits.[3,4] Our goal in this study was to determine the efficacy of specific falconry-based methods. We predicted that the proper use of certain falconry techniques would reduce stress-related behaviors and the time required to pre-condition raptors for release.

Methods

Specific testing methods are described below. For statistical testing, we analyzed all birds as one complete group and broken down into three species groups: accipiters, falcons, and buteo+ (buteo hawks plus the northern harrier [*Circus cyaneus*]). We conducted t-tests using the GraphPad online tool.[5]

Towel vs. falconry hood

Raptor rehabilitators typically wrap a bird much like a burrito to secure the wings and keep the head and feet covered. This allows for relatively easy access to most body parts for physical examination, feeding, medicating, or assessing wounds. While this method does keep a bird restrained and it can sufficiently calm many birds, it does not always reduce stress in high-stress species like accipiters, nor does it allow for full control of the bird during certain treatments.

To determine if the use of falconry hoods might provide a more effective means of calming birds while restraining them than towels, we assessed both methods. We alternately restrained twenty-seven birds using either a towel or a falconry hood and documented stress-related behaviors each time. Stress behaviors were rated from 1 (no footing, no attempts to escape, breathing normally) to 4 (constant biting/footing, constant attempts to escape, fast open-mouthed breathing). We tested four sharp-shinned hawks (*Accipiter striatus*), three Cooper's hawks (*Accipiter cooperii*), four American kestrels (*Falco sparverius*), six peregrine falcons (*Falco peregrinus*), three ferruginous hawks (*Buteo regalis*), five red-tailed hawks (*Buteo jamaicensis*), one Swainson's hawk (*Buteo swainsoni*), and one northern harrier.

Pet carriers vs. tethering

Raptor rehabilitators commonly use pet carriers for restricted activity housing that allows the rehabilitator easy access for medication and wound care and limits the activity of a bird that would otherwise injure itself in an unlimited activity enclosure. Pet carriers are easy to clean, well ventilated, and portable. Most pet carriers also limit visual stimuli and can be easily covered with a towel for warmth or additional visual insulation. However, some species still demonstrate stress-related behaviors in pet carriers, particularly accipiters and falcons, leading to damage to feathers and ceres. Some rehabilitators report using itraconazole prophylactically when housing accipiters in pet carriers to prevent the onset of aspergillosis from stress (E.P. Elliston, pers. comm.).

We assessed stress and body condition of twenty-six accipiters and falcons either held in pet carriers or hooded and perched on falconry blocks. These included five sharp-shinned hawks, 11 Cooper's hawks, five American kestrels, and five peregrine falcons.

We kept tethered birds hooded and perched on falconry blocks when not eating or being treated for injuries. Tethered birds ate on the perch or on the glove. We restrained and fed other birds in pet carriers with openings covered by towels.

Cage vs. falconry exercises

We documented the time required for pre-conditioning before release using three methods. We define pre-conditioning as the time between limited activity and release. Release criteria followed Minimum Standards.[1] We provided 11 birds with traditional cage flight conditioning. This involved housing in a large rectangular raptor mews constructed of wooden slats that allowed for unlimited activity and the ability to practice natural daily behaviors. Of these, six had been injured, two with wing injuries. Five were healthy nestlings.

We flew six birds on a creance, also known as long-line or leash flying. The creance is a strong but light-weight line that allows a bird to be nearly free flying while still under control. Of these, five had been injured, three with wing injuries. One was a healthy nestling.

We tested eight birds using specialized strength building exercises called "Jump-Ups", in which the bird flies to the fist or a higher perch from a low perch. As the bird's flight muscles build up, the length of the session and/or height of the higher perch is increased. Of these, six had been injured, five with wing injuries. Two were healthy nestlings. We conditioned an additional three birds, all healthy nestlings, using a combination of Jump-Ups and creance flight.

Results

Towel vs. falconry hood

Unpaired t-test results showed significant differences in stress-related behaviors when using towels vs. hoods (P ranged from 0.0001–0.0005). Accipiters were the only species group to have a range of one to four for both methods. The average rating was much higher when using a towel than a falconry hood (Table 1). The other two groups (falcons and buteo+) ranged from one to four when using towels and one to three when using hoods. We expected that accipiters and falcons would demonstrate a more dramatic difference as compared to the buteo+ group. However, all three groups demonstrated identical results with the exception of one sharp-shinned hawk that ranged from one to four for both methods.

Pet carriers vs. tethering

All 14 tethered birds retained excellent feather and cere condition. None of the 12 birds kept in pet carriers were in excellent condition. Two were in good condition, nine required a tail guard, eight suffered damage to wing feathers, and three suffered cere damage. Eight birds kept in pet carriers had more than one category of damage (i.e. feathers and cere damage).

Cage vs. falconry exercises

Cage flight alone required considerably, though not statistically significant (P = 0.1283), more conditioning time before release in most cases (Fig. 1, Table 2). Creance flight and Jump-Ups were similar in time required for conditioning when used alone. The very small sample of three birds provided with a combination (Combo) of creance and Jump-Ups required far more time than either method alone. Due to the extremely small sample size, we cannot speculate on reasons for this.

TABLE 1. Stress-related behavior ratings for all birds: towels compared to falconry hoods.

ALL BIRDS	TOWEL	HOOD
Average rating	3.1	1.6
Median rating	3.0	2.0
N	76	82

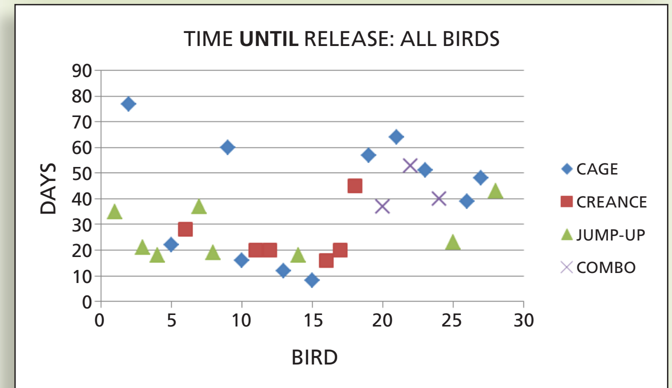

FIGURE 1. Time until release by conditioning method.

TABLE 2. Summary of conditioning time by method, in days.

	CAGE	CREANCE	JUMP-UPS	COMBO
Average	41	25	27	43
Median	48	20	22	40
Range	8-77	16-45	18-43	37-53
N	11	6	8	3

Conclusions

Management Implications

While our sample size is small, this study demonstrates that the use of certain falconry techniques has the potential to reduce behaviors indicative of stress, improve feather and cere condition, and reduce the amount of time required to condition raptors before release. It should be noted that even falconry-style tethering can result in some damage to the leg feathers but, in our experience, this remains an improvement over kennel or small cage confinement, particularly for high-stress species. As with any other method, the users of hoods should consider disinfection and proper fit for each individual bird. It should also be noted that these methods should not be undertaken without sufficient training from an experienced falconer or falconry-trained rehabilitator. These methods are often time intensive and may not be suited for all birds at high-volume rehabilitation centers.

The reduction in time required to rehabilitate most raptors for release that was achieved through the use of falconry techniques, while not statistically significant, allowed us to get birds back into the wild sooner while reducing food costs and freeing up needed space in cages. More studies of this type might have the advantage of increasing the sample numbers and increasing clarity of understanding.

About the authors

Kristin Madden has been an avian biologist and rehabilitator for over 20 years, specializing in raptors. Her Master's degree research focused on nest-site defense in urban Cooper's Hawks. She is a former Clinic Director for Wildlife Rescue Inc. of New Mexico and continues to volunteer with them. Kristin has been integrating falconry techniques into raptor rehabilitation for a decade. She currently serves in the U.S. Fish and Wildlife Service Southwest Region.

Matthew Mitchell has practiced the art of falconry since 1968, started captive breeding of raptors in 1989, and became a sub-permittee of Wildlife Rescue Inc. in 1983. He has rehabilitated a variety of animals since then, but has specialized in raptor rehabilitation. In particular he has focused on preparing raptors for final release into the wild.

Acknowledgments

All of these birds were held under the permit held by Wildlife Rescue Inc. of New Mexico (WRI). We appreciate the assistance of everyone at this all-volunteer organization. We particularly thank E. Penny Elliston for her thoughtful review of this paper and for her recommendations. WRI is housed on the ground of the Rio Grande State Park Nature Center and none of this would have been possible without their ongoing support of these activities.

We also wish to thank the U.S. Fish and Wildlife Service, Migratory Birds Program, Permits office and the N.M. Department of Game and Fish for their long-term support and assistance to the WRI team.

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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Case study: methods and observations of overwintering *Eptesicus fuscus* with White-Nose Syndrome in Ohio, USA

Molly C Simonis,[1,2] Rebecca A Crow,[2] and Megan A Rúa[1]

A healthy large brown bat *(Eptesicus fuscus)*.

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ABSTRACT: Temperate, cave-dwelling bat populations in eastern North America are facing drastic declines due to the emergent disease called White-Nose Syndrome (WNS). In Ohio, USA, wildlife rehabilitators may accept native bats during the winter months when bats are typically hibernating. During the winter months this deadly fungal infection is the most damaging to individual hibernating, temperate bats' physical and physiological condition, because the bats are more vulnerable to disease while their immune response is low during hibernation. Here, we provide observations and methods for successful care and release of overwintering bats with WNS. In the winter of 2016, we administered simple topical treatments and visually investigated patterns during the care of nine *Eptesicus fuscus,* assumed to be infected with *Pseudogymnoascus destructans* through visual confirmation of orange-yellow fluorescence under ultraviolet light and fungal culture. We developed systematic methods for infected-bat husbandry that led to the successful release of seven of the nine big brown bats treated.

KEYWORDS: bats, *Eptesicus fuscus*, *Pseudogymnoascus destructans*, White-Nose Syndrome, wildlife disease, wildlife rehabilitation

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Introduction

White-Nose Syndrome (WNS) has devastated northeast bat populations in the USA, and continues to spread westerly each year.[1] The fungal pathogen *Pseudogymnoascus destructans* (*Geomyces destructans*), which causes WNS, was first detected in Ohio in 2011,[2,3] and state wildlife laws restricted bat rehabilitation during hibernating months in order to monitor populations of infected animals.[4] Currently listed as an endemic state,[5] the Ohio Department of Natural Resources–Division of Wildlife (ODOW) now allows bat rehabilitation during the winter months under newly created decontamination protocols.[6]

Treatments for WNS have become a research focus for cave-dwelling bat research in the USA.[7–10] Simple treatments for individuals, such as apple cider vinegar solutions *in vivo* and orange essential oil concentrations *in vitro*, have resulted in inhibition of *P. destructans*.[7,10] More complex treatments, such as the use of natural microbiota, also result in inhibition of *P. destructans* growth, with potential for applications at a landscape scale.[8,9] In this investigation, we aim to provide methods and simple treatment observations that are helpful to the individual care of *P. destructans*-infected *Eptesicus fuscus* (big brown bats) admitted into wildlife rehabilitation facilities. Excluding the use of apple cider vinegar solution treatments, to our knowledge there are no publications involving other easily accessible, simple treatments for wildlife rehabilitators.[7] We focus on the use of chlorhexidine solution 0.2% and miconazole nitrate 1% topical ointment for treatments, which are typically available to wildlife rehabilitators through their veterinarians. Chlorhexidine solution 0.2% is an antimicrobial agent used for common veterinary dermatological fungal and bacterial conditions, and miconazole nitrate 1% topical ointment is a broad-spectrum anti-fungal agent used for yeast and filamentous fungal infections.[11,12] The use of natural microbiota is not investigated here. Additionally, methods of systematic decontamination practices are incorporated with the daily husbandry of individual *E. fuscus* throughout their stay in Brukner Nature Center's Wildlife Rehabilitation Unit in Troy, Ohio.

TABLE 1. Treatment groups and dates for *Eptesicus fuscus* patients at Brukner Nature Center during winter 2016–17.

Patient	Treatment Date	Admit Date	Treatment Start	Treatment End	Disposition	Disposition Date
1465	Miconazol	16 Dec 16	24 Dec 16	4 Feb 17	Released	28 Mar 17
1467	Control	21 Dec 16	4 Feb 17	18 Mar 17	Euthanized	27 Mar 17
1468	Control	23 Dec 16	24 Dec 16	4 Feb 17	Released	28 Mar 17
1469	Chlorhexidine	23 Dec 16	4 Feb 17	18 Mar 17	Released	11 Apr 17
1470	Chlorhexidine	23 Dec 16	24 Dec 16	4 Feb 17	Released	11 Apr 17
2	Control	4 Jan 17	4 Feb 17	18 Mar 17	Euthanized	27 Mar 17
3	Chlorhexidine	7 Jan 17	4 Feb 17	18 Mar 17	Released	28 Mar 17
5	Miconazol	13 Jan 17	4 Feb 17	18 Mar 17	Released	28 Mar 17
11	Miconazol	2 Feb 17	4 Feb 17	18 Mar 17	Released	10 Apr 17

Methods

Fungal culture

Big brown bat (*Eptesicus fuscus*) patients housed at Brukner Nature Center's Wildlife Rehabilitation Unit were swabbed on 10 February 2017 in areas along the flight membranes and muzzles, selectively chosen through visualization of orange-yellow fluorescence. We swabbed each bat once with a sterile inoculating loop, and once with sterile water and a sterile swab. Each sweep was transferred to an individual Sabouraud Dextrose Agar (SDA) plate (two SDA plates per *E. fuscus*). Plates were transferred to Wright State University in Dayton, Ohio, and kept at 10°C incubation for approximately four months. All United States Geological Survey (USGS) biosafety measures for WNS were followed for transfer, housing, and disposal of contaminated plates in a Biosafety Level-2 laboratory.[5] Culture plates were examined under a dissecting microscope on 13 March 2017 (31 days of incubation) under × 40 magnification for evidence of conidial growth. Slides of culture growth were created with fungal tape on 31 May 2017 (110 days of incubation), examined under a confocal microscope at 60 µm magnification, located at Wright State University's Microscopy Core in Dayton, Ohio. Voucher specimens were taken and stored at 4°C and –80°C.

Animal care and P. destructans *treatments*

All *E. fuscus* (n = 9) were admitted to Brukner Nature Center's Wildlife Rehabilitation Unit in the winter of 2016 (Table 1), and cared for under permit recommendations (permit #55501).[6] Patients were housed individually in mesh screen 72.8-liter reptariums or ventilated 68.1-liter plastic storage totes with hand towels draped over the sides. Two bats (patients 1467 and 2) were housed together in a 113.6-liter ventilated plastic tote with hand towels draped over the sides, as they were found stranded in the exact same residential home prior to admittance. *Pseudogymnoascus destructans*-infected bat enclosures were quarantined in the same room at 18 to 19°C, with a humidifier, decontaminated every other day with Clorox® wipes, and clean towels provided. All items removed from enclosures were decontaminated following procedures outlined by ODOW Minimum Standards, which requires national decontamination protocols for bats with suspected *P. destructans* through orange-yellow ultraviolet (UV) fluorescence.[6,13–15]

We weighed all bats upon intake, and every other day thereafter. Patients were provided with daily feedings of oral pediatric electrolyte solution within the first week of admittance to account for the dehydration caused by *P. destructans* infection. Bats were roused from torpor daily for hand feedings of 3 g of mealworms, with an additional 3 g of mealworms and water available *ad libitum* until they were consistently gaining weight above 14 g for 3 days. We chose weight consistency above 14 g as a benchmark for a sustainable weight, since it is the low end of the accepted weight range for *E. fuscus* and we did not want to expend more energy during torpor daily by rousing individuals if unnecessary.[16] Hand feedings continued every other day after 14 g, unless the individual regularly free-fed.

Bats were scanned with a 385 nm UV flashlight upon initial exam for bright, orange-yellow fluorescent spots on flight membranes, muzzles, or both. Orange-yellow fluorescent spots and areas were assumed to be cupping erosions formed by *P. destructans* hyphae, and bats were considered infected.[15] Big brown bat patients were not considered for *P. destructans* treatment protocol until additional injuries, conditions, or both were fully resolved (e.g., soft tissue injuries, parasites, etc.). Only those patients presenting emaciation (<14 g), dehydration (skin tugor >3 s), and UV detection of orange-yellow fluorescence were immediately placed into treatment groups.

Three *E. fuscus* were placed in a control group with no topical treatments applied to the flight membranes. Bats administered with topical chlorhexidine 0.2% solution (n = 3) or topical miconazole nitrate 1% ointment (n = 3) were treated once per day for 14 days, and once per week for 28 days thereafter, at the recommendation of Troy Animal Hospital and Bird Clinic veterinarians. Topical treatments were applied dorsally and ventrally to the wing membranes and uropatagium. Photos of muzzles and all ventral and dorsal flight membranes were taken prior to initial treatment and then once per week throughout treatment. Treatments opportunistically began on two different start dates, due to an increase in patient intake and recovery of additional aforementioned injuries of *E. fuscus* patients already in our care (Table 1). One replication of each treatment or control group began on 24 December 2016 (n = 3), and two more replications (n = 6) began on 3 February 2017. A total of nine bats were enrolled in this study. Excluding extended time, no changes were made in treatment protocol between replications. Decontamination protocols were followed between each patient.[6]

If considered healthy, patients were released back to the township where originally found in May 2017. Two non-releasable *E. fuscus* candidates were humanely euthanized by cervical dislocation. Both euthanized *E. fuscus* accumulated large wing holes and tears during their care, and concerns for a long-term residence in captivity (a potential stay of 6–8 months, from winter to summer) outweighed continued treatment.

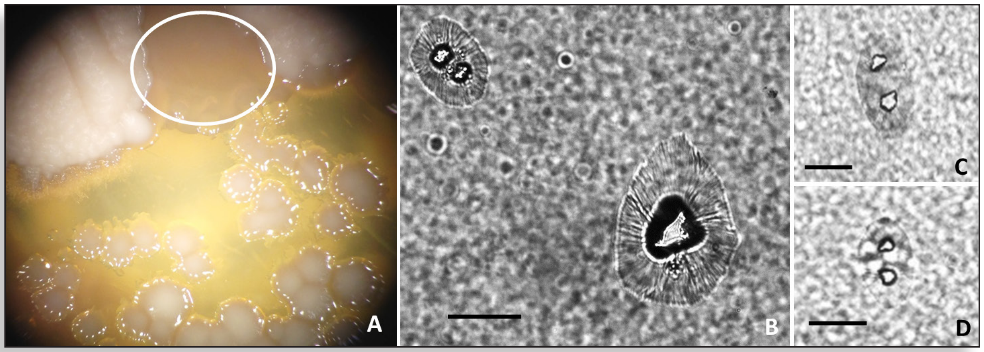

FIGURE 1. Examples of Sabouraud Dextrose Agar (SDA) growth and conidia identification of *Pseudogymnoascus destructans* culture. Scale bars (B to D) are 20 µm. A) Colony formation on SDA plate. The white circle indicates the biofilm associated with *P. destructans* culture growth. Photo taken at 40x magnification under dissecting microscope. B) Two conidia from *E. fuscus* patient 2 (2017 admit). C) Conidia from patient 1470 (2016 admit). D) Conidia from patient 1465 (2016 admit).

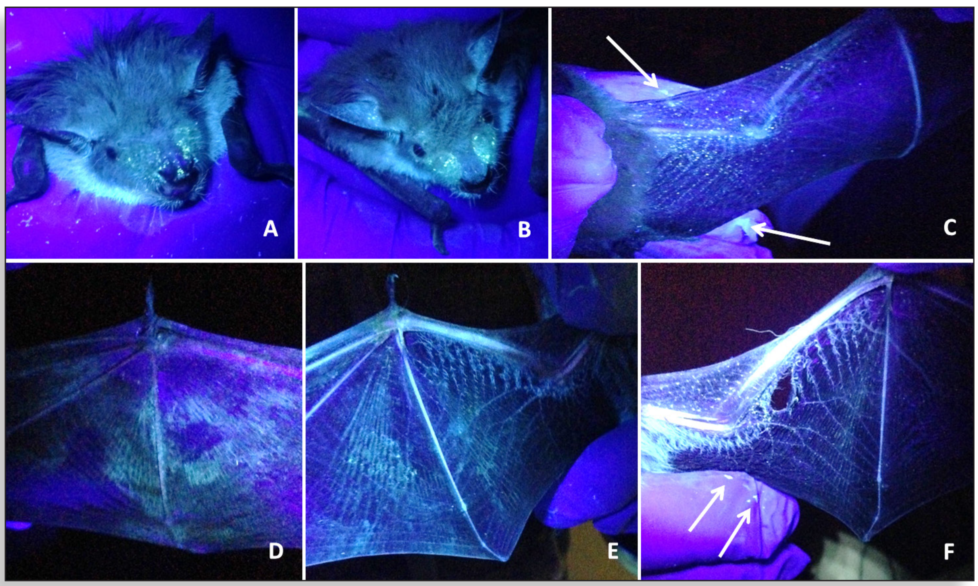

FIGURE 2. Examples of orange-yellow ultraviolet (UV) fluorescence and damage visualized on *E. fuscus* during treatment. Arrows indicate highly fluorescent urine stains on gloves, which only occurred while handling patients 2 and 1467. A) Patient 11 with fluorescence on muzzle. B) Patient 5 with fluorescence on muzzle and ears. C) Patient 2 with fluorescence on right dorsal wing. D) Patient 11 with fluorescent smudging on left dorsal wing. E) Patient 1467 with fluorescent smudging on right ventral wing. F) Patient 1467 with hole and necrotic tissue obtained during its stay.

Results

Pseudogymnoascus destructans culture

Incubation of culture swabs began on 10 February 2017, and growth was first seen on 24 February 2017. By 13 March 2017 (31 days of incubation), five culture plates had fungal growths distinctive of *P. destructans*. Colonies were cream-colored, with a mucoid biofilm surrounding elevated colonies (Fig. 1A). Observed slides indicated conidia typically associated with *P. destructans* (Fig. 1B to 1D), and were used to confirm our initial determinations of bats infected with assumed *P. destructans* cupping erosions detected by UV light.[17]

Patient observations

Eptesicus fuscus (big brown bat) patients within this study were admitted to Brukner Nature Center's Wildlife Rehabilitation Unit in the winter of 2016. Five *E. fuscus* were admitted in 2016 (patients 1465, 1467, 1468, 1469, and 1470), and four *E. fuscus* in 2017 (patients 2, 3, 5, and 11). We considered all patients admitted infected with *P. destructans* through visual confirmation of orange-yellow spots found on their flight membranes, muzzles, or both (Fig. 2A to 2C).

Upon initial exams, it was noted patients 1467 and 2 appeared to have greater fluorescent burden assumed to be *P. destructans*. Patients 1467 and 2 were also the most independent *specimens*, needing the least amount of individual husbandry. These specific patients were both treated as controls (receiving no additional treatments), and their observed fluorescent burden increased throughout the winter. Much of their orange-yellow fluorescent spots became orange-yellow fluorescent smudging or scarring (Fig. 2E). Both patients 1467 and 2 also began to form necrotic holes and tears in their flight membranes (Fig. 2F). Although in the same enclosure, patients 1467 and 2 were never observed roosting together. Both patients additionally expelled highly fluorescent

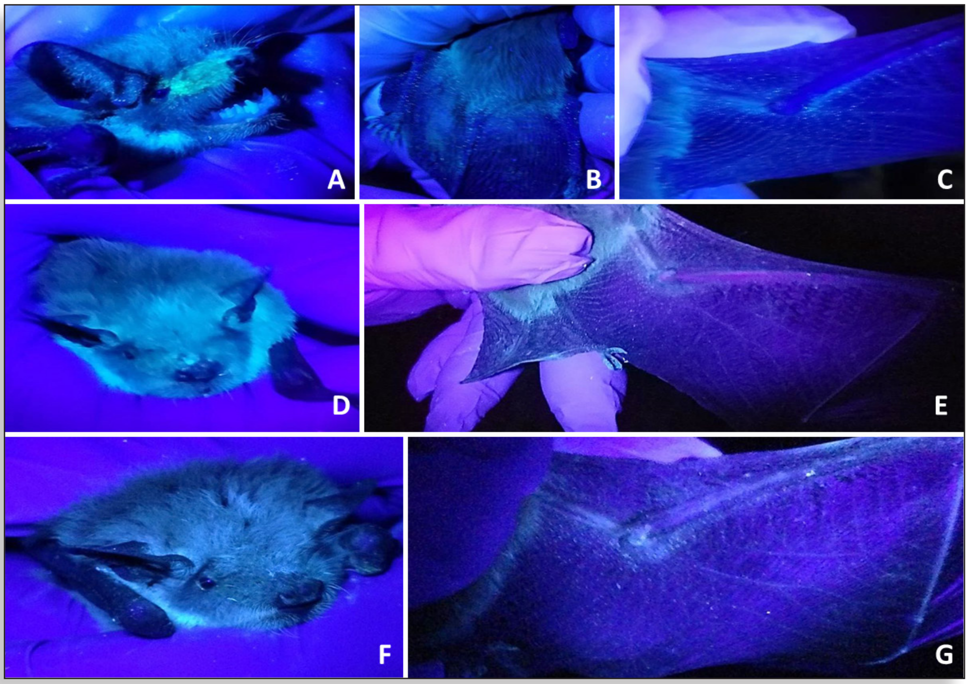

FIGURE 3. Photos of *E. fuscus* patient 1468 under UV light throughout its stay at Brukner Nature Center's Wildlife Rehabilitation Unit. A to C) Photos taken 23 Dec 2016 (0 d). D and E) Photos taken 3 Feb 2017 (42 d). F and G) Photos taken 24 Mar 2017 (91 d). B, C, E, and G) All are dorsal views and correctly oriented.

urine while handled (Fig. 2C and 2E), and this behavior was not observed in any other patients. All observed areas of orange-yellow fluorescence on all control bats (*n* = 3) intermittently lost its fluorescent color during the treatment period. Areas appeared under UV light as white, dry spots in the same areas where once fluorescing orange-yellow. Big brown bat patients 1467 and 2 were euthanized on 27 March 2017, due to progressive wing damage and an increased observed fluorescent burden. The third control *E. fuscus* (patient 1468) showed improvement with supportive care and fluoresced minimally upon release (Fig. 3).

Bats treated with topical chlorhexidine 0.2% solution (*n* = 3) visually had the least fluorescent smudging and scarring over time. These *E. fuscus* patients additionally had minimal amounts of observed orange-yellow fluorescent areas by the end of the treatment period. Visual orange-yellow fluorescence of assumed *P. destructans* cupping erosions disappeared and reappeared throughout the treatment period. When orange-yellow color was not visible, the same areas appeared as mentioned above in the control patients. *Eptesicus fuscus* in the chlorhexidine 0.2% solution treatment group were additionally observed to have a decrease in muzzle fluorescence, although treatment was not applied facially. All *E. fuscus* in the chlorhexidine 0.2% solution treatment group (*n* = 3) were released.

Bats treated with topical miconazole nitrate 1% ointment visually had the most fluorescent smudging over time (patient 11 in Fig. 1D). Within the first two weeks of treatment, *P. destructans* cupping erosions appeared larger, and then dissipated to original size with the included blotchy fluorescence on the wing membranes. All *E. fuscus* treated with miconazole nitrate 1% ointment also displayed a decrease in fluorescence on muzzles, contrary to where treatment was applied. Visual fluorescence additionally increased and decreased throughout the treatment period. All *E. fuscus* in the miconazole nitrate 1% ointment treatment group (*n* = 3) were released.

Discussion

Fungal culture and slide examination indicated that at least five of the nine *E. fuscus* patients were most likely infected with *P. destructans*. For the four patients without fungal growth in culture, it is likely there was no transfer of *P. destructans* during swabbing and plating, even though we swabbed bats opportunistically in fluoresced areas. Multiple culture plates were contaminated with other fungal growth (mainly yeast, *Aspergillus*), which we expected to happen since the Rehabilitation Unit at Bruckner Nature Center is not a sterile environment. Although histology is used for confirming WNS and qPCR analysis indicates *P. destructans* fungal load best across all stages of disease severity, as a nonprofit organization, we used the resources that were readily available to us at the time to confirm *P. destructans* presence on our big brown bat patients.[18,19]

Seven of the nine bats in this case study were successfully released back into the wild. Although patients 1467 and 2 were euthanized, it is not to be assumed because they did not receive treatment in a control group. They are to be considered as individuals with infections that appeared more virulent than others. What should be more encouraging is patient 1468. Big brown bat patient 1468 only received supportive care throughout its stay and showed improvements during the treatment period, and more visual improvements upon release (Fig. 3). Although statistics are not shown here (due to blurred photos refraining post-hoc analysis in Image-J®), it is possible that the health of patient 1468 benefited from a warmer environment, feeding, and supplemented pediatric electrolyte solution. Big brown bats have varying thermoregulatory patterns across geographic locations and have longer bouts of torpor during hibernation in comparison to *Myotis lucifugus* (little brown bat) under *P. destructans* infection.[20,21] Since all *E. fuscus* in our study were local (within ~100 km of the Rehabilitation Unit), and we regularly disrupted torpor to ensure caloric intake under the warmer temperatures, it is likely *E. fuscus* 1468 and all other released bats benefited from the same supportive care, regardless of topical treatment application. Further analysis with more detailed, measurable metrics is needed to determine if our methods of supportive care alone do provide the proper means of rehabilitative aid to individual bats during the winter months.

Our observations are in agreement with the 2011 findings of Meteyer and his colleagues, where treatments of apple cider vinegar were used to treat infected bats.[7] They found that both treated and untreated bats benefited at the end of the experimental procedure, due to supportive care and warmer body temperatures.[7] We cannot confirm without histology or PCR that all bats released were negative for *P. destructans,* as shown at the end of the apple cider vinegar treatments conducted by Meteyer and others, nor do we believe they were ever negative for *P. destructans* due to the waxing and waning of fluorescence during their stay.[7] However, we believe quality of life was greatly increased.

We observed orange-yellow UV fluorescence on the wings and muzzles of all nine *E. fuscus* patients. Spots of orange-yellow muzzle fluorescence are documented, but images are not commonly represented across the literature.[15] We do not find our observation to be outside the realm of possibility, since fungal swabbing protocols require sweeps across the wings and muzzles of bats.[5] It is possible that the fluorescence on *E. fuscus* patients' muzzles could be attributed to other microbes or ocular, nasal, or both types of secretions. However, these areas of the muzzles that glowed orange-yellow in color also went in and out of fluorescence in the same fashion as the assumed fluoresced cupping erosions on the flight membranes.

We can confirm observations of drastic changes to the fluorescent appearance of fungal cupping erosions week to week. The fluorescence of assumed cupping erosions along the wing membranes of experimental patients would not always appear with the typical bright, orange-yellow color associated with *P. destructans* infection and WNS. When not fluorescing under UV light, the wing membranes appeared to have flaky, white flecks of skin in the same areas once fluoresced. Conversations between other Ohio-based wildlife rehabilitators and RA Crow revealed that no other organization had detected UV fluorescence on admitted bats' flight membranes and muzzles throughout the winter of 2016 (2017 phone conversations with Ohio Wildlife Rehabilitators Association bat rehabilitation members and RA Crow; unreferenced). The alternating appearance of the wing membranes thought to be infected by *P. destructans* in combination with other wildlife rehabilitators' observations suggests two opposing ideas: 1) we were indicating false positives of infection by UV detection during the initial intake exams, or 2) other rehabilitators were indicating false negatives of infection by UV detection within a WNS endemic state. Cupping erosions can sometimes be microscopic. Original testing from infected New York bats indicated about 30% of negatively fluoresced biopsies had single, microscopic cupping erosions upon further investigation.[15] Additionally, UV fluorescence for *P. destructans*-infected bats is greatly increased in late hibernation.[19] Although active fluorescent properties of *P. destructans* are not always present under UV light, we overwhelmingly agree that detecting orange-yellow fluorescence is a highly resourceful, noninvasive solution for accurately detecting *P. destructans* with high confidence. This convenient method of detection is simple and available with minimal resources to any wildlife rehabilitator. Since we observed periods of changing individual fluorescence, we would highly recommend full decontamination of all patient materials, regardless of UV fluorescent status upon intake. This recommendation is extended beyond our current state guidelines, where full decontamination is required only for those individual bats that present active UV fluorescence of *P. destructans*.[6] Recent reports provide support for the spread of *P. destructans* during the summer months, when fluorescence is not typically detected during this time.[22] We would recommend systematic decontamination practices in North America during any bat's residency within a rehabilitation unit, regardless of geographic location, life history stage, or time of year, to prevent further exposure, disease severity, or both, similar to what we practiced during the experimental time period of this case study.

About the Authors

Molly C. Simonis is a PhD student in the Environmental Sciences Program at Wright State University in Dayton, OH. Her research interests focus on ecologic and physiologic responses to disease in North American temperate bat species.

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Morbidity, outcomes and cost-benefit analysis of wildlife rehabilitation in Catalonia (Spain)

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Northern Gannet *(Morus bassanus)*.

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ABSTRACT* There are few studies of careful examination of wildlife casualties in wildlife rehabilitation centers. The release rate is considered the main outcome indicator but other parameters, such as length of stay and number of released animals per euro and day, could be reliable estimators of rehabilitation costs. A retrospective study was done based on 54,772 admissions from 1995–2013 by the Wildlife Rehabilitation Center of Torreferrussa (Catalonia, Spain) assessing morbidity, outcomes and cost-benefits of WRC rehabilitation practices. Most frequent causes of admission were: 39.8% confiscation of protected species, 31.8% orphaned young, and 17.4% trauma casualties. The highest proportion of releases was in captivity confiscation, followed by the orphaned category. For the trauma group, 46.8% of releases were hedgehogs (44 days) and 25.6% owls (103 days). In the cost-benefit index, the trauma casualties and infectious diseases had the

(CONTINUED ON PAGE 18)

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Introduction

Wildlife Rehabilitation is defined as the treatment and temporary care of injured, diseased, and displaced indigenous animals, and the subsequent release of healthy animals to appropriate habitats in the wild.[1] Benefits and limitations of this activity have been thoroughly discussed.[2,3] Moreover, there is a consensus on the value of wildlife rehabilitation centers (WRC) in monitoring the health of ecosystems, detecting threats to wild animal populations and improving of the wild animal welfare.[4] There are thousands of these centers worldwide working with a huge diversity of species and with different levels of specialization, different management protocols and diverse budgets. Namely, benchmarking can be a very complicated task among the high heterogeneity of WRC.

The information recorded in the WRC can become a material of great value for conservation, providing evidence of the natural or anthropogenic menaces for the species. Although there are many morbidity studies in wildlife,[5,6,7,8] most of them are restricted to specific zoological categories, and studies covering a wide variety of animal species or covering long periods of time are still scarce.[9,10,11] Moreover, reviews of wildlife casualties providing objective criteria about cost-benefit of the casualties' treatments are also poorly reported in the literature.[12,13]

In the present study, we analyze 54,772 cases attended at the WRC of Torreferrussa, comprising 302 different wild species in a 19-year-long period, including primary causes of admission (morbidity), release and death rates (as main outcome indicators), the rehabilitation stay period in the center, and a cost–benefit index as an approach to calculate the rehabilitation costs. In order to improve our understanding and the efficiency of the rehabilitation process, our objective was to evaluate the relative importance and temporal variation of different primary causes of admission during the study period, as well as to evaluate the effectiveness of the rehabilitation in different taxa and in relation to these primary causes.

Materials and methods

Study design

A retrospective study was performed using the original medical records of the animals admitted at the WRC of Torreferrussa (Catalonia, North-East Iberian Peninsula). The center receives animals from Catalonia, mainly from the North and Central areas. Catalonia is a state of Spain located at the Mediterranean subregion of the western Palearctic (3°19'–0°9' E and 42°51'–40°31' N). Wild animals admitted alive from 1995 to 2013 were included in the analyses. Any domestic or exotic species, non-wild born individuals or captive born cases, as well as any case with a total lack of information about the patient were excluded from the analysis.

The rehabilitation center is under the direction of the Catalan Wildlife-Service, who stipulates the management protocols and Ethical Principles according to the Catalan[14] and Spanish legislation.[15]

Animal classification

For each individual admitted to the center we recorded species, sex and age. For statistical analysis, species were grouped in the following broader taxonomic categories: Amphibians (including Anura and Caudata), Reptiles (including Testudines and Squamata), Mammals (including Carnivora, Artiodactyla, Chiroptera, Rodentia, Lagomorpha and Insectivora), Diurnal birds of prey (Accipitriformes), Owls (Strigiformes), Marine birds (including Procellariformes, Suliformes, Charadriformes), Herons and allies (including Pelecaniformes, Ciconiformes and Phoenicopteriformes), Waders (Charadrifomes), Other aquatic birds (including Anseriformes, Gruiformes and Podicipediformes), Swifts (Apodiformes), Passerines (Passeriformes), and Other birds (including Columbiformes, Galliformes, Coraciiformes, Caprimulgiformes, Piciformes, Bucerotiformes, Cuculiformes and Otidiformes). Sex was determined when possible by inspection in dimorphic species or by gonadal examination at necropsy. The age was categorized as "first calendar year" and ">1 year calendar" for all the animal groups.[16]

Morbidity analysis

The categories and subcategories of the causes of admission were based on the primary diagnoses.[17,18] Briefly, causes were grouped in the following main categories: "Trauma" associated with an anthropogenic activity or structure (collision—with vehicles, buildings or other human structures, power lines, fences—, electrocution, gunshot, and unknown trauma), "Orphaned" (chicks, fledging or young animals, supposedly abandoned by their parents or fallen from their nest), "Captivity" (animals maintained in captivity for more than 6 months and/or confiscated by the rangers or the police due to poaching or illegal pet trade), "Infectious disease" (infectious or parasitic disease, based in clinical diagnoses or by confirmation of a pathogenic microorganism), "Metabolic or nutritional disease" (low body condition, weakness, and other diseases grouped by organ system), "Misplacement" (animals accidentally found in wrong places, such as buildings or other human made structures, water bodies, or vehicles), "Other causes" [including natural injuries or casualties (predation, entangled by plants...), intoxication (confirmation of toxic agents), and a miscellaneous of causes as oiled birds, bycatch, predation...], and "Undetermined" (when it was not possible to assign the cause to any of the above mentioned categories). Primary causes were also grouped in two categories, according to the human contribution, as follows: anthropogenic (gunshot, captivity, intoxication, electrocution, collisions with power lines, vehicles, human structures and fences, oiled, unknown trauma, misplacement, and other) and natural (metabolic or nutritional, infectious disease, and orphaned).

A prognostic scoring was defined according to the severity of the illness or injury at the moment of the admission, including the following categories: 1, apparently healthy; 2, mild weakness or thinning, uncomplicated fractures; 3, severe (including dehydration, open fractures, deep wounds); and 4, very severe (major injuries, emaciation, paralysis, blindness, respiratory distress).

Outcome analysis

After admission a bird could follow four different outcomes: 1) Euthanasia, which was humanely assisted death applied to animals with low prognosis or low quality of life, 2) Unassisted death, which occurred during treatment of some animals, 3) Release to the wild, of successfully healed individuals with good perspectives to adapt in the wild, and 4) Captivity, for non-releasable animals that were kept permanently captive, due to their poor prognosis of survivability in the wild. According to these categories, four outcome indicators of the final dispositions of the rehabilitation process were considered and expressed as a rate between the number of cases of each category by the total number of admissions in a given period of time;[13] 1) Release rate (R_r: number of animals released to the wild/total number of animals admitted), 2) Euthanasia rate (E_r: number of animals euthanized/total number of animals admitted), 3) Mortality rate (M_r: number of animals experiencing unassisted death during treatment/total number of animals admitted), and 4) Captivity rate (C_r: number of animals kept permanently captive/total number of animals admitted).

Cost–benefits estimator

The time of the rehabilitation stay (T_s) in the center was used as the basic estimator or approach for assessing the cost of the reha-

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worse values with 1.3 and 1.4 released animals/euro/day respectively, and were particularly low in raptors, waders, marine birds, and Chiroptera. On the contrary, captivity (4.6) and misplacement (4.1) had the best index, particularly in amphibians, reptiles, and passerines.

Conclusions / Significance: Cost–benefit studies including the release rate, the time of stay at the center and the cost benefit index should be implemented for improving management efficiency of wildlife rehabilitation centers.

[*Abstract edited for space—ed.]

bilitation process. This parameter (T_s) was defined as the length of time that the animal was retained in the center, that is, the period in days from the date of admittance to the date of release or death of the animal. In order to study the T_s, the percentiles 10 (P_{10}) and 90 (P_{90}) of this variable were selected as cut-off points.

On the other hand, a cost-benefit index was calculated as a ratio between the number of released animals and the total cost in euros (cost per day in euros * number of animals) for each taxonomic group and cause of admission and prognostic category. The daily cost per animal was assumed the same for all species along the rehabilitation process. In order to estimate the daily cost per animal, we selected data from 2008 to 2012. Thus, the average expenses of the WRC (334.583 euros, including staff), were divided by the product [(number of cases/year) * 365 days)], obtaining a value of 0.19 euros/animal/day. Therefore, this estimator expresses the number of released animals per euro of expenses per day of stay, along the period of the study.

Other variables

The variable "People that brought the animal" included: Rangers, Other Police Authorities, Private Individuals, Others, and Unknown.

Statistical analysis

Descriptive statistics, normality test and inferential analyses were done using 95% of confidence intervals (95%CI) with SPSS Advanced Models™ 15.0 (SPSS Inc. 233 South Wacker Drive, 11th Floor Chicago, IL 60606-6412). Morbidity and outcome studies were analyzed for variation among the different groups of animals, seasons or among years of the study. Comparisons of the median were evaluated using the U-Mann-Whitney and Kruskal-Wallis test. Chi-square or Fisher exact tests were used for comparisons between the causes of admission, outcomes rates, sex, age and taxonomical categories. Linear regression model was used to estimate the trend of the causes of admission and final dispositions during the period of study. Mean, Confidence Intervals of 95% (CI95%), Median (P50) and Percentiles 10 and 90 (P10; P90) were provided for the descriptive analysis of the cost-benefit of the rehabilitation process.

Results

Animal data section

The revision process was done in 65,335 admission reports. Most of the animals were brought to the WRC by the competent authorities, such as the Rangers (75%), other police authority (9%) and by private citizen (12%). The final sample for the study included 54,772 cases (10,563 cases were excluded for not fulfilling the inclusion criteria described above, including dead admissions for forensic investigation). The final study population included 302 different species (Table 1), most of them (88.5% of cases) considered as protected species by the Catalan legislation and represented about 60% of the total species reported in Catalonia.[19,20,21] Some species are included in the Spanish threatened list[22] as "in danger of extinction" or "vulnerable" such as *Testudo hermanni, Testudo graeca, Botaurus stellaris, Aythya nyroca, Gypaetus barbatus, Chlidonias niger, Calonectris diomedea, Phalacrocorax aristotelis, Ardeola ralloides, Circus pygargus, Aquila fasciata, Milvus milvus, Neophron percnopterus, Pandion haliaetus, Tetrao urogallus, Tetrax tetrax, Larus audouinii, Aegolius funereus, Phoenicurus phoenicurus,* and *Miniopterus schreibersi*. However, both groups of threatened species represented a small percentage (3%) of the total cases admitted for rehabilitation.

Birds accounted for 48,633 (89%) admissions, followed by 3,293 (6%) Mammals, 2,705 (5%) Reptiles, and 141 (0.3%) Amphibians. As regards to the sex, 16,926 (31%) animals were males, 7,865 (14%) females, and 29,981 (55%) were undetermined. Within the male group, 10,661 animals were finches, representing 63% of the males included in the study. As regards to age, 29,549 (54%) of admissions were first calendar year animals, 16,376 (30%) were >1 calendar year animals and 8,874 (16%) were of undetermined age.

Primary causes of morbidity/morbidity analysis

Anthropogenic interferences were involved in 64% of the admissions (Fig. 1). "Captivity" was the most frequent cause of admission with 21774 animals [39.8%, (CI95%: 39.3–40.2)] in the overall period of study. Within this category, 75% of passerines and 73% of tortoises were the most frequently confiscated species (Table 2). "Orphaned" was the second most prevalent category with 17,410 cases [31.8% (31.4–32.3)], mainly comprised by swifts (74%), rodents, and rabbits (63%), and owls (57%). "Trauma" casualties were the third most important category with 9,538 cases [17.4% (17.1–17.7)]; within this category, waders (71%), birds of prey (60%), herons and allies (59%), and carnivores (41%) presented the majority of the casualties (Table 2).

Further analysis of the trauma category showed that 73% of the trauma were classified as of unknown origin (lack of information about the circumstances of the trauma or accident). Twenty percent of traumas were due to gunshot (10%) and collision with vehicles (10%) (Fig. 1). Diurnal birds of prey, herons and allies were the most affected by gunshot, representing 26.6% and 18.5% of cases respectively. Interestingly, 12% of the gunshot injured birds were admitted out of the hunting season. Within the category of collision with vehicles, mammals accounted for the higher proportion, especially affecting artiodactyls (52.5%) and carnivores (50.7%), followed by owls (22.5%).

Misplacement is an important reason of bringing to the Wildlife Rehabilitation Centers reptiles (especially in squamata with 68%) and hedgehogs (31%). Finally, note that "Other" has included causes with a very small number of cases, but relevant from the point of view of the impact of human activity, such as poisoning (25 cases), bycatch (37 cases), and oiled birds (54 cases).

Primary infectious and parasitic diseases included a wide variety of conditions. Thus, aspergillosis, trichomoniasis, coccidiosis and other endoparasites, avian poxvirus, and *E. coli* and *Salmonella* spp. infections were the most common diseases diagnosed in birds.

TABLE 1. Species included in the study.

BIRDS

Anseriformes	n	%
Anas platyrhynchos	526	92.4
Aythya nyroca[β]	9	1.6
Tadorna tadorna	8	1.4
Anas querquedula	4	0.7
Anser anser	4	0.7
Anas crecca	3	0.5
Anas penelope	3	0.5
Netta rufina	3	0.5
Somateria mollissima	3	0.5
Anas acuta	1	0.2
Anas strepera	1	0.2
Aythya ferina	1	0.2
Aythya fuligula	1	0.2
Cygnus olor	1	0.2
Tadorna ferruginea	1	0.2
Total	**569**	**100**

Podicipediformes	n	%
Tachybaptus ruficollis	19	54.3
Podiceps nigricollis	10	28.6
Podiceps cristatus	6	17.1
Total	**35**	**100**

Phoenicopteriformes	n	%
Phoenicopterus roseus	38	100

Gruiformes	n	%
Gallinula chloropus	96	58.2
Rallus aquaticus	27	16.4
Porphyrio porphyrio	13	7.9
Fulica atra	9	5.5
Crex crex	8	4.8
Porzana porzana	8	4.8
Grus grus	2	1.2
Porzana parva	2	1.2
Total	**165**	**100**

Pelecaniformes	n	%
Ardea cinerea	195	41.1
Bubulcus ibis	109	23
Egretta garzetta	70	14.8
Ixobrychus minutus	55	11.6
Ardea purpurea	17	3.6
Nycticorax nycticorax	12	2.5
Botaurus stellaris[β]	11	2.3
Platalea leucorodia	2	0.4
Ardeola ralloides[β]	1	0.2
Egretta alba	1	0.2
Plegadis falcinellus	1	0.2
Total	**474**	**100**

Apodiformes	n	%
Apus apus	7030	85
Apus melba	1214	14.7
Apus pallidus	28	0.3
Total	**8272**	**100**

Galliformes	n	%
Coturnix coturnix	50	58.1
Alectoris rufa	35	40.7
Tetrao urogallus[β]	1	1.2
Total	**86**	**100**

Caprimulgiformes	n	%
Caprimulgus europaeus	298	68
Caprimulgus ruficollis	140	32
Total	**438**	**100**

Charadriiformes	n	%
Larus michahellis	518	47.4
Scolopax rusticola	162	14.8
Larus ridibundus	131	12
Burhinus oedicnemus	47	4.3
Larus audouinii[β]	35	3.2
Fratercula arctica	29	2.7
Vanellus vanellus	26	2.4
Alca torda	23	2.1
Himantopus himantopus	23	2.1
Charadrius alexandrinus	17	1.6
Larus melanocephalus	12	1.1
Sterna sandvicensis	10	0.9
Sterna hirundo	9	0.8
Charadrius dubius	8	0.7
Gallinago gallinago	4	0.4
Calidris minuta	3	0.3
Numenius phaeopus	3	0.3
Pluvialis apricaria	3	0.3
Tringa totanus	3	0.3
Calidris alpina	2	0.2
Haematopus ostralegus	2	0.2
Larus minutus	2	0.2
Rissa tridactyla	2	0.2
Tringa ochropus	2	0.2
Actitis hypoleucos	1	0.1
Calidris alba	1	0.1
Calidris canutus	1	0.1
Calidris ferruginea	1	0.1
Charadrius hiaticula	1	0.1
Charadrius morinellus	1	0.1
Chlidonias hybrida	1	0.1
Chlidonias niger[β]	1	0.1
Larus fuscus	1	0.1
Limosa lapponica	1	0.1
Limosa limosa	1	0.1
Philomachus pugnax	1	0.1
Stercorarius parasiticus	1	0.1
Sterna albifrons	1	0.1
Tringa glareola	1	0.1
Tringa nebularia	1	0.1
Uria aalge	1	0.1
Total	**1093**	**100**

Coraciiformes	n	%
Ciconia ciconia	121	100

Piciformes	n	%
Picus viridis	194	85.1
Dendrocopos major	22	9.6
Jynx torquilla	7	3.1
Dryocopus martius	3	1.3
Dendrocopos minor	2	0.9
Total	**228**	**100**

Coracciiformes	n	%
Merops apiaster	117	57.9
Alcedo atthis	77	38.1
Coracias garrulus	8	4
Total	**202**	**100**

Bucerotiformes	n	%
Upupa epops	139	100

Strigiformes	n	%
Athene noctua	1655	31.8
Otus scops	1476	28.3
Strix aluco	1064	20.4
Tyto alba	678	13
Bubo bubo	209	4
Asio otus	111	2.1
Asio flammeus	15	0.3
Aegolius funereus[β]	1	0
Total	**5209**	**100**

Accipitriformes	n	%
Falco tinnunculus	1994	40.6
Buteo buteo	1150	23.4
Accipiter nisus	637	13
Accipiter gentilis	344	7
Falco peregrinus	161	3.3
Gyps fulvus	96	2
Pernis apivorus	88	1.8
Falco naumanni	76	1.5
Circaetus gallicus	67	1.4
Falco subbuteo	61	1.2
Circus aeruginosus	44	0.9
Hieraaetus pennatus	42	0.9
Circus pygargus[β]	40	0.8
Milvus migrans	39	0.8
Hieraaetus fasciatus[β]	19	0.4
Circus cyaneus	15	0.3
Falco columbarius	10	0.2
Milvus milvus[β]	10	0.2
Pandion haliaetus	4	0.1
Aquila chrysaetos	3	0.1
Aegypius monachus	2	0
Buteo rufinus	2	0
Falco vespertinus	2	0
Gypaetus barbatus[β]	2	0
Neophron percnopterus[β]	2	0
Total	**4910**	**100**

Procellariformes	n	%
Hydrobates pelagicus	4	44.4
Calonectis diomedea[β]	3	33.3
Puffinus yelkouan	2	22.2
Total	**9**	**100**

Suliformes	n	%
Phalacrocorax aristotelis[β]	37	37
Morus bassanus	34	34
Phalacrocorax carbo	29	29
Total	**100**	**100**

Columbiformes	n	%
Streptopelia decaocto	349	58.7
Columba palumbus	222	37.3
Streptopelia turtur	24	4
Total	**595**	**100**

Cuculiformes	n	%
Cuculus canorus	31	50.8
Clamator glandarius	30	49.2
Total	**61**	**100**

Otidiformes	n	%
Tetrax tetrax[β]	1	100

Passeriformes	n	%
Carduelis carduelis	10623	41
Carduelis chloris	3436	13.3

(continued)

TABLE 1. (Continued)

Carduelis cannabina	2755	10.6
Fringilla coelebs	1431	5.5
Passer domesticus	1270	4.9
Delichon urbicum	1001	3.9
Serinus serinus	835	3.2
Turdus merula	778	3
Pica pica	634	2.4
Carduelis spinus	616	2.4
Sturnus vulgaris	345	1.3
Hirundo rustica	264	1
Garrulus glandarius	198	0.8
Parus major	152	0.6
Corvus monedula	140	0.5
Motacilla alba	128	0.5
Erithacus rubecula	118	0.5
Turdus philomelos	115	0.4
Sylvia atricapilla	114	0.4
Passer montanus	73	0.3
Oriolus oriolus	66	0.3
Parus caeruleus	65	0.3
Emberiza cirlus	61	0.2
Sylvia melanocephala	53	0.2
Fringilla montifringilla	40	0.2
Phylloscopus collybita	38	0.1
Pyrrhula pyrrhula	38	0.1
Acrocephalus scirpaceus	33	0.1
Ficedula hypoleuca	30	0.1
Phoenicurus ochruros	27	0.1
Luscinia megarhynchos	26	0.1
Coccothraustes coccothraustes	25	0.1
Prunella modularis	22	0.1
Loxia curvirostra	21	0.1
Corvus corax	17	0.1
Phylloscopus trochilus	15	0.1
Corvus corone	14	0.1
Parus cristatus	14	0.1
Turdus viscivorus	12	0
Aegithalos caudatus	11	0
Emberiza cia	11	0
Parus ater	11	0
Melanocorypha calandra	10	0
Regulus ignicapilla	10	0
Sylvia cantillans	10	0
Lullula arborea	9	0
Saxicola torquatus	9	0
Hippolais polyglotta	8	0
Pyrrhocorax pyrrhocorax	8	0
Sylvia communis	8	0
Emberiza schoeniclus	7	0
Galerida cristata	7	0
Petronia petronia	7	0
Regulus regulus	7	0
Anthus pratensis	6	0
Cettia cetti	6	0
Emberiza calandra	6	0
Cisticola juncidis	5	0
Hirundo daurica	5	0
Ptyonoprogne rupestris	5	0
Sylvia borin	5	0
Turdus iliacus	5	0
Alauda arvensis	4	0
Anthus triviallis	4	0
Lanius collurio	4	0
Lanius senator	4	0
Muscicapa striata	4	0
Phoenicurus phoenicurus[β]	4	0
Sitta europaea	4	0
Sturnus unicolor	4	0
Troglodytes troglodytes	4	0
Acrocephalus arundinaceus	3	0
Certhia brachydactyla	3	0
Hippolais opaca	3	0
Sylvia undata	3	0
Bucanetes githagineus	2	0
Calandrella brachydactyla	2	0
Locustella luscinioides	2	0
Motacilla cinerea	2	0
Saxicola rubetra	2	0
Serinus citrinella	2	0
Anthus richardi	1	0
Certhia familiaris	1	0
Emberiza citrinella	1	0
Monticola saxatilis	1	0
Monticola solitarius	1	0
Montifringilla nivalis	1	0
Ficedula albicollis	1	0
Prunella collaris	1	0
Turdus torquatus	1	0
Total	**25888**	**100**

MAMMALS

Insectivora	**n**	**%**
Erinaceus europaeus	1309	93.5
Aetechinus (=Atelerix) algirus	81	5.8
Crocidura russula	8	0.6
Sorex araneus	1	0.1
Suncus etruscus	1	0.1
Total	**1400**	**100**

Carnivora	**n**	**%**
Vulpes vulpes	154	43
Meles meles	74	20.7
Martes foina	66	18.4
Genetta genetta	34	9.5
Mustela nivalis	21	5.9
Felis silvestris	8	2.2
Mustela lutreola[β]	1	0.3
Total	**358**	**100**

Rodentia	**n**	**%**
Sciurus vulgaris	3538	9.6
Apodemus sylvaticus	17	4.3
Eliomys quercinus	11	2.8
Rattus norvergicus	5	1.3
Rattus rattus	4	1
Glis glis	3	0.8
Marmota marmota	1	0.3
Total	**394**	**100**

Artiodactyla	**n**	**%**
Sus scrofa	103	60.9
Capreolus capreolus	48	28.4
Cervus elaphus	9	5.3
Rupricapra rupricapra	7	4.1
Dama dama	1	0.6
Ovis ammon	1	0.6
Total	**169**	**100**

Lagomorpha	**n**	**%**
Oryctolagus cuniculus	92	94.8
Lepus granatensis	5	5.2
Total	**97**	**100**

Chiroptera	**n**	**%**
Pipistrellus pipistrellus	506	57.8
Pipistrellus pipist. pygmaeus	235	26.9
Pipistrellus kuhlii	88	10.1
Tadarida teniotis	12	1.4
Eptesicus serotinus	10	1.1
Microquiropterus sp.	9	1
Plecotus auritus	7	0.8
Miniopterus schreibersi[β]	3	0.3
Nyctalus leisleri	3	0.3
Pipistrellus nathusii	2	0.2
Total	**875**	**100**

AMPHIBIANS

Bufo calamita	56	71.8
Hyla meridionalis	9	11.5
Bufo bufo	7	9
Alytes obstetricans	1	1.3
Discoglossus pictus	1	1.3
Hyla arborea	1	1.3
Bufo viridis	1	1.3
Rana iberica	1	1.3
Rana temporaria	1	1.3
Total	**78**	**100**

Caudata	**n**	**%**
Salamandra salamandra	38	60.3
Lissotriton helveticus	10	15.9
Triturus marmoratus	8	12.7
Pleurodeles waltl	7	11.1
Total	**63**	**100**

REPTILES

Squamata	**n**	**%**
Malpolon monspessulanus	133	33.4
Rhinechis scalaris	114	28.6
Timon lepidus	57	14.3
Chamaeleo chamaeleon	23	5.8
Natrix maura	21	5.3
Anguis fragilis	8	2
Tarentola mauritanica	8	2
Hemorrhois hippocrepis	7	1.8
Natrix natrix	7	1.8
Vipera aspis	5	1.3
Vipera latasti	5	1.3
Zamenis longissimus	4	1
Coronella girondica	2	0.5
Hierophis viridiflavus	2	0.5
Hemidactylus turcicus	1	0.3
Lacerta viridis	1	0.3
Total	**398**	**100**

Testudines	**n**	**%**
Testudo hermanni[β]	1111	48.2
Mauremys leprosa	747	32.4
Testudo graeca[β]	414	17.9
Emys orbicularis	35	1.5
Total	**2307**	**100**

[β] Menaced species according to the Spanish laws.

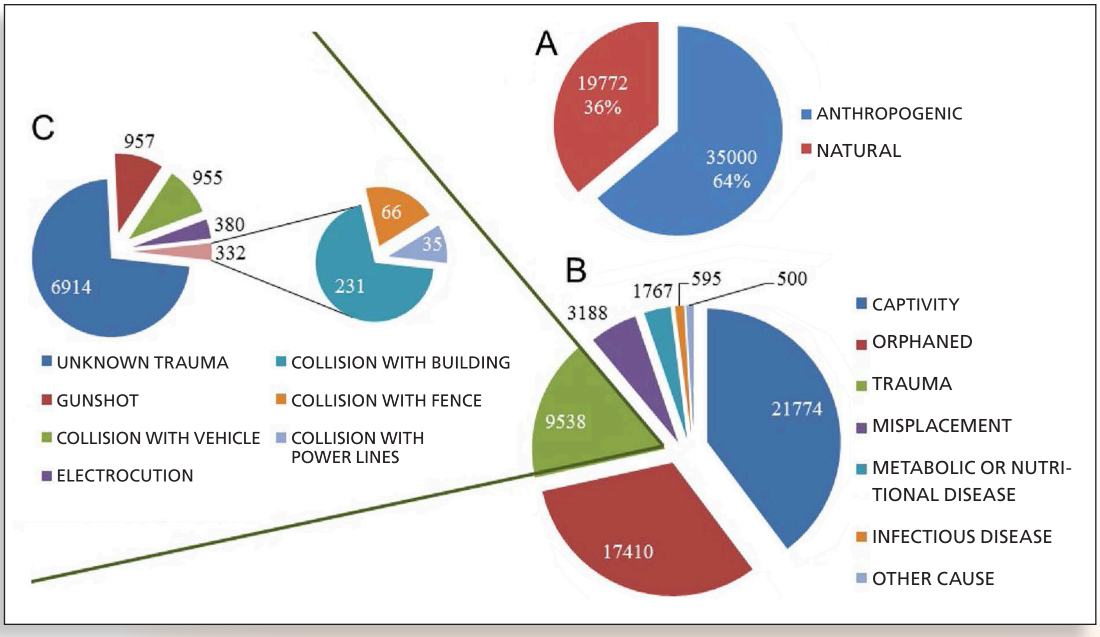
TABLE 2. Primary causes of admission expressed as a proportion within the animal group (rows). The "Undetermined" category was included in the "Other causes" due to the low number of cases (n = 58).

ANIMAL GROUP	Total Admissions	Captivity		Orphaned		Trauma		Misplacement		Metabolic or nutritional		Infectious disease		Other cause	
	N	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Amphibians	141	31	22.0	0	0.0	7	5.0	50	35.5	0	0.0	0	0.0	53	37.6
Chelonians	2307	1678	72.7	58	2.5	171	7.4	381	16.5	7	0.3	2	0.1	10	0.4
Squamata	398	22	5.5	8	2.0	87	21.9	271	68.1	5	1.3	2	0.5	3	0.8
Other aquatic birds	769	11	1.4	389	50.6	126	16.4	112	14.6	72	9.4	47	6.1	12	1.6
Herons	633	2	0.3	53	8.4	372	58.8	33	5.2	131	20.7	28	4.4	14	2.2
Waders	316	5	1.6	30	9.5	224	70.9	11	3.5	28	8.9	15	4.7	3	0.9
Marine birds	886	10	1.1	210	23.7	307	34.7	43	4.9	182	20.5	38	4.3	96	10.8
Owls	5209	136	2.6	2968	57.0	1486	28.5	341	6.5	192	3.7	38	0.7	48	0.9
Birds of prey	4910	266	5.4	823	16.8	2970	60.5	283	5.8	346	7.0	148	3.0	74	1.5
Swifts	8272	15	0.2	6153	74.4	1192	14.4	668	8.1	228	2.8	1	0.0	15	0.2
Other birds	1749	55	3.1	601	34.4	807	46.1	112	6.4	85	4.9	75	4.3	14	0.8
Passerines	25889	19470	75.2	4779	18.5	1107	4.3	257	1.0	170	0.7	62	0.2	44	0.2
Insectivora	1400	38	2.7	431	30.8	220	15.7	436	31.1	178	12.7	59	4.2	38	2.7
Carnivora	358	15	4.2	82	22.9	146	40.8	38	10.6	26	7.3	27	7.5	24	6.7
Rodents and rabbits	491	17	3.5	310	63.1	96	19.6	13	2.6	3	0.6	49	10.0	3	0.6
Artiodactyla	169	3	1.8	51	30.2	61	36.1	5	3.0	3	1.8	4	2.4	42	24.9
Chiroptera	875	0	0.0	464	53.0	159	18.2	134	15.3	111	12.7	0	0.0	7	0.8
Overall	**54772**	**21774**	**39.8**	**17410**	**31.8**	**9538**	**17.4**	**3188**	**5.8**	**1767**	**3.2**	**595**	**1.1**	**500**	**0.9**

TABLE 3. Stay (days) at the center for released animals in the WRC of Torreferrusa.

STAY AT THE CENTER	Trauma			Orphaned			Captivity			Misplacement			Metabolic/ nutritional			Infectious			Others		
	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}	P_{10}	P_{50}	P_{90}
Amphibians	0	1	.	0	1	20	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.
Chelonians	0	4	22	0	2	31	0	2	18	0	3	25	1	2	.	3	7	.	0	4	58
Squamata	0	1	5	0	0	.	0	1	6	0	0	4	0	2	.	0	1	.	1	3	.
Waterfowl	0	5	66	0	50	118	0	0	.	0	2	66	0	3	16	5	14	82	0	0	.
Herons	7	47	141	10	41	119	.	.	.	1	11	66	4	19	72	0	17	.	7	19	.
Waders	0	7	114	26	41	170	.	.	.	0	1	.	7	9	.	2	5	.	.	.	.
Marine birds	0	28	78	3	49	88	1	2	.	0	5	67	0	13	50	4	14	47	1	19	84
Owls	16	104	442	21	66	175	16	128	474	0	28	212	11	57	249	31	131	623	2	65	349
Birds of prey	24	121	434	1	43	147	13	127	397	1	27	228	6	42	249	26	78	659	0	33	311
Swifts	0	1	32	2	19	42	0	27	.	0	0	25	0	6	21	.	.	.	0	3	.
Other birds	0	5	47	0	21	55	4	20	20	0	1	24	0	10	43	6	14	.	0	9	.
Passerines	0	11	52	5	26	68	0	12	57	0	2	42	0	8	58	0	16	48	1	11	67
Insectivora	16	44	124	12	49	166	1	19	181	3	28	132	16	50	160	21	48	93	14	58	237
Carnivora	5	33	121	0	22	183	4	38	171	0	13	60	12	27	90	16	32	.	0	3	143
Rodents and rabbits	0	51	156	11	54	152	0	11	78	0	13	.	.	.	.	.	.	.	.	.	.
Artiodactyla	0	27	.	0	19	113	.	.	.	0	1	.	.	.	.	.	.	.	1	2	.
Chiroptera	0	15	80	1	55	85	.	.	.	0	1	64	3	20	76	.	.	.	.	.	.

FIGURE 1. Primary causes of admission.
A) Proportion of anthropogenic and natural causes.
B) Absolute cases of primary causes of admission.
C) Absolute cases of trauma category.



In mammals, the most prevalent diseases were myxomatosis in rabbits, sarcoptic mange in carnivores, and parasitic pneumonia and abscesses in hedgehogs.

As regards to the distribution of cases along the calendar year, 48% were admitted in summer, 26% in spring, 15% in autumn and 11% in winter. The increase of cases during the spring and summer seasons was consequence of the onset of reports of orphaned animals which represented 38% and 48% of the admissions respectively. In autumn and winter, illegal captures (54–56%) and traumas (30–27%) were the most common causes of admission.

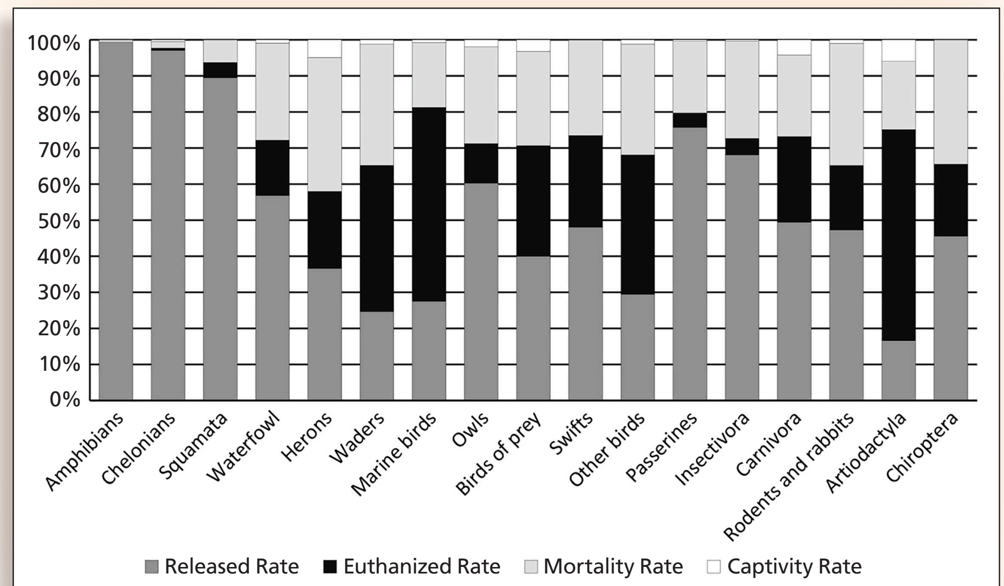


FIGURE 2. Outcome rates in the different zoological groups.

Year regression analyses showed a significant rise of the total number of attended animals along the years of study (R^2 = 0.82; b = 271.55; p< 0.001). Among them, orphaned (R^2 = 0.89; b = 112.0; p< 0.001), and animals suffering from trauma (R^2 = 0.76; b = 22.3; p = 0.00), metabolic/nutritional (R^2 = 0.71; b = 5.95; p< 0.001) or infectious/parasitic diseases (R^2 = 0.77; b = 3.95; p< 0.001) had a significant increase. By contrast, in the trauma category, a slight decrease was observed in the collision with vehicles (R^2 = 0.41; b = -1.63; p = 0.001); on the other hand, the slopes of regression for collision with buildings (R^2 = 0.57; b = 1.07; p< 0.001) and electrocution (R^2 = 0.58; b = 0.95; p = 0.001) were very close to 1. No trend was observed in gunshot reports (R^2 = 0.16; b = -0.09; p = 0.1).

Outcome analyses

Overall, 72,77 animals were euthanized (E_r = 13%), 12,280 animals died during the rehabilitation process (M_r = 22%), 493 were kept in captivity (C_r = 1%), and 34,722 animals were released (R_r = 63%).

Outcome rates were different depending on the animal group and cause of admission. Marine birds (27.5%), waders (24.7%), and artiodactyla (16.6%) had the lowest release rate, while amphibians and reptiles, as well as passerines presented the highest R_r above 75% (Fig. 2). By contrast, the highest natural mortality (M_r) was reported in the orphaned waders (56.7%), herons (45.3%), passerines (29.3%), and swifts (27.8%) (Fig. 3).

When the outcomes rates were stratified by cause of admission and animal group, the “Captivity” “Misplacement” and “Orphaned” categories showed the highest Rr (Fig. 3). In the “Captivity” category scores above 85% were found in amphibians, reptiles, hedgehogs, and passerines. In the “Orphaned” Rr

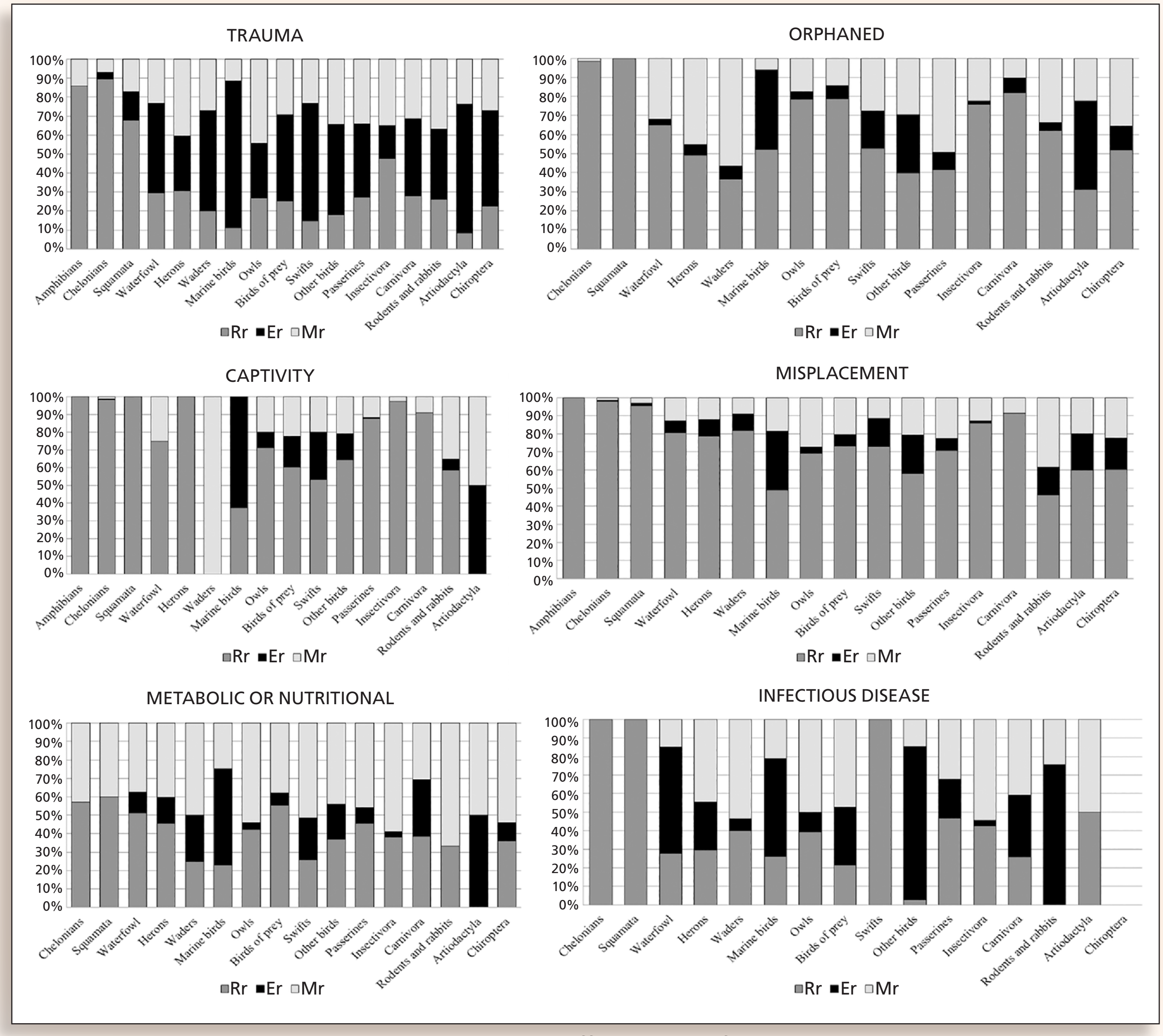


FIG 3. Outcome rates according to the zoological group in the different causes of admission. Rr = Released rate; Er = Euthanized rate; Mr = Mortality rate.

above 75% were achieved in owls, diurnal birds of prey, hedgehogs, and carnivores. On the other hand, the highest rates of mortality due to natural (Mr) or assisted (Er) death were seen for "Trauma," "Metabolic or nutritional," and "Infectious disease" (Fig. 3).

Outcomes have been also estimated stratified by taxonomic group and prognostic category (Fig. 4). A higher release rate in the majority of taxonomic groups was observed in cases categorized as good prognosis (categories 1 and 2), with R_r values higher than 60%. In particular, reptiles have the highest release rates in all clinical categories. On the other hand, the M_r increases as the prognosis worsens. It should be noted that the groups with the highest M_r are seabirds and Chiroptera, especially in the categories with the best apparent prognosis (Fig. 4). Finally, the E_r was higher in categories 2 and 3, with values larger than 25%. In addition, the highest E_r values were obtained in Artiodactyla, with observed values of 54%, 50%, 34.8%, and 68.6% in the clinical categories 1 to 4, respectively (Fig. 4).

Cost–benefit estimator

Overall, the median T_s at the center was 9 days (P10 = 0; P90 = 69). The median days of stay at the centre was 17 days (P_{10} = 0; P_{90} = 80) for released animals, 3 days for natural death (P_{10} = 0; P_{90} = 40), and 0 days for euthanized (P_{10} = 0; P_{90} = 32).

In the group of released animals, the longest T_s were observed in diurnal birds of prey and owls with around two months of hospitalization (Table 3). In mammals, rodents and rabbits, hedgehogs, and bats have T_s values around one and a half months. Similarly, when we consider the cause of admission, the overall process of rehabilitation of trauma casualties and the orphaned young took the longest median T_s (more than one month) and by contrast,

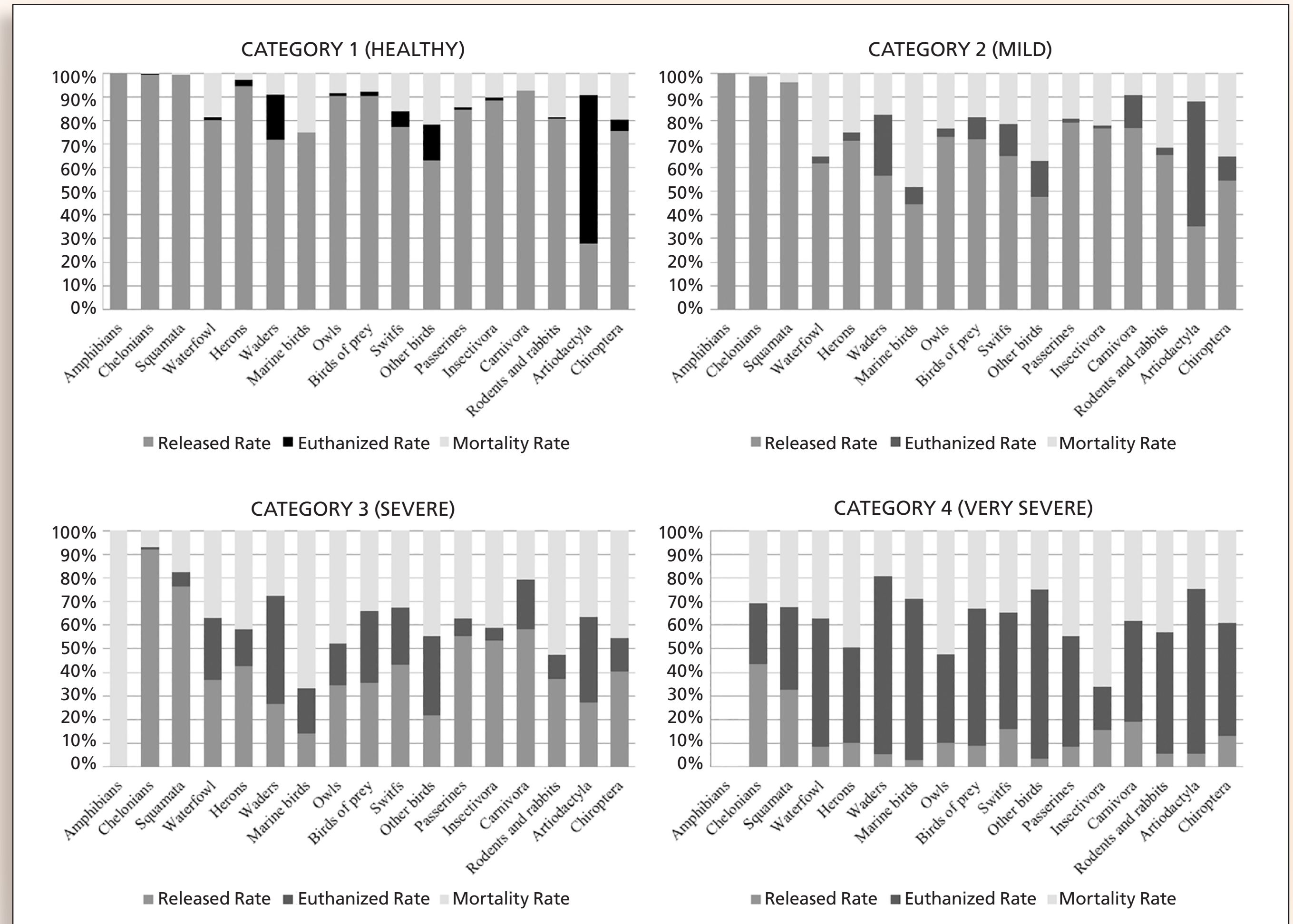


FIG 4. Outcome rates according to the zoological group in the different prognostic categories. Category description: 1, apparently healthy; 2, mild weakness or thinning, uncomplicated fractures; 3, severe (including dehydration, open fractures, deep wounds) and 4, very severe (major injuries, emaciation, paralysis, blindness, respiratory distress).

misplacement had the shorter time (3 days). Trauma has the higher T_s (P_{90} = 284), independent of the zoological group. Importantly, hand-rearing orphans had median Ts between 20–60 days, with values around 20 days in swifts and other bird categories, which represent the largest number of chicks. On the other hand, both infectious diseases and metabolic and nutritional were associated with high recovery times, especially in hedgehogs, carnivore, owls, and birds of prey. Finally, it was noteworthy the high T_s of birds of prey that have been kept illegally in captivity.

As regards the cost–benefit index, the best values were observed in amphibian, reptiles, and passerines, with values ranging from 4 to 5 released animals per euro and day (Table 4). On the other hand, when we consider the cause, the best results were obtained in the captivity (4.6 animals/euro/day) and misplacement (4.1) categories (Table 4). Interestingly the orphaned group represented 2.9 animals/euro/day, and the most efficient hand-rearing corresponded to raptors in birds, and Carnivora and Insectivora in mammals. On the other hand, the worst values were observed in the group of trauma casualties (1.3 animals/euro/ day) and infectious diseases (1.4), especially in raptors, waders, marine birds, and bats. In general, the cost–benefit index was higher in the cases with better prognosis (Table 5).

Discussion

It is important to take into consideration that the purpose of the Wildlife Rehabilitation Centers (WRC) is the release of healthy animals to the appropriate habitats in the wild after temporary care in captivity. For this reason, the evaluation of data about the rehabilitation practice is essential to have reference values for comparison purposes among different WRC in order to critically analyze the protocols and improve efficiency if necessary in each center. To our knowledge, the present epidemiological study is one of the largest and long-term studies conducted in a WRC. Data reported in this study should have a significant impact in the morbidity analysis as regards the large number of animals (> 55000) and diversity of species (>300) included. Moreover, it provides new information about outcomes and the cost-benefit estimators of the rehabilitation process that can be useful as a reference for professionals involved in wildlife medicine and management.

It is well documented that anthropogenic factors are the most

TABLE 4. Cost-benefit analyses of the rehabilitation process. The cost-benefit index express the number of released animals per euro and days of stay at the WRC.

ANIMAL GROUP	Overall ratio	Trauma	Orphaned	Misplacement	Captivity	Infectious disease	Metabolic or nutritional
Amphibians	5.2	4.5	na	5.3	5.3	na	na
Chelonians	5.1	4.7	5.2	5.1	5.2	5.3	3.0
Squamata	4.7	3.6	5.3	5.0	5.3	5.3	3.2
Waterfowl	3.0	1.5	3.4	4.1	2.9	1.5	2.7
Herons	1.9	1.5	2.6	4.1	2.6	1.5	2.4
Waders	1.3	1.1	1.9	4.3	na	2.1	1.3
Marine birds	1.4	0.6	2.7	2.6	1.6	1.4	1.2
Owls	3.2	1.3	4.1	3.6	3.4	2.1	2.2
Birds of prey	2.1	1.3	4.0	3.8	2.9	1.1	2.7
Swifts	2.5	0.8	2.8	3.8	2.8	5.3	1.4
Other birds	1.5	0.9	2.1	3.1	3.0	0.1	1.9
Passerines	4.0	1.4	2.2	3.7	4.6	2.5	2.4
Insectivora	3.6	2.5	4.0	4.5	5.1	2.2	2.0
Carnivora	2.6	1.4	4.0	4.4	3.5	1.4	2.0
Rodents and rabbits	2.5	1.4	3.2	2.4	3.1	0.0	1.8
Artiodactyla	0.9	0.4	1.4	3.2	na	2.6	0.0
Chiroptera	2.4	1.2	2.7	3.2	na	na	1.9
Overall causes	3.3	1.3	2.9	4.1	4.6	1.4	2.1

NA = NOT APPLICABLE.

TABLE 5. Cost-benefit analyses of the rehabilitation process according to the prognostic category. The cost-benefit index expresses the number of released animals per euro and day stay at the WRC.

PROGNOSIS CATEGORY*	1 (Healthy)	2 (Mild)	3 (Severe)	4 (Very severe)
Amphibians	5.0	0.3	0.0	0.0
Chelonians	4.2	0.7	0.3	0.0
Squamata	3.9	0.7	0.4	0.2
Waterfowl	3.9	0.8	0.4	0.2
Herons	0.8	1.8	2.1	0.5
Waders	1.9	1.5	1.4	0.4
Marine birds	0.8	3.0	1.3	0.3
Owls	2.9	1.6	0.6	0.1
Birds of prey	1.5	1.9	1.5	0.4
Swifts	2.3	1.4	1.1	0.5
Other birds	2.4	1.7	0.9	0.2
Passerines	3.0	1.8	0.4	0.0
Insectivora	3.0	1.4	0.6	0.2
Carnivora	2.2	1.0	1.2	0.8
Rodents and rabbits	2.7	1.9	0.5	0.2
Artiodactyla	2.3	1.1	1.1	0.8
Chiroptera	2.1	1.9	0.9	0.4
Overall	2.9	1.6	0.6	0.2

*1, apparently healthy; 2, mild weakness or thinning, uncomplicated fractures; 3, severe (including dehydration, open fractures, deep wounds) and 4, very severe (major injuries, emaciation, paralysis, blindness, respiratory distress).

prevalent cause of admission in the WRC worldwide, representing up to 31% of the total admissions.[11] In this study, the most frequent cause of admission (40%) was the illegal confiscation of protected species, in particular of finches and tortoises. In Spain, trapping and confinement for leisure purposes (singing competition) of male birds of the family Fringillidae is a traditional activity.

However, nowadays there are much more regulation that is restricted and more persecuted illegal captures. In Europe, the illegal taking and trading in wild birds is still a serious problem with clear regional patterns, having a considerable negative impact on biodiversity across the continent.[23] Illegal possession of reptiles, principally of tortoises for pet trade, is an important threat for species of the genus Testudo in the Mediterranean and Asia Minor regions.[24,25] In Spain, this trade has never reached the high levels observed in some other countries, although a regular national trade has been found within the natural range of the species around urban centers such as Madrid and Barcelona.[26] Moreover, in different areas of Spain, the capture of wild tortoise species to keep them as pets is a long-established tradition.[27]

The second leading cause of admission in this study was the orphaned young, representing a 32% of the cases. This percentage of orphaned was very similar to the 28% reported in United Kingdom;[28] but higher than the 17% in Andalusia (Southern Spain)[29] and the 14% reported in Australia.[9] As previously described,[10,30] most of the attended cases belong to species living in close contact with urban and surrounding areas. Indeed, the Wildlife Rehabilitation Center is located in a densely populated region and the finding of juvenile wild animals is very common. Moreover, the social awareness on animal welfare and the information campaigns in the media have also contributed increasing the number of cases attended at the center along the period of study. Hand-rearing wildlife is a long, difficult, and expensive time-consuming task, although it can highly change depending of the species (owls are much more easy to rear than swift for instance). Many aspects should be considered critical for the success of the process, including both the physical development of healthy animals and the acquisition of natural behavior. On the other hand, the majority of those admissions are concentrated during the breeding season of these species along the summer and spring months, demanding an implementation of staff and economical resources management. Successful post-release survival rates of hand-reared wild animals have been reported in some species, justifying those efforts and expenses.[31,32,33,34]

Trauma related with anthropogenic activities represented another important cause of morbidity. In our study, the trauma of unknown origin represents the largest number of admissions and shows an increasing trend, compared to other causes of injury. Unfortunately, this result can be explained by errors in the identification and classification of the origin of trauma, which are intrinsic to the collection of information in the Wildlife Rehabilitation Centers. A more detailed analysis of the trauma category has confirmed that collisions with vehicles are the second leading cause of injury, especially in mammals and birds, as in other reports.[11] Gunshot was still present, indicating that, despite the legal protection of most of the species in Spain, illegal hunting has not been eradicated. In particular, shooting was relevant mainly in birds of prey, which have traditionally been considered competitors for humans.[35]

Misplacement was especially important in amphibians, reptiles, and Insectivora (mainly hedgehogs). In most of these cases, those animals are found in the proximity of human settlements or buildings. Similar to the young category, living near humans, increases the possibility of contact of these animals with the public, especially in densely populated areas.[10]

Finally, the positive increase of the admissions due to primary infectious and metabolic diseases along the years of study might be consequence of the improvement in diagnostic and health protocols. In this kind of studies it is worthy to remark that mortality rates attributed to infectious or parasitic diseases or chronic poisoning may be underestimated, being a possible bias of the study. However, due to financial constraints at the WRC, we must assume such kind of bias since it is economically unaffordable a thorough analysis in all admitted cases.

In our study, the analysis of the rehabilitation outcomes showed an overall release rate (R_r) over 50% of the admissions, higher than previously reported outcomes in other generalistic Wildlife Rehabilitation Centers. In a recent review, an overall R_r = 40% has been published in the centres of the RSPCA in UK.[12] Similarly, the R_r in Wildlife Rehabilitation Centers in Australia ranged from 38 to 45%.[9] The analysis of the rehabilitation outcomes showed that "Captivity", "Misplacement," and "Orphaned" categories presented the best rate scores of releases. The highest R_r found in the "Captivity" and "Misplacement", could be mostly explained by the large proportion of healthy animals, especially the recently captured birds. In fact, the severity of the clinical condition has been reported as the best predictor for the individual survival and release of wildlife casualties despite the species.[36,37] The best R_r of the Orphaned young was seen for the raptors and owls and in the hedgehogs. These results are very similar to that described in other Wildlife Rehabilitation Centers.[28,38]

As regards as the M_r the overall value of 22% is lower than the 34% published in Australia.[9] As mentioned above, higher mortality is associated with the severity of injuries. For this reason, the highest M_r were observed in most groups of animals due to trauma, infectious and metabolic or nutritional diseases. On the other hand, the highest rates of natural death (M_r) were found in "Orphaned" waders and passerines. Hand-rearing of these birds results is a challenging task due to the heterogeneity of species and diets and the inherent fragility of the pediatric patients.[39] Many factors must be considered in order to address this problem such as the composition and preservation of food, hand-rearing and weaning protocols, or prophylactic medical treatments; moreover, other additional difficulties in wildlife rehabilitation practices are obtaining necropsy specimens that are not autolytic and the budget constraints for postmortem studies. The overall value (11%) of M_r in the illegal captive category was lower than that reported in parrots in South America.[40] The mortality reported in that study of parrot trade was mainly consequence of massive confiscations of animals kept or transported improperly, and it comprised a mortality of 31% during transport, related to stress, sickness, rough handling, and asphyxiation. Severe deficiencies in animal welfare are of major concern in wildlife trade.[41]

Finally, it would be emphasized that euthanasia is the most reasonable decision when the animal's welfare is compromised, due to the animal injuries or when the prognosis is poor or the animal unsuitable for release.[1,42] In two retrospective studies performed in Australia, the E_r was 50% in Queensland,[43] and 18% and 24% in Victoria and New South Wales, respectively.[9] In the present work, the overall E_r was lower; however, a stratified analysis of the data is necessary in order to compare the outcomes between centers. The higher proportion of euthanasia was observed in the trauma casualties, independent of the animal group. In fact, injuries that are associated with serious disabilities such as severe fractures, neurological deficits or soft tissue damage can lead to the decision to euthanize.[11] Although we have not detailed the clinical signs of the patients included in this paper, it would be inferred that wing fractures or luxations in swifts and bats or soft tissue damage in marine birds are associated with a very poor prognosis. In the group of orphaned, the most critical aspect in the rehabilitation process is the acquisition of natural behavior and skills to survive in the wild. Moreover, assessing the degree of socialization is a difficult task. Unfortunately, wild animals suffering socialization problems or imprinting should not be released. The higher E_r has been observed in marine birds and Artiodactyla. In fact, most of the Artiodactyla are considered as game species in Catalonia. In those cases, euthanasia considerations are based not only on the clinical prognosis and the individual welfare, but also taking into account biological hazards and economic criteria.

Importantly, the early assessment of prognosis and suitability for release is crucial in order to avoid unnecessary suffering of wildlife attended in Wildlife Rehabilitation Centers.[44] For this reason, the main goal of these Centers is to achieve the release as quickly and effectively as possible. In consequence, the time of stay could be a useful tool for the evaluation of Wildlife Rehabilitation Center. Unfortunately, this parameter is scarcely reported in the literature. In the mentioned work in Australia, 64% of the casualties have a time of stay (T_s) between 0–5 days and 7% stay more than 100 days.[9] In our experience, the media T_s is 9 days and the P_{90} is 69 days for the overall cohort. Due to the non normal distribution of this variable, this variable should be presented as median and percentiles.

Moreover, in our study, the T_s was introduced as an estimator of the cost of the rehabilitation process, since each day of hospitalization in the center represents a cost in staff, food, and medicines. Although this is not a complete measure of the real cost, this parameter can be an indication of resource usage, and be useful as a rough approach to efficiency.[44] Taking into account this concept, passerines represented the group with the lowest cost per animal released (T_s of 12 days). By contrast, poached birds of prey had the longest stay (128 days), mostly due to plumage and behavior abnormalities. Orphaned young passerines and swifts had also shorter stays than birds of prey and owls. Indeed, swifts represented 20% of the admitted hand-reared birds with a median stay of 19 days and a P_{90} of 40 days. Within the overall group of the orphaned young, the P90 was higher than 5 months as a result of the management policies of the center which does not allow releasing young animals during the winter months, especially mammals as bats and hedgehogs. Finally, trauma-related casualties were in general time-consuming, with long Ts and in consequence less efficient saving costs; in birds of prey were especially long (Ts = 114 days of median) because of the muscle-skeletal and nervous system injuries requires long clinical healing and rehabilitation. Similarly, conditions as infectious or metabolic diseases are also associated to long recovery times.

Economic evaluation (EA) is a quantitative technique developed by economists to promote the most efficient use of the resources. In human medicine, there are different studies of EA, as cost-effectivity, cost-utility or cost-benefit.[45] The cost and benefits associated with oiled bird care has been discussed, but those analyses are still scarce in WRC.46 In the present study, we used a cost-benefit study in order to compare the effectiveness of the rehabilitation process according to the cause of admission and zoological group and prognostic category. The cost-benefit index revealed the worse results in the trauma casualties and infectious diseases, but also a low value in the orphaned group.

One of the most important limitations in this study was to assume that the daily cost was the same for the different species, clinical conditions and husbandry protocols. Although this approach is not accurate, [it] allows an overall success estimation of the rehabilitation process and the detection of differences between zoological groups and admission categories. Nevertheless, our analyses must be considered partial because we did not perform comparisons among different alternatives of health or rehabilitation protocols, according to the specificities of the causes of admission and the diversity of species. A correction factor for the cost-benefit parameter should be introduced in further studies to compensate for cost differences depending on the species or taxonomic categories.

Finally, in Catalonia, the Wildlife Service is the only one that has competence in the care of wild species that are found injured or orphaned. For this reason most of the animals have been collected by the competent authorities from the wild or most of the time they picked up from citizen's home. It should be noted that private citizens are the following group bringing animals directly to the WRC, as expected in an area so populated as the area of influence of our center.

In our opinion, the cost-benefit analysis of wildlife rehabilitation based on the admission causes and the prognostic category are complementary and useful for the detection of critical points in the clinical and husbandry protocols and the management of WRC. In conclusion, we suggest that an initial approach to cost-effectiveness studies of Wildlife Rehabilitation Centers should include both the outcomes indicators, the stay at the center, and a cost-benefit index in the different zoological groups and primary cause of admission. In the future, it would be desirable to conduct more specific cost-effectiveness analysis to improve the overall performance of rehabilitation, both for economic reasons and in order to improve the animal welfare.

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Partners for Wildlife

By Molly O'Bryan

Molly O'Bryan, MPH is the Program Director for the Partners for Wildlife initiative at The Raptor Center.

Wildlife rehabilitators provide a critical and valued service to their communities, with an estimated half million wild animals seen by passionate and engaged rehabilitators each year in the United States. The Raptor Center (TRC) at the University of Minnesota has an international reputation as a long-standing headquarters for quality rehabilitation, medical and surgical care, and education. Over the years, faculty and staff at TRC noticed a need for grassroots support to improve animal welfare conditions within wildlife rehabilitation. With this in mind, TRC embarked on a first-of-its-kind three-year initiative to raise the bar for wildlife rehabilitation care across all species—not just raptors—called Partners for Wildlife (P4W). "We are applying our hard-learned lessons to start the conversation and create a structure that will benefit wildlife," says Dr. Julia Ponder, TRC's Executive Director. The program will begin with pilot efforts in seven states (WI, MN, ND, MT, ID, WA, and AK).

Animal welfare in wildlife rehabilitation

The World Organization for Animal Health (OIE) defines animal welfare as "how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behavior, and if it is not suffering from unpleasant states such as pain, fear, and distress." Many of us are familiar with animal welfare concepts in livestock, domestic pets, and zoo animals. However, welfare in wildlife rehabilitation settings can be trickier to define, particularly because these settings are inherently stressful for wild animals that would not typically tolerate human contact.

The good news is that welfare is not an all-or-nothing concept. It is possible to reduce stress-causing events while also ensuring that other indicators of good welfare are met in order to reduce the psychological and physiological impacts of stress. For example, an animal that is experiencing pain from a fracture as well as stress from human handling would not necessarily be experiencing poor welfare if its nutritional needs are being met, it is being housed in a safe and appropriate environment, offered enrichment opportunities, given pain relief, and handled minimally and thoughtfully.

Ensuring good welfare is not only a matter of ethics—it also reduces the healing time and increases the likelihood of release. However, what happens when an animal's prospects for release are poor and how do welfare considerations come into play in those cases? Some centers hesitate to humanely euthanize an animal that stands little chance of full recovery, even when severe pain and distress are present. Others will err on the side of placing an un-releasable wild animal as an education ambassador rather than euthanizing, even when the animal will experience chronic pain or be unable to adjust to human interaction. These situations raise questions as to whether living in captivity with protracted discomfort provides a better welfare outcome than euthanasia. In the official view of TRC, all species would benefit from wildlife rehabilitation centers agreeing on a set of guidelines for good animal welfare.

The Partners for Wildlife approach

In order to improve animal welfare in wildlife rehabilitation, P4W will take a three-pronged approach.

First, P4W will work directly with rehabilitators to discover opportunities to improve animal welfare in their centers. Together, rehabilitators and P4W will strategize for improvements and upgrades, and P4W will provide small grants to make big impacts on the welfare of animals in rehabilitation. In turn, the lessons learned and opportunities identified will help in the creation of standardized approaches among centers.

Juvenile martial eagle *(Polemaetus bellicosus)* in flight cage.

Second, the project aims to build relationships and strengthen communication between veterinarians and rehabilitators. During each of the first three years of the initiative, three wildlife rehabilitators and three general practice veterinarians will be named to the fellowship program, creating a community where they can interact routinely and develop partnerships. Recipients will begin the fellowship experience with a kickoff workshop that will bring together key P4W stakeholders in order to come to a common understanding of the true concept of animal welfare in wildlife rehabilitation. Throughout their fellowship, they will remain in touch with the program regarding hurdles they are facing in their centers, and be encouraged to work closely with their rehabilitator or veterinarian counterparts to find solutions. At the end, veterinarians and rehabilitators will pair up to build a proposal intended to improve or inform animal welfare.

Lastly, the project will build professional capacity in clinical wildlife medicine by offering six one-year clinical internships over the course of the project to veterinarians hoping to specialize in wildlife medicine. The expectation is that these interns will grow into mentors for future veterinarians with an interest in clinical wildlife veterinary medicine.

In bringing passionate people together and working towards a common set of objectives, it is TRC's hope to spread awareness and understanding. This model has acted as the backbone for TRC for decades, as the center has used public education and veterinarian training to further improve the lives of raptors as well as the environment.

"This project is mission-driven because our mission is not just about us; it's about leveraging our knowledge (and that of our partners) to help wildlife," says Ponder. "Built into this program are a variety of efforts to change the world of wildlife rehabilitation—by improving it and by using new tools to educate people." ■

Stay tuned for more on The Raptor Center's Partners for Wildlife program in upcoming issues of the Journal of Wildlife Rehabilitation.

News
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PON1—by disrupting their neurological systems.

Clark and Meyer worked with Joseph Gaspard, Ph.D., director of science and conservation at the Pittsburgh Zoo & PPG Aquarium, and Robert K. Bonde, Ph.D., now a scientist emeritus at the U.S. Geological Survey's Wetland and Aquatic Research Center, to obtain marine mammal blood samples from U.S. and international scientists as well as conservation biologists. Collaborators at the University of Washington tested blood samples from several marine mammals with an organophosphate byproduct and observed that the blood did not break down the organophosphate byproduct as it does in land mammals. This indicated that unless a different biological mechanism is protecting marine mammals, they would be susceptible to "organophosphate poisoning," a form of poisoning that results from the buildup of chemical signals in the body, especially the brain.

As an example of the potential real-world consequences of losing *PON1* function, the researchers explain that in Florida, "agricultural use of organophosphate pesticides is common and runoff can drain into manatee habitats. In Brevard County, where 70 percent of Atlantic Coast manatees are estimated to migrate or seasonally reside, agricultural lands frequently abut manatee protection zones and waterways."

World's Largest Penguin Colony Sees 90% Population Decrease

PARIS (July 27, 2018)—Thanks to high resolution satellite images, researchers at the Centre d'Etudes Biologiques de Chizé found a massive 88% decline in the king penguins (*Aptenodytes patagonicus*) colony located at the Terres Australes et Antarctiques Françaises (TAAF) nature reserve.

Since the 1960s, the island of Cochons in the Southern Indian Ocean has been home to the largest king penguin colony in the world, which is also the second largest colony of any penguin species. Due to its isolation and inaccessibility, however, there have been no population estimates for decades.

Scientists used high resolution satellite images to measure size changes of the colony since the last visit of the island by a scientific team. In 1982, the colony had 500,000 breeding pairs and a population of over 2 million. To evaluate the areas occupied by penguins between 1960 and today, scientists compared satellite images of the colony year to year and realized that the population decreased, while nearby vegetation increased. Snapshots taken from a helicopter during the Antarctic Circumpolar Expedition confirmed the dramatic colony reduction.

These results suggest that the decline began in the late 1990s, coinciding with climate change in the Southern Ocean related to the El Niño phenomenon. This weather event has also affected the foraging capacity of another colony located 100 km from the island of Cochons and also caused its decline.

The presence of diseases has also been posed as a hypothesis for the population decline, as avian cholera is currently decimating seabird populations on other islands in the Indian Ocean.

Field studies carried out by CNRS researchers, with the support of the French Polar Institute Paul-Emile Victor and in close partnership with the team of the Southern Lands Nature Reserve, will soon be conducted to confirm the first satellite images.

A Decade Sees Tiger Population Double in Nepal

KATHMANDU (September 23, 2018)—On National Conservation Day 2018, Nepal announced that there are now an estimated 235 wild tigers in the country, nearly doubling the baseline of 121 tigers in 2009. If these trends continue, Nepal could become the first country to double its national tiger population since the TX2 goal—to double the world's wild tiger population by 2022—was set at the St. Petersburg Tiger Summit in 2010.

"Our commitment to the Global Tiger Recovery Program gains new ground with Nepal's growing tiger numbers and the successful implementation of Nepal's

Tiger Conservation Action Plan," stated Bishwa Nath Oli, Secretary of the Ministry of Forests and Environment. "Protecting tigers is a top priority of the government, and we are thankful for the able support of our partners, enforcement agencies, local communities and the international community for a common purpose."

Nepal conducted its national tiger survey between November 2017 and April 2018 in the transboundary Terai Arc Landscape (TAL), a vast area of diverse ecosystems shared with India. Camera traps and occupancy surveys were used to estimate tiger occupancy and abundance, and line transect surveys to derive prey density. The last survey in 2013 had estimated the population at 198 individuals.

"This significant increase in Nepal's tiger population is proof that when we work together, we can save the planet's wildlife—even species facing extinction," said Leonardo DiCaprio, WWF–US board member and chairman of the Leonardo DiCaprio Foundation, which has funded tiger conservation in Nepal's Bardia National Park and elsewhere since 2010. "Nepal has been a leader in efforts to double tigers within its own borders and serves as a model for conservation for all of Asia and the world. I am proud of my foundation's partnership with WWF to support Nepal and local communities in doubling the population of wild tigers."

The success in Nepal has been largely attributed to the country's political commitment and the adoption of innovative approaches towards tiger conservation. Nepal was the first country to achieve global standards in managing tiger conservation areas, an accreditation scheme governed by the Conservation Assured Tiger Standards (CA|TS). With four years to go, the TX2 goal of doubling tiger numbers globally can only be achieved if all the tiger-range countries step up and commit to a similar level of excellence.

In May this year, Nepal celebrated a new benchmark with the achievement of 365 days of zero poaching of rhinos on five occasions between 2011 and 2018. This is another example of conservation change that can be achieved when a country unites and coordinates the efforts of the government, enforcement agencies, conservation partners and local communities.

"Every tiger counts, for Nepal and for the world," stated Dr. Ghana S. Gurung, Country Representative, WWF-Nepal. "While Nepal is but a few tigers away from our goal to double tiger numbers by 2022, it also underscores the continued need to ensure protection, and improved and contiguous habitats for the long-term survival of the species."

The tiger and prey-base survey was led by the Government of Nepal's Department of National Parks and Wildlife Conservation and Department of Forests, in partnership with WWF-Nepal, National Trust for Nature Conservation and Zoological Society of London (ZSL) Nepal. It was funded by WWF, ZSL Nepal, National Trust for Nature Conservation, USAID's Hariyo Ban Program II, KfW/IUCN, Leonardo DiCaprio Foundation, Panthera and WildCats Conservation Alliance.

Public–Private Collaboration to Help Whooping Cranes

WASHINGTON, D.C. (August 23, 2018)—Endangered whooping cranes are safer during their twice-yearly migratory journeys, thanks to years of effort by Kansas utility companies to identify and mark powerlines that pose the greatest risk to the birds. Although rare, collision with powerlines is the greatest known source of mortality for fledged whooping cranes.

"Whooping cranes number only about 750 in the world, including more than 500 that migrate between Aransas Wildlife Refuge in Texas and their Canadian breeding grounds," said Steve Holmer, Vice President of Policy at American Bird Conservancy. "We're grateful for the work by Westar Energy and other companies who are helping to make the whooping cranes' long-distance journey safer and more likely to succeed."

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The work in Kansas to reduce collisions is focused around the Quivira National Wildlife Refuge and Cheyenne Bottoms, important stopover areas between the species' wintering and breeding grounds. These sites provide essential habitat allowing the birds to rest and refuel before continuing the 2,500-mile journey.

The Kansas Electric Utility Whooping Crane Conservation Plan and associated Advisory Group formed in 2013 in response to line-marking guidance released by the U.S. Fish and Wildlife Service in 2010. Members of the Advisory Group include the Kansas Electric Power Cooperative; Kansas Biological Survey; Midwest Energy; Westar Energy; Kansas Department of Wildlife, Parks and Tourism; Kansas Ornithological Society; The Nature Conservancy; Sunflower Electric Power Corp.; and the U.S Fish and Wildlife Service (advisory).

Participating Kansas electrical utilities aimed to pool financial resources and collaborate to make the highest-risk lines safer for cranes, regardless of which company owned and operated the lines. All powerlines within 5 miles of Cheyenne Bottoms and Quivira were assessed for marking based on the surrounding landscape and documented habitat selection criteria often used by whooping cranes.

Using guidelines developed by the Avian Power Line Interaction Committee, various marker designs have been used in this effort. While most markers can be installed by hand, some require the use of helicopters to install markers on transmission lines not accessible from the ground.

"It has been very exciting to see how industry, regulators, and organizations come together to identify high priority areas that can then be addressed with line marking to help protect not only whooping cranes, but so many other species that can be at risk from line collisions," said Chuck Otte, Kansas Ornithological Society and member of the Advisory Group.

In addition, an American Bird Conservancy and International Crane Foundation whooping crane mapping study provided additional data, analyzing the distribution of wind turbines and associated powerlines and towers near stopover sites in the crane's migratory corridor. These intersections with powerlines will be reviewed by the companies for inclusion in line-marking efforts in the future. ■

TAIL END

Wallace knows he really shines on the Toe-Strut.

Sanderlings *(Calidris alba)* at Moss Landing, California.

INSTRUCTIONS FOR AUTHORS

POLICY Original manuscripts on a variety of wildlife rehabilitation topics (e.g., husbandry and veterinary medicine) are welcomed. Manuscripts that address related topics such as facility administration, public relations, law, and education are invited as well.

Associate editors and anonymous reviewers, appropriate to the subject matter, evaluate each submitted manuscript. Concurrent submission to other peer-reviewed journals will preclude publication in the *Journal of Wildlife Rehabilitation* (JWR). The International Wildlife Rehabilitation Council (IWRC) retains copyright on all original articles published in the JWR but, upon request, will grant permission to reprint articles with credit given to the IWRC–JWR.

SUBMISSIONS All submissions should be accompanied by a cover letter stating the intent of the author(s) to submit the manuscript exclusively for publication in the JWR. Electronic submissions are required; hard-copy manuscripts are not accepted. The manuscript file should be attached to the submission letter (which can be the body of your email) and sent to:

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MANUSCRIPT Manuscripts should be MS Word documents in either PC or MAC platform (*no PDF files*).

Manuscript should be typed in Times Roman, 12 pt., double-spaced throughout with one-inch margins.

Include the name of each author. Specify the corresponding author and provide affiliation, complete mailing address, and email address. The affiliation for all authors should be included in a brief (maximum of 100 words) biography for each that reflects professional experience related to rehabilitation or to the manuscript subject matter rather than personal information. Biographies may be edited due to space limitations.

Include an abstract that does not exceed 175 words and choose several (up to 14) key words.

Templates have been developed for the following submission categories: case study, technique (including diets), research, and literature review; authors may request a copy of one, or all, of these templates from the editor (jwr.editor@theiwrc.org) before developing a manuscript for submission to the JWR.

STYLE The JWR follows the Scientific Style and Format of the CSE Manual for Authors, Editors, and Publishers, 8th Edition. The complete "JWR Author Instructions" document is available at:

http://theiwrc.org/journal-of-wildlife-rehabilitation/ jwr-submission-guidelines

or by email request to the Editor. This document provides formatting guidelines for in-text citations and the Literature Cited section; provides the JWR textual requirements for tables, figures, and photo captions; and describes quality and resolution needs for charts, graphs, photographs, and illustrations.

A whooping crane (*Grus americana*) prepares for takeoff.

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